

# Indian Railway- Innovation and Technology

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**Abstract- India is the second most populous country in the world<sup>1</sup>. Indian Railway has the fourth largest rail network in the world after the United States, China and Russia. The entire infrastructure is managed by the Railways Board, and it has a monopoly in providing rail services in India. The transport sector is an important part of the nation's economy. India's public transport systems are amongst the most exploited systems in the world. The history of rail transport in India began in the mid-nineteenth century. It enjoys being the most used transport system. It not only integrates the social, economic and cultural foundation of the country but also is a giant facilitator in terms of employment opportunities.<sup>1</sup> Indian Railways provides an effective Innovation Ecosystem involving the free flow of technology and information among people, enterprises and institutions, which is the key to an innovative process. It allows interactions between the actors needed to turn an idea into a process, product, or service to achieve the ultimate objective of the organization.**

## INTRODUCTION

The present articles focus on '*Indian Railway – Innovation and Technology*'. Indian Railway (IR) is one of the largest and busiest rail networks in the world, transporting over 17 million passengers and more than 2 million tons of freight per day. It is the world's eighth-largest commercial or utility employer, with more than 13 lakh employees. IR operates long-distance and suburban rail systems on a multi-gauge network consisting of Broad, Meter and Narrow Gauge. It passes through the length and breadth of the country over a total route length of 64,460 kilometres, over 7146 stations and owns 229,381 wagons, 55,339 coaches and 9549 locomotives of rolling stock (IR Yearbook, 2011). According to the World Bank, IR is one of the top five national railway systems in the world; with others being the United States, Former Soviet Union, (FSU) Canada and China (WTO,1998). The first train in India was run on 22 December 1851 for the hauling of canal construction material in

Roorkee (Milne 1995). Later, on 16 April 1853, the first passenger train service was run between Bori Bunder in Bombay and Thane, covering a distance of 34 kilometres.

Indian Railways provides an effective Innovation Ecosystem involving the free flow of technology and information among people, enterprises and institutions, which is the key to an innovative process. It allows interactions between the actors needed to turn an idea into a process, product, or service to achieve the ultimate objective of the organisation. Being the Lifeline of the nation, IR has been continually making innovations in its Technology, Service, Operations and Overall System to lead the nation on a path to a modern and ever-progressing future. A few innovative improvements are the State of the Art SMART Coaches having special diagnostic systems and sensors connected to integrated computer systems for increased passenger comfort, SMART Locomotives having new features such as Asset Performance Monitor (APM), Locotrol, LocoVision, Rail Integrity Monitor (RIM) etc, SMART Yards with ICT systems, sensors and data analytics to automatically gather information on rolling stock conditions, Automated Train Examination System (ATES), new technology Signalling Systems with new features being added as indigenous Automatic Train Protection (ATP) system, Centralized Traffic Control (CTC), Train Management System (TMS) etc. Besides these many improvements such as Dedicated Freight Corridors, Self-designed Vande Bharat Express, Tejas Express, Vistadome Coaches, New Signalling Systems, Long Haul Freight Trains, High Capacity & High-Speed Wagons, Kisan Rail, Solar Powered Passenger Coaches etc have been done to bring about a sea change in the Customer comforts and expectations.

Several initiatives have been taken in the recent past for promoting innovation in IR:

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#### A. Collation of best practices for widespread circulation

At present, Indian Railways is divided into 17 zones & 8 Production Units (PUs), which regularly engage in the implementation of innovative ideas and best practices. Indian Railways has also embarked upon this journey by bringing in such changes. Regular sharing of ideas is taking place in any organisation but instead of looking at only short-term changes, there are some key activities which must be carried out in the long term to build a sustainable knowledge sharing platform. For this, the 'Collation of best practices for widespread circulation Rail Good Works Portal' has been created with the aim: Integrated sharing of implemented best practices with a larger knowledge management portal, providing uploading access to a higher set of people to keep the momentum going in the long term and Tracking the performance of portal and taking the necessary steps to drive usage

It aims at proliferating these ideas across the organization, by enabling all employees to share the best work undertaken in their respective units with the entire Indian Railways on a real-time basis. These ideas can then be leveraged by the larger organization. At this common platform, all entities can freely share the best work undertaken in their respective field with the entire Indian Railways. The portal is accessible through the following link:

<http://www.indianrailways.gov.in/railwayboard/InnIdeas/HomePage.jsp>

The portal has so far received more than 6500 ideas and solutions on key issues that IR is trying to solve. Improving Customer Experience, Safety Improvement, Asset Management and Maintenance, Human Resource Development, Operations Improvement and Digital Initiatives are the top areas in which the suggestions are being received. Selected best ideas are also circulated by Railway Board for dissemination and initial mass scale implementation across Railway units, wherever applicable.

Recently, to further drive efficiency in the organisation, Hon'ble MR has directed collation, assimilation and brainstorming of best practices, ideas and suggestions to work upon. This generated a lot of enthusiasm among all the units and within 3 days, around 2000 Best Practices/ Suggestions were received from field units and more are being received. These will be utilized for adaption on IR and improve efficiency & productivity, increased revenue, cost

reduction, enhanced customer satisfaction etc. The same is being shared through the online portal 'eDrishti'.

#### B. Suggestion Scheme for Best Innovation

Every Year IR conducts a "Suggestion Scheme" for awarding the Best Innovations on Indian Railways. The objective is to identify and award creative employees who are working tirelessly to bring improvements to IR. This Scheme intends to improve the morale and motivation of IR's workforce and to encourage them to come up with low-cost innovations for improving the productivity, quality and efficiency of Indian Railways.

The Scheme is operated at three levels:

1. Division/Workshop
2. Zonal/Production Units levels
3. Railway Board's level.

A key characteristic of this Scheme is that practically implemented innovations which have proved their usefulness are considered under it. "Suggestion Scheme" is an excellent platform for motivating Railway Employees to proactively engage in a creative process; the ultimate aim being to improve Quality and Productivity in every aspect of Railway Working. Every Year enthusiastic participation is seen from all Zonal Railways/ Production Units.

#### C. Innovation Challenges and Competitions

Hon'ble Prime Minister has said, "The true essence of democracy is Jan Bhagidari. Together we will solve all the issues that are affecting the nation. This will be done through Jan Bhagidari". Keeping with sentiment and actively promoting the participation of everyone in governance, Indian Railways has undertaken many initiatives to seek new ideas /innovations to address some outstanding issues facing this organisation. Some of these efforts are given below:

##### a) Igniting minds through Innovation Challenges

Hon'ble Minister for Railways in his Budget Speech 2016 announced setting up Navrachna – Innovation to give 'Innovation grants to employees, startups and small businesses'. Rs 50 Crore were set aside for providing innovation grants to employees, start-ups and growth oriented small businesses to support internal and external innovation. The following six areas were given as challenges:

4. Identifying new non-fare revenue sources for Indian Railways

5. Design of Wagons for efficient loading and transportation of new commodities.
6. Easy Accessibility to trains from low level platforms
7. New Idea/ Suggestion to improve the working of Indian Railways
8. Increasing passenger carrying capacity of coaches of Indian Railways
9. Developing new Digital capabilities at stations of Indian Railways

- b) Competition for the design of waterless & odourless toilets in trains

In response to Hon'ble Prime Minister's clarion call for a clean India under the 'Swachh Bharat Abhiyaan', Indian Railways conducted a public competition for Waterless Odourless toilets in trains. The central idea of this competition was to develop such a design which shall not have a foul smell and use no water for operation and maintenance. After evaluation of valid entries by a Jury of distinguished experts from Railways, Industry and Academia/ Research Fields, Winners of the competition were declared and awards worth Rs.5.25 lakhs were distributed amongst winners.

- c) Competition on "How to raise money for Railways to provide better Services (Jan Bhagidari)"

The Challenge was designed as an online competition hosted at [www.innovate.mygov.in](http://www.innovate.mygov.in) providing submissions of original innovative solutions for 'How to raise money for Railways to provide better Services (Jan Bhagidari)'. The solution was expected to include the idea, detailed business plan, and implementation strategies for raising money.

#### RESEARCH & LINKAGES WITH ACADEMIA

Apart from general ideas, any organisation must evolve with the ongoing times and keep an eye on the future. Research is the tool which increases the level of Innovation in any organisation. Research must always be of high quality to produce knowledge that is applicable for growth and it should have implications for policy and future project implementations. Indian Railways has been actively involved in research and engaging with the academia to proceed towards an "Aatma-Nirbhar Bharat" in the Transport Sector and the development of cost-effective solutions. Centres

for Railway Research (CRRs) have been created in collaboration with IITs and MOUs have been signed with IIT/ Kanpur, IIT/KGP, IIT Madras & IIT /Roorkee. Industry 4.0 has been integrated into the present Coach Production system with the collaboration of MCF/ Rae Bareilly & IIT Kanpur teams. The results are improved machinery health, coach production and inventory usage.

SRESTHA has been envisaged for "Upgradation of Technology and Leveraging 'Make in India' on Railways" at RDSO. It is expected to pave the way of Long Term Railway Research in collaboration with the Industry, Premier Research Institutes and bright minds of the nation.

International collaboration has been done with Korea Railroad Research Institute (KRRI) for the mutual sharing and development of transportation knowledge wealth. Continued Collaborations are being done with many nations for technical Feasibility Studies, High Speed Corridors evaluations, Technical Co-operations in Rail Safety, Joint Exploration of Business Studies etc. These have been benefitting both the involved parties in collaborations.

#### INNOVATIONS DURING COVID

While the nation was reeling under the effects of COVID-19, Indian Railways rose to the occasion and geared up its entire machinery in a big way to innovate, to not only keep the spread of COVID-19 in check but also did innovations, which ultimately lead to development as Transportation Product for Indian Railways. The challenges during COVID 19 were of unprecedented scale and required innovative thinking to not only keep the business of IR alive but also fulfil its social responsibilities. Indian Railways produced several ideas to keep the wheels running and keep its manpower and customers protected from COVID19. Some of the innovations done were:

- In-house development and production of PPEs, Coveralls, Hand Sanitizers, Masks, material delivery robots at hospitals etc during Lockdown. Efforts were made to design the Ventilators.
- Running of Time Tabled Parcel Special Trains & freight trains and Kisan Rail
- Digital Initiatives in the Passenger Segment as Mobile Ticketing, QR-codes in tickets for Contactless Ticketing and Rail Travel, Chalak Dal

Mobile app for Contactless crew sign-on/signoff, Online recharge of suburban cards, Kolkata Metro, facilitation of Payments through the use of robust Digital IT enabled system with minimal staff presence etc

- For efficient management of the system and paving the way for Work from Home, e-Office working expanded over the Indian Railways and used Tele- Presence & Video Conference Systems for meetings/ Interactions at every level.
- Drones were also used for monitoring Projects.
- COVID Care Coaches were created to facilitate the quarantine of COVID Patients

With its roots in the 19th century and nearly 190 years of history since the opening of the first passenger railway in the world between Liverpool and Manchester, railway transportation has a long history. Although the basic concept of low-friction wheels on rails remains the same, the implementation has undergone significant changes, buoyed by multiple technological interventions. Now, two centuries later, technological innovations are expanding the capabilities of railway systems and helping to achieve faster speeds, greater capacity, and better safety to compete with other forms of transportation. Technology has transformed the way the industry works—fuelled by railway operators’ eagerness to reap benefits by making their operations more efficient, safe, and profitable.

Technology has the potential to impact five key dimensions of rail transportation

- Safety enhancement: Technology can make train operations safer by detecting flaws in the tracks, remote monitoring the tracks, digitizing and automating maintenance, and improving basic processes such as welding and grinding. Improvements in signalling and telecommunication, crash safety of rolling stock, and surveillance of human operations can reduce errors and lessen the impact of accidents.
- Infrastructure upgrades: Mechanized construction can enhance the speed for infrastructure upgrades—track laying and electrification while improving cost-effectiveness.
- Train operations effectiveness: The effectiveness of train operations is best measured through asset reliability, utilization, and employee productivity.

Technology can help improve asset reliability through sensor-based condition monitoring and data-driven predictive maintenance. Decision support systems can play a strong role in enhancing asset utilization and employee productivity.

- Passenger experience improvement: The passenger experience is formed at each step of the journey—from planning a trip and booking a ticket to travelling to the railway station, arriving at the station, and travelling on the train. Technology can affect each stage of the experience. Seamless availability of information for planning, omnichannel ticket booking, smart railway stations, value-added services such as Wi-Fi and infotainment, and accurate train tracking based on GPS are just a few examples of ways that technology can enhance the passenger experience.
- Organizational capability enhancement: Technology can have a powerful impact on an organization's capability through effective training and assisting in decision-making. With the introduction of virtual reality (VR) that can simulate real-life scenarios, training has been revolutionized. IT dashboards and management information systems have been used extensively across industries to enable data-driven decision-making. Safety is the most important aspect of rail operations, and Indian Railways envisions running at near-zero fatalities shortly. Many global railway systems have successfully implemented technological innovations in four areas to enhance the safety of operations:
  1. Signalling & telecommunication: Improving train control through better communication.
  2. Rolling stock: Better crash-worthiness to ensure minimal casualties in mishaps.
  3. Personnel: Better supervision of train operators and aid post facto analysis of accidents.
  4. Tracks: Identifying broken rails and rail flaws, gaps in track geometry, and missing fittings and enabling remote track monitoring. Track failures and defects cause about 15 per cent of all accidents on Indian Railways. Various track-related technologies are in use across the globe—from those that identify flaws to those that help with predictive maintenance. Some can be mounted on regular train services while some require special vehicles.

The prominent innovations being used in railway systems around the world, which have applicability for Indian Railways, are described below.

1. **Broken Rail Detection:** Track circuits are the only commercially deployed method for detecting broken rails. However, the primary function of such track circuits is signalling and not broken rail detection. Track circuits are used in North American railways (Canadian National and BNSF) and Japanese railways. Multiple new technologies are in various stages of development for detecting broken rails, including ultrasonic track-lined broken rail detection, distributed acoustic sensing, and magnetic flux leakage detection systems. However, none of these is deployed commercially in a large network in any advanced railway system. For mature global railway operators, the focus is always on the early identification of defects and prevention of broken rails. Although Indian Railways is doing a trial of ultrasonic track-lined broken rail detection over two years on two 25-kilometer stretches, the organization could consider focusing on enhancing the effectiveness of rail flaw detection through technology, rather than investing in broken rail detection enablement.
2. **Ultrasonic Rail Flaw Detection:** Ultrasonic flaw detection (USFD) units can enable early identification of rail flaws. Although used extensively at Indian Railways, the efficiency of the process can be significantly improved through the adoption of innovative USFD technology. Indian Railways can consider using a non-stop USFD mechanism to increase coverage of flaw detection while using stop-and-verify systems for focused testing. At the same time, the organization could continue to pilot locomotive-mounted flaw detection on specific sections to assess the accuracy and effectiveness of the system. The use of digitization (B-scan USFD technology) can further enable the storage of track data and help in trend analysis of rail health to predict failures early and take corrective actions.
3. **Track Monitoring:** Track monitoring systems help identify irregularities in the tracks and can be done through specially designed test trains or technology-enabled physical inspection. The process can include monitoring of signal and telecommunication systems and overhead

electrification lines. Track monitoring rail vehicles can be of two types: autonomous railcars and automated test trains.

#### Signalling and Telecommunication

Although the primary aim of signalling technologies is to ensure safety, modern technologies also help to maximize the use of rails. Globally, two systems are used for automated train protection: the European Train Control System (ETCS) and communication-based train control (CBTC). While CBTC is largely useful only for suburban or metro rail, ETCS has utility for long-haul train networks. ETCS is comprised of three levels and involves track-side or radio-based communication technology. ETCS Level 1 involves using line-side signals and an on-track device called a balise, which communicates with ETCS equipment on board to calculate the next braking point, thereby keeping over-speeding in check.

ETCS Level 2 involves continuous communication of the movement authority and permissible speed through a radio block centre using a GSM-R radio channel. This information is displayed for the operator and negates the need for track-side signals. This helps increase track capacity as operations are more efficient. Although significant investment is required to upgrade all trains on the network to operate without track-side signals, the life-cycle costs of the technology are lower because of the reduced infrastructure requirement. Moreover, this system provides better reliability, maintainability, and safety. Major railway systems such as DB, SNCF, Renfe, and Chinese Railways have implemented ETCS Level 2.

4. **Modern Linke Hofmann Busch (LHB) coaches** are much safer than the traditional Integral Coach Factory coaches. Several safety mechanisms are used on the LHB coaches, including the following:
  5. Centre buffer couplers, prevent coaches from climbing on top of each other during an accident.
  6. Reduced tare weight because of lighter construction materials.
  7. Efficient braking systems.

With these features, the crashworthiness of LHB coaches is much greater, thereby reducing the risk of fatalities in the event of an accident and improving passenger safety. While Indian Railways has been enhancing the share of LHB coaches in its fleet, the

same needs to be fast-tracked to enhance passenger safety in case of accidents.

#### Personnel:

Human error has been one of the biggest reasons for railway accidents across the world. Technological innovations allow for greater supervision and implementation of standard operating procedures to reduce errors and make railway systems safer.

One such innovation is locomotive-mounted video surveillance. These cameras provide continuous high-definition footage of both the interior and exterior of the locomotive, enabling the gauging of operator performance and identification of any inconsistencies on or alongside the track. This surveillance helps identify the root cause of any incidents and acts as a training tool for the crew as well as a maintenance tool to pinpoint the exact location of track-related irregularities. Several companies have come up with such technology, including Rail view by Klein Tech and Loco VISION by GE. Key applications offered by these technologies include driver fatigue detection, trespasser alerts, and wayside monitoring. Indian Railways can consider piloting these applications to gauge their effectiveness in train running and safety.

#### Infrastructure Upgrades

Multiple technologies exist that can improve the rate of construction, enhance structural integrity, and improve the cost-effectiveness of projects, thereby contributing to faster infrastructure upgrades.

8. Track laying forms a large part of all infrastructure projects that rail systems undertake.
9. Multipurpose Track-Laying Machines: They operate on patented technology and are suitable for handling large panels. A big advantage of these machines is that they operate head-on, which means that any hold-up on the adjacent line can be avoided.
10. As Indian Railways progresses toward large-scale electrification, it will be crucial to induct innovative technologies for enhancing the rate of electrification. Several machines can be used:
11. A self-propelled overhead electrification laying train (SPOLT) is used for putting in place the contact and catenaries wires required for the electrification of rail systems. This train has automatic tensioning arrangements, guide masts,

and instrumentation for ensuring proper tension and uniform rotation of wiring drums.

12. An eight-wheeler self-propelled multi-utility vehicle (SPMUV) has a cab at one end and a swivelling platform and crane at the other end, which supports maintenance, adjustment of overhead equipment, and mast erection operations.

#### TRAIN OPERATIONS EFFECTIVENESS

The key objective of train operations effectiveness is increasing asset availability and utilization. Multiple existing and new technologies are in play that can help Indian Railways achieve this. Key technologies are highlighted below.

- Overall Asset Performance Management: Overall asset performance management systems are designed to enhance the reliability of operations and increase the availability of assets. In such systems, deploying sensors along the entire network provides data that is fed into a predictive maintenance tool, which can provide an advanced warning of a potential failure and allow for planned maintenance.
- Operations optimization: Operations optimization tools help ensure maximum asset utilization by making sure the locomotives, rolling stock, and crew are available at the origin and changeover points when required and trains run efficiently across the network. Given the vast nature of rail networks, it is very difficult to optimize train movement manually.

#### PASSENGER EXPERIENCE IMPROVEMENT

Railways are such an integral part of the common man's life that a small change in experience is easily recognized and appreciated. Also, to keep abreast with Indian consumers' rising expectations, Indian Railways must transition from a traditional railway station model to a smart railway system. The tenets of smart railway stations include seamless connectivity and enhanced passenger experience.

For Indian Railways, full digital access control could be one of the major goals. However, it will be very challenging to establish right away given the changes in the ticketing system and the level of passenger know-how that is required. Access control can be

implemented in a phased manner starting with a partly digital and partly manual solution wherein security personnel are deployed alongside automatic gates to educate passengers about the new technology. Many global rail systems use GPS positioning and footpath mapping to track trains in real time and relay the information to passengers. These systems can automatically and accurately measure any delays in operations. Using such systems goes a long way in enhancing the passenger experience and optimizing the use of resources.

#### ORGANIZATIONAL CAPABILITY ENHANCEMENTS

Technology can improve organizational capability enhancement in railways, especially in personnel training and leadership decision-making. Several technologies such as virtual reality and training simulators enable the recreation of real-life scenarios, leading to hands-on training as opposed to basic classroom-based training. These technologies are particularly relevant for roles with significant manual intervention. Technology and digitization interventions such as management information systems and dashboards are widely used across industries to improve the visibility of the organization's performance to the top management and enable sound decision-making. They also assist in the centralized management of current projects and the planning of new projects based on tracking key performance indicators and availability of resources. Dashboards are useful not only to top management and decision-makers for enhanced visibility of the organization but also for middle and lower executives to track day-to-day activities and plan tasks. Additionally, they can be a key decision-making tool that provides insights across functions using the organization's data. Dashboards allow management to view consolidated information from across the organization and from different software applications. They are useful in monitoring the progress of key projects and undertaking timely interventions to ensure the fulfillment of organization goals. They also simplify the complexity of running organizations by prioritizing access to vital information.

#### CONCLUSION

Over the last five decades, Rail transport has faced major headwinds. The transformation of global supply chains has made the logistics business more challenging than ever, with increasing pressure to deliver fast and flexible services at a lower cost. In that quickly evolving context, freight rail is grappling with fierce competition from road transport a trend that will only intensify under the effect of disruptive technologies like autonomous trucks and on-demand mobility services.

Railways are in the midst of a profound transformation, driven by emerging digital technologies like 5G, big data, the Internet of Things, automation, artificial intelligence, and blockchain. It is hard to overstate the impact of digitization on the railway sector. Digital technology is pretty much impacting every component of railway operations. With these breakthroughs, digital development provides a unique opportunity for railways not just to stay relevant, but also to increase their share in the overall logistics market, and to become an integral part of the transition toward a greener, more sustainable freight transport. Despite its many promises, the digitization of rail also comes with many challenges, ranging from concerns over privacy and security to regulation, issues related to the ownership of data and proprietary systems, public acceptability, the impact on jobs, and the fear of investing in stranded assets.

The vision of Indian Railways is to be a Global Leader in Railways by leaping as a creator and innovator of technologies and systems. Through a new way of thinking and a creative culture ingrained through policies and system enablement, IR in due course will take its place globally, standing true to its reputation as an innovator in rail technology creation and dissemination. Indian Railways is surely an organisation where the motivated manpower, industry, research community, academia and leadership come together to create new opportunities, and where an innovative mindset and functionally enabling ecosystem will drive it further to fulfil the aspirations of present and future India.

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