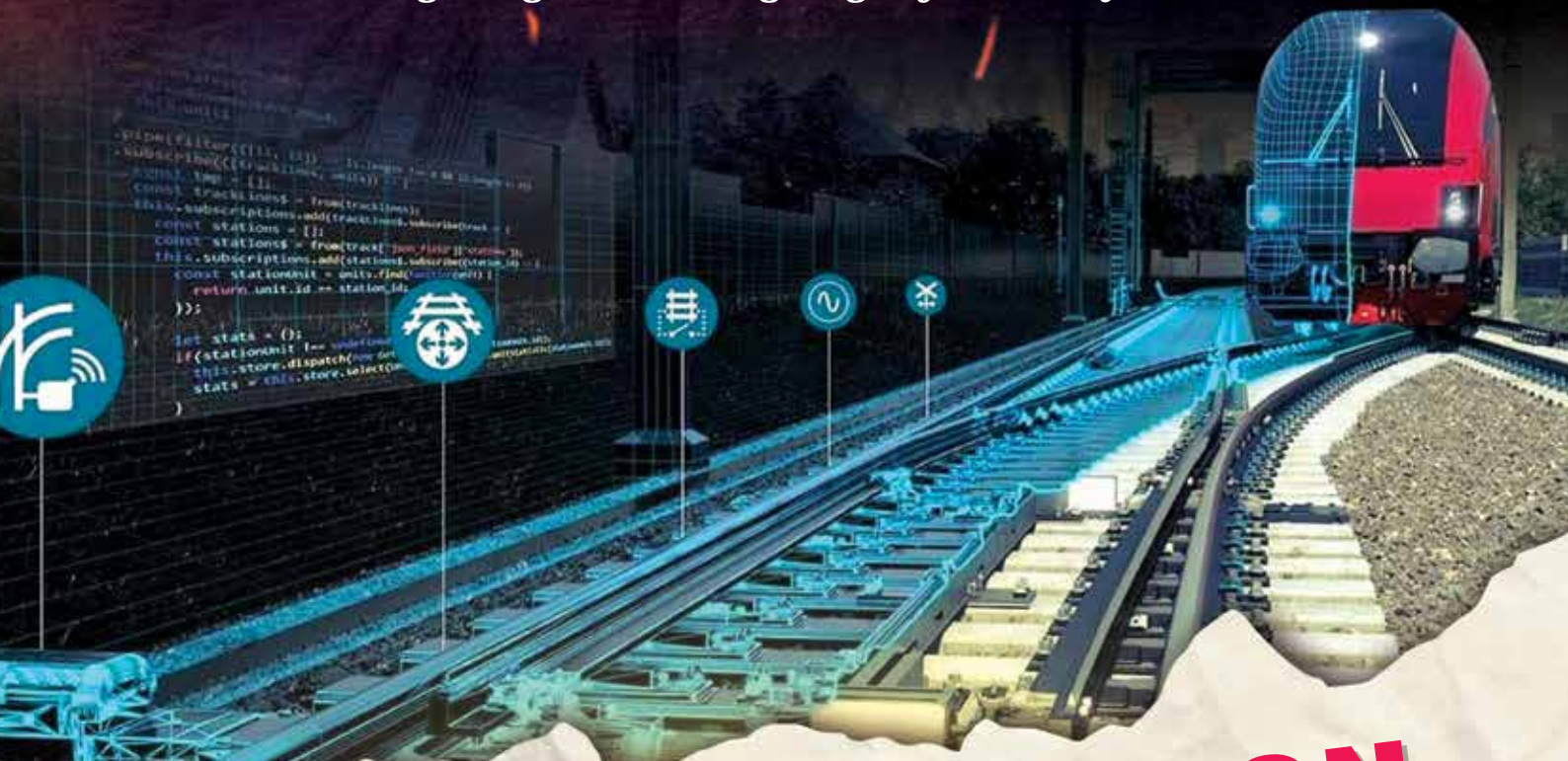




Navigating the Cutting Edge of Industry News



REVOLUTION ON TRACKS:

The Next Era of Indian Railways

IN THE HOT SEAT
Sudhanshu Mani

INNOVATION SPOTLIGHT
Sravan Kumar Appana

RESEARCH REPORT
On Track to the Future: The Growth
and Modernization of Indian Railways

VOICES OF INDUSTRY
From Design to Deployment:
Semiconductor Life Cycle in Railways





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A New Beginning in Industrial Storytelling

With immense excitement and a vision for the future, we welcome you to the inaugural edition of *Machine Edge Global*! This marks the beginning of an insightful journey into the dynamic world of manufacturing, automation, aerospace & defence, construction equipment, pharma, supply chain & logistics, industrial chemicals, and beyond. Our goal is to bridge the gap between industries, innovation, and ideas, serving as a platform for knowledge exchange and thought leadership.

In today's rapidly evolving industrial landscape, staying ahead of the curve requires more than just expertise—it demands collaboration, continuous learning, and adaptability. *Machine Edge Global* aspires to be more than just a magazine; we envision it as a movement. With tiny yet determined steps, we have entered the market, and we are here to soar. However, this journey is not ours alone—it is powered by the collective insights, expertise, and support of industry leaders, professionals, and visionaries like you.

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As we embark on this journey, we promise to deliver informative, enlightening, and thought-provoking content. Our upcoming editions will feature in-depth interviews, expert analyses, and insightful articles, ensuring that *Machine Edge Global* becomes a trusted resource for professionals across sectors.

We invite you to join us in this exciting venture—share your expertise, engage with our content, and be a part of this growing community. Together, let's build a future where knowledge drives progress, and industries thrive through collaboration.

At *Machine Edge Global*, we're not just reporting on the future—we're shaping it, one story at a time.

A handwritten signature in dark ink, reading "Neha Basudkar Ghate". The signature is written in a cursive, flowing style.

Neha Basudkar Ghate

Editor In Chief,
Machine Edge Global

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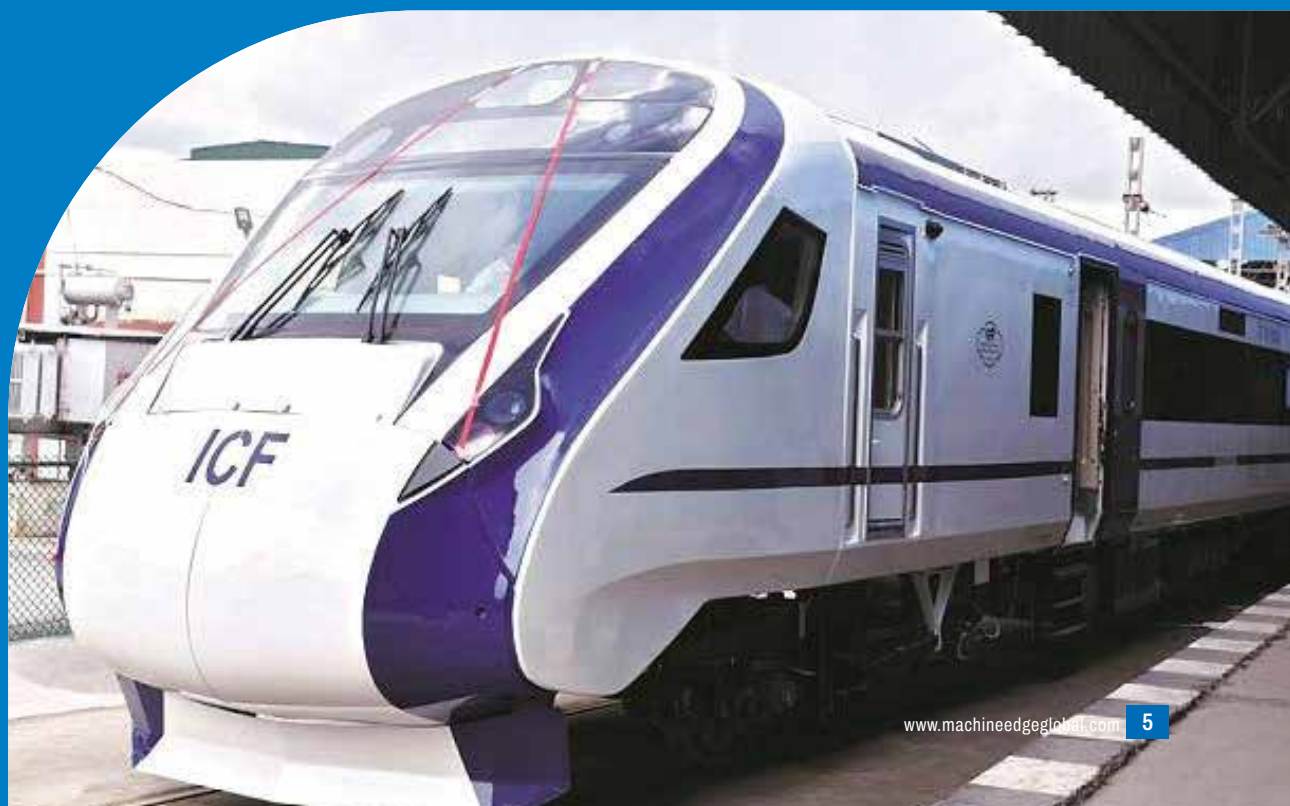
SUDHANSHU MANI

Retired General Manager, Integral Coach Factory (ICF) and Creator of India's first semihigh speed train- Vande Bharat Express

WRITTEN BY: Neha Basudkar Ghate

Editor In Chief |

neha.machineedge@gmail.com



As India nears its 100th year of independence, the future of Indian Railways has never been more crucial. In this insightful interview, Sudhanshu Mani—the visionary behind the Vande Bharat Express, shares his candid take on the challenges and opportunities shaping the rail sector.

With a distinguished career in railway innovation, Mani delves into the technology gaps in train manufacturing, the push for high-speed, eco-friendly travel, and the critical steps needed for Indian Railways to lead the way by 2047. He also sheds light on boosting freight traffic, enhancing train quality, and strengthening passenger safety—outlining a compelling roadmap for the railway’s evolution.

This conversation with Mr Mani, not only reflects on the progress made but also highlights the urgent need for visionary leadership and technological advancement to ensure Indian Railways remains a pillar of India’s growth in the decades ahead.

Q. What is your take on the increasing privatization of railway services? Is it the key to modernization, or does it risk alienating the common passenger? How can Indian Railways collaborate with private players without compromising its social obligations?

▶ Indian Railways operates as a commercial entity with a crucial social responsibility, providing affordable travel for millions. While fares for lower classes must remain low, a balanced approach—retaining government control over essential services while privatizing high-end segments—can enhance efficiency.

Ensuring dignity in travel is paramount. Overcrowding forces passengers into undignified conditions, but solutions

exist. Running longer trains and guaranteeing at least a seat for every passenger can be achieved with the right mindset, even within the current fare structure.

Privatization can play a key role in premium train services, where operators can enhance onboard experiences while railways focus on infrastructure upgrades like track modernization to reduce travel time. A past attempt at privatizing high-end trains failed due to a flawed tender process that placed all risks on private players. A revised approach could create a win-win model benefiting both railways and investors.

Manufacturing is another area ripe for reform. Globally, rolling stock production is corporatized or privatized, ensuring efficiency and competitiveness. India should follow suit, gradually transitioning its production units toward a corporate structure.

Station redevelopment, too, demands private participation. The earlier Public-Private Partnership (PPP) model faltered due to poor tender design, leading to excessive government investment under the EPC model. However, without a long-term maintenance plan, new stations will degrade quickly. Reintroducing PPPs with a fair revenue model can ensure sustainability, as seen in airports, ports, and highways.

Importantly, station designs should prioritize functionality over aesthetics. Unlike airports, railway stations must enable smooth, quick passenger movement, ideally within minutes. Achieving this requires punctual operations, which are possible with the right focus.

A hybrid model is the way forward—government oversight where affordability is key and privatization where efficiency and quality can improve. With well-structured policies balancing risk and reward, Indian Railways can modernize while upholding its social obligations.

Q. Indian Railways serves as a lifeline for the common man while also embracing luxury travel. How do you see this balance evolving, especially with initiatives like the Vande Bharat Express and upcoming Bullet trains? Can the Indian Railways offer luxury and speed like Vande Bharat to the masses without making it inaccessible due to high fares?

▶ **Evolution of Railway Services: Speed and Accessibility**

The Vande Bharat Express, designed for speeds up to 180 km/h but currently limited by track conditions, will achieve its full potential as infrastructure upgrades allow for 160 km/h operation, with future enhancements reaching 200 km/h. Bullet trains, operating at 250 km/h or above, serve a distinct purpose and complement

- Indian Railways operates as a commercial entity with a crucial social responsibility, providing affordable travel for millions.
- Faster modernization of tracks will allow Vande Bharat trains to compete with air travel, replicating Europe’s success in intercity rail transport.



rather than compete with Vande Bharat, each playing a role in modernizing India's rail network.

Economic and Environmental Impact of High-Speed Rail

Rail travel is cleaner and more sustainable than road or air transport. Strategic high-speed rail corridors—such as Mumbai-Ahmedabad, Chennai-Bengaluru, and Delhi-Lucknow—can replace short-haul flights, offering faster and greener alternatives. The Mumbai-Ahmedabad corridor, for instance, aims to cut travel time to just 2.5–3 hours, making air travel redundant.

Balancing Bullet Trains and Existing Rail Networks

High-speed rail development is funded through Special Purpose Vehicles (SPVs) and external borrowings, while Indian Railways continues to receive government CAPEX for infrastructure upgrades. Faster modernization of tracks will allow Vande Bharat trains to compete with air travel, replicating Europe's success in intercity rail transport.

The Future of High-Speed Rail in India

Skepticism about high-speed rail should be tested through execution, as seen in China's 30,000 km network. Rather than debating its feasibility, India should focus on completing the Mumbai-Ahmedabad project and then assess further expansion. A phased rollout of three to four additional high-speed lines will provide real-world insights.

By modernizing conventional rail for semi-high-speed travel while selectively introducing Bullet trains, India can create a balanced, efficient, and future-ready railway system catering to both common passengers and premium travellers.

Q. What should be the key priorities for Indian Railways in the Union Budget 2025, and how can it achieve financial sustainability while improving infrastructure and freight efficiency?

► Funding vs. Execution: The Real Challenge

With ₹2.65 lakh crore allocated earlier—and as equalled in this budget—funds are not an issue. The real challenge lies in execution: Indian Railways must efficiently utilize these resources. Key priorities should be:

- Track upgrades
- Signaling modernization
- Enhanced safety measures

While new trains like Vande Bharat are being produced, there has been little real innovation in the past six years. The focus must shift from optics—station redevelopment and train launches—to core infrastructure upgrades that impact efficiency and safety.

Financial Sustainability vs. Budget Allocation

While CAPEX funds are available, Indian Railways remains financially unsustainable, heavily reliant on government grants.

- The actual operating ratio likely exceeds 100% when pensions and depreciation are factored in.
- Over 70% of costs go to salaries and pensions, making expense cuts difficult.
- Only the remaining 30% can be optimized using modern

tools and processes, AI, automation, and machine vision etc. for efficient maintenance.

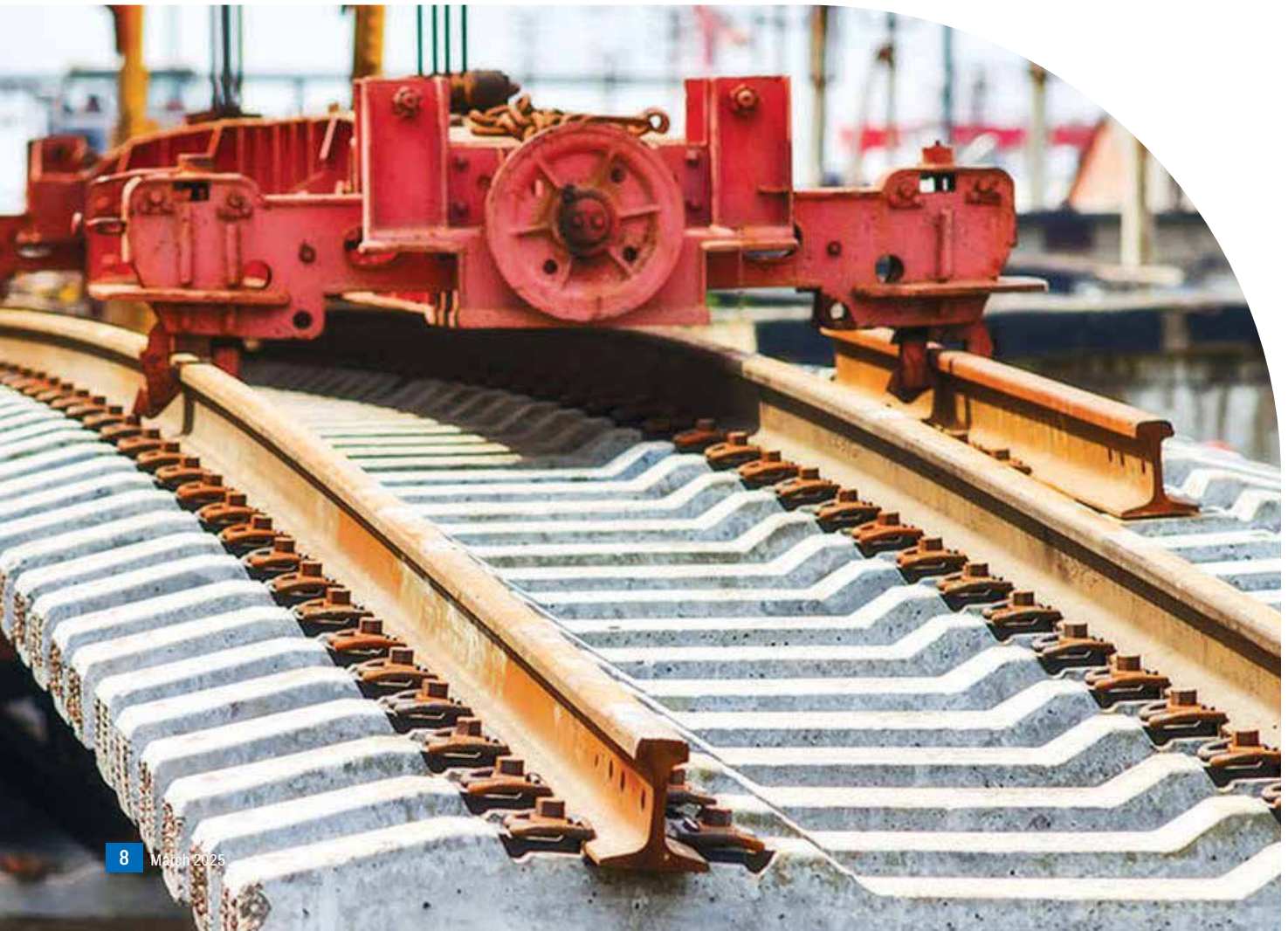
Revenue Challenges & Passenger Fare Dilemma

Raising fares is politically sensitive, though only AC 3-tier and AC chair car are profitable. Even AC 1st and AC 2nd classes are subsidized, while sleeper and general classes cannot bear fare hikes.

Freight Revenue & Policy Reforms

Freight revenue, which subsidizes passenger travel, makes rail freight uncompetitive. The subsidy burden should be shared by the central, state, and municipal governments rather than solely freight earnings.

- Traditional freight (coal, cement, steel, grains, fertilizer, petroleum) is stagnating, except coal, which has grown due to renewable energy gaps.
- Expansion into non-traditional freight is key:
 - Special wagons & customized tariffs
 - Multimodal logistics for seamless inter-modal transfers
 - Timetable-based freight movement via Dedicated



Freight Corridors (DFC) and gradually on other routes too for some trains

Despite initiatives like Gati Shakti and DFC, their full impact is yet to be seen. Railways must empower local officials to set competitive tariffs and ensure predictable freight services.

Conclusion

Rather than just increasing budgets, Indian Railways must focus on capacity building, infrastructure modernization, and revenue optimization. By improving freight efficiency, leveraging technology for cost reduction, and restructuring passenger subsidies, the railways can become financially sustainable and operationally effective.

Q. Freight traffic on Indian Railways has been stagnating, with its share declining from around 27% to nearly 25% today. Despite initiatives like Gati Shakti and the National Rail Plan, the projected freight growth has not materialized as expected. What are the key challenges affecting freight expansion, and what measures should Indian Railways take to enhance its freight revenue and market share?

► The freight share of Indian Railways has indeed declined, now nearing 25%, despite the overall freight carriage increasing. Historically, at the time of independence, railways accounted for over 85% of freight traffic. The National Rail Plan projects that by 2030, railways should be carrying 3000 million tons, and by 2047, it should handle 50% of total freight. However, instead of increasing, the share is shrinking.

To reverse this trend, several freight-focused initiatives must be implemented, including:

- Multimodal Logistics & Terminals: Strengthening first-mile and last-mile connectivity for efficient freight collection and distribution.
- Special Wagon Design & Freight Tariff Reforms: Introducing specialized wagons and allowing more flexible, localized freight tariff structures.
- Timetabled Freight Services: Unlike passenger trains, freight trains currently operate based on demand accumulation. A shift to scheduled, timetabled freight services—similar to passenger ticketing—would attract more users by ensuring predictability.
- Policy Reforms & Autonomy: Granting more decision-making power at regional levels to adapt pricing and scheduling based on local needs.
- Investment in Infrastructure & Efficiency: Enhancing

**By 2047,
Vande Bharat trains should be
crisscrossing the country at
200 km/h,
forming an extensive high-
speed rail network that
significantly reduces air
travel between cities.**

rail infrastructure to improve freight speed and reliability, ensuring timely deliveries.

Without these measures, freight traffic will continue to stagnate. Currently, Indian Railways relies heavily on government-funded CAPEX, but in the long run, it must generate its own surplus for investment to remain a financially sustainable organization.

Q. What is Indian Railways' roadmap to achieving near-zero accidents? How can AI help identify and prevent near misses? What steps are needed to accelerate Kavach implementation?

► The perception that railway safety has declined is incorrect. In reality, Indian Railways has significantly improved its safety record. In 2024, the total fatalities were around 25, whereas a decade ago, this number ranged between 500-600 per year. The statistics from 2023 were skewed due to the unfortunate Balasore triple train tragedy in Odisha, which claimed 292 lives. However, such incidents should be treated as exceptions rather than a reflection of the overall safety trend.

Despite these improvements, moving towards a near-zero accident regime requires proactive measures. Key initiatives include:

1. **Kavach Implementation:** Kavach is India's indigenous safety system, considered an alternative to the European Train Control System (ETCS) Level 2. The government has expressed confidence in its effectiveness, but progress has been slow. In the last three years, no significant expansion has taken place

beyond the initial implementation on the South Central Railway. To make a meaningful impact, there must be a focused and accelerated deployment, covering at least 4,000 km per year, ensuring that even half the network (35,000 km) is covered in the next nine years.

2. AI for Preventing Near Misses: Artificial Intelligence (AI) has the potential to revolutionize railway safety by analyzing real-time digital data from station loggers and locomotive computers. Currently, this data exists in isolation. By integrating AI-driven analytics, railways can detect and flag hundreds of near-miss incidents daily, alerting authorities in real-time and enabling

immediate action. This approach will help eliminate human errors, which often arise due to operational stress and the pressure to run more trains. A robust AI-based system can systematically reduce near misses, thereby preventing accidents before they happen.

3. Infrastructure Upgrades & Legacy Replacements

The decline in accident rates is largely attributed to continuous investment in:

- Eliminating unmanned level crossings, which used to cause 30-40% of railway accidents.
- Upgrading tracks to support safer and smoother train operations.



- Replacing ICF coaches with LHB coaches, which significantly reduce casualties in case of a collision.

While these measures have made railways safer, future safety improvements must go beyond infrastructural enhancements. The focus should now shift to technology-driven monitoring, predictive analytics, and real-time intervention to achieve a near-zero accident framework. A well-planned roadmap, backed by strategic investment and execution, can make this vision a reality.

Q. The Vande Bharat Express was introduced as a symbol of India's progress in train manufacturing. Can you share insights into its manufacturing process and whether there have been significant technological upgrades in the recent versions?

▶▶ The recent Vande Bharat trains have not undergone any major technological upgrades—only cosmetic enhancements or ‘frills’. If you look at the list of improvements, they do not contribute significantly to technological excellence. Six years have passed since the prototype, yet instead of focusing on technological advancements, the emphasis has remained on mass production. While Vande Bharat was a leap forward compared to conventional Indian trains, it still lacks some world-class features. For example, the exterior quality of trains in developed countries matches that of high-end automobiles, whereas Indian trains—including Vande Bharat—are yet to reach that standard. The same applies to interiors; while they look plush, they do not match global benchmarks. Some components, like the propulsion system, are world-class, but the overall train still has room for improvement.

Rather than focusing on sheer numbers, India should prioritize quality enhancements before expanding production. Currently, around 25% of Vande Bharat trains operate at low occupancy, raising concerns about their deployment strategy. The need for sleeper versions was anticipated years ago, yet they are only now undergoing testing. Similarly, aluminium-bodied trains, which offer energy efficiency and aesthetic superiority, have not materialized due to delays in decision-making and a lack of long-term planning.

While India made a commendable move by tendering 100 aluminium trains—large orders like this only nations like China or India can undertake—the tender was ultimately scrapped. This reflects a pattern of one step forward and three steps back. India must acknowledge the gaps in Vande Bharat's development, foster leadership with a commitment to technological progress, and take decisive steps toward building truly world-class trains.

Q. What is your vision for IR by 2047 – As India enters its 100th year of Independence.


▶▶ If you look at the National Rail Plan, it already presents a remarkable vision for Indian Railways. I cannot improve upon that, but unfortunately, we are not realizing it. Even after three to four years since its introduction, we are slipping behind.

The vision is straightforward. Rather than fixating on a specific percentage, I would emphasize the need for continuous growth in freight traffic. We should aim to reverse the decline in the railway's modal share of transportation. Even if we gain just 2% annually, in a decade, that would add up to 20%, which is crucial since rail freight is a clean and green mode of transport.

For passenger travel, I envision a developed India where people travel with dignity and comfort—perhaps with air-conditioned coaches becoming the norm, except for one or two general coaches catering to those who prefer non-AC travel due to medical reasons or affordability constraints. Ideally, there could be one dedicated train on each route for migrant workers who cannot afford AC fares. However, our current policies seem to contradict this vision, as we are still manufacturing non-AC trains, which will remain in service for the next 36 years.

By 2047, Vande Bharat trains should be crisscrossing the country at 200 km/h, forming an extensive high-speed rail network that significantly reduces air travel between cities. In addition we should have at least 5000 km of HSR. In fact, a system where airlines like Indigo sell train tickets for intercity routes—similar to what Lufthansa does in Germany—should become a reality in India.

Railway stations should also evolve—not into extravagant structures with granite facades and shopping malls but into functionally efficient spaces that prioritize passenger comfort, hygiene, and convenience. Trains should run on time, passengers should know exactly where their coach will arrive via their mobile devices, and the overall travel experience should be seamless.

Safety is paramount, and by 2047, we should aim for near-zero accidents. Additionally, India must take the lead in developing a groundbreaking railway technology. While Vande Bharat is a significant achievement for us, the technology behind it has existed globally for 30 years. We need to pioneer something entirely new—perhaps in Hyperloop or another innovative transit system. China has done this with Maglev transportation system, despite the technology originating in Germany and Japan. Similarly, India must commercialize and lead in a cutting-edge railway technology that has yet to be fully realized worldwide. This, in summary, would be my vision for Indian Railways by 2047. 





SRAVAN KUMAR APPANA, CO-FOUNDER AND CHIEF EXECUTIVE OFFICER, iGoWise MOBILITY PVT.LTD.

In the bustling streets of India, where narrow lanes and crowded roads pose daily challenges, Sravan Kumar Appana envisioned a new way of moving people—safely, efficiently, and inclusively. As the Co-founder and CEO of iGoWise Mobility Pvt.Ltd., he drew inspiration from an unlikely source: bullet train stabilization. Applying these advanced principles to everyday vehicles, Sravan and his team crafted a revolutionary twin-wheeler trike. This innovative design features a tiltable upper body for agility and a stable lower base for unmatched balance, even on uneven roads—a perfect solution for India’s dynamic terrains.

Your twin-wheeler trike platform incorporates bullet train stabilization techniques. Can you explain how this technology works and what its benefits are in the mobility sector?

» Our twin-wheeler trike technology is inspired by the principles used in bullet train stabilization systems but adapted for road vehicles to enhance safety. This concept is based on centrifugal force—the same force you felt growing up in a merry-go-round. I believe that this concept is very important because, without suitable tethering, centrifugal force can cause vehicles to fly off on a curvy path. Meanwhile, bullet trains move at the speed of 400 km/h, overcome this challenge by combining two factors: proper coordination between the track with banking and also by tilting its body inwards to counteract this force. This coordination resists centrifugal forces and maintains stability. On the other hand, typical two-wheelers on proper race tracks use their body by leaning into turns on smooth tracks, typical road conditions, especially those with potholes or uneven surfaces make these maneuvers risky and prone to slipping.

Our two-wheeled trike technology is an innovative application of these principles. Since we cannot rely solely on the banking availability on our roads, we have separated the road-based trike into two loosely coupled independent bodies. First is the upper body, the part that carries the rider and pillion, which can tilt inward like a bullet train to resist centrifugal force. Second is the lower body, which provides road grip and low CG stability, similar to how a rail track stabilizes a train. This combination guarantees high-speed agility and anti-topple stability, even on uneven roads. This design is not only practical for tricycles, but it also has a wider impact across mobility and more. For example, it can improve the stability of double-decker buses or even improve the stability of a child's first tricycle.

iGowise has achieved 12 patents so far. Could you highlight one or two of the most groundbreaking patents and their significance?

» The essence of iGowise's technology is its patented shifting and tilting mechanisms that provide greater stability and agility. This allows the vehicle to perfectly adapt to the road and driving conditions. This innovative technology guarantees a safer and smoother journey, especially on rough terrain or during sharp turns. Another key innovation is our patented Pillion Step-through utility, designed specifically for the Indian market. It highlights the challenges faced by women wearing saris and

passengers carrying luggage or children. This allows them to board, deboard, and sit comfortably without struggling with tall seats. Other than these we have a few more unique engineering elements that are in progress and will be patented soon.

Can you share insights into your R&D journey, especially in achieving regulatory certifications and developing prototypes?

» One veteran from the automotive industry told us that building R&D from scratch in India is the hardest path to follow; however, it was too late for us to back up as we already got started by that time. The first challenge that we faced in our journey was prototyping. Hundreds of component suppliers mainly focus on

large quantities and minimum orders and as a result, small R&D needs are not being addressed. These customizations require large investments and significant commitments to purchase. This makes turning or finishing components a significant challenge. The next hurdle that comes the way is testing as established testing agencies charge high prices also the types of equipment are generally expensive.

Getting certification is another hurdle to cross. Innovating often means explaining new ideas to regulatory agencies, submitting endless documents, and waiting for never-ending approval deadlines. All these lengthy procedures strain the energy of

small startups. In our journey tooling was our major concern as it is very expensive, to moving from prototypes to mass production cost us too much money. As the capital expenditure requirement goes higher we try to reduce the operational cost to maintain the balance.

In what ways do your products align with India's push for sustainable and smart cities?

» The design and functions of our models emphasize their compact size, making them ideal for narrow and congested roads in urban areas, without occupying unnecessary space. Additionally, our products are developed especially for the aspirational class by making them super accessible for everyone in the family. People are looking for solutions that help their lives and their livelihoods. If we can address their main concerns such as safety, comfort, and capacity instead of just offering hyper-speeds and sporty looks, they are willing to adopt new formats that might help the environment by mitigating the problem of city pollution. While charging anxiety is the issue that many users are still apprehensive of, with our technology, we offer



India has made progress in EV growth with strong policies, but startups need better R&D support. Charging infrastructure remains a concern for long-route users.

efficient swift charging solutions through our LEVs. These products showcase the convenience of charging light EVs at common urban locations like homes, offices, malls, or even any retail shop just like we charge our smartphones today.

What’s your perspective on India’s readiness to support EV growth, particularly in terms of infrastructure and policy?

>> India has made commendable progress in promoting the growth of electric vehicles, strong policy measures, and infrastructure initiatives aimed at increasing demand. While the demand-side incentives are basic, the focus is now shifting to supply-side advancements. However, there is still much to be done to support startups in deep technology R&D like timely support for validation, test facilities, and certifications & clearances. This kind of support is important to accelerate innovation and bring advanced EV technologies into the market. On the other hand, the charging infrastructure remains a concern for the users, especially for those who rely on their EVs for longer routes. India has already installed 12,146 high-capacity charging stations, but the number is relatively small compared to developing nations like the USA or China. To meet our ambitions, India needs a vast charging station network supported by advanced charging technology.

In what ways can collaboration with OEMs, financiers, and service providers further your mission of making dignified mobility accessible?

>> Collaboration is the key to making dignified mobility accessible by creating a win-win solution for everyone and reducing risk for all parties. Offering affordability to users without compromising on product reliability and service quality is only possible through innovative financing and pricing models. Additionally, by leveraging AI-powered technology and deep user understanding can mitigate the risks and foster trust among the customers.



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On Track to the Future:

The Growth and Modernization of Indian Railways: BDB India



4th
largest
railway network
in the world

Over
68,000
kilometers of track



The Indian Railways, a vital component of India's transportation backbone, witnessed significant strides in 2024. This report analyzes the key developments within the sector, including substantial investments in infrastructure like high-speed rail corridors and dedicated freight lines. Technological advancements, such as advanced signaling systems and AI-powered solutions, are being implemented to enhance safety and efficiency. Passenger services are seeing improvements with the introduction of new trains like Vande Bharat and a focus on passenger comfort. The freight sector is also witnessing growth with the development of dedicated freight corridors. While challenges such as funding and land acquisition persist, the Indian Railways is poised for significant growth, driven by government initiatives, private sector participation, and a focus on sustainability and modernization.

As of 2024, the Indian Railways remains one of the largest and most complex rail networks in the world, playing a crucial role in the country's transportation infrastructure. Here's a detailed overview of the Indian Railways' impressive scale and capacity based on the latest statistics from 2024.

1. Network Size

- **Rank:** 4th largest railway network in the world.
- **Extent:** Over 68,000 kilometers of track.

2. Daily Operations

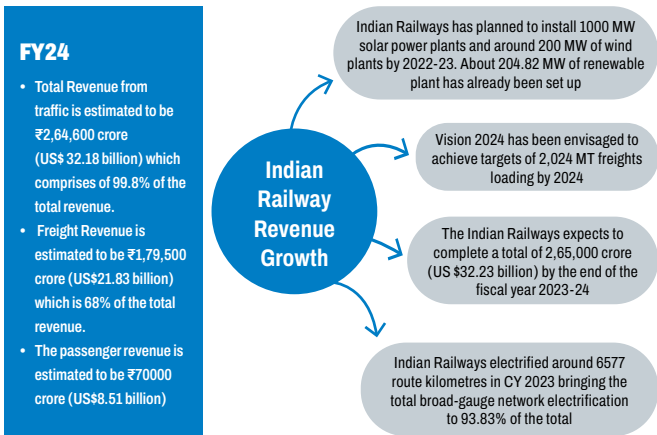
- **Trains:** Approximately 23,000 trains operate each day, showcasing the massive scale of operations and the critical role of rail transport in India.
- **Passengers:** The network serves around 25 million passengers daily, reflecting its importance in providing affordable and extensive connectivity across the country.
- **Freight:** Around 3 million Metric Tonnes (MT) of freight are transported daily, highlighting the railways' crucial role in logistics and cargo movement.

3. Rolling Stock

- Railway rolling stock includes very high-speed trains, mainline trains, metro trains, freight trains, and special vehicles. The Indian railway and metro rolling stock market is expected to reach a value of ₹4,74,735 crores (USD 56.89 billion) over the next five years.
- IRFC is a financing arm of the Indian Railways that leases rolling stock to the railways. As of August 2024, IRFC's market capitalization was ₹2,34,958 cr.
- The Indian Railways has installed Electrical/Electronic Interlocking Systems at 6,589 stations and Level Crossing (LC) Gates at 11,048 level crossing gates as of June 2024.

Key players in the rolling stock / coupler manufacturing in India	
Indian Coach Factory (Indian Railway)	Texmaco Rail and Engineering
Modern Coach Factory (Indian Railway)	Medha Servo Drives
Rail Coch Factory (Indian Railway)	Titagarh Wagons
BEML	Jindal Rail Infrastructure
Bombardier Transportation India	Jupiter Wagons
Hyundai Rotem	Alstom India
Texmaco	Modern Industries
BESCO	Escorts

Revenue Growth for Indian Railways



1. Revenue Trends

- Indian Railways has seen robust revenue growth, with substantial increases in both passenger and freight revenues. This growth reflects improvements in efficiency, service quality, and capacity utilization.
- Revenue from passenger services has grown due to higher ridership, increased fares for premium services, and expansion of the network. Enhanced passenger amenities and the introduction of new trains and services have contributed to this growth.
- Freight services have seen substantial revenue increases, driven by rising demand for cargo transportation, the development of dedicated freight corridors, and improved logistics efficiency.

2. Revenue Statistics

- Fiscal Performance:** Indian Railways' financial reports show a marked increase in both gross and net revenues. The exact figures can vary year-to-year, but the trend has been positive.
- Revenue Sources:** Revenue is generated from multiple sources, including passenger fares, freight charges, catering services, and other ancillary services.

3. Strategic Initiatives

- Electrification and Sustainability:** The push towards

full electrification and sustainability initiatives is expected to reduce operational costs and increase profitability in the long term.

- Digitalization:** Improved digital platforms for ticket booking, real-time tracking, and customer service have enhanced operational efficiency and revenue collection.
- Diversification:** Efforts to diversify revenue streams through commercial exploitation of railway land, advertising, and new business ventures are also contributing to revenue growth.

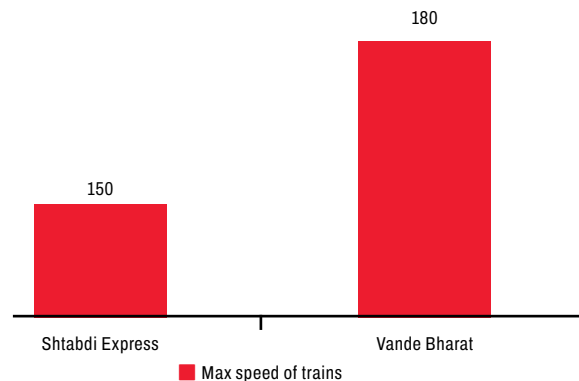
Indian Railways has shown impressive revenue growth, supported by modernization, increased capacity, and strategic initiatives. This positive trend is expected to continue as the railways enhance their services and infrastructure to meet growing demand.

India's Aspiration for Railways sector



Increasing Demand for Passenger Rail system in coming years

Vande Bharat trains for high speed Network



Passenger handling capacity to be ramped up

- Increase the capacity to 1,000 crores in four to five years, currently carrying around 800 crore passengers

annually. FY 24 IR added 5,200 km of new tracks equivalent to the entire rail network of Switzerland.

- Increase average speed to 120 km/hr and HSR to 200-250 km/hr with improved comfort. 12 High Speed Rail corridors (HSR) have been allocated a capex of ~₹ 5.1 lakh cr (FY26-31). Total 452 railway projects of total length of 49,323 km and costing ~₹ 7.33 lakh cr. are in different stages of planning / sanction / execution with 3 bullet train corridors to be developed over the next 10 years.

New and Modern trains - A Key Growth Driver

Approximately 2000 new trains on its network in the next five years with 100% electrification.

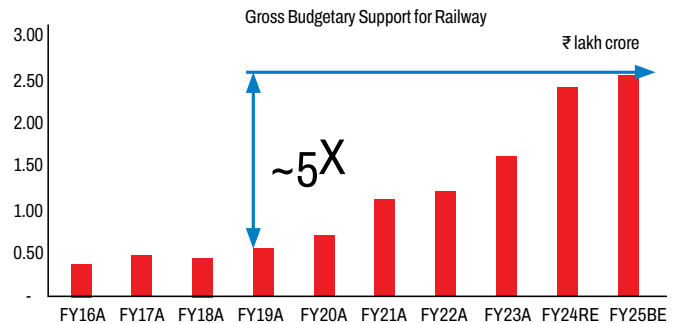
The Government of India aims to aggressively launch Vande Bharat train in the next 3-4 years. The estimated opportunity size in the next 3 to 4 years is Rs 48,000- 52,000 cr. for Vande Bharat and Rs 60,000 to 65,000 cr. for other variations of Vande Bharat trains.

Railways likely to add ~ 500 vande bharat trains and 1000 regular new trains to existing fleet in three years. India is to be promoted as a key export hub for coaches.

Government targets to increase total operational metro rail network by >2x to 1,700 km over the next 3-4 years & this expansion will entail procurement of 2,000-2,500 metro rail coaches over the next 5-6 years.

Railways on a capex drive to meet its aspirations

FY19-FY23 capex at 8.8 lakh crore



Make in India and import substitution key driver of private capex in the next 10 years

Government plans to offer output-linked incentives to companies producing items such as wheels, brakes, transmission systems, and other parts that are typically imported.

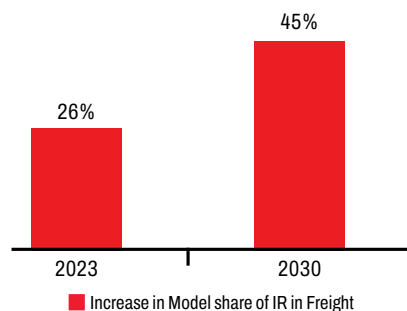
PLI scheme is for a three-year period, with projected incentives of Rs 1,000-1,500 crore.

The initiative aims to reduce dependence on imports, and potentially attract foreign manufacturers to establish or expand their operations in India's railway rolling stock sector.

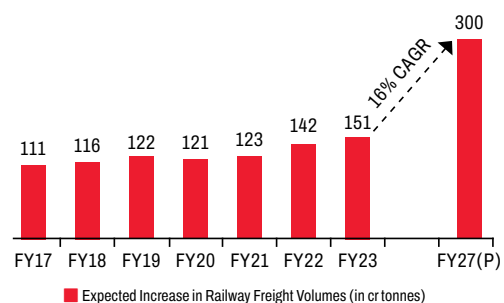
It is particularly targeted at supporting the manufacture of components for LHB and the Vande Bharat train sets.

Freight sector a key focus area: Key to India's Competitiveness

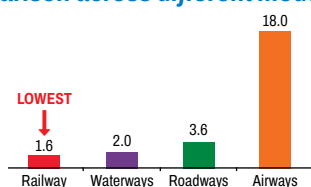
Increase in model share of freight from IR



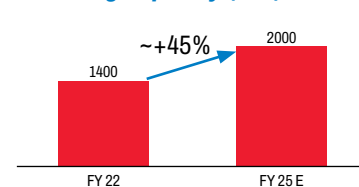
Railway freight volumes expected to double in 4 years



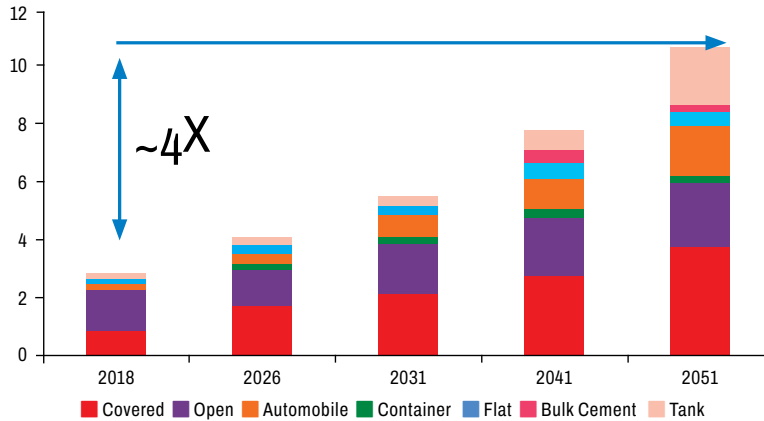
Cost comparison across different modes (Cost/tn)



IR's FRS loading capacity (MT) over the years



Total wagon requirement for the next 3 decades (Units in lacks)



Navigating Growth and Innovation in 2024

The Indian railway industry is on the cusp of transformative change, driven by an array of ambitious projects and strategic initiatives. With a focus on modernization, sustainability, and enhanced connectivity, the Indian Railways is set to play a pivotal role in the country’s economic and social development.

Railway capex to double in next 5 years to 17 lakh crore

Rs lakh crore	FY24E	FY25P	FY19-23	FY24E-28P	FY24E-28P CAGR	FY24E-28P/ FY19-23	Sources of fund (FY24E-28P)
Infrastructure (B)	14.0	14-16%	45.5	95-88	10-12%	1.9	
Roads	3.8	11-13%	13.3	24	11-13%	1.8	60% Centre, 21% State, 19% Private
Power	2.9	35-40%	10.8	22	13-15%	2.0	16% Centre, 30% State, 54% Private
Railways	2.9	7-9%	8.8	17	8-10%	1.9	84% Centre, 16% Private
Urban infra	2.4	3-5%	5.7	13	8-10%	2.2	43% Centre, 53% State, 4% Private
Other infra	2.0	8-10%	6.9	12	9-11%	1.7	18% Centre, 47% State, 35% Private

● Centre ● State ● Private

1. Accelerated Infrastructure Development

- **Electrification Milestones:** In 2024, the Indian Railways is advancing its electrification agenda with the goal of covering a substantial portion of the network. By reducing dependency on diesel and cutting greenhouse gas emissions, this push towards full electrification aligns with India’s broader sustainability goals.
- **High-Speed Rail Expansion:** The Mumbai-Ahmedabad high-speed rail project, one of the flagship initiatives, is expected to achieve significant milestones in 2024. Additionally, plans for new high-speed corridors are progressing, with feasibility studies and preliminary work setting the stage for future expansions.
- **Dedicated Freight Corridors:** The Western and Eastern Dedicated Freight Corridors are nearing completion, with operations expected to start on key segments. These corridors are anticipated to

enhance freight efficiency, reduce congestion on passenger lines, and support economic growth by streamlining logistics.

2. Technological Innovations

- **Advanced Signaling Systems:** 2024 will see further implementation of modern signaling technologies such as the European Train Control System (ETCS). These systems are crucial for improving safety, reducing delays, and optimizing train operations.
- **Smart Stations and AI Integration:** Railway stations are becoming smarter with the integration of digital solutions. AI-driven systems for ticketing, real-time updates, and passenger management are enhancing the travel experience and operational efficiency.
- **Green Technologies:** The Indian Railways is investing in green technologies, including solar power and energy-efficient trains. Initiatives like solar-

powered stations and hybrid locomotives are part of a broader strategy to reduce the environmental impact of rail transport.

3. Policy and Regulatory Developments

- **Increased Private Sector Participation:** The Indian government continues to encourage private sector involvement through public-private partnerships (PPPs). New policies are being introduced to facilitate private investment in train operations, station development, and freight management.
- **Regulatory Reforms:** Regulatory frameworks are being updated to streamline project approvals, land acquisition, and operational standards. These reforms aim to accelerate project implementation and improve overall efficiency.

4. Passenger and Freight Services

- **Enhanced Passenger Experience:** Efforts to improve passenger amenities are gaining momentum. Upgrades to train interiors, better food services, and enhanced safety measures are set to elevate the travel experience. Additionally, new routes and services are being introduced to meet growing demand.
- **Freight Efficiency:** With the launch of the dedicated freight corridors, the efficiency of cargo transport is expected to improve significantly. This development will support industries by reducing transportation costs and delivery times.

5. Economic and Social Impact

- **Job Creation and Skill Development:** The railway sector's expansion is creating job opportunities across various domains, from construction to technology. Skill development programs are also being introduced to ensure a skilled workforce for future projects.
- **Regional Development:** Improved rail connectivity is expected to spur regional development, particularly in underserved areas. Enhanced access to markets, education, and healthcare is fostering balanced growth across the country.

Opportunities offered by Indian Railway Sector

1. Rolling Stock Manufacturing

- **Locomotives and Coaches:** Industries that produce and supply rolling stock have prospects due to the continuous demand for new, high-speed, energy-efficient coaches and locomotives. Private Train Operations: In order to encourage investment in rolling stock and operational services, the government has made a few routes available for private operators

to operate passenger trains. Freight Wagons: Indian Railways is developing and modernizing its freight operations, which includes freight wagons. Customized freight wagons are in demand, as are containers designed to hold specific kinds of cargo (such as tankers and refrigerated units).

Opportunity pipeline from Indian Railway - 5 years

Project	Units	Value
Vande Bharat coaches	7,000	~ ₹ 1500 bn
Metro coaches	2,500	~ ₹ 250 bn
Propulsion units	5,000	~ ₹ 600 bn
Wagons	150,000	~ ₹ 700 bn
Track lines	50000 kms	~ ₹ 7.33 lakh cr

2. Infrastructure Development

- **Track Laying and Maintenance:** As Indian Railways extends and modernizes its network, it is opening doors for building and engineering companies engaged in rail infrastructure projects, such as track laying, signal systems, and electrification. Redevelopment of Stations: Indian Railways is transforming its stations into contemporary centers featuring parking, malls, and connections to other transit systems. Architects, urban planners, and infrastructure companies can benefit from this. Dedicated Freight Corridors: This will benefit engineering, technology, and construction companies by requiring significant infrastructure investments in the form of track laying, signaling, and electrification.

3. Public-Private Partnership (PPP)

- **Private Train Services:** Indian Railways is opening up chances for private businesses in both operation and maintenance by allowing private operators to run passenger trains on specific routes. Freight Terminals: For effective cargo handling and transportation, industries can invest in constructing and running private freight terminals, particularly those close to industrial hubs. Railway Sidings: To facilitate direct transport and save logistical costs, industries such as steel, coal, and cement can set up their own railway sidings.

4. Technology and Digitalization

- **AI and data analytics:** For better operational efficiency, predictive maintenance, and train scheduling, Indian Railways is progressively implementing AI. This presents potential for big data, analytics, and AI-focused IT organizations. IoT and Automation: A

developing market for tech companies is IoT-based solutions for tracking trains, passenger services, and railway operations. Smart Ticketing and Payment Solutions: Businesses can offer solutions for contactless passenger payment methods, automated fare collecting, smart card systems, and online ticketing.

5. Signaling and Telecommunications

- **Advanced Signaling Systems:** Upgrading the signaling system with automation, real-time monitoring, and safety mechanisms is a priority for Indian Railways, providing opportunities for companies specializing in communication and signaling technologies. Telecommunications Networks: With an expanding network, Indian Railways requires modern telecommunication systems for communication, safety, and disaster management.

6. Green Energy and Sustainability

- **Railway Electrification:** Indian Railways aims to electrify its entire network, opening opportunities for companies in electrical equipment manufacturing, transmission, and distribution. Renewable Energy Projects: Indian Railways is promoting solar and wind energy for its operations, including the installation of solar panels on railway land and buildings, presenting opportunities for renewable energy companies. Energy Efficiency Solutions: Companies that offer energy-efficient products and solutions can collaborate to improve the energy usage of stations, trains, and railway infrastructure.

7. Freight and Logistics

- **Multimodal Logistics Parks:** The development of logistics parks to integrate rail with road, sea, and air transport offers investment opportunities for logistics and warehousing companies. Container Train Operations: Private operators can invest in container train services to move goods efficiently across regions, contributing to the growing logistics sector. Cold Chain and Specialized Cargo: With the demand for cold chain logistics, especially for pharmaceuticals and perishable goods, industries involved in specialized freight solutions can capitalize on this opportunity.

8. Research and Development (R&D)

- **Railway Technology Innovation:** There is growing interest in R&D for improving rail technologies, including modern signaling, energy efficiency, train design, and passenger safety. Collaborations with Foreign Firms: Indian Railways is open to partnerships with global companies for the transfer of technology and innovations in high-speed rail, safety mechanisms, and train manufacturing.

9. Catering, Hospitality, and Tourism



- **Railway Catering:** With IRCTC controlling the catering services, private companies can partner to provide food and beverages on trains and at stations. Railway Tourism: Companies can partner with Indian Railways to offer tourism packages, such as luxury trains, heritage routes, and pilgrimage circuits. Station Retail and Hospitality: The development of commercial spaces in and around railway stations, including restaurants, retail shops, and hotels, provides ample business opportunities.

10. Safety and Security

- **Surveillance and Security Systems:** Indian Railways is investing in safety systems, such as CCTV, fire detection systems, and automated barriers. Companies providing safety technologies can collaborate in these areas. Disaster Management Solutions: Companies specializing in disaster management, emergency response, and real-time monitoring systems can contribute to Indian Railways' safety initiatives.

11. Urban Transport Integration

- **Metro Rail Projects:** Indian Railways, in partnership with state governments, is involved in various metro rail projects. There are opportunities for construction companies, urban planners, and technology providers. Last-Mile Connectivity: Companies providing solutions for last-mile connectivity, such as Electric Vehicles (EVs), ride-sharing, and micro-mobility, can integrate with railway networks, particularly in urban and suburban areas.

In conclusion, the Indian Railway sector in 2024 is transforming with substantial opportunities across multiple



industries such as infrastructure, technology, renewable energy, and transportation. The government's focus on modernization and private-sector participation further enhances the potential for collaboration and investment.

Challenges

1. Funding and Financial Viability

- The scale of infrastructure projects, such as high-speed rail corridors and dedicated freight lines, requires substantial investment. Securing adequate funding and ensuring financial viability are ongoing challenges.
- Balancing the cost of infrastructure upgrades with the need to keep passenger and freight rates competitive is a delicate task.

2. Infrastructure Maintenance

- A significant portion of the railway network is old and requires modernization. Maintenance and upgrades are essential to ensure safety and efficiency.
- Despite ongoing expansions, some parts of the network continue to face capacity constraints, leading to congestion and delays.

3. Safety and Security

- Ensuring the safety of passengers and freight is paramount. The industry must continuously invest in safety measures and modern signaling systems to prevent accidents.
- With increasing passenger numbers and freight movement, security measures need to be robust to address potential threats and ensure passenger safety.

4. Land Acquisition and Environmental Impact

- Securing land for new projects can be complicated due to legal, social, and environmental concerns. Delays in land acquisition can impact project timelines.
- Large infrastructure projects can have environmental implications, including disruption of natural habitats and increased carbon footprints.

5. Technological Integration


- Integrating new technologies with existing legacy systems can be challenging. Ensuring seamless interoperability between old and new systems is critical for operational efficiency.
- As the railway system becomes more digitized, cybersecurity threats become a concern. Protecting sensitive data and infrastructure from cyber-attacks is essential.

Government Investments

In 2024, the Indian Government made significant investments in the Indian Railways, focusing on infrastructure development, modernization, and safety improvements. The capital expenditure (Capex) for FY 2024-25 has reached a record ₹2.5 lakh crore, marking a 25% increase from the previous year. This funding is directed towards various projects, including high-speed rail corridors, station modernization, and rolling stock upgrades such as electric and hybrid trains, contributing to India's green energy goals.

Key initiatives include the expansion of the Vande Bharat train services, the development of Vande Metro for suburban areas, and the introduction of Amrit Bharat non-AC trains to cater to the masses. Additionally, new safety technologies, such as the indigenously developed 'Kavach' system, advanced signaling, and track monitoring systems, are being widely deployed to enhance operational safety. These investments are expected to boost employment, improve passenger experience, and contribute to environmental sustainability.

Conclusion

In conclusion, 2024 witnessed a period of significant transformation for the Indian Railways. With substantial investments in infrastructure, technological advancements, and a focus on passenger and freight services, the sector is poised for continued growth. While challenges such as funding, safety, and environmental impact remain, the Indian Railways is embracing modernization through initiatives like high-speed rail, electrification, and private sector participation. The future of Indian Railways holds immense potential, contributing significantly to India's economic growth and social development while addressing the growing demands of a rapidly developing nation. 

PANKAJ PANJWANI,
CEO and Founder,
KeenSemi

KEENHEADS
Creating Legends

From Design to Deployment:

Semiconductor Life Cycle in Railways

Semiconductors are the invisible architects behind the modern evolution of railways, enabling innovation, safety, and efficiency across all facets of transportation. The life cycle of a semiconductor—from its conceptual design to final deployment—represents a meticulous journey of engineering brilliance and technological advancements. By delving into this life cycle, This article uncovers how semiconductors continue to revolutionize railway systems, meeting the demanding requirements of durability, reliability, and adaptability in an ever-evolving transportation landscape.

Modern transportation owes much of its progress to the unassuming yet indispensable semiconductor. These tiny components shape the future of mobility, enabling smarter, safer, and more efficient systems. From design to deployment, the semiconductor life cycle is a story of relentless innovation and precision engineering. In today's railway systems, semiconductors power everything from automated ticketing systems to high-speed trains, ensuring safety, efficiency, and sustainability. But what goes into creating these silent powerhouses of technology? The lifecycle of a semiconductor, from its initial design to its deployment in railway systems, is a fascinating journey of precision, innovation, and adaptability.

The Beginning: Semiconductor Design and Innovation

Semiconductors and electronics are becoming backbone of modern railways, trams and city metro transportation. With introduction of smaller and more efficient semiconductor devices, the electronic system are much compact and utilize the space overhead or underfloor, creating more space for passengers and goods in the cabin. The semiconductor life cycle starts with architecture of a system that must perform a specific function. The system architecture is broken down into two components, H/W architecture and S/W architecture. The semiconductor design, a phase that lays the foundation for functionality, efficiency, and compatibility starts once the System, H/W and S/W are finalized. In railways, semiconductor designs must account for extreme conditions—fluctuating temperatures, electromagnetic interference, and high vibration levels. They must also be able to perform at full functionality for at least 10 years.

Design engineers work closely with railway system architects to develop Application-Specific Integrated Circuits (ASICs) or Field-Programmable Gate Arrays (FPGAs). These components are customized to handle tasks like real-time data processing for train traction control systems, enabling advanced communication protocols in signalling systems, management of doors and exits,

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As railways evolve to meet the demands of the future, semiconductors will continue to drive innovation, paving the way for a more connected and eco-friendly world

radar or vision based driverless execution and several other ancillary functions.

The design phase involves creating or integrating required IP, and then rigorous simulation and modelling not only for functionality but also environment in which the semiconductor will operate. For example, engineers might simulate the thermal behaviour of a power semiconductor in a braking system to ensure it doesn't overheat during prolonged use. Advanced tools like Finite Element Analysis (FEA) and machine learning models help optimize designs, minimizing energy consumption while maximizing performance.

Fabrication: Bringing Designs to Life

Once the design is finalized, it moves to the fabrication stage. This involves producing semiconductor wafers in highly controlled cleanroom environments. The intricate process includes depositing multiple layers of materials, etching circuits, and doping silicon with precise impurities to create transistors.

In railway applications, durability is key. Semiconductor wafers destined for rail systems often undergo additional

Vehicle information management system

- Vehicle control transmission system
- Motorman's equipment

Pantograph

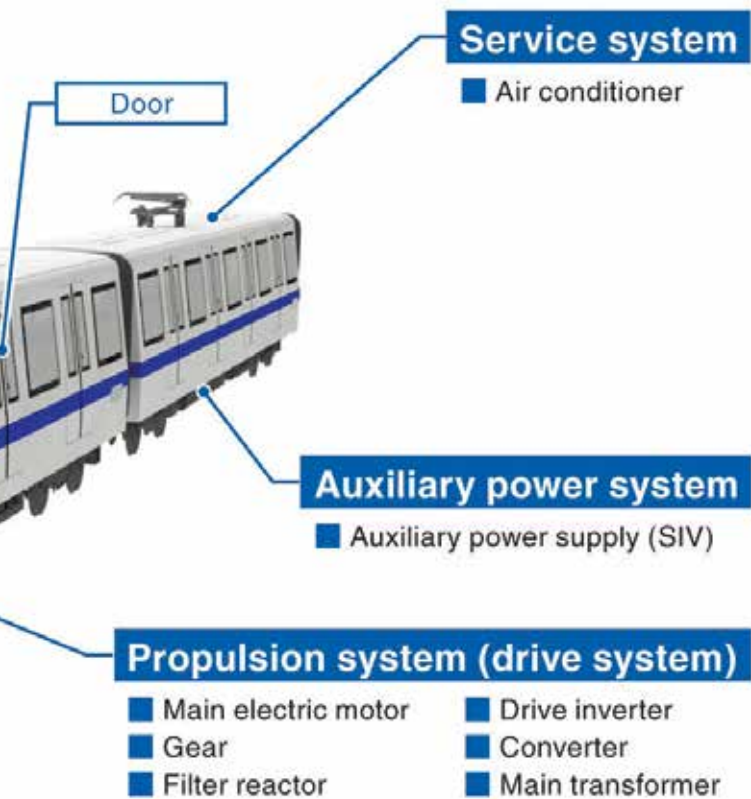


treatments, such as surface passivation, to protect them from moisture, dust, and mechanical stress. These wafers are then diced into individual chips and encapsulated to ensure they can withstand the rigors of railway operations.

One of the key differentiators between commercial semiconductor product and transportation specific semiconductor product is the packaging.

Testing and Validation: Ensuring Reliability in Harsh Environments

After fabrication, the chips undergo rigorous testing and validation. For railways, where safety is paramount, these tests are particularly stringent. Power semiconductors used in traction control systems, for instance, must be tested for high voltage endurance, thermal stability, and failure tolerance. Reliability testing often involves accelerated life testing, where semiconductors are subjected to extreme stress conditions to predict their lifespan. Functional testing ensures that the chips perform as intended in real-world railway scenarios, such as maintaining consistent communication between a train and the control center, even during heavy rainfall or snowstorms.



Integration: Merging Semiconductors with Railway Systems

Once validated, the semiconductors are integrated into larger systems, such as Train Control And Monitoring Systems (TCMS), signalling networks, or propulsion units. This stage demands close collaboration between semiconductor manufacturers, railway engineers, and system integrators.

For example, semiconductors in signalling systems enable real-time communication between trains and control centers, ensuring smooth traffic flow and preventing collisions. These chips are embedded in wayside equipment, such as track circuits and axle counters, as well as on board train antennas and processors. Similarly, power semiconductors in traction inverters convert electrical energy from overhead lines into the precise voltage and frequency needed to drive train motors. This not only enhances energy efficiency but also enables regenerative braking, where kinetic energy is fed back into the grid.

Deployment: On the Tracks and Beyond

With integration complete, the semiconductor-powered

systems are deployed in railway networks. This phase involves installing, calibrating, and fine-tuning the systems to ensure seamless operation. Deployment is often a phased process, starting with pilot tests on a limited section of the railway before scaling to the entire network.

For instance, the deployment of Positive Train Control (PTC) systems—a safety overlay that uses GPS, wireless communications, and on board computers—relies heavily on semiconductors. These systems are meticulously tested to ensure that trains automatically slow down or stop in case of potential hazards. Even after deployment, semiconductors continue to play a role in predictive maintenance. Advanced sensors, powered by semiconductors, monitor the health of railway components, alerting operators to potential issues before they escalate into failures.

Semiconductors Driving the Future of Railways


As railway systems become more digitised and automated, the role of semiconductors will only grow. Innovations such as 5G-enabled communication systems, autonomous trains, and energy-efficient hydrogen-powered locomotives all rely on advanced semiconductor technology.

One emerging area is the use of Silicon Carbide (SiC) and Gallium Nitride (GaN) semiconductors, which offer higher efficiency and greater thermal tolerance than traditional silicon chips. These materials are particularly promising for high-power applications, such as inverters and converters in railway electrification systems.

Another exciting development is the integration of Artificial Intelligence (AI) into semiconductor design. AI algorithms are being used to optimize the performance of railway systems, from dynamic scheduling to real-time fault detection.

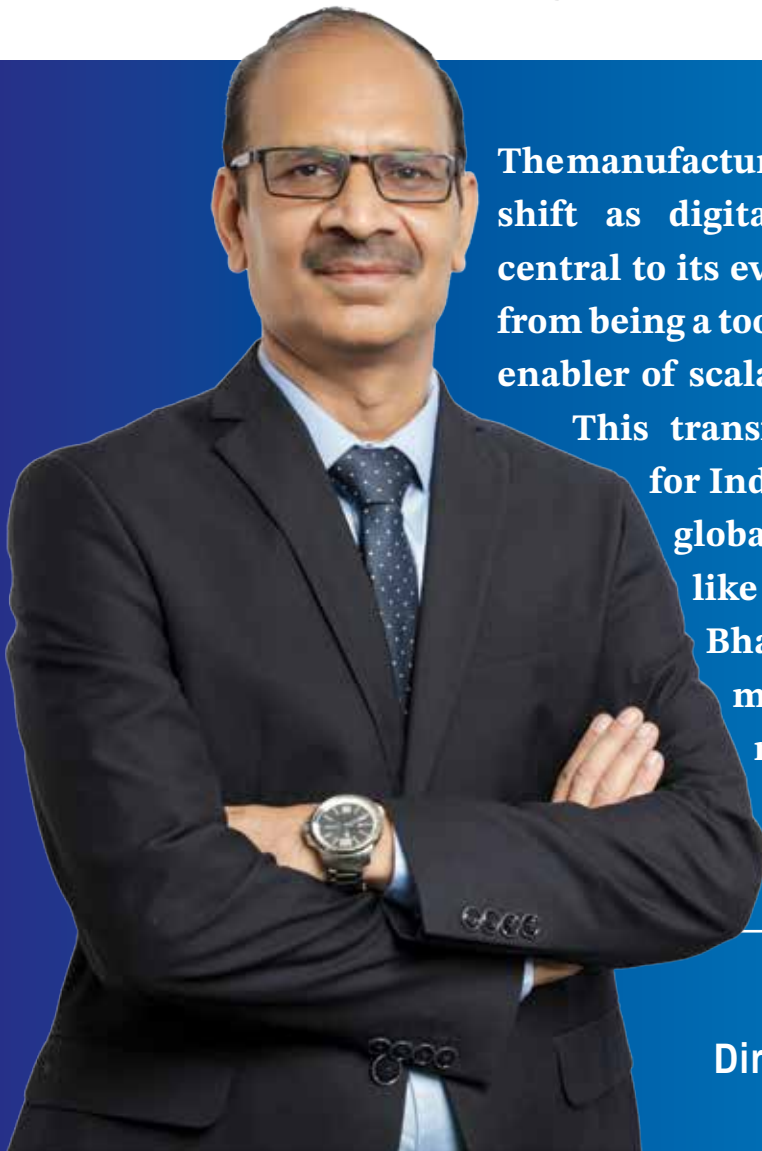
Conclusion: The Silent Workhorses of Modern Railways

From the drawing board to the tracks, the lifecycle of a semiconductor in railways is a testament to human ingenuity and technological advancement. These tiny yet powerful components form the backbone of modern railway systems, ensuring safety, efficiency, and sustainability.

As railways evolve to meet the demands of the future, semiconductors will continue to drive innovation, paving the way for a more connected and eco-friendly world. The next time you board a train or pass by a railway crossing, take a moment to appreciate the sophisticated technology humming quietly in the background—semiconductors, the unsung heroes of rail transport. 

Automation for the Future:

Unlocking Scalability, Sustainability, and Efficiency in Manufacturing



The manufacturing industry is experiencing a paradigm shift as digitalization and sustainability become central to its evolution. Automation has transitioned from being a tool for operational efficiency to a critical enabler of scalability, sustainability, and innovation.

This transformation is particularly significant for India, which is on the path to becoming a global manufacturing hub under initiatives like 'Make in India' and 'Aatmanirbhar Bharat'. This article deep dives into the multifaceted impact of automation on modern manufacturing, from driving energy efficiency to fostering smart, localized production systems.

SHAILESH SHARMA,
Director- Operations, SKF India



lead times, and optimize inventory management. The rise of smart factories, equipped with intelligent automation and IoT-enabled systems, is transforming traditional manufacturing setups. These factories enable seamless data exchange between production, maintenance, and supply chain systems, ensuring operations can adapt swiftly to market demands. For example, predictive maintenance powered by AI and real-time analytics minimizes downtime by identifying potential equipment issues before they occur. This ensures that operations run smoothly, even during periods of high demand, thus supporting scalability.

The global manufacturing industry stands at a transformative juncture. Rapid advancements in digital technologies, coupled with pressing sustainability challenges, are reshaping how we produce and consume goods. Automation, once viewed as a tool for improving operational efficiency, has now evolved into a cornerstone of scalability, sustainability, and innovation in manufacturing.

As India positions itself as a global manufacturing hub under initiatives like 'Make in India' and 'Aatmanirbhar Bharat,' embracing automation is not just a necessity but a strategic imperative for the sector's growth. Here's how automation is unlocking unparalleled opportunities for manufacturers while addressing key challenges in the industry.

Enhancing Scalability through Smart Manufacturing

Automation offers manufacturers the flexibility to scale operations without compromising efficiency or quality. By integrating digitally connected systems into the production process, manufacturers can streamline workflows, reduce

Driving Sustainability with Energy and Resource Efficiency

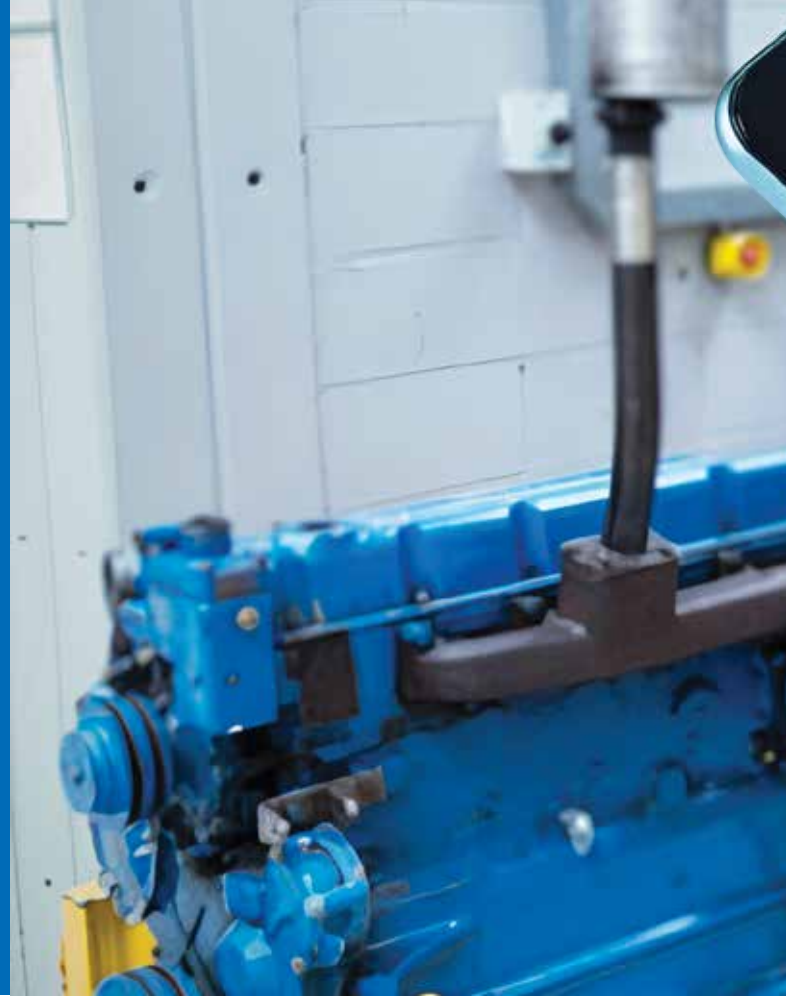
Sustainability has become a critical focus for manufacturing industries worldwide. Automation plays a pivotal role in enabling manufacturers to reduce their environmental footprint through:

Energy Efficiency: Advanced automation systems, powered by machine learning algorithms, analyze energy consumption patterns and optimize usage across operations. This not only reduces costs but also helps manufacturers meet stringent environmental regulations.

Waste Reduction: Automated systems can analyze production processes to identify inefficiencies and minimize waste. For instance, additive manufacturing techniques like 3D Printing reduce material waste by producing components with precision. As industries transition to cleaner energy solutions, automation becomes essential for integrating renewable energy sources into manufacturing processes. Whether it's optimizing solar panel placement in factories or reducing water usage in production, automation ensures resource efficiency at every step.

Key benefits include:

- **Improved Decision-Making:** Advanced analytics tools and digital twins provide manufacturers with deeper insights into operational performance. These insights empower leaders to make data-driven decisions and continuously optimize processes.
- **Cost Savings:** By automating labor-intensive tasks and reducing energy consumption, manufacturers can achieve significant cost reductions. Savings can be reinvested in innovation and expansion, enhancing competitiveness.



Reinventing Productivity with Robotics and AI

Automation and robotics are redefining productivity in manufacturing by handling repetitive tasks with unmatched precision. From robotic arms in assembly lines to AI-driven quality checks, these technologies enhance speed and consistency while reducing human error.

Regionalisation and Proximity to Customers

Global trade dynamics are evolving, pushing manufacturers to adopt a region-specific approach. Automation facilitates the localization of production, allowing companies to set up smaller, agile factories closer to customers. This shift reduces transportation costs and emissions while enabling faster delivery of goods. Moreover, regional facilities equipped with

automated systems can adapt quickly to local market needs, ensuring a more personalized customer experience.

Preparing for the Future of Manufacturing

India's manufacturing sector is on a growth trajectory, with the potential to contribute USD 1 trillion to the economy by 2025. Key industries like automotive and industrial machinery are driving demand for precision components, particularly ball bearings. The rise of Electric Vehicles (EVs) and industrial automation further underscores the need for innovation in manufacturing.

However, challenges such as counterfeit products, rising energy costs, and sustainability pressures persist. Automation, coupled with AI and digital transformation, offers solutions to these challenges by improving process efficiency, reducing costs, and enhancing product quality.



The Path Ahead: Lean, Green, and Digital

The future of manufacturing lies in adopting sustainable and smart approach, for example: SKF India's 'Lean, Green, and Digital' approach. Lean manufacturing focuses on eliminating waste and optimizing workflows, green practices ensure environmental sustainability, and digital technologies drive innovation and efficiency.

Automation will be at the heart of this transformation, enabling manufacturers to: Achieve carbon neutrality through energy-efficient practices. Innovate with sustainable production methods, such as using eco-friendly materials and recycling by-products. Build resilient supply chains with real-time tracking and forecasting capabilities.

Automation is no longer a choice but a necessity for manufacturers aiming to thrive in a competitive, sustainability-driven global landscape. By embracing smart technologies, manufacturers can unlock scalability, sustainability, and

efficiency, ensuring long-term success. As India aspires to become the world's manufacturing powerhouse, investing in automation and digital transformation will be critical. For industry leaders, the message is clear: the future of manufacturing is automated, and the time to act is now.

Conclusion

Automation is redefining the manufacturing landscape, empowering industries to achieve scalability, sustainability, and efficiency in unprecedented ways. By integrating advanced technologies like robotics, AI, and IoT, manufacturers can enhance productivity, reduce environmental impact, and adapt to dynamic market demands. As India aims to cement its position as a global manufacturing leader, embracing automation and digital transformation is no longer optional—it is imperative. The future of manufacturing is lean, green, and digital, and the time to accelerate this journey is now. [u](#)

Technological Advancements in EV Batteries: Shaping the Future

In India, where the EV market is witnessing rapid growth, cutting-edge battery technologies are playing a pivotal role in fostering adoption and reducing dependency on traditional fossil fuels. This article talks about the technological strides shaping the EV battery landscape, exploring how India is navigating challenges and opportunities to become a global leader in sustainable transportation.

What if your car could charge in 10 minutes, drive 500 kilometers, and help create a greener future? Electric vehicles (EVs) are driving us toward this vision, and India is a key player in this global transformation. With EV sales growing by 20% in 2024—reaching 100,000 units compared to 82,688 in 2023—electric vehicles now represent 2.4% of total vehicle sales, according to the Federation of Automobile Dealers Associations (FADA). This rapid adoption highlights a significant shift in consumer preferences, propelled by advancements in EV battery technology.

At the heart of this transformation lies battery innovation, which is unlocking breakthroughs in sustainability, affordability, and performance. While lithium-ion batteries have been the backbone of this progress, emerging technologies and innovations in Cathode Active Materials (CAM) are poised to redefine the industry's future.

Lithium-Ion Batteries: The Foundation of EVs

Lithium-ion batteries have revolutionized the EV market

with their high energy density, fast charging cycles, and long lifespans. Today, they power most EVs globally and have played a critical role in reducing reliance on internal combustion engines. However, lithium-ion batteries come with limitations. Their reliance on scarce materials such as lithium, cobalt, and nickel has driven up costs and raised concerns about environmental sustainability and ethical sourcing. To overcome these challenges, manufacturers are exploring alternative chemistries within the lithium-ion family:

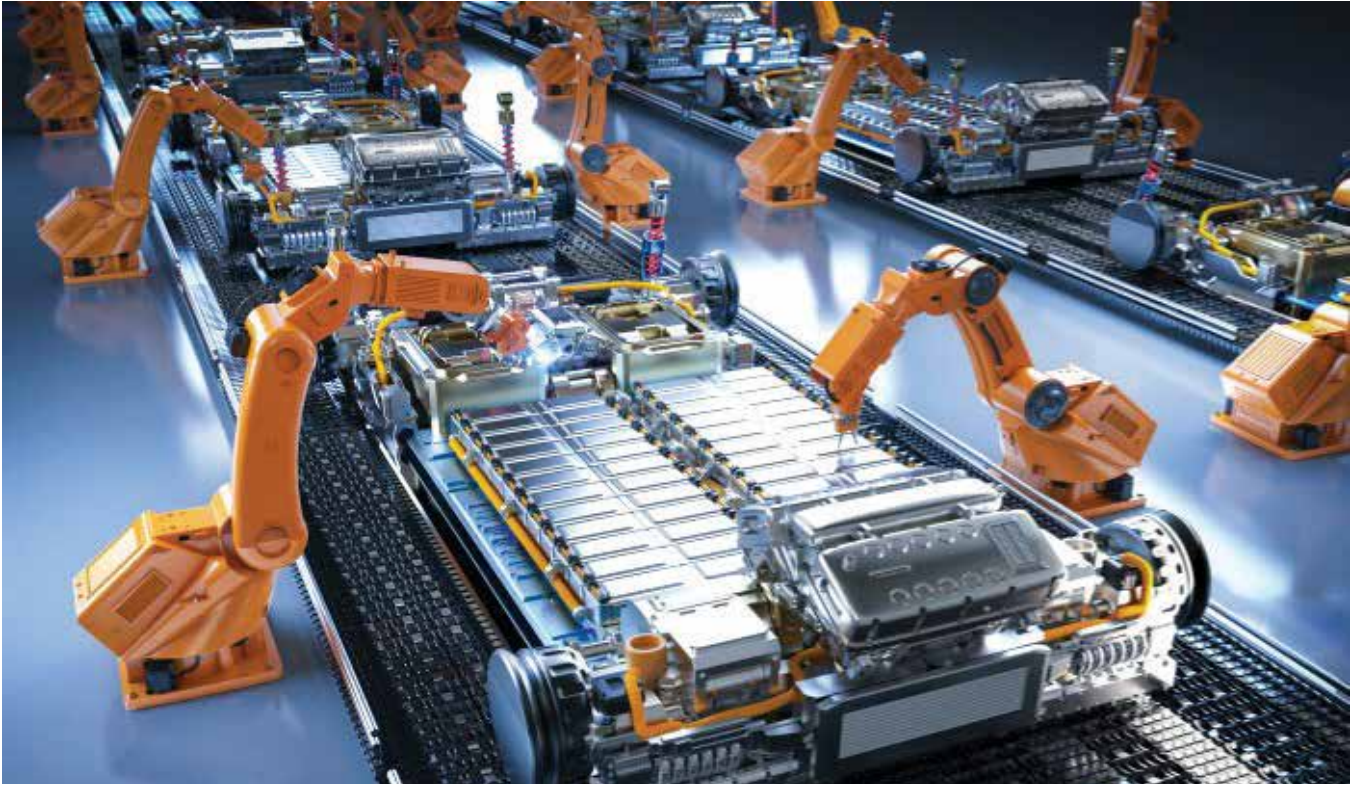
1. **Lithium-Iron Phosphate (LFP) Batteries:** These batteries eliminate cobalt and nickel, offering a safer and more cost-effective solution while aligning with sustainability goals.
2. **Lithium-Sulfur Batteries:** Featuring a sulfur-based cathode, these batteries promise enhanced energy density and affordability, addressing range anxiety among EV users.

Emerging Battery Technologies: A New Frontier

As the limitations of lithium-ion technology become

A portrait of Ankit Sharma, a man with dark hair and a beard, wearing a blue checkered blazer over a white shirt. He is smiling and has his hands clasped in front of him. The background is a blurred office setting with a whiteboard and wooden paneling.

ANKIT SHARMA,
CEO & Co-Founder,
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evident, alternative battery chemistries are paving the way for the next generation of EVs:

1. **Solid-State Batteries:** Using solid electrolytes instead of liquid, these batteries promise faster charging, improved safety, and 25–50% longer ranges. They are lighter, making them ideal for high-performance EVs.
2. **Sodium-Ion Batteries:** With sodium being significantly more abundant than lithium, these batteries offer a low-cost alternative for mass-market EVs. The commercialization of sodium-ion batteries by Natron Energy in 2024 demonstrates their growing potential.
3. **Zinc-Manganese Oxide Batteries:** By delivering higher energy density at a competitive cost, this chemistry addresses one of the largest barriers to EV adoption—affordability.
4. **Organosilicon Electrolyte Batteries:** These batteries prioritize safety by engineering liquid solvents at the molecular level, mitigating risks such as overheating and leakage.

Each of these technologies caters to different use cases, from cost-sensitive mass adoption to premium, high-performance vehicles.

Cathode Active Materials (CAM): Driving Innovation in Batteries

Cathode Active Materials (CAM) are at the core of EV battery performance, directly influencing energy density, cycle life, and overall safety. Recent advancements in CAM technology are not only boosting battery efficiency but also addressing challenges related to sustainability and cost.

Key Innovations in CAM

1. **Nickel-Rich Cathodes and Cobalt-Free Alternatives:** Nickel-rich chemistries, such as NMC 811 (80% nickel, 10% manganese, 10% cobalt), remain critical for delivering high energy density and long-range capabilities, particularly for premium EVs. While NMC 811 has reduced cobalt content compared to earlier formulations like NMC 622, it still relies on cobalt, which poses challenges around cost, supply chain risks, and ethical sourcing. To address these limitations, manufacturers are exploring low-cobalt and cobalt-free alternatives to meet the industry's growing demand for sustainability and affordability
 - **NMC 9.5.5:** With nickel content exceeding 90% and cobalt below 5%, this formulation reduces costs while maintaining the high energy density required for long-range EVs.
 - **Lithium Nickel Manganese Oxide (LNMO):** A promising cobalt-free alternative, LNMO offers high voltage operation, superior cycling stability, and

environmental benefits, although commercial scalability remains a challenge.

- **Lithium Manganese Iron Phosphate (LMFP):** Building on the proven stability and affordability of LFP (Lithium Iron Phosphate), LMFP introduces manganese to achieve Higher Energy Density, LMFP provides 15–20% greater energy density than LFP, making it suitable for mid-range EVs requiring longer ranges.
- **Enhanced Safety:** Retaining the strong thermal stability of LFP, LMFP ensures safety during high-temperature operations, especially in regions with extreme climates.
- **Cost Effectiveness:** Like LFP, LMFP eliminates cobalt and nickel, leveraging abundant and inexpensive materials like iron and manganese. LMFP is rapidly gaining traction as a strong candidate for mass-market EVs, especially in applications requiring a balance between range, cost, and safety. By integrating advancements in nickel-heavy chemistries with cost-effective solutions like LMFP, battery manufacturers are expanding the range of options to cater to diverse EV segments—from premium vehicles to mass-market models.

2. Sulfur-Based Cathodes: Research into sulfur-based cathodes is making significant progress, offering the potential for batteries with dramatically lower costs and higher energy storage capacities. Sulfur is abundant, inexpensive, and environmentally benign, making it a promising alternative for large-scale adoption.

India, under initiatives like Atmanirbhar Bharat, is focusing on building a sustainable domestic CAM manufacturing ecosystem to reduce its dependence on imports from China, which currently dominates 90% of the global CAM supply. This shift will not only enhance energy security but also position India as a key player in the global EV supply chain.

Addressing Cost and Sustainability Challenges

Affordability and sustainability remain two of the biggest hurdles for EV adoption. Battery costs, driven by the prices of raw materials, have traditionally been a barrier. However, falling green metal prices and advancements in production technologies are making EVs increasingly accessible. According to Goldman Sachs, these trends could soon bring EVs within reach of a broader consumer base. Sustainability is equally critical. The fast-paced adoption of EVs has raised concerns about waste management. Current recycling technologies can recover up to 95% of valuable materials like lithium and cobalt, fostering a circular economy. This reduces dependency on mining, minimizes environmental impact, and supports the industry's transition toward greener practices.



Affordability and sustainability remain two of the biggest hurdles for EV adoption


India's Role in the Global EV Transition

India's EV ecosystem is at a tipping point. Government initiatives such as the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) program and the Production-Linked Incentive (PLI) scheme are creating a favorable environment for domestic EV and battery manufacturing. However, challenges like limited charging infrastructure and dependence on imported materials persist.

By investing in upstream and midstream activities—such as securing critical raw materials, expanding refining capacities, integrating recycling systems, and setting up facilities for cathode, anode, electrolyte, and cell manufacturing—India can significantly reduce its reliance on imports, enhance energy security, and establish itself as a global leader in the EV market. Collaborative efforts among policymakers, manufacturers, and researchers will be crucial to addressing supply chain bottlenecks, fostering innovation, and driving sustainable, long-term growth.

Conclusion

The EV revolution is being fueled by rapid advancements in battery technology, from lithium-ion innovations to emerging chemistries like solid-state and LMFP. Addressing challenges around cost, sustainability, and supply chain dependencies is critical to making EVs accessible and efficient for the global market. India is uniquely positioned to lead this transition by focusing on upstream resource security, midstream infrastructure like cathode, anode, and electrolyte production, and robust recycling systems. Collaborative efforts among policymakers, researchers, and industry leaders will be vital in overcoming bottlenecks and fostering innovation.

With strategic investments and innovation, EVs can evolve from an alternative solution to a global cornerstone of sustainable transportation, driving economic growth and environmental progress for the future. 



How Carbon Steel is Shaping the Future of Railways

Railways are the backbone of any modern economy. They connect cities, towns and industries, driving growth, development and opportunities. But as the world moves toward faster, greener and more efficient transportation, the materials that form the core of railway infrastructure need to evolve. This is where carbon steel steps in - a material that has been around for decades but continues to find new and innovative applications in shaping the future of railways.



PANCAJ N UMRANIA,
Executive Director,
KND Steel

Since the advent of railways in the 18th century, steel has played a pivotal role in the development of tracks, rolling stock and railway components.

Carbon steel, known for its high strength, durability and cost effectiveness, has been the material of choice for railway manufacturers worldwide. Over the years, advancements in metallurgy have further enhanced the properties of carbon steel, making it even more reliable for demanding applications in rail transport.

Strength and Durability: Key to Railway Safety

One of the primary reasons carbon steel is indispensable in railway construction is its exceptional strength-to-weight ratio. Railway tracks must endure massive loads and constant wear from heavy trains traveling at high speeds. Carbon steel's inherent toughness ensures that tracks can withstand these forces without significant deformation or failure.

Moreover, carbon steel is highly resistant to fatigue, a critical factor for components like axles, wheels and couplings that experience repeated stress during operation. This resistance helps maintain the structural integrity of railway systems, ensuring passenger and cargo safety.

Precision Engineering for High Speed Rail

As countries around the world invest in high speed rail networks, the demand for precision engineered components has skyrocketed. Carbon steel, with its excellent machinability and ability to hold tight tolerances, is ideal for manufacturing these high-precision parts. From the rails themselves to the intricate mechanisms in braking and suspension systems, carbon steel ensures smooth, reliable and high speed performance.

Sustainability and Recyclability: A Green Solution

In an era where sustainability is no longer optional, carbon steel offers a significant advantage. It is one of the most recyclable materials in the world. Old railway tracks and components can be melted down and reprocessed into new products, reducing waste and conserving natural resources.

Furthermore, the durability of carbon steel means fewer replacements over time, which translates to lower overall environmental impact. Combined with modern manufacturing techniques that reduce energy consumption



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**Carbon steel has long been the
cornerstone of the railway industry
and its role is only growing in
importance as we look to the future**



and emissions, carbon steel is becoming a key contributor to the railway industry's green initiatives.

Innovations in Carbon Steel for Railways

Innovation in carbon steel metallurgy is opening up exciting possibilities for railway applications. High Strength Low Alloy (HSLA) steels and advanced carbon steel composites are being developed to offer even greater performance. These materials provide superior strength while remaining lightweight, improving fuel efficiency and reducing the wear and tear on tracks. Additionally, modern surface treatments and coatings are enhancing the corrosion resistance of carbon steel components, making them suitable for use in extreme environments, from humid coastal regions to arid deserts.


Supporting the Future of Smart Railways

The future of railways is not just about speed and efficiency, it is also about smart infrastructure. Sensors, monitoring systems and automated maintenance technologies are becoming integral to modern railways. Many of these smart systems rely on carbon steel components for housing and protection. The robustness of carbon steel ensures these systems can operate reliably in harsh railway environments, safeguarding critical data and operations.

Conclusion: A Timeless Material for a Modern Industry

Carbon steel has long been the cornerstone of the railway industry and its role is only growing in importance as we look to the future. From ensuring safety and durability to supporting sustainability and innovation, carbon steel is shaping the railways of tomorrow.

As an Executive Director at KND Steel, with over a decade of experience in carbon steel strips, I have witnessed first hand how this remarkable material continues to evolve and adapt to meet the ever changing demands of the industry. At KND Steel, we take pride in being a trusted supplier to OEMs in sectors like automotive, electrical, defence, medical and railways. Our journey of over 42 years has been about more than just supplying steel, it's about contributing to the growth of industries and the building of nations.

In the context of railways, carbon steel is more than just a material, it's a symbol of strength, reliability and progress. As we move forward, it will undoubtedly remain at the heart of innovations that shape the future of rail transportation, one track, one train and one journey at a time. 

BHARAT MOBILITY GLOBAL EXPO 2025:


A Grand Showcase of Innovation and Sustainability in the Automotive Industry

New Delhi: The Bharat Mobility Global Expo 2025 concluded on a high note at Bharat Mandapam, New Delhi, bringing together leading automotive brands that unveiled groundbreaking innovations in Electric Vehicles (EVs), sustainable mobility, and next-generation automotive technology. The second edition of the prestigious expo witnessed the launch of several new products, reinforcing India's position as a global hub for mobility solutions.





A Testament to India's Automotive Future

The Bharat Mobility Global Expo 2025 successfully underscored India's commitment to electrification, sustainable mobility, and automotive innovation. From EVs to ethanol-powered vehicles and cutting-edge technology, the expo served as a platform for the future of mobility. With significant industry players unveiling their latest advancements, the event further strengthened India's position as a global leader in the mobility landscape. 

IMTEX 2025

Concludes on a High Note, Showcasing the Future of Manufacturing

Bengaluru: IMTEX 2025, Southeast Asia's largest machine tool and manufacturing technology exhibition, organised by the Indian Machine Tool Manufacturers' Association (IMTMA), took place from January 23 to 29 at the Bangalore International Exhibition Centre (BIEC), Bengaluru. It featured a spectacular display of cutting-edge technologies, live demonstrations, and insightful discussions, drawing significant participation from the global manufacturing ecosystem.





A Grand Showcase of Innovation and Technology

IMTEX 2025, held alongside Tooltech 2025 and Digital Manufacturing 2025, brought together the latest advancements in CNC machining, tooling, automation, robotics, additive manufacturing, CAD/CAM, metrology, and smart manufacturing. The event was spread across 90,000 square meters in eight halls, with over 1,100 exhibitors from 23 countries presenting groundbreaking solutions to a captivated audience. With dedicated country pavilions from Germany, Italy, Japan, Korea, Spain, Taiwan, and the United States, the exhibition reinforced India's position as a key player in the global manufacturing landscape. IMTMA welcomed nearly 2,000 trade delegations representing diverse user industries, underlining the strategic importance of the event in fostering business collaborations and driving industry growth.

Engaging Knowledge Sessions and Parallel Events

Beyond the exhibits, IMTEX 2025 featured a host of engaging knowledge-sharing platforms. The International Seminar on Machining Technologies, held on January 24-25, provided deep insights into emerging metal-cutting innovations and global best practices. The i2 Academia Square, featuring an Academia Pavilion, showcased innovative student projects aimed at bridging the gap between academic research and industrial applications. The Manufacturing Technology Quiz Contest and TechTalk sessions added to the vibrancy of the event, fostering intellectual exchange and industry-academia interaction.


IMTMA's 'Engagement with Overseas Buyers' on January 25-26 facilitated meaningful buyer-seller interactions, promoting exports of Indian machine tools and strengthening

global trade relations. The Jagruti-IMTMA Youth Programme provided an invaluable opportunity for students to explore the latest advancements in the manufacturing sector, igniting curiosity and inspiring future engineers.

Debut of Industry-Focused Summits

For the first time, IMTEX 2025 hosted two major industry-focused summits. The Auto Components Industry Transformation Summit, co-organized by IMTMA and the Automotive Component Manufacturers Association of India (ACMA) on January 26, emphasized the evolving synergy between the machine tool and auto component industries. Meanwhile, the JMTBA Seminar on Export Controls for Japanese Machine Tools, held on January 27 at the IMTMA Technology Centre, strengthened business collaborations between India and Japan, facilitating smoother trade processes.

A Resounding Success for Indian Manufacturing

IMTEX 2025 underscored the dynamic transformation of India's manufacturing sector, showcasing the nation's growing technological prowess and its readiness to meet domestic and global demands. Industry leaders, OEMs, sourcing agents, researchers, and academia came together to witness, experience, and embrace the next generation of manufacturing solutions. With a strong emphasis on innovation, automation, and digital transformation, IMTEX 2025 has once again cemented its reputation as the premier platform for the machine tool and manufacturing technology industry. As the industry looks forward to the next edition, the insights and collaborations fostered at this landmark event will continue to drive the growth of Indian manufacturing in the years to come. 

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PROCEDURE	Strictly as per the guidelines of the project initiator