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Future Rail India

Innovation • Safety • Sustainability

PEOPLE | TECHNOLOGY | INFRASTRUCTURE | OPERATIONS | A GREENER TOMORROW

THEME – ISSUE 1

FUTURE OF RAILWAY SIGNALLING IN INDIA

Transforming Today.
Connecting Tomorrow.

PEOPLE
TECHNOLOGY
SUSTAINABLE
RAILWAYS
FOR A BRIGHTER
INDIA

CLEANER
GREENER
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TOGETHER

PEOPLE
MOVE
INDIA
FORWARD

A STRONGER
RAILWAY
FOR A STRONGER
INDIA

INFRASTRUCTURE FOR GROWTH

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ABOUT THE MAGAZINE

Publication Information

Future Rail India is as a bi-monthly specialist magazine focused on railway signalling, telecommunications, safety, technology, competence and related railway systems. It is intended as a knowledge platform for railway professionals, metro organisations, railway PSUs, OEMs, system integrators, training institutes, technology specialists and engineering students.

Purpose

- Design signalling/telecom systems to optimise RAMS and minimise environmental impact.
- Benchmark credibility, commitment and excellence beyond compliance.
- Support safe and healthy workplaces and a strong safety culture.
- Enable cross-industry benchmarking, best-practice sharing, continuous monitoring and proactive risk management.
- Encourage excellence in design, development, manufacturing and installation.
- Support learning, S&T standards/trends, train-operation optimisation and competence development.
- Explore AI, Quantum Technology and OT Cybersecurity in railway systems.

Target Audience

- Indian Railways S&T Engineers
- Metro Rail signalling staff
- Railway PSU engineers
- S&T executives from OEMs
- S&T executives from system integrators
- Railway signalling companies
- Railway S&T training institutes
- Engineering students in railway electronics, AI and cybersecurity

Estimated target readership: Railway professionals, metro organisations, railway PSUs, OEMs, system integrators, training institutes, technology specialists and engineering students.

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Anshul Gupta, IRSSE (Retd.), FIRSE, joined the Indian Railway Service of Signal Engineers in 1986 and superannuated in March 2023 after a distinguished career spanning railway signalling, operations, infrastructure, technology and administration. He served as Divisional Railway Manager (DRM) of Adra, Ranchi and Delhi Divisions and as General Manager, Northeast Frontier Railway, heading both Open Line and Construction organisations.

As General Manager, Northeast Frontier Railway, covering eight states of the North East and parts of Bihar and North Bengal, he led major national railway projects, including connectivity to the capitals of Manipur, Mizoram, Sikkim and Nagaland. He also contributed to international connectivity with Bangladesh, Nepal and Bhutan and promoted advanced GeoTech and LiDAR-based surveys for strategic and economic railway development.

His professional expertise encompasses railway signalling and train control, safety systems, operations, project planning and execution, business development, asset monetisation, telecommunications, vendor and product development, and quality assurance.

He has been associated with several pioneering technology initiatives, including Train Collision Avoidance System (Now called **Kavach**), AI-powered OFC acoustic sensing for intrusion and hazard detection, AI/IoT-based predictive maintenance, Digital Twin-based train operation optimisation, Quantum Key Distribution (QKD) pilots, and an Indian Railways Cybersecurity Framework based on global standards. He also contributed to the development of an early Electronic Train Control and Interlocking System for Indian Railways.

Currently, he serves as an Advisor to RailTel Corporation of India Limited, working on the adoption of AI/ML, OT Cybersecurity and Quantum Technologies through practical railway use cases. He is heading Institution of Railway Signal Engineers IRSE (UK) Licensing Assessment Scheme in India for competency assessment in railway signalling and is involved in AI- and Quantum Technology-based railway optimisation research.

As Secretary, IRSE (UK) – Indian Section, he promotes professional competence and assessment in modern railway command, control and signalling systems. His current focus is on developing safe, intelligent, secure and technology-driven railway systems and contributing to India's vision of technological self-reliance.

FROM THE EDITOR'S DESK

Welcome to the first issue of Future Rail India. This magazine has been conceived as a professional knowledge platform for the railway signalling and telecommunications community, bringing together practical experience, technology developments, safety learning and competence-focused perspectives.

The railway sector is experiencing rapid change across signalling, train protection, communications, automation, cybersecurity and data-driven operations. Our objective is to provide a constructive forum where engineers, railway organisations, technology providers, training institutions and students can share knowledge and learn from one another.

This first issue focuses on the future of railway signalling in India and introduces themes including AI, digital technologies, train protection, communications, safety and skills. We welcome original technical articles, case studies, interviews, professional perspectives and learning contributions from the wider railway community.

Anshul Gupta
Editor-in-Chief

CONTENTS

Volume 1 | Issue 1

No.	Section / Article	Author / Organisation	Page
1	From Editor's Pen	Anshul Gupta	9
2	Accelerating KAVACH development via the Generic Test Facility: An Independent, OEM-Neutral Testing Framework for Multi-Vendor KAVACH Interoperability	Saurabh Bandopadhyaya, Prashant Kumar Verma, Priya Agrawal	13
3	Contribution to OT Cybersecurity Policy for Railway Signalling Systems	Pratik Teli	17
4	The Uniform Braking Algorithm (UBA) for the Indian Railways	Srinidhi M Rao, G G Tronics India Private Limited	19
5	National KAVACH Testing and Accreditation Lab: Following World Class Railways to Shift from Field Trials to Lab Trials	Anshul Gupta, FIRSE, IRSSE(Retd)	20
6	Importance of IRSE License in Indian Railways	Ms Ruchi Rani, RailTel IRSE Licensing Assessment Agency	25
7	Mission Critical Communication for Indian Railways	Mr Sanjit Kumar Sahoo, Cellcomm Solutions Limited	26
8	Building High-Value System of Systems Solutions for Highly Disruptive, Complex and Dynamic Indian Railways Scenarios	Dasari Ramakrishna, EFFTRONICS SYSTEMS PRIVATE LIMITED	27
9	Unified Maintenance Strategy in Kavach for S&T sub-assets	Ms Neela Pavani, IRSSE, Indian Railways	28
10	Leveraging AI-Enabled Aerial Digital Twins to Strengthen Kavach Implementation	Shreyas Nayak, Skylark Drones Private Limited	29
11	5G Solutions for Railway Safety & Crowd Management	Mr Rajesh Tuli, CORAL TELECOM LIMITED	30
12	AI Powered Kavach Design Document Generation System	Laxmiprasad Putta, Vassar Labs IT Solutions Private Limited	31
13	Human Factors and Human-in-the-Loop AI for Modern Metro Operations: Challenges, Resilience and Enhanced Operational Safety	Kasturi Kamlakar Patil, Maha Mumbai Metro Operation Corporation	32
14	Intelligent by Design: Applying Emerging Technology Trends to the Railway Ecosystem from Operational Efficiency and Predictive Maintenance to Left-Shifted Development	A Practitioner's Perspective — Mr Biswajit, Tata ELXI	33
15	CP PLUS Railway Surveillance & Safety Solution Intelligent Mobile Surveillance for Safer, Smarter & Secure Railways	Mr. M.A. Johar, President - Project Business at CP PLUS	34
16	Salient Features of Universal Braking Algorithm of Kavach: Addressing the IR-specific Challenges	Lalit Mansukhani, Principal Chief Safety Officer, Southern Railway; T. Nagaraj, Director/T&RS/Kavach/RDSO	36
17	From Deterministic Train Protection to Intelligent Railway Operations: The Next Evolution of Indigenous Railway Signalling Systems.	Sourajit Mukherjee, NOVA Control Tecnologix Private Limited	37
18	From Fiber Sensing to Aerial Intelligence: An Integrated DAS and Autonomous Drone Dock Framework for Elephant Intrusion Detection and Cable Theft Response in Railway Corridors	Ms. Bharti Jain, Rail Vikas Nigam Limited	39
19	Industry Perspectives		40
20	Training & Skill Development		42
21	Product & Vendor Showcase		43
22	Safety Lessons		45
23	Student Corner		47
24	Author Guidelines		49
25	Editorial & Content Policy		50
26	Online Publication & Archive and Publication Information		51

From Editor's Pen

1. Introduction to Digital Twin driven Railway Asset Upkeep – Industry 5.0

Digital Twin is an AI/ ML powered transformative technology that creates a virtual mathematical modelling-based representation of physical assets, operational parameters, present system of maintenance, repairs & overhauling enabling real-time monitoring, analysis, optimization and integration of works, inventory & human resources at all the locations on a railway section/ depot or production unit. This virtual counterpart acts as a mirror, providing real-time as well as predictive (future) insights and data synchronization to optimize operations, asset performance and enhance operational decision-making.

For Indian Railways, Digital Twin can be a transformative game-changer. By implementing this technology, the railways can access a wealth of data-driven insights into asset behavior, gaps in the operations, predicting maintenance needs and proactively addressing issues before they escalate and also providing path for an optimal maintenance & overhauling regime. It opens avenues to create capacity, elevate safety, reduce downtime and optimize resource allocation, positioning Indian Railways at the forefront of railway innovation.

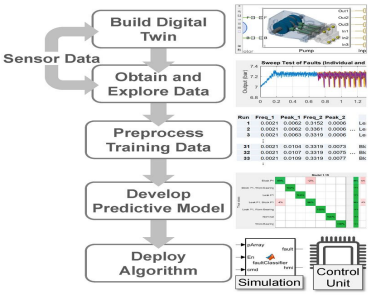


Fig. 1: Digital Twin flow process

(Source: https://www.mathworks.com/company/newsletters/articles/predictive-maintenance-using-a-digital-twin.html)

2. Global Success Stories with Digital Twin

Embarking on a journey of triumph, nations like Germany, Japan, USA have ingeniously harnessed the potential of Digital Twin to revolutionize their rail systems. Witnessing unprecedented efficiency gains and a paradigm shift in safety standards, Digital Twin has elevated rail operations to new heights across the globe. In Germany, Digital Twin applications have been instrumental in monitoring and optimizing railway infrastructure, estimated 20% increase in line capacity, resulting in faster and better train services, an astounding 30% increase in asset lifespan, significantly prolonging the service life of critical components. Moreover, maintenance costs have witnessed an impressive 25% reduction, freeing up valuable resources for further innovations in rail technologies.

Across the vast landscapes of the United States, Digital Twin technology has played a pivotal role in predictive maintenance of rail tracks, averting potential disasters and reducing accidents by a staggering 40%. By continuously monitoring the health of rolling stocks, tracks, railways have been empowered to take proactive measures, ensuring smooth, faster and safe operations for millions of passengers.

As these countries embrace the Digital Twin revolution, their success stories resonate with inspiration, underscoring the immense possibilities for Indian Railways. Embracing this innovation heralds a future of optimized operations, predictive maintenance and an unparalleled rail experience for millions, positioning Indian Railways as a global trailblazer in the realm of rail technology.

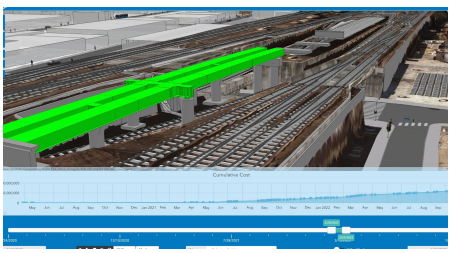


Fig. 2: Digital Twin Application in the USA rail network for simulation testing (Source: https://www.esri.com/about/newsroom/publications/wherenext/5d-the-new-frontier-for-digital-twins

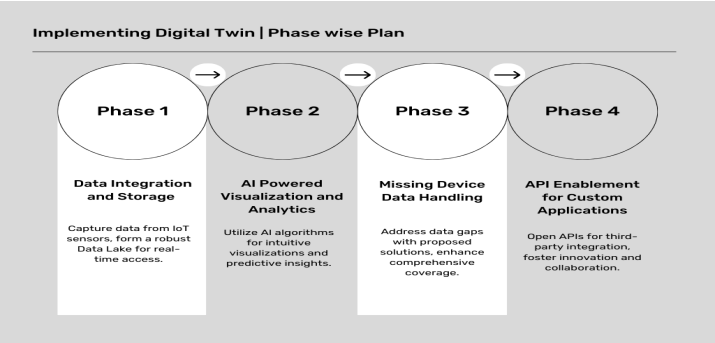


Fig. 3: Digital Twin Phase Wise Plan

3. Emphasizing Systematic Approach

Amidst the substantial benefits of Digital Twin lies the cornerstone of success - a systematic approach. Crafting a roadmap fortified by a robust foundation and meticulous phase planning is paramount to unleash the technology's boundless potential. It is planned to create a 4-phase implementation strategy on Indian Railways to embark on an extraordinary journey of unrivalled efficiency, heightened safety and a trailblazing paradigm shift in the realm of modern rail operations. With precision and foresight, this transformative venture will redefine the rails, charting a course towards innovation and excellence. The utility of digital twins extends beyond mere visualization; it involves the seamless integration of data streams, visualisation of key performance indicators, and live operational information. By providing a comprehensive overview of the railway ecosystem, digital twins facilitate data-driven decision-making, predictive maintenance, and performance enhancement. Such tools prove instrumental in addressing actual maintenance requirements, inventory management, T&P efficiency, Worker performance and ultimately improving the overall efficiency and safety of the rolling stock as a whole.

4. Digital Practices:

Digital twins can play a pivotal role in railway workshops by revolutionizing maintenance practices on incoming due for overhauling or scheduled maintenance rolling stocks, thus optimizing workshop operations. Through the creation of virtual replicas of rolling stock and equipment, workshops can harness real-time data from sensors and IoT devices to monitor the health and performance of components. This allows for predictive maintenance and early fault detection, where potential issues are identified before they escalate, minimizing downtime and reducing operational disruptions. Digital twins facilitate a comprehensive view of each train's condition, enabling workshops to schedule maintenance activities efficiently, plan for necessary part replacements, and optimize resource allocation. Technicians can access detailed information about the state of each component, allowing for targeted and precise repairs. Additionally, digital twins enable simulation-based training for workshop personnel, enhancing their skills in handling various maintenance scenarios and ensuring optimal performance and safety standards for the entire railway fleet. Overall, digital twins empower railway workshops to transition from reactive to proactive maintenance strategies, resulting in improved reliability, reduced costs, and enhanced overall efficiency.

5. Standards:

Artificial Intelligence is now being adopted on Railways on a large scale, but it has become a hype also, as many system providers are bringing their simple data acquisition and data representation systems as AI powered systems with no demonstration of advanced problem-solving, or ability to adapt/ learn from new information, or non-exhibition of human-like understanding without clear programming rules, and most importantly having no compliance with various standards pertaining to AI as listed below. These are mostly noncertified with no traceability of its stochastic capability as per international standards. In US, NIST has released a detailed AI draft framework for the development of such AI powered systems. Similarly, IEC , which India follows extensively, also have has also come out with various standards. It is high time that RDSO should also develop its capability in this area and start following these standads which other strategic sector already do. A few of the important ones are:

ISO 42001/2003
IEC 5338 AI system life cycle processes
IEC 38507 for Risk Management, Governance Implications
IEC 22989:2022 which establishes terminology for AI & describes ethical concepts in the field of AI, that biasness is avoided and AI system is fair and to make positive social impact.
IEC TR 24208 is to ensure trust worthiness.

6. Approach towards Building a World Class Digital Twin:

For setting up of Digital Twin or an **"Industrial Metaverse"** for real-time monitoring, analysis, planning, and maintenance of physical assets/facilities. Apart from the existing data already available on the Digital Twin platform; organsiation has to enable the collection of additional data points within the facility itself. This contextualized data **enhances the decision-making process**, enabling swifter and more informed choices. This shall optimize operational procedures and mitigate potential hazards fast, and can help foresee potential breakdowns, predict traffic congestions, optimize workforce requirements, reduce carbon footprint, enhance safety by accurate tracking and geo-fencing, and reduce downtimes of machines & assets using predictive maintenance. As the railway industry embraces the digital age, the integration of digital twins emerges as a pivotal strategy to propel operational excellence and meet the evolving demands of modern transportation.

7. Summary:

In the symphony of innovation, Digital Twin heralds a transformative note for Indian Railways. The Digital Twin concept is more than technology; it's a gateway to precision, efficiency and safety. As the Digital Twin takes its place, Indian Railways will embrace a new era of operational and maintenance excellence. From predictive maintenance to resource optimization, from enhanced safety to passenger-centric services, the benefits are profound and far-reaching. United in our commitment, RailTel and Indian Railways embark on a journey that promises a future where rails become a stage for technological marvels. With each phase, each insight and each advancement, the railways carve a path toward unparalleled efficiency and a reimagined travel experience.