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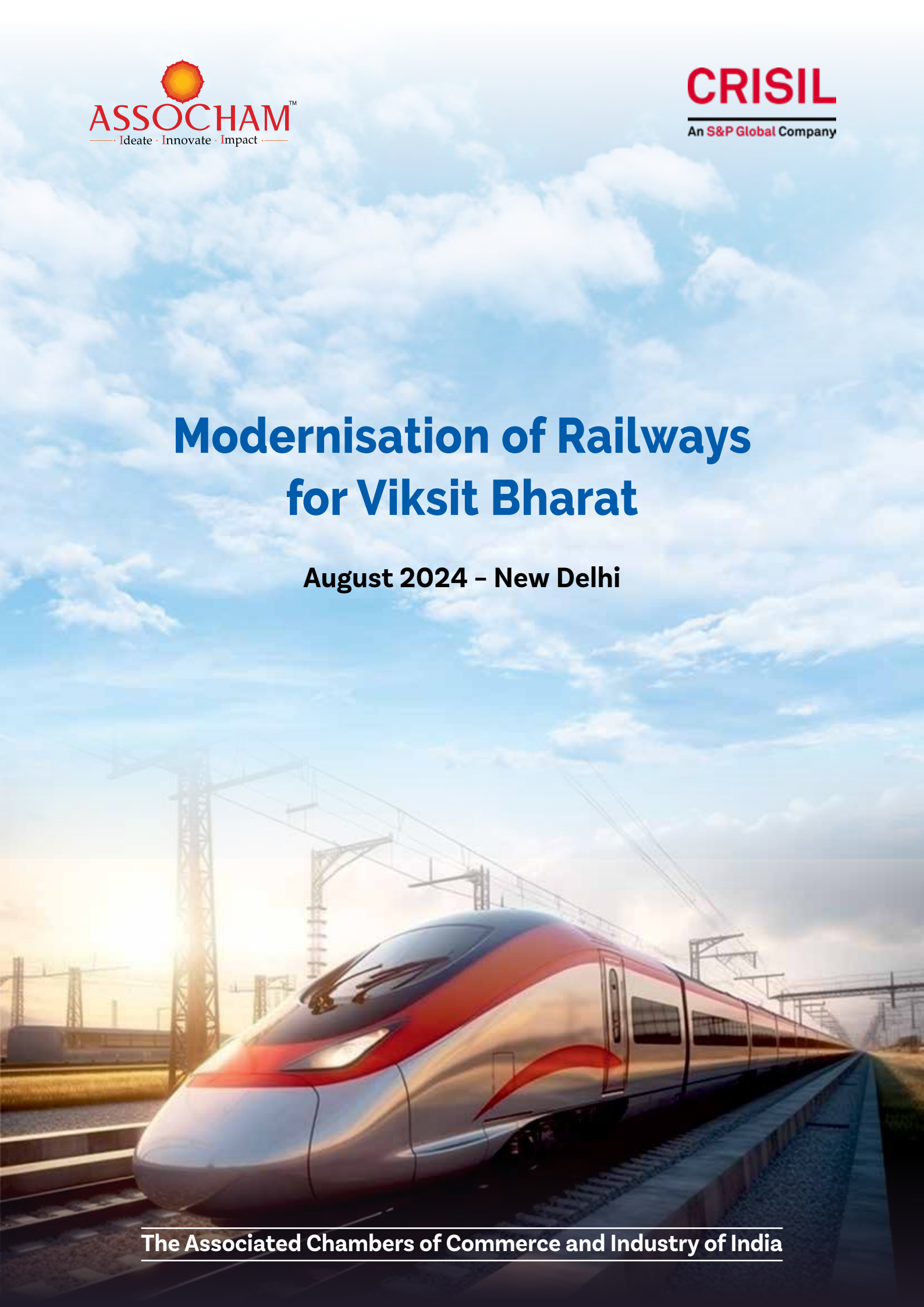
Modernisation of Railways for Viksit Bharat

August 2024 – New Delhi



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Deepak Sood
Secretary General, ASSOCHAM

Message

The modernisation of Indian Railways is crucial for achieving the vision of Viksit Bharat, as it is a pillar of the nation's infrastructure and economy. By upgrading the rail network, India can significantly improve connectivity, reduce travel time, and boost economic activities across regions. Modernisation efforts are aimed at enhancing efficiency, safety, connectivity, and sustainability, thereby contributing to overall national progress. These advancements not only enhance passenger experience but also contribute to regional development by connecting industrial hubs and fostering economic growth.

The adoption of advanced digital systems, such as Real-time Train Information Systems and AI-driven predictive maintenance, etc ensures safer and more efficient operations. Smart stations equipped with automated services, digital ticketing, and enhanced security features are being developed to cater to the needs of modern travellers. Moreover, the complete electrification of the rail network and the introduction of energy-efficient trains are crucial for reducing the carbon footprint of the railways, aligning with India's broader sustainability goals.

These innovations are revolutionizing the way railways are conceptualized, designed, and managed, utilizing cutting-edge technology to foster collaborative partnerships among stakeholders. As a result, Indian Railways is undergoing a transformation that is reshaping the future of rail transportation in the country. The modernization and expansion of rail infrastructure present a multitude of challenges and opportunities at various stages. To propel India towards self-reliance and meet the challenges ahead, the Indian rail sector needs to focus on developing indigenous technology and fostering innovative potential. This will enable the delivery of intelligent solutions for safety, security, connectivity, seamless operation, and sustainability.

Railways being one of the key focus areas of ASSOCHAM, our efforts are to provide valuable inputs to the Government for the right policy formulation and bring in comprehensive support to the industry. To take our initiatives forward, ASSOCHAM, jointly with CRISIL India, has prepared this report on 'Modernisation of Railways for Viksit Bharat' to highlight the major initiatives being taken by Indian Railways towards its modernization.

We hope that the report will provide important insights to policymakers, industry leaders and stakeholders and will be helpful in making the Indian rail transport system of international standards and the discussions at the conference will be useful and informative to stakeholders.

(Deepak Sood)

CRISIL
An S&P Global Company

Ashutosh Bhandari
Director - Transport, Logistics and Mobility
CRISIL – Market Intelligence and Analytics

Foreword

Demand for speedy, comfortable, safe and reliable rail transport has burgeoned over the years in tandem with India's growth.

That has spurred a transformation of Indian Railways, focused on safety, enhancement of capacity and induction of modern technology.

The transformation is backed by government policies and initiatives such as the National Rail Plan, Amrit Bharat Station Scheme, Gati Shakti Multi-Modal Cargo Terminal, and Electric Locomotive Factory-Madhepura.

After all, for the nation to realise its progressive socio-economic goals, it is important that Indian Railways lives up to its fabled moniker – 'lifeline of the nation'.

Under the Viksit Bharat vision, the Viksit Rail component encompasses modernization of railway infrastructure, track and rolling stock electrification, incorporation of advanced technologies for faster, safer and comfortable journey and network expansion to unserved areas.

The modernisation will ride on an investment plan of Rs 10-12 lakh crore over the next five years, complete with modern world-class facilities.

Following the successful deployment of Vande Bharat, new generation of trains – Vande Metro, Vande Sleepers, Amrit Bharat, Namo Bharat, among others – are being developed and rolled out rapidly.

To provide connectivity to hitherto unserved areas of the country, Indian Railways is regularly achieving engineering and technological marvels in tunnelling and bridge construction.

Indigenisation of technology has been a strategic initiative, aimed at reducing dependency on foreign technology and enhancing self-reliance. This involves expansion of the Indigenous train protection system Kavach, modernization of production units, workshops and factories to improve their efficiency and ability to manufacture modern rolling stock and components domestically, and adoption of AI and big data for predictive maintenance.

In line with the National Hydrogen Mission, Indian Railways is likely to introduce its first hydrogen train this year. This initiative is part of a broader effort to enhance the sustainability and efficiency of the national transporter.

To segregate freight and passenger traffic and cater to specific requirement, the government is developing dedicated freight corridors (DFCs).

Under PM Gati Shakti, three economic corridors – (i) energy, mineral and cement corridors, (ii) port connectivity corridors (iii) high traffic density corridors – have been identified to enable multi-modal connectivity and to decongest and speed up railway network. The new corridors are expected to comprise of over 400 smaller projects and add ~40,000 km of new tracks over the next 6-8 years.

All these initiatives will help Indian Railways is setting and achieving new world standards.

We hope this report, titled 'Modernization of Railways for Viksit Bharat', compiled by CRISIL Limited in collaboration with ASSOCHAM, will catalyse discussion towards Viksit Bharat and maximise the benefits from investments planned in the sector.

I take this opportunity to thank ASSOCHAM and all other stakeholders who have supported us in developing this paper and wish them success in their endeavours.

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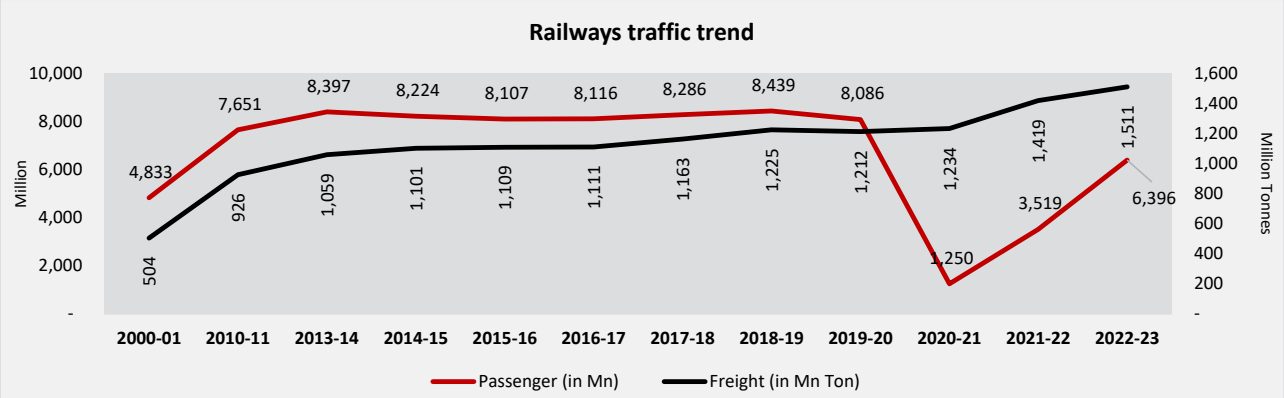
Chapter 1: Indian Railways – future-ready tracks

Indian Railways (IR), the second-largest employer in India, is undergoing an unprecedented transformation. A multi-gauge, multi-traction system, the mammoth organisation manages ~1,06,500 running track[1] kilometre and operates about 11,000 trains every day, of which 7,000 are passenger trains.

1.1 Trends – traffic, earnings and operating ratio

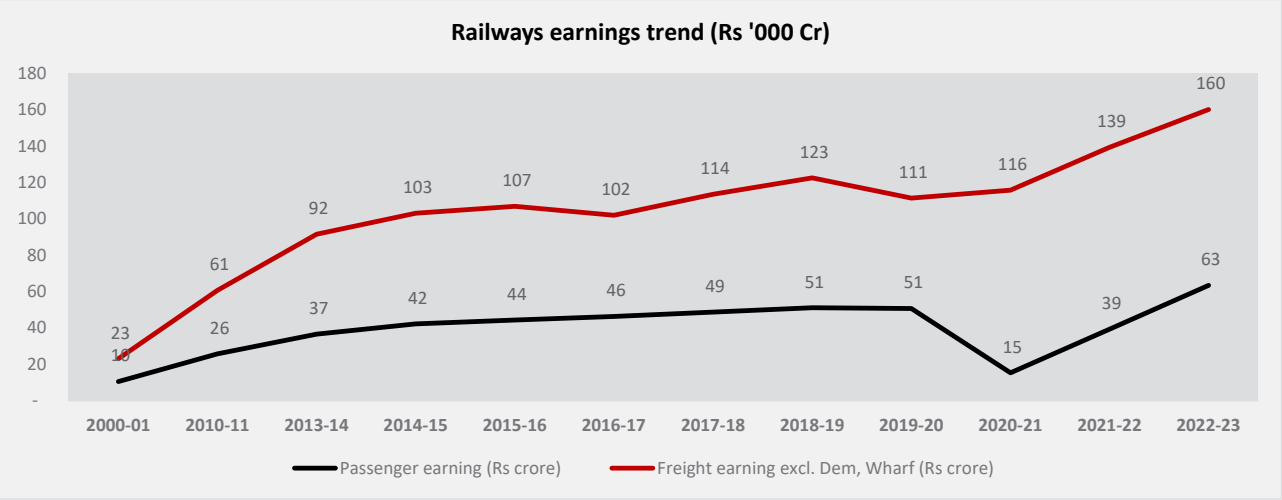
Between FY 2000-01 and FY 2022-23, railway passenger traffic clocked a compound annual growth rate (CAGR) of 1.3% – the tepid rate of growth mainly due to a compound annual decline rate of 3% in passenger traffic to 6,396 million (from 8,397 million) in the nine years since FY 2013-14. Freight traffic, however, clocked a CAGR of 5.1% and 4.0% since FY 2000-01 and FY 2013-14, respectively.



Source: Indian Railways Statistics Summary 2022-23

Passenger earnings increased at a CAGR of 8.5% between FY 2000-01 and FY 2022-23, led by hike in passenger fares, dynamic pricing, discontinuation of senior citizen concessions (reintroduced in the current year budgets) and rise in passengers carried by IR. Simultaneously, freight earnings (excluding demurrage and wharfage charges) increased at a CAGR of 9.2%.

1 Indian Railways Statistics Summary 2022-23



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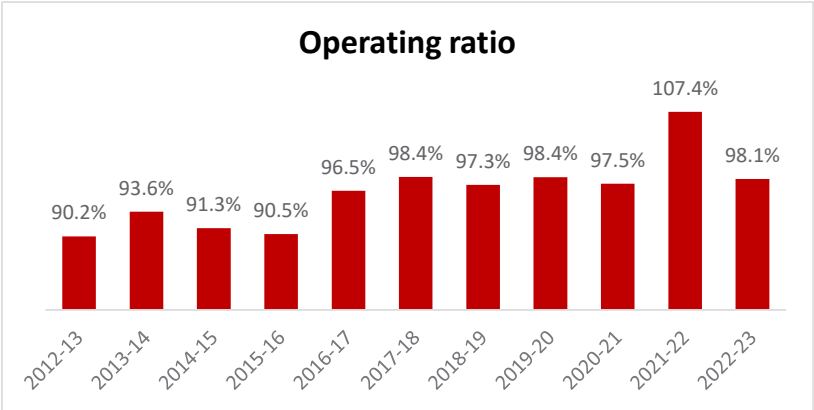
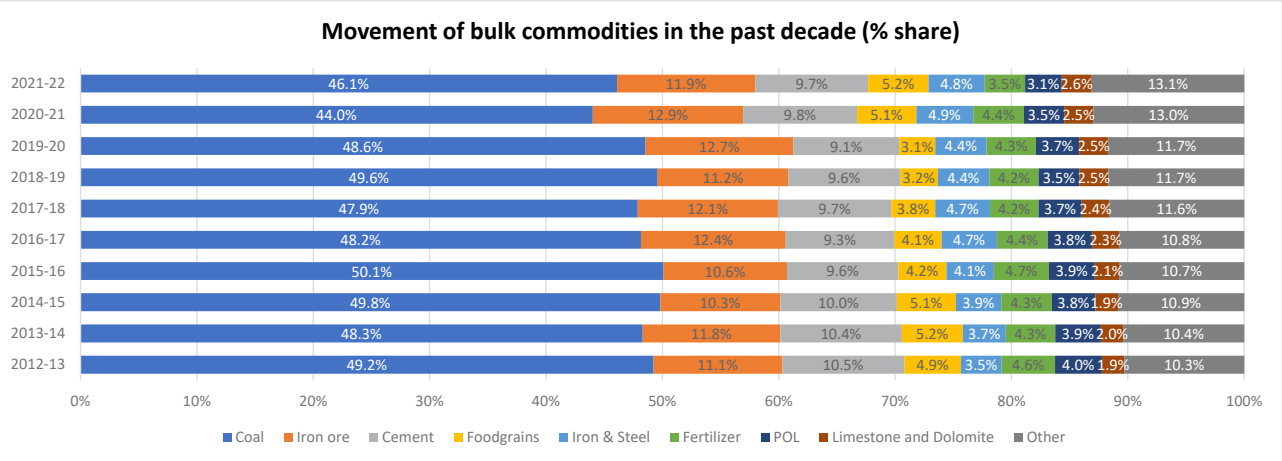


The operating ratio for IR is its operating expenses as a percentage of revenue, thereby indicating how efficiently it can earn with every rupee spent in operations. A lower operating ratio is considered better and indicates sound financial health. However, the operating ratio of IR has been high at over 90%, with it going up to 107.4% in FY 2021-22, which means that during the year, IR spent Rs 107.4 to earn Rs 100 – indicating negative surplus. A high operating ratio has created a vast investment gap for capacity expansion.

1.2 Freight mix and trends

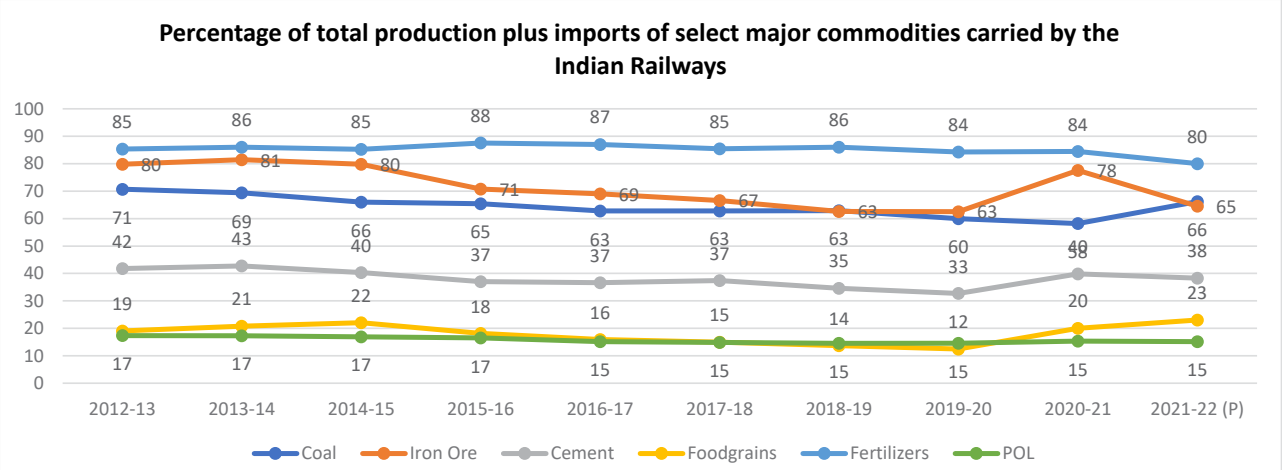
The railway transports a wide range of goods and industrial outputs such as coal, cement, iron ore, steel, petroleum and agricultural products such as foodgrains and fertilisers. The product mix, which has been skewed towards the movement of bulk commodities such as coal, cement, iron ore, steel, petroleum, foodgrains and fertilisers, is amenable for bulk movement of raw materials from production centres to factories and finished/semi-finished products from factories to consumption areas/ports for exports.

Over the past decade (from FY 2012-13 to FY 2021-22), coal constituted ~48.2% of the total freight movement, followed by iron ore (11.7%) and cement (9.8%).



Source: Indian Railways Year Books

The rail coefficient is the percentage of freight carried by rail over the total availability, which is calculated as a sum of internal production plus imports; it is an index of the market share of the railways in the industry. The below table presents the rail coefficient for major commodities between FY 2012-13 and FY 2021-22.



Source: Indian Railways Year Books

The graphical representation of the trends in rail coefficients of major commodities indicates a downward trend for most commodities, except foodgrains.

With freight traffic being sensitive to price hikes, IR has steadily lost market share to roads in various commodities such as cement, foodgrains and petroleum, oil and lubricants (POL). While cement and fertilisers have moved to roads, POL has moved to the pipeline. IR has managed to contain the market share only for commodities that are comparatively challenging to shift to other modes.

During the past few years, although there has been no increase in freight, various initiatives have been introduced including tariff rationalisation, classification of new commodities, short lead concession under which discount in freight of 50%, 25% and 10% is granted to the traffic booked up to 0-50 km, 51-75 km and 76-90 km, respectively, except for coal and coke and iron ore traffic.

1.3 Need for efficient freight transportation

In the vast tapestry of India's transportation landscape, efficient movement of goods has always been an integral thread, interweaving economic development, connectivity and sustainability. With the growth of the Indian economy, the need for a robust and efficient freight transportation system has become vital. IR is aptly called the 'Lifeline of the Nation' as it connects the country's length and breadth with a common thread.

During 2022-23, IR carried 1,511 million tonne (MT)[2] of originating freight loading; this was 92 MT or ~6.5% higher than the previous year. Despite the increasing freight volume, rail share freight declined steadily from 85% in 1951, to 60% in 1991, to about 27% in FY 2018-19[3]. This was due to the exponential increase in road network, while the railway infrastructure saw a gradual increase driven by political implications and not economic considerations. The pace of infrastructure development lagged demand, leading to decreased efficiency due to route congestion, etc.

The need to increase rail modal share has been driven by its cost effectiveness, reliability, faster transit time and environmental factors such as carbon emission etc. India being a large subcontinent, efficient and low-cost transportation of a wide range of commodities to and from hinterland is vital for its healthy, evenly spread and balanced economic growth.

To increase its modal share, IR needs to augment its capacity to meet the future increase in demand for infrastructure. As an interim target towards the National Rail Plan (NRP), IR has envisioned freight loading of 3,000 MT by 2027 (Government of India, 2022).

1.4 Government initiatives

Realising the importance of railways to enable sustainable supply chain systems, the government has launched Gati Shakti Multi-modal Cargo Transport Policy in 2021 and Mission 3,000 MT by 2027 in 2022 to leverage the modal shift to railways for freight transport. However, infrastructural constraints, multiple handling of goods, non-flexible tariff structure, etc. are the key hurdles in realising the target.

The NRP aims to increase IR's declining modal share to 45% by 2030, by developing capacity ahead of demand (2050), enabling increase in freight train speed from 25 km per hour (kmph) to 50 kmph and reducing cost of rail transport by 30%. This is proposed to be achieved by projects such as construction

2 Indian Railway Statistical Summary 2022-23
3 Mission 3000 MT – Report of the Multi-disciplinary committee for planning various measures to meet future demand of freight loading of 3000 MT per annum by 2027

of dedicated freight corridors (DFCs) on important high-density routes, running heavy haul trains with overall load of 13,000 tonne, diversification of freight basket, liberalised automatic freight rebate scheme in traditional empty flow directions, rationalisation of station-to-station rates policy, etc.

With the initiatives and policies of the government such as NRP, Amrit Bharat Station Scheme, Gati Shakti Multi-modal Cargo Terminal, Electric Locomotive Factory-Madhepura, etc., the role of IR is slowly changing from that of manufacturer/carrier to that of operator.

Under the Viksit Bharat vision, the Viksit Rail component encompasses the comprehensive agenda of modernisation of the railway infrastructure, track and rolling stock electrification, incorporation of advanced technologies for faster, safer and comfortable journey, along with network expansion to unserved areas.

There have also been several micro initiatives to attract more passengers to the railways by upgrading terminals, introducing premium trains, improving average speed, provisioning of improved passenger amenities, etc.

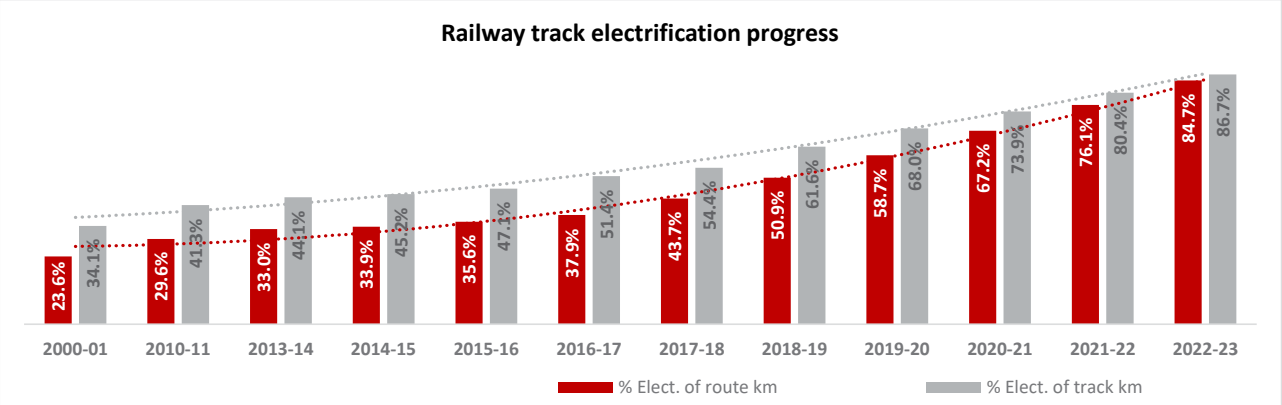
Chapter 2: Infrastructure modernisation drive

With the government's goal of total transformation of IRs, modernisation has become an ongoing and continuous process. Several projects and initiatives (aggregation/implementation of technology, policies enticing private sector participation, etc) have been taken up to develop and modernise infrastructure and thereby enhance operational efficiency and customer experience. Incorporation of artificial intelligence (AI) for enhanced infrastructure delivery and maintenance is underway. Additionally, the government's economic rationale for the modernisation push is that capital expenditure (capex) on IR has a huge multiplier effect on the economy.

2.1 Bursting capacity seams

Permanent way: Railway track, bridges, tunnels

Operations of IR are constrained by the acute shortage of physical capacity, which has resulted in severe congestion on the network. In several major trunk routes, tracks are handling capacities that are in excess of 140-150% of the rated capacity. Since FY 2000-01 to FY 2022-23, running track km has increased merely at a CAGR of 1.2% to ~106,500 km. However, of this, by FY 2022-23, about 86.7% has already been electrified.[4]



Upgrading tracks, including electrification and implementation of modern signalling systems, is a priority for ensuring safe and efficient train operations, providing smoother operations, reducing delays and optimising train schedules. Upgraded tracks can support higher speed, which is essential for accommodating high-speed trains. Additionally, improved tracks contribute to increased line capacity, allowing more trains to operate on a particular route.

Capex for upgradation and addition of tracks is necessitated to resolve the capacity constraint. Till a few years back, the lack of capital investments meant shortage of railway network capacity, which aggravated the underlying infrastructure constraint.

4 Indian Railway Statistical Summary 2022-23

Over the years, as the network has become more congested – caused by increased and frequent train operations, a widening mix of different kinds of trains with varying speeds running on the same tracks – the need to maintain train operations and traffic requirement has dictated terms that are ever in danger of running afoul of normative safety standards.

Modern tracks, combined with advanced signalling systems and well-maintained and modern tracks reduce the need for frequent maintenance, which, in turn, minimises downtime. As per reports, laying new tracks is a part of the new Vision 2047 document for IR, under which it expects to add 100,000 km of new alignments, including some replacements, doubling and gauge conversion works over the next 25 years costing Rs 15-20 trillion.

2.2 Freight corridors – DFCs, economic corridors, high traffic density corridors, port connectivity

Being the fourth largest railway network in the world, IR plays a vital role in the country's freight transportation. Of the bulk commodities carried, coal alone accounts for a significant portion of the total freight revenue. However, there has been a growing trend in containerised cargo, which is crucial for the transportation of manufactured goods and export-import trade. The containerised cargo would help in increasing operational efficiency as it would lead to a reduction in loading and unloading time.

To segregate freight and passenger traffic and cater to specific requirement, the Government of India has been working towards developing DFCs. The eastern and western DFCs aim to speed up freight movement and decongest the existing railway network. Since these are along the eastern and western leg of the golden quadrilateral, some gaps were felt in providing pan-India freight connectivity. Three additional DFCs are under various stages of planning.

Under PM Gati Shakti, to enable multi-modal connectivity, three economic corridors have been identified to decongest and speed up railway network. These are (i) energy, mineral and cement corridors, (ii) port connectivity corridors (iii) high traffic density corridors. The new corridors will comprise over 400 smaller projects and add ~40,000 km of new tracks over 6-8 years.

It is understood that IR has already begun the survey work on four multi-modal lines (proposed in FY 2024-25 Interim Budget) to complement the eastern and western DFCs. These are aimed at providing additional impetus to logistics efficiency and reducing logistics cost related to rail movement. The supplementary corridors are likely to decongest high-density rail routes and facilitate modal shift from road to rail and to coastal shipping, thereby reducing carbon footprint of logistics.

2.3 Technological firsts

Development of world-class railway infrastructure is overriding as it is an imperative growth engine for India's supply chain. For this, the induction of new age technologies and data-based platforms (geographic information system [GIS], radio-frequency identification [RFID], internet of things [IoT]) for planning,

construction, operations and maintenance are necessary. To provide connectivity to earlier unserved areas of the country, IR is overcoming challenging terrains and achieving engineering and technological marvels.

Tunnelling methodology

While constructing the 111-km-long Katra-Banihal section of the Kashmir rail link project in the challenging Himalayan terrain (shear zone coupled with high ingress of water), IR developed a new tunnelling method to complete the construction of Tunnel-1. The method involved providing pre-excavation support measures to tackle the flowing conditions encountered while excavating the tunnel.

As informed by Railway Minister Ashwini Vaishnaw, "We have innovatively developed (I)-TM as Himalayan tunnelling method for tunnelling through the Himalayan geology to build tunnels in Jammu & Kashmir." The 3.2-km-long single tube tunnel is the most difficult section of the project.

Bridge

To connect Jammu & Kashmir with the rest of India, the Jammu-Udhampur-Srinagar-Baramulla Rail Line was initiated in 2023. The section included construction of several tunnels and bridges through precarious terrains, including Chenab bridge spanning over the Chenab river to connect the Kashmir Valley with Udhampur.

After overcoming project suspension, alignment changes, design modifications, cost overruns, the project is slowly, but steadily progressing. The world's highest arch railway bridge called the Chenab rail bridge is an engineering marvel achieved by IR. It forms a large steel arch, the first of its kind in India, for which no codes or design guidance exists in the country. The bridge has been designed and constructed using global designs and technology. As another first by IR, the electrification work has been undertaking by using the Rigid Overhead Conductor System at 25 kilovolt.

Underwater tunnel

Underwater tunnelling and transport system is a feat in itself. India's first metro system -- Kolkata metro – has managed to achieve this accomplishment by becoming the first transit system in India to commute under a river. This was achieved by the 520-metre underwater tunnel. The tunnels for the metro route, including the engineering marvel of the river tunnels were developed by Afcons Infrastructure Ltd.

It can be concurred that IR has been shifting from traditional infrastructure development and transitioning towards modernised technologies.

2.4 Innovative signalling and telecommunication

As per news reports, the Indian Institute of Technology, Kharagpur, is developing a tamper-proof signalling system based on blockchain technology for IR. Embedded with enhanced safety measures, the new

system would complement the existing data logger which is considered the black box of rolling stock. The aim is to make available live status and monitoring of trains. Usage of the blockchain technology would do away with data manipulation and bring about transparency.

2.5 Gati Shakti Multi-modal Cargo Terminal: Multi-modal connectivity

As part of PM Gati Shakti National Master Plan, IR introduced Gati Shakti Cargo Terminal (GCT) initiative to boost its freight volumes (modal share) and attract private participation. The objective is to develop multi-modal logistics facilities under public-private partnership (PPP) mode and reduce logistics costs. As per the policy, GCTs can be developed under two scenarios:

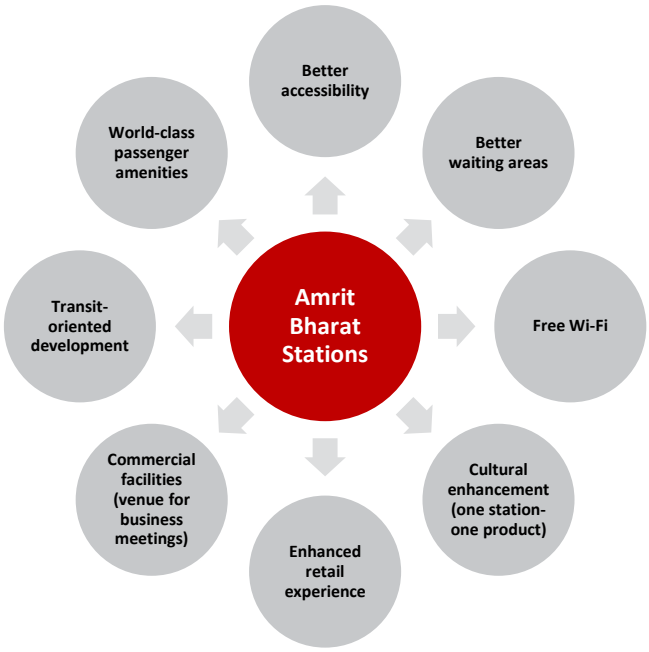
- **Railway land:** IR to identify land parcel and open tendering select concessionaire for development and operation of the GCT.
- **Private land:** Private stakeholder to identify land near railway infrastructure (siding), obtain requisite clearances from IR, construct and operate GCT.

The development of GCTs should lead to faster goods movement and decongestion of tracks for passenger trains.

2.6 Amrit Bharat Station Scheme

The main purpose of railway stations has been to facilitate passenger and freight movement. However, with urbanisation, they are being recognised as multifunctional hubs. Redevelopment of stations not only enhances IR's passenger infrastructure but enables it to leverage the unused real estate potential.

The Rail Land Development Authority having been entrusted with the mission of "Development of land/air space entrusted to the authority on sound commercial principals for generation of non-tariff revenue and creation of assets for IR" is tasked with redevelopment of stations to not only modernise transportation infrastructure but also to create vibrant, sustainable and interconnected urban centres.



Additionally, in 2023 the Ministry of Railways (MoR) has introduced the Amrit Bharat Station Scheme aimed at comprehensive upgradation and modernisation of 1,275 stations[5] across the IR network. These enhancements encompass.

5 https://pib.gov.in/PressReleasePage.aspx?PRID=1897980

Chapter 3: RS

As of 2023, the rolling stock of IR consisted of 315,791[6] freight wagons, 66,106 passenger carriages and 14,360 locomotives (locos). With 1.19 million employees, IR is one of the world's largest employers. Its vision is to develop a world-class railway system which will be able to cater to demand by keeping pace with growth and support economic growth and development. The MoR envisioned the National Rail Plan (NRP) for India keeping the year 2050 as the horizon. The plan is to create a future-ready railway system by 2030. The objective of the plan is to create capacity ahead of demand, which would cater to growth in demand right up to 2050 and increase the modal share of the railways to 45% in freight traffic.

3.1 Modernisation of RS: Retrofitting of locos, wagons and passenger coaches

Tilting trains

The IR has been working on the modernisation of its RS and is planning to roll-out tilting trains, a technology that will enable trains to manoeuvre curves at high speeds. Approximately 100 Vande Bharat trains will be equipped with this technology.

Smart locos

As majority of the route of IR has been electrified, it is converting its fleet of diesel locos into electric locos, which will help in reducing fossil fuel consumption. This will complement its vision of becoming a net-zero carbon emitter by 2030. Introduction of smart locos with AI and machine learning (ML) based propulsion systems will help in optimising loco performance and reducing maintenance cost. AI and ML help monitor the health of equipment through sensors or cameras. Instead of manual inspections, digital tracking of faults will lead to timely repair or replacement.

To accommodate a higher number of trains in a section, electronically controlled pneumatic brakes/ electropneumatic (ECP/ EP) brakes are being incorporated to reduce braking distance and thus closer spacing of trains.

- Integrated vehicle control unit: Loco control have been integrated with modern safety and operational subsystems namely distributed power wireless control system (DPWCS)/ Kavach/ end of train telemetry (EoTT).

Wagon design and modernisation

Modernising wagons is one of the key initiatives taken by IR to cater to the emerging need of more efficient and cost-effective transportation of existing commodities and expansion of the commodity basket. A new wagon design policy[7] was issued in August 2022, which has been revised further and is titled as

6 Indian Railways Statistical Summary 2022-23
7 Indianrailways.gov.in

New Wagon Design Approval Policy - Revision 2.0. The policy aims at adoption of advanced materials and technologies to create more durable and efficient wagons.

Integration of real-time monitoring systems and automatic braking technology can help the railways achieve operational reliability and safety. Modern wagons designed for high speeds and greater payload capacities will streamline loading and unloading processes while reducing maintenance needs.

To cater to the increase in demand for automobile carrying vehicles, Integral Coach Factor (ICF) coaches, which are being phased out, are being converted to NMG (new modified goods) coaches. While NMG coaches have a speed potential of 75 kmph, NMGH coaches were introduced with higher speed potential of 110 kmph, which shall create more line capacity.

The railways is continuously modernising passenger coaches to enhance travel experience for passengers across its railway network. The focus is on upgrading interior amenities to provide comfort and convenience to passengers. These include improved seating arrangements, better ergonomics, adjustable lighting and charging points, to keep passengers connected during their journey. Safety is being prioritised with incorporation of surveillance cameras and emergency communication.

3.2 New design RS

Vande Bharat

Improving passenger comfort is a key focus area for IR. In view of this, the railways have taken measures to include modern RS in its vast rail network. The modern coaches have improved interiors with upgraded fire-retardant properties, bio toilets, light emitting diode (LED) lights and screw-less fibre-reinforced polymer (FRP) panelling for interiors, among others.

As a boost to the Make in India campaign, India's first indigenous semi high-speed train, Vande Bharat, was launched in 2019. The IR aims to expand the network of these trains to every nook and corner of the country, offering three different models: Vande Bharat Sleeper, Vande Bharat chair car and Vande Bharat Metro. Some of the features of the Vande Bharat trains are quick acceleration, maximum speed of 160 kmph, automatic sliding doors, retractable footsteps and zero discharge vacuum bio toilets. Along with manufacturing Vande Bharat train sets, the railways is tying up with technology partners for manufacturing energy-efficient trains based on different technologies.

Amrit Bharat

The railways have recently started Amrit Bharat trains. The Amrit Bharat train is an LHB (Linke-Hofmann-Busch) push-pull train with locomotives at both ends for better acceleration and enhance passenger comfort significantly. These trains fall under the superfast category and are non-air-conditioned, low-cost, sleeper-cum-unreserved express trains. It is a service connecting cities which are more than 800 km apart or involve more than 10 hours of travel with existing services. These trains prioritise safety and

efficiency using a semi-permanent coupler to reduce jerks caused during start and stop. Furthermore, the space between two coaches is fully covered, aiming to minimise air pressure. These trains have maximum speed of 130 kmph.

Tourist coaches

With the aim of providing world-class modern travelling experience for passengers, the Indian railways introduced Vistadome tourist coaches. These coaches provide panoramic view through wider body side windows as well as through transparent sections in the ceiling. Some of the features are observation lounge, electronically controlled opalescence glass windows in roofs, ergonomically designed reclining seats with 180-degree rotating facility and CCTV systems.

Smart coaches

The IR has started including smart coaches in its network. These coaches are equipped with modern amenities such as smart public address and passenger information systems, smart heating, and ventilation and air conditioning systems. The RS has benefited from the implementation of IoT and monitoring systems. Real-time data is collected, enabling monitoring and predictive maintenance. This has led to improved asset monitoring and maintenance, optimised energy usage and efficient traffic management. The real-time train information system (RTIS) was developed by IR in collaboration with Indian Space Research Organisation (ISRO). The exact location of a train is obtained through global positioning system (GPS) sensors on the locomotive. Train data, including arrival and departure times at stations as well as run-through, location and speed, can be obtained through the RTIS installed on locos and trains.

3.3 Bharat Gaurav trains

To showcase India's rich cultural heritage and magnificent historical places, the Bharat Gaurav trains scheme, consisting of theme-based tourist circuit trains, was launched in November 2021. IR is aiming to leverage the core strengths of the tourism sector of India to run theme-based trains and tap the vast tourist potential of India.

Under this policy, service providers have to be registered, who will then be offered rakes consisting of ICF coaches under the right-to-use model by IR. The service providers will also have the option of procuring new coaches directly from production units through the NRC (non-railway customer) plan, and will have the flexibility to decide the business model, including themes, routes, itinerary, tariff and other attributes connected with this model.

3.4 Future of RS

Vande Metro

Aimed at revolutionising intracity transport, speed trial of Vande Metro was conducted between Villivakkam and Walajah Road Junction on August 3, 2024, by the Chief Commissioner of Railway Safety. The trial was

successful and the train demonstrated capability and potential to transform urban transportation. The Vande Metro, a 12-coach, fully air-conditioned train, is capable of running at speeds of up to 110 kmph. It is specifically designed for intercity travel for distances ranging from 150 km to 200 km. This new mode of transport promises to provide passengers with a significantly improved travel experience compared with existing options.

Hydrogen for Heritage

The IR plans to operate 35 hydrogen trains under the Hydrogen for Heritage scheme at a cost of Rs 80 crore[8] per train and ground infrastructure of Rs 70 crore per route on various heritage and hill routes. CRISIL estimates the initial running cost of hydrogen fuel train sets to be higher, which will subsequently reduce with increase in number of trains. Furthermore, the use of hydrogen as fuel provides larger benefits towards green transportation technology to support zero carbon emission goals as a clean energy source.

Besides, IR has awarded a pilot project for retro fitment of hydrogen fuel cell on existing diesel electric multiple unit (DEMU) rake, along with ground infrastructure at cost of Rs 111.83 crore, which will be run on the Jind-Sonipat section of Northern Railway.

8 https://pib.gov.in/PressReleasePage.aspx?PRID=1896102

Chapter 4: Financial landscape

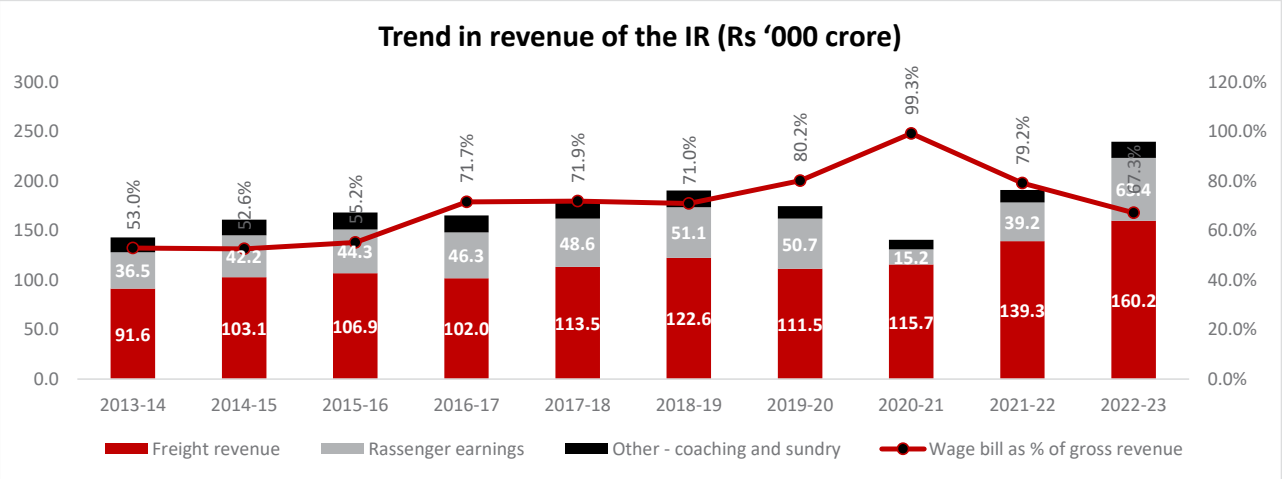
The terms funding and financing are often used interchangeably, but they are not the same. Funding refers to the revenue streams which are used to pay for a project or service, while financing refers to the financial instruments or mechanisms adopted to access external money to pay for projects and services.

The importance of financing for IR cannot be overstated. Efficient and effective financing ensures the timely completion of railway projects, connectivity enhancement, congestion reduction and passenger safety and convenience.

Typically, revenue expenditure of IR is met through revenue receipts. The excess of revenue receipts over revenue expenditure is transferred to the Railway Reserve Funds, such as development fund, capital fund, Rashtriya Rail Sanraksha Kosh (RRSK) and debt service fund, to be used as internal accrual for capex. The capex of IR is funded through gross budgetary support from the general exchequer, extra budgetary resources from the market and partnerships along with internal accrual.

4.1 Finance and revenue mobilisation

Gross revenue receipts (GRR) of IR consist of earnings from freight traffic, passenger traffic, other coaching earnings (which include parcels and luggage), and sundry earnings such as rent, catering receipts, interest, advertisements on rolling stock and station buildings. Over the past decade, the GRR of IR has increased at CAGR of 5.9% to ~Rs 240,000 crore in FY 2022-23. However, the wage bill of IR increased at CAGR of 8.7% over the same period to Rs 161.4 thousand crore. Meeting only the wage bill is a huge strain on the system, leaving negligible funds for projects and infrastructure.



Source: Indian Railways Statistics Summary, 2022-23

Thus, the expenditure of IR is financed through: (i) internal resources (freight and passenger revenue, and leasing of railway land); (ii) budget support from the central government; and (iii) extra-budgetary resources

(primarily borrowing but also includes institutional financing, public-private partnerships and foreign direct investment). Working expenses (salaries, staff amenities, pension and asset maintenance) are met mostly through internal resources. Capex (such as procurement of wagons and station redevelopment) is financed through internal resources, budget support from the central government and extra-budgetary resources.

Indian Railway Finance Corporation

The Indian Railway Finance Corporation (IRFC) was set up in 1986 for mobilising funds from domestic and international capital markets to meet the portion of extra budgetary resources requirement of IR. Since inception, IRFC has funded the acquisition of 13,349 locos[9], 73,979 passenger coaches and 259,661 freight wagons.

- ***Lease model***

  IRFC has adopted a cost plus lease arrangement with the MoR to finance the RS and project assets. The lease is usually for 30 years[10], comprising primary tenure of 15 years followed by a secondary tenure of 15 years. As part of the lease, recovery of the principal and interest is affected during the primary lease period and at the end of the lease, and assets are typically sold to IR at nominal price. The MoR pays lease rentals to IRFC on half-yearly basis in advance to enable IRFC to service the debt. In FY 2022-23, the MoR paid lease rental of Rs 28,819.91 crore[11], of which Rs 14,988.10 crore constituted the capital component and the balance Rs 13,831.81 crore was the interest component.

- ***Extra-budgetary resources - Institutional Finance (EBR-IF)***

  From FY 2015,-16 another mechanism of financing, EBR-IF, was deployed by IRFC, wherein long-term finance was provided for throughput enhancement projects such as doubling and electrification, which are otherwise not adequately funded owing to resource constraints. Cumulative EBR-IF funds made available by IRFC to IR till FY 2022-23 stood at Rs 169,510 crore[12], including Rs 15,338 crore in FY 2022-23. The MoR paid Rs 5,117.04 crore as lease rentals in FY 2022-23 (Rs 1,804.40 crore capital component and Rs 3,312.64 crore interest).

4.2 Strategies to enhance rail freight share

Owing to intense competition from the increasing road network, the railways' modal share in freight traffic has been tapering. Along with competition, analysts have observed a bunch of factors contributing to the slowdown in freight revenue. In a 2023 report, The Energy and Resources Institute (TERI) said that the cross-subsidisation of passenger operations from freight business has resulted in sub-optimal prices being charged on freight transport. The passenger segment needs to be financially viable and market-driven, with any subsidisation to the marginalised from the Union Budget. It also said that a move towards market-driven freight tariff policy can be considered.

9 IRFC website: https://irfc.co.in/from-the-desk-of-cmd
10 IRFC website: https://irfc.co.in/operation/leasing-background#:~:text=IRFC%20follows%20a%20leasing%20model,secondary%20period%20of%2015%20years.
11 Indian Railway Annual Report & Accounts 2022-23
12 Indian Railway Annual Report & Accounts 2022-23

Since decades, freight revenue has been used to cross subsidise passenger fares. For example, Railway Minister, Ashwini Vaishnaw, said that the national transporter is charging about Rs 45 from passengers for a ticket that costs Rs 100. CRISIL believes with dynamic pricing and premium trains, among other factors, some efforts are being made to increase the share of passenger revenue in GRR.

Over the past decade, freight revenue accounted for an average 67% of the GRR of IR. Of the volume of freight traffic carried by the mammoth transporter, ~48% is coal traffic. However, with the country's objective to reduce its carbon footprint and industries exploring hydro and solar power, coal traffic may decline in the long term, impacting freight traffic. The IR will likely consider the following options for maintaining and enhancing freight share and revenue:

- ***Truck-on-train:*** A model like Banas dairy's truck-on-train may be explored for other commodities, such as perishables and automobiles, to provide faster transportation and reduce carbon emission.
- ***Estimated arrival time versus consistency:*** As passenger trains are timetabled and given first preference, freight trains wait at or before junctions for want of path. As per a report by TERI, the wait time may be 2-6 hours[13] and may lead to increased transit time. Informing customers about approximate transit time and maintaining consistency with regard to arrival time may enable customers to plan onwards dispatch of freight effectively.
- ***Operationalisation of freight corridors:*** Operationalisation of DFCs, economic corridors and port connectivity projects will bifurcate freight and passenger traffic, provisioning line capacity for specific purposes. This will increase the average speed of trains, reduce travel time and in turn lead to reduction of operational cost.

4.3 Alternate financing options

Having explored sovereign financing, leasing and EBR-IF models through IRFC and private investments, IR needs to adequately tap the public and private sectors, institutions and capital markets for raising finances.

Institutional financing

In November 2023, the Railway Executive Committee signed a memorandum of understanding (MoU) with RailTel to finance infrastructure projects worth Rs 30,000 crore in telecom, IT and railway signalling over a period of five years. The IR will explore similar tie-ups with institutions to leverage conventional sources of funding to finance projects through institutional debt. Similar MoUs may be signed with other non-banking financial companies (NBFCs), such as Power Finance Corporation, Housing and Urban Development Corporation Ltd, and National Bank for Agriculture and Rural Development (NABARD); and insurance companies such as Life Insurance Corporation of India and The New India Assurance Co Ltd. While institutional financing can provide low-cost, long-term financing, the same can be serviced through

13 https://www.teriin.org/sites/default/files/2023-11/Strategies%20to%20Increase%20Railway%27s%20Share%20in%20Freight%20Transport%20in%20India%20-%20Executive%20Summary.pdf

enhanced revenue generation. Prioritised projects aimed at reducing capacity constraint of freight carrying routes may be financed through such debt.

Bonds, funds and trusts

Given increased population, travel and freight requirements, there is an ever-increasing demand for railway services. The IR needs to explore infrastructure bond issuance to raise capital for expanding its rail network. These bonds would be sold to institutional investors and high networth individuals (HNIs) who receive interest payments over time, while IR would obtain the necessary financing for projects. Additionally, increased access to multilateral development funds, infrastructure funds, sovereign wealth funds and investment trusts will support the capex of IR and enhance the speed of implementation.

Enhanced PPP initiatives

Although PPP models have been implemented in station redevelopment, electrification and signalling (engineering, procurement and construction [EPC] and PPP-annuity), construction of Special Purpose Vehicle (SPV)[Please expand] rail lines and train services, a lot of scope is untapped.

- ***Port connectivity:*** With the announcement of port connectivity corridors aimed at enhancing connectivity to major ports for streamlined logistics and a large number of ports being expanded and developed, it is time for major ports and state maritime boards to invest heavily in railway infrastructure. Enhanced rail-port infrastructure would enable faster evacuation at ports, making place for incremental cargo. With Rail Vikas Nigam Ltd (RVNL) having formed several port connectivity SPVs such as KRCL – Krishnapatnam port, HPRCL – Paradip port, BDRCL – Dahej port, this option should be explored for other major and upcoming ports.
- ***Energy, mineral and cement corridors:*** Under the PM Gati Shakti framework, energy, mineral and cement corridors have been proposed to promote efficient transportation of critical resources. Increase in transportation speed and reduction in logistics cost must be leveraged by seeking investments from private companies expected to benefit from these corridors.
- ***High-speed rail project:*** The IR could collaborate with private investors to finance the construction of a high-speed rail network. The financing structure may involve a combination of public funds, private investments and revenue generated from ticket sales.

Non-tariff revenue

In 2018, guidelines for New Innovative Non-Fare Revenue Ideas Scheme (NINFRIS) were issued. The scheme was to be implemented at divisional level of zonal railways. Seeking, receiving, evaluating and implementing new ideas and concepts is an on-going activity of the zonal railways. The following ideas were received under the non-fare revenue category:

- Display of advertisement in passenger reservation system (PRS) ticket
- LED digital wall and screens

- Three-dimensional (3D) product displays for products and services
- BMI (Body Mass Index) kiosk at various stations and workshops
- Vinyl wrapping on platform raisers
- Advertisement on pay slips ad bottle crushing machines

While targets are set for non-fare revenue for zonal railways, implementation and monitoring may be expedited.

Tapping solar energy

As part of its green railways initiative, solar power has been harnessed at several railway stations. Railways should consider mandating all its offices and colonies to use solar panels. The IR owns considerable land along its network, some of which is unutilised. Adoption of Renewable Energy Service Company (RESCO) model for these land parcels may be considered for energy cost optimisation and revenue generation (if excess power is generated). Under the model, both capex and operating expenditure will be borne by the RESCO developer while IR can benefit by procuring the renewable energy at a competitive rate through a long-term contract.

Adoption of model EPC contract and MSS

Earlier EPC contractors had to coordinate with fewer implementation agencies, such as RVNL and Indian Railway Construction International Ltd. However, with EPC contracts being implemented by zonal railways, contractors have to coordinate with an increased number of stakeholders. Each zonal railway has separate eligibility criteria and terms and conditions, which make coordination complex.

Additionally, as per the report of the Committee on Creative Financing for Indian Railways, IR currently undertakes construction through item rate contracts, which are prone to time and cost overruns. In case of national highways, the Cabinet has approved a model EPC contract, which has since been adopted by National Highway Authority of India and Border Roads Organisation. Similarly, the railways is developing DFCs through lump sum / EPC contracts. The IR should, therefore, develop standardised EPC documents for separate categories and sizes of projects to be implemented by the zonal railways.

Moreover, it is advisable to incorporate value engineering into the procurement mechanism – a systematic, organised approach to providing necessary functions in a project at the lowest cost. This would promote substitution of materials and methods with less expensive alternatives without sacrificing functionality. The approach may be in the form of Manual of Standards and Specifications (MSS), which would standardise the specifications based on efficiency, economy and safety.

4.4 Monetisation plans

Core asset monetisation plans under the National Monetisation Pipeline (NMP)

Based on the mandate for asset monetisation under Union Budget for FY 2021-22, NITI Aayog prepared an asset pipeline for monetisation. The NMP estimated aggregate monetisation potential of Rs 6.0 lakh crore through core assets of the central government over four years from FY 2021-22 to FY 2024-25. The NMP was aimed at tapping private sector investment for new infrastructure creation. For IR, the monetisation pipeline was worth ~Rs 1.52 lakh crore.[14]

The monetisation pipeline consisted of DFC assets to be monetised by IR for operations and maintenance after commissioning, redevelopment of 400 stations[15] and privatisation of 90 trains and 15 railway stadiums. However, the station redevelopment projects, proposed under the PPP model, are now being taken up under the EPC model. Additionally, as per industry, attempts to privatise train operations have faltered partly due to the risky nature of contracts skewed towards the interest of IR.

Non-core monetisation plans under RLDA

An IR organisation with the objective of redevelopment of land and air spaces – residential, commercial and transportation hubs for generation of non-tariff revenue and creation of assets for IR, the RLDA seeks to monetise surplus railway land. The organisation is looking to study the IR land parcels (both developed or under development) for monetisation through Real Estate Investment Trusts (REITs) sponsored by it.

The plan is to float several location and sector-specific REITs that would invite investment from domestic and international investors looking to participate in and earn returns from real estate investments—without having to buy, manage or finance any properties. Additionally, land parcels may be offered on lease to private developers to generate regular revenue.

14 Government of India portal - https://www.india.gov.in/spotlight/national-monetisation-pipeline-nmp
15 https://www.deccanherald.com/business/indian-railways-unlikely-to-meet-rs-1-52-lcr-asset-monetisation-target-2727924

Chapter 5: Future of Railway Technology – Excellence & Opportunities

5.1 Indigenisation of railway technology

Indigenisation of technology is a strategic initiative of IR, in order to reduce dependence on foreign technology and enhance self-reliance. This involves deployment of advanced technologies developed within the country with a focus on key areas such as:

➢ *Rolling stock manufacturing*

- Vande Bharat Express is the first semi-high-speed train, designed and manufactured by the Integral Coach Factory (ICF) in Chennai. It showcases India's capability to produce modern, high-speed trains.
- IR has gradually phased out traditional ICF coaches in favour of Linke Hofmann Busch (LHB) coaches, which are safer and more comfortable. Manufacturing of these coaches has been indigenised.
- IR manufactures various electric and diesel locomotives in the domestic market, including the WAG-12 and WAP-7 models.
- IR also plans to run 35 hydrogen trains under the Hydrogen for Heritage initiative. It aims to incorporate hydrogen fuel cells as an alternative to diesel engines. The first of these trains is expected to run on the Jind-Sonipat section of Northern Railways.

➢ *Railway infrastructure and signalling*

- Efforts are underway to develop indigenous signalling and train control systems such as the Train Collision Avoidance System (TCAS), which enhances safety and reduces reliance on foreign systems.
- Indigenous technology for laying, welding and maintenance of tracks has been developed to improve the quality and durability of railway tracks.

➢ *Electrification and green energy*

- IR is on track to achieve 100% electrification of its broad-gauge network, which will curb carbon emissions and reliance on imported fuels.
- IR has been investing in solar and wind energy projects to meet a significant portion of its energy needs through renewable sources.

➢ *Digitalisation and IT systems*

- IR has developed indigenous software solutions for passenger reservations, freight management and operations. Systems such as the Centralised Traffic Control (CTC) and Real-time Train Information System (RTIS) enhance the overall efficiency.

➢ *Research and development*

- The Research Designs and Standards Organization (RDSO) plays a pivotal role in indigenisation of railway technology. RDSO is the sole R&D arm of IR, which acts as the technical advisor to the railway board, zonal railways and production units. Collaboration with private sector companies and start-ups is encouraged to foster innovation.

➢ *Make-in-India initiative*

- The Make in India initiative supports indigenisation of railway technology by encouraging domestic production of railway components and systems. IR is increasingly engaging in public-private partnerships (PPPs) to boost local manufacturing capabilities and technology development. Vande Bharat trains, made under this initiative, showcase India's capability to produce modern, high-speed trains.

- IR is also focussing on sourcing and manufacturing components locally for passenger services.

➢ *Modernisation of workshops and factories*

- IR is modernising its production units, workshops and factories to improve efficiency and ability to produce modern rolling stock and components domestically. It is constantly focused on training and upskilling the workforce to handle advanced technologies and manufacturing processes.

➢ *Passenger amenities and services*

- IR is focused on development of indigenous designs and technologies to modernise railway stations, which includes set up of smart stations with better amenities for passengers. 1,309 Amrit Bharat stations have been identified to offer passengers modern amenities and better accessibility.

➢ *Export potential*

- As IR develops indigenous technologies, there is growing potential to export these solutions to other countries, especially in the developing world. There are plans to launch a standard gauge version of Vande Bharat Trains, which can be exported to different countries.

5.2 Advanced traffic management & control systems

IR needs to deploy advanced traffic management and control systems to enhance safety, efficiency and reliability across its vast network. Here are few key systems and technologies being implemented or developed:

TCAS

TCAS is an indigenous automatic train protection (ATP) system developed by RSDO along with other industry players. It prevents train collisions by automatically controlling the train's speed in case of any signal violation or if the train is on a collision course. IR is rolling out TCAS across high-density routes, significantly enhancing safety.

CTC

CTC systems enable centralised monitoring and control of train movements across large sections of the railway network. This system optimises train operations, reduces delays, and improves overall network efficiency. It facilitates real-time tracking of trains, automated signalling adjustments and centralised decision-making for routing and scheduling of trains. CTC systems are being implemented in phases across high-density corridors and major junctions.

Automatic Train Control (ATC)

ATC is an advanced system that ensures trains adhere to speed limits and signals by providing automatic control inputs to the braking and propulsion systems. ATC is being implemented in suburban networks and high-speed routes to ensure safety and efficiency.

RTIS

RTIS is an advanced system for real-time tracking and monitoring of train movements. It leverages GPS and satellite communication to provide accurate locations. It is being deployed across various zones, enhancing the ability to provide timely information to passengers and improve operational efficiency.

Electronic Interlocking (EI) Systems

EI systems replace traditional mechanical and relay-based interlocking systems and offer a more reliable and flexible method of controlling train movements through junctions and stations. It provides enhanced safety through fail-safe operations and remote control capability and has less maintenance requirements. IR is rapidly upgrading to EI systems at key junctions and stations across the network.

KAVACH: Indigenous Automatic Train Protection (ATP) System

KAVACH is an indigenous ATP system developed by IR to prevent train accidents by controlling train speeds and preventing collisions. It facilitates automatic braking, collision avoidance, SOS alerts, and adherence

to speed limits. KAVACH is being installed on busy rail corridors and seen as a cost-effective solution for enhanced safety.

Predictive maintenance systems

Predictive maintenance systems use data analytics, AI, and IoT to monitor the condition of tracks, rolling stock and other infrastructure components on a real-time basis, so as to predict failures before they occur. IR is increasingly adopting these systems to reduce downtime and improve safety.

High-density network (HDN) capacity enhancement

HDN projects aim to enhance the capacity of busy routes through advanced signalling, improved track infrastructure, implementation of double-line tracks and better traffic management systems. These enhancements are being prioritised on high-density corridors such as Delhi-Mumbai and Delhi-Howrah routes.

5G and IoT Integration

Integration of 5G networks and IoT devices into the railway infrastructure will enable real-time data transfer and monitoring of train and track conditions, enhanced connectivity and stronger operational control. IR plans to leverage the 5G technology for better connectivity and control across its network.

5.3 Technology for freight transport services

IR has been adopting various technologies to modernise and improve freight transport services. These technologies play a key role in enhancing efficiency, reliability and sustainability of freight transport services and are aligned with broader goals of improving logistics and supply chain management across the country.

Some key technologies being implemented or explored in for freight transport:

Freight Operations Information System (FOIS)

FOIS is a comprehensive system that digitises and manages freight train operations, including scheduling, tracking and billing. It allows customers to track their consignments real-time and improves management of rolling stock and resources.

RFID-Based tracking

IR is deploying radio-frequency identification (RFID) tags on wagons and locomotives to enable real-time tracking.[16] This system offers greater visibility on movement of freight trains, reduces delays and improves asset management.

16 https://pib.gov.in/PressReleasePage.aspx?PRID=1640873#:~:text=Indian%20Railways%20is%20on%20a,been%20covered%20under%20RFID%20project.

Dedicated Freight Corridors (DFC)

DFCs such as the Eastern and Western DFCs are being developed to separate freight traffic from passenger traffic, allowing for faster, efficient movement of goods. These corridors are equipped with modern signalling systems, high-capacity tracks, and advanced logistics infrastructure.

Electronic in-train information system (ETIS)

ETIS provides real-time data on status of trains, including speed, location and other operational parameters. This improves monitoring and control of freight operations, ensuring timely delivery.

Long-haul and high-capacity wagons

IR is introducing long-haul freight trains and high-capacity wagons to transport larger volume of goods more efficiently. These wagons are designed for specific commodities, such as steel, coal, or containers, optimising loading capacity and reducing the number of trips required.

AI and Big Data Analytics

AI and analytics are used to predict when maintenance is needed on tracks and rolling stock, reducing the risk of breakdowns and improving reliability of freight services. AI-driven systems are optimising routes and schedules based on real-time data, traffic patterns and historical performance, ensuring timely delivery of goods.

Automated and digitalised freight systems

IR has introduced online payment systems and digital platforms for booking and managing freight services, making the process more accessible and user-friendly for customers. Smart Freight Operations Optimisation and Real Time Information (SFOORTI) is a dashboard that provides real-time information on freight operations, helping in better planning and optimisation of resources.

Chapter 6: Safety & Security

6.1 Why is railway safety of paramount importance?

Having carried 6,396 million passengers in 2022-23, IR is the world's largest railway network under a single management. With the huge asset base and passenger movement, safety and security of passengers and the system is of paramount importance. Railway safety encompasses protection of life and property through regulation, management and technological development of all forms of rail transportation. Various activities/functions such as disaster management, accident reporting, ex-gratia announcement/ payment, public Information with respect to accidents, accident inquiry safety drive, safety shield, inspections, level crossings, etc. are covered under railway safety.

While IR is making continuous efforts to ensure safe transport of people and goods, every time there is an accident, the efforts come under scrutiny. These accidents highlight the urgent need for comprehensive reforms and stronger protocols to ensure the well-being of passengers and prevent devastating accidents in future. But why is railway safety so important?

- ***Carry high volume of passengers:*** With IR operating the world's fourth-largest rail network and millions of people relying on the system for their daily commute, ensuring safety becomes crucial. IR needs to maintain the trust and confidence of the public in the system. Instances of accidents and safety lapses can erode the reputation of the railways and faith of the passengers in the reliability and security of train travel.

- ***Economic impact:*** Railways is a crucial component of the country's transportation infrastructure and plays a vital role in the economy. Any disruption due to safety aspects can have an adverse impact on industries and businesses.

- ***Global standards:*** The focus on safety is not only crucial for passenger well-being, but also to align with global best practices and meet global standards. Countries such as Japan, China, and some European nations have demonstrated that high safety standards are achievable. Comparison with such nations and benchmarks is bound to happen.

- ***Regulatory compliance:*** Safety is a regulatory requirement and a legal obligation for IR. Adherence to safety protocols and regulations is not only necessary to prevent accidents but also to comply with national and international standards. This ensures that the railways operate within a framework that safeguards the well-being of passengers.

6.2 Changing railway safety scenario

Over the years, IR has taken a series of safety measures which have improved safety of train operations, as evident from the trend of accidents in the adjacent figure. The number of consequential train accidents has declined sharply from about 473[17] in FY 2000-01, to 48 in FY 2022-23. Although IR has been upgrading its infrastructure, putting plans and mechanisms in place to enhance safety and security, it does face challenges in achieving mission zero accident.

- ***Financing constraints:*** IR perpetually faces financing constraints for upkeep of its infrastructure, including allocation and utilisation of funds for safety-related works. Decline in funding for track renewal, diversion of funds to non-priority tasks, and constraints in the Rashtriya Rail Sanraksha Kosh pose obstacles to effectively addressing safety concerns.
- ***Congestion and overcrowding:*** The existing railway network encounters severe capacity constraints, especially on major trunk routes, leading to over-utilisation in terms of back-to-back train operations, along with overcrowded trains and increased risk. The high volume of passengers and over-utilisation can impact safety protocols and pose challenges in managing passenger flow during emergencies.
- ***Technical glitches and system failures:*** Occurrence of technical glitches and system failures, such as the electronic interlocking error in the Balasore train crash, poses a significant challenge to ensuring the safety of passengers. These issues can lead to signalling errors, track misalignment and other critical safety hazards.
- ***Human factors:*** Human negligence or error, such as crossing railway tracks, incorrect setting of points, mistakes in shunting operations, and over-speeding, have been identified as human factors contributing to train accidents.

17 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1983975

In the Railway Budget 2016-17, Mission Zero Accident[18] was one of the missions announced, comprising two sub-missions:

i) Elimination of unmanned level crossings (UMLC) over broad gauge in the next 3-4 years.

ii) TCAS to prevent collisions and signal passing at danger by the locomotive pilot.

6.3 Government Initiatives

6.3.1 Infrastructure interventions

Safety performance is monitored periodically, and few initiatives undertaken by IR, to improve safety of train operations include

- ***Elimination of level crossings:*** IR has been working towards elimination of manned level crossings, which are prone to accidents. Efforts are made to incorporate underpasses and overpasses instead. This often leads to an increase in project cost and development timelines. But since it reduces accidents and casualties, this mechanism has been adopted.

- ***Automatic block signalling:***[19] Automatic block is a system in which movement of trains is controlled by stop signals, which are operated automatically by passage of trains past signals. The automatic signalling arrangement facilitates an increase in line capacity without any additional stations being constructed and maintained.

- ***Interlocking:*** An arrangement of signals, points and other appliances, operated from a panel, so interconnected by electrical locking that their operations must take place in proper sequence to ensure safety. Till May 21, 2023, 6,427 stations[20] were equipped with electrical/electronic interlocking systems to eliminate accidents caused by human failure. Additionally, interlocking of level-crossing gates has been provided at 11,093 locations.

- ***RRSK:*** The RRSK is a fund created in 2017-18 with a corpus of Rs 1 lakh crore over a period of five years, for critical safety related works. It focuses on replacing and renewing tracks, bridges, signalling, rolling stock, training, and amenities for safety critical staff. The RRSK works are to be funded from Gross Budgetary Support (GBS) and railways revenue/resources, including mobilisation of resources through extra budgetary resources (EBR), as per Ministry of Finance guidelines.

6.3.2 Technology Interventions

- ***Deployment of KAVACH:*** Kavach is an indigenously developed anti-collision train system (developed by RDSO). It is a technology intensive system, which requires safety certification of the highest order. The system assists the locomotive driver in running the train within specified speed limits, by automatic application of brakes and helps the train run safely during severe weather conditions (fog, rain, etc.).

18 https://pib.gov.in/newsite/PrintRelease.aspx?relid=175371
19 https://indianrailways.gov.in/railwayboard/uploads/directorate/signal/2023/20-Automatic%20Block%20Signalling.pdf
20 https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/aug/doc202389235801.pdf

The first field trials for passenger trains were conducted in February 2016. Based on experience gained and independent safety assessment of the system by a third party (independent safety assessor: ISA), three firms were approved in 2018-19, for supply of Kavach. Subsequently, Kavach was adopted as a national ATP system in July 2020. Till December 2023, Kavach was deployed on 1,465 route kms and 139 locomotives (including electric multiple unit rakes) on South Central Railways. Efforts are being made to develop more original equipment manufacturers to enhance the capacity and scale up the implementation.

- ***Video Surveillance Systems:*** The IR is taking strides from mere CCTV video surveillance to include powerful analytics. AI is being integrated to provide facial recognition, license plate recognition, people counting and motion detection on station premises. Camera analytics can help colour search, differentiate and identify people, search of person based on attributes, monitor attentiveness of staff, unauthorised entry, etc.

  RailTel is already providing IP-based video surveillance systems at stations and train coaches. This system has video analytics and facial recognition software to ensure proactive high-tech security at railway stations. RailTel is also providing a monitoring facility in all railway zonal/divisional headquarters, which will notch up the surveillance activity, and ensure better security for passengers and railway properties. The target is to provide video surveillance systems at 5,102 stations[21], of which 308 stations have already been covered.

- Interventions such as equipping locomotives with vigilance control devices (VCD) to ensure alertness of loco pilots, implementation of fog safety devices (FSD), a GPS-based device provided to loco pilots in fog affected areas. This device would enable them to gauge the distance of approaching landmarks such as signals, level-crossing gates etc and thus ensure safety and security.

6.4 Heading towards zero accidents

As India continues to grow, demand for safe and reliable rail transport will increase. Continued investment in upgrading tracks, signalling systems, and rolling stock is crucial but technological interventions to strengthen railway safety and minimise human errors will be a crucial factor.

Leverage advanced technologies and AI:

- Continuous adoption of technology to reduce human error, enhance safety monitoring, early detection of faults, and real-time decision-making enhance overall safety operations.
- AI can help manage extensive digital data from station data loggers and microprocessors on locomotives and trains effectively, and can filter out irregularities and highlight recurring abnormalities.
- Implementing AI-driven predictive maintenance practices for real-time monitoring and response can

21 https://www.railtel.in/key-projects/video-surveillance-system.html

shift maintenance efforts from where not required towards sections where it is required on priority, and to avert accidents.

- IOT adoption: Integrating legacy assets and infrastructure to communicate amongst themselves to trigger condition-based maintenance requirements needs to be taken up.

➢ ***Safety training:*** Enhanced training modules to sensitise railway staff and stricter adherence to operating procedures and protocols can reduce human error in operations.

➢ ***Start-up incubator/ accelerator:*** Encouraging research in developing innovative safety technologies and practices, tailored to Indian conditions, can lead to breakthroughs in preventing accidents. The innovation policy of IR – 'Start-ups for railways' aims to leverage innovative technologies, developed by Indian start- ups/micro, small and mid-sized enterprises/ innovators/entrepreneurs, to improve operational efficiency and safety . Under this, grant of up to Rs 1.5 crore on an equal sharing basis, with provision of milestone-wise payment, may be provided to innovators for development of a prototype. Upon successful testing of the shortlisted prototype, enhanced funding will be provided to scale up deployment.

Establishment of a railway technology-focused start-up incubator/accelerator may be explored. Every alternate year, a cohort of 2-5 start-ups may be selected, groomed and guided by senior railway/ RDSO officials. Even if these result in 2-3 practical innovations over a period of few years, it would be an encouraging sign for the startup ecosystem.

➢ ***Strengthen maintenance practices:*** Prioritise track maintenance, inspections, and infrastructure upgrades to prevent derailments and ensure safe operations. IR needs to deploy mechanised methods of track maintenance and leverage improved technologies to enhance the efficiency and effectiveness of maintenance activities.

➢ ***Expand the vendor base:*** For exponential implementation, robust availability of components and equipment is required. To ensure substantial, reliable and continuous supply of components and equipment, there is need to enhance existing vendor capacity and to bring in new vendors under the shortlisted/ empanelled list.

Chapter 7: Sustainable Railways

7.1 De-carbonisation, solar power

IR is actively working on several initiatives to reduce carbon footprint and promote environmental stewardship. These initiatives highlight ' commitment to sustainability and its role in supporting India's broader environmental and climate goals. By adopting these technologies and practices, IR strives to become a greener and more sustainable mode of transport. Here are some key initiatives related to decarbonisation, solar energy, and other green technologies:

Electrification of rail routes

Under the Mission 100% electrification, IR aimed to achieve 100% electrification of its broad-gauge network and planned to gradually shift towards green energy usage for traction and non-traction purposes. IR is inching closer to its mission, with the share of electrified tracks increasing from 24% in 2000[22] to 40% in 2017 and 86.7%[23] by the end of 2022-23. Imminent achievement of full electrification would position it as the world's largest green railway network.

Electrification reduces reliance on diesel locomotives, significantly lowering carbon emissions and operational cost. Electricity used for running electric trains is increasingly being sourced from renewable energy, contributing to the overall reduction of carbon footprint. Railways is also in the process of converting majority of its diesel engines into electric ones to further reduce carbon footprint.

Solar energy initiatives

IR has set a target to install 20 GW of solar power capacity by 2030[24]. Solar panels are being installed on rooftops of railway stations, workshops, and other buildings, as well as on vacant railway land. Few trains have been equipped with solar panels on roofs to power lights, fans and other electrical systems within coaches, reducing the need for diesel generators.

Wind energy projects

IR is also investing in wind energy projects to generate power for its operations. Wind turbines have been installed in several locations, contributing to the renewable energy mix within overall power consumption.

Energy efficiency improvements

Trains equipped with regenerative braking systems convert kinetic energy during braking into electrical

22 https://indianrailways.gov.in/railwayboard/uploads/directorate/secretary_branches/IR_Reforms/Mission%20100%25%20Railway%20Electrification%20-%20Moving%20towards%20Net%20Zero%20Carbon%20Emission.pdf
23 Indian Railways Statistical Summary 2022-23
24 Green Railways - https://indianrailways.gov.in/railwayboard/uploads/directorate/secretary_branches/IR_Reforms/Green%20Railways%20(use%20of%20renewable%20energy).pdf

energy, which is fed back into the grid or used to power other trains. This reduces energy consumption and enhances efficiency. IR is adopting energy-efficient appliances and systems across its operations, including LED lighting, energy-efficient heating, ventilation and air-conditioning (HVAC) systems, and other low-power devices.

Biofuels and alternative fuels

IR has initiated trials of blending biodiesel with conventional diesel for its diesel locomotives. This not only reduces greenhouse gas emissions, but also promotes use of renewable resources. Since railways is converting majority of its diesel engines into electric ones, some will be used for repair and shunting purposes. Some locomotives are being modified to run on CNG, which emits fewer pollutants compared to diesel.

Green certifications and eco-friendly stations

Few railway stations have been certified with the Indian Green Building Council (IGBC) Green Rating[25]. These stations incorporate eco-friendly designs, rainwater harvesting, waste management systems, and energy-efficient lighting. IR is implementing water conservation measures, including rainwater harvesting, water recycling plants, and use of treated wastewater for non-potable purposes.

Sustainable procurement and waste management

IR is increasingly using eco-friendly material for construction, track laying and other infrastructure projects. This includes use of fly ash for concrete production and recycled materials for track ballast. Waste segregation and recycling programs have been introduced at major stations, along with deployment of bio-toilets in trains to manage human waste in an environment-friendly manner.

Smart and sustainable urban transport

IR is collaborating with metro and urban transport systems to develop integrated, multi-modal transport solutions that reduce reliance on personal vehicles, thereby reducing urban congestion and pollution.

25 https://www.pib.gov.in/PressReleasePage.aspx?PRID=1893510, https://scr.indianrailways.gov.in/view_detail.jsp?lang=0&id=0,5,268&dcd=20404&did=1693918800791A9FFD4EAC07F4E4C29FC71161E7445A8

Chapter 8: A Long Way to Go for Modernisation of Railways for Viksit Bharat - Recommendations

Although IR has made considerable progress, it still has a long way to go to meet present and future requirements and meet global standards. IR should adopt a strategic approach to address issues related to infrastructure, technology, sustainability, passenger services and overall operational efficiency. Focus should be on adopting modern infrastructure solutions such as expansion of the high-speed rail network beyond the Mumbai-Ahmedabad corridor to connect major cities, reducing travel time, boosting economic growth and fast-tracking doubling and quadrupling of tracks to increase the capacity of congested routes.

- **Increased private sector participation –** Despite various schemes, private sector participation has not been very forthcoming in railways, as compared to roads and airports. To some extent, private passenger and container train operations can be considered a success. Recently, multi-modal logistics parks (MMLPs) have shown some uptake. Going forward, innovative initiatives are required to leverage capital, efficiency and technology of the private sector.

- ***Freight traffic growth* –** In order to increase the modal share of railways in freight, so as to cut down on cost of logistics and enhance sustainability in cargo movement, a multitude of initiatives need to be taken. This includes rationalisation of fare, addressing connectivity issues, promoting private sector participation, development of customised wagons and containers, promoting multi-modal connectivity, making railways 'user-friendly' for industries such as e-commerce, and new marketing plans etc. We are likely to see such initiatives in the medium to longer run.

- ***Go Green* – *T***o transform IR into green railways, in addition to 100% electrification of broad-gauge network, to improve energy efficiency of locomotives and trains, harnessing solar power at railway stations has also been initiated. Railways may consider mandating all its offices and buildings to use solar panels, harvest rainwater, etc. Adoption of the RESCO model may be considered pan-India, not only to harness solar power, but also to utilise railway land parcels. Additionally, fast-tracking hydrogen-powered trains would provide multi-fold benefits in the direction of green transportation technology, to support zero carbon emission goals as a clean energy source. Deployment of more energy-efficient rolling stock and focus on lightweight material and regenerative braking systems, to reduce energy consumption, would eventually add up towards carbon neutrality.

- ***Technological interventions* –** These include adoption of advanced technologies such as AI and ML for predictive maintenance, efficient scheduling and improved safety. All railway coach factories and manufacturing units should be converted to smart manufacturing units with industry 4.0

interventions to realise digital transformation, deliver real-time decision making and enhance productivity. Start-up ecosystems and the private sector could be leveraged to provide workable prototypes for various problem statements. IoT could be utilised for real-time monitoring of trains, tracks, and infrastructure and to ensure timely maintenance and minimal disruptions.

Accomplishments of IR illustrate its commitment towards providing efficient, innovative and passenger-centric services, while contributing to the economic progress of the country, through modern infrastructure, safety measures and sustainable feats.

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The Associated Chambers of Commerce & Industry of India (ASSOCHAM) is the country's oldest apex chamber. It brings in actionable insights to strengthen the Indian ecosystem, leveraging its network of more than 4,50,000 members, of which MSMEs represent a large segment. With a strong presence in states, and key cities globally, ASSOCHAM also has more than 400 associations, federations and regional chambers in its fold.

Aligned with the vision of creating a New India, ASSOCHAM works as a conduit between the industry and the Government. The Chamber is an agile and forward looking institution, leading various initiatives to enhance the global competitiveness of the Indian industry, while strengthening the domestic ecosystem.

With more than 100 national and regional sector councils, ASSOCHAM is an impactful representative of the Indian industry. These Councils are led by well-known industry leaders, academicians, economists and independent professionals. The Chamber focuses on aligning critical needs and interests of the industry with the growth aspirations of the nation.

ASSOCHAM is driving four strategic priorities - Sustainability, Empowerment, Entrepreneurship and Digitisation. The Chamber believes that affirmative action in these areas would help drive an inclusive and sustainable socio-economic growth for the country.

ASSOCHAM is working hand in hand with the government, regulators and national and international think tanks to contribute to the policy making process and share vital feedback on implementation of decisions of far-reaching consequences. In line with its focus on being future-ready, the Chamber is building a strong network of knowledge architects. Thus, ASSOCHAM is all set to redefine the dynamics of growth and development in the technology-driven 'Knowledge-Based Economy. The Chamber aims to empower stakeholders in the Indian economy by inculcating knowledge that will be the catalyst of growth in the dynamic global environment.

The Chamber also supports civil society through citizenship programmes, to drive inclusive development. ASSOCHAM's member network leads initiatives in various segments such as empowerment, healthcare, education and skilling, hygiene, affirmative action, road safety, livelihood, life skills, sustainability, to name a few.

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Jindal Rail Infrastructure Limited

Complete Freight Car Solutions

BFNV Wagon jointly designed by RDSO and JRIL with Industry Partner JSW Ltd. for steel coils

ACT1 (Autocar Taller wagon) jointly designed by RDSO and JRIL with Industry Partner IVC Logistics for SUV over SUV

Innovative Freight Car Solutions for efficient transportation by rail
Industry centric solutions to improve rail modal share
Key differentiators: Proven capabilities in design & engineering, planning & execution and a constant focus on quality
State-of-the-art manufacturing facility
Services offered:

- ⇒ Multi-purpose high capacity wagons
- ⇒ Development of wagon designs to global practices
- ⇒ Indigenous development of wagon accessories

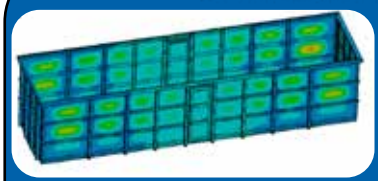
BOSM wagon jointly designed by RDSO and JRIL with Industry Partner JSPL

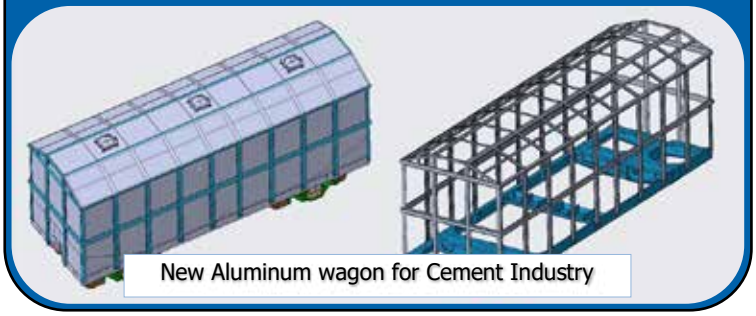
CMP (Coil Multipurpose wagon) for hot rolled/cold rolled coils, steel plates/billets/containers

Design and Manufacturing of Gondola wagon for Export to Mozambique

Gondola Tandem wagon in Master-Slave configuration

Optimisation using Smart Techniques





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