Optimizing Rail Network Efficiency with Geospatial Data and Digital Twin

Key Note Address

Mission Railways Transformation: Digital Conquest

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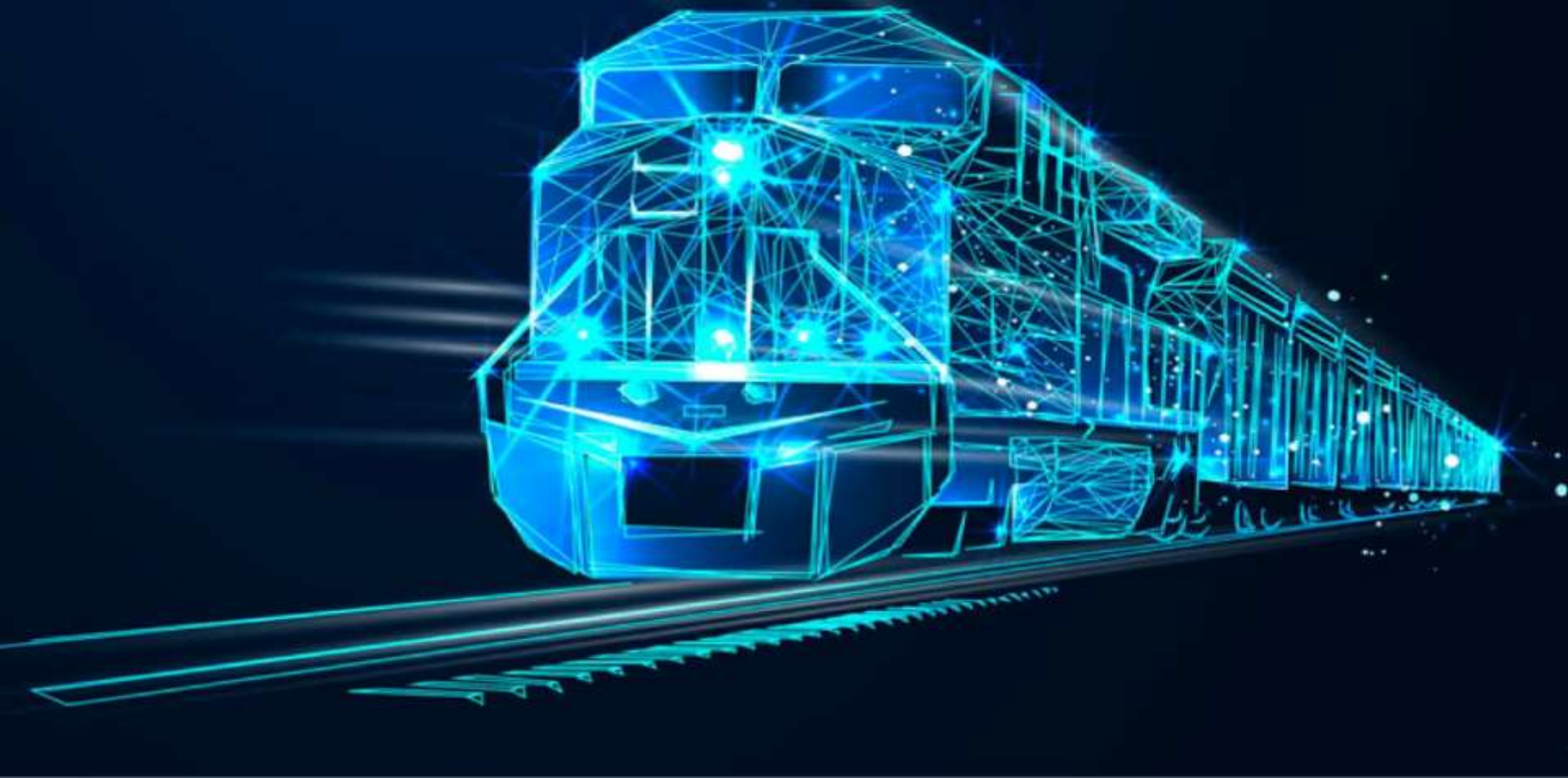
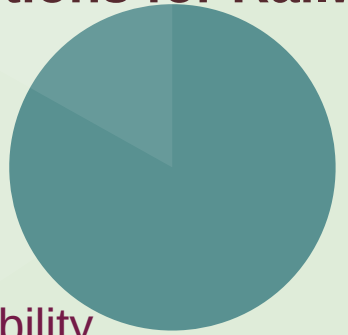
Session Overview

- Role of geospatial data in modern rail networks
- Digital twin platforms for rail efficiency
- Real-world applications and case studies
- Policy alignment and modernization goals

Transformation in Railways : Digital Conquest



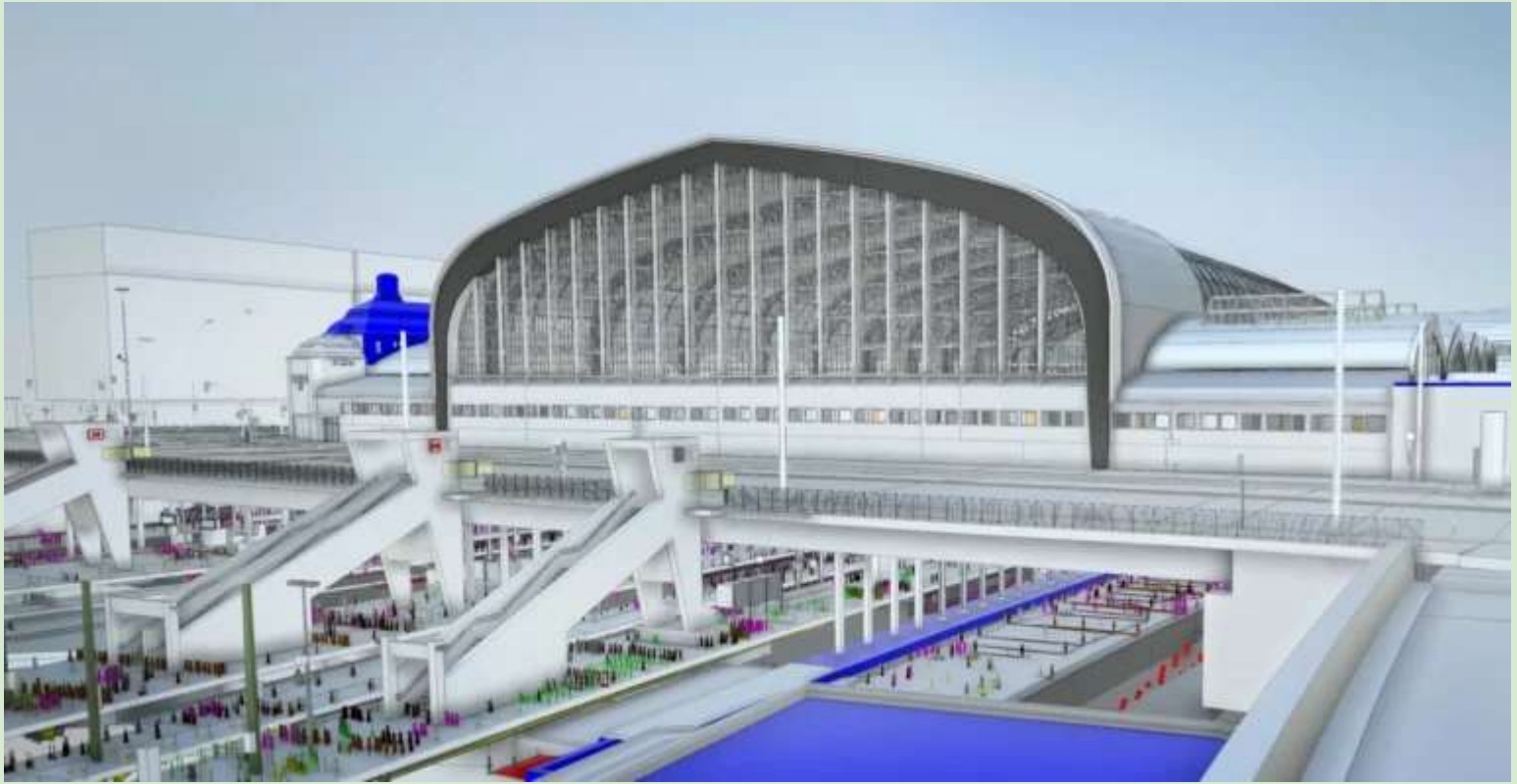
Transformation of Railways:
AI in Railways and Innovative AI solutions for Railways



- Reshaping the landscape of transportation.
- Ushering in a new era of efficiency, safety, and reliability.
- Enables railway operators to anticipate potential failures, optimize maintenance schedules, and ensure uninterrupted train operations.
- Driving the transformation of railways into a smarter, more resilient, and future-ready mode of transportation.

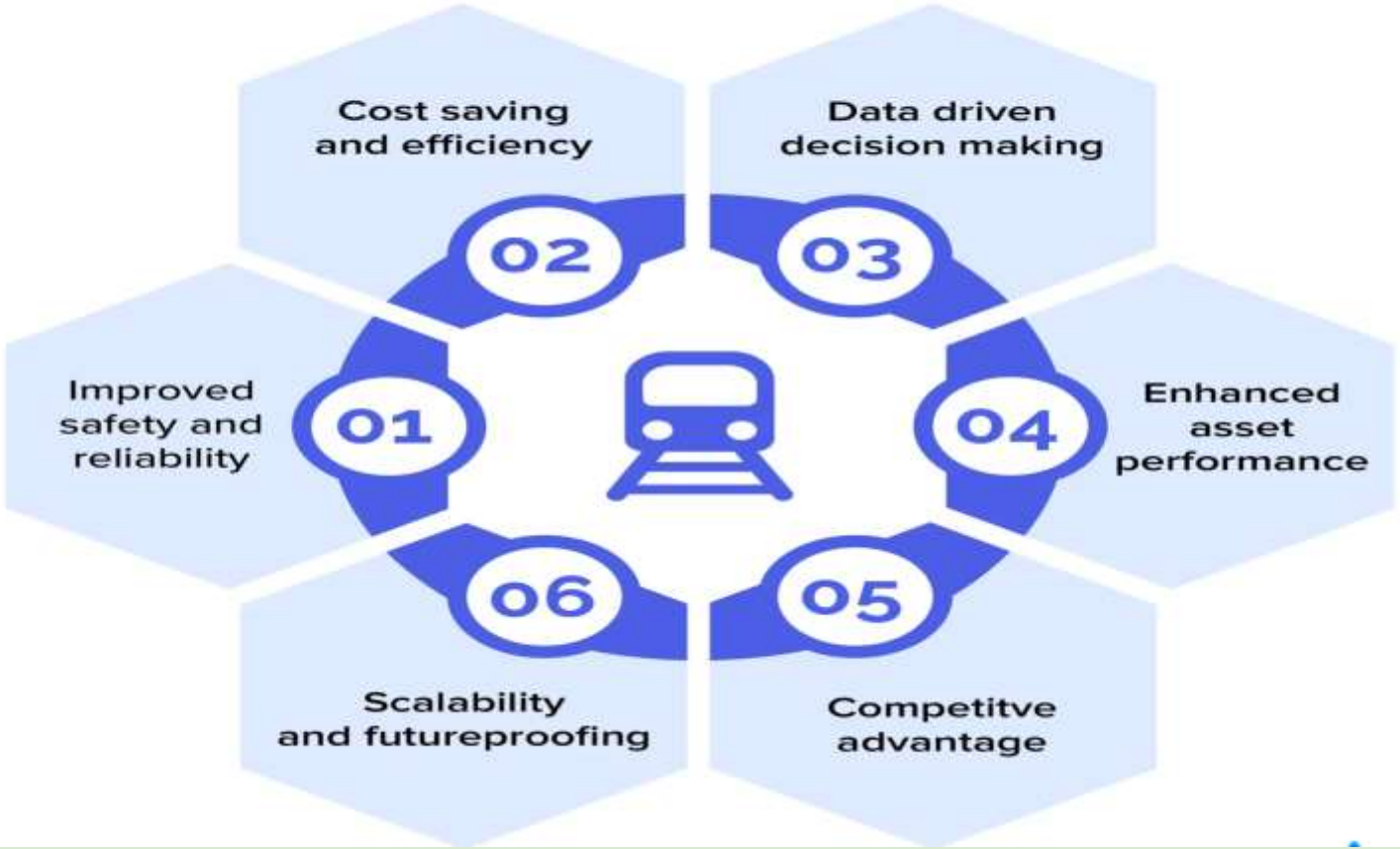
Improvisation on AI for rail transport policy and revenue management

- passenger flow prediction,
- capacity management,
- life cycle cost,
- enhanced asset performance, predictive maintenance,
- high-level automation and
- auto-adaptive systems.



Building Information Management

Advantages of harnessing artificial intelligence for railways operations



Traffic & Operations Management

AI-Powered Solutions

- Dynamic capacity management
- Intelligent timetabling systems
- Resource optimization
- Real-time adjustments

Implementation Benefits

- Improved passenger flow
- Enhanced freight management
- Optimal crew scheduling
- Reduced delays and disruptions

Digital Twin Technology

Implementation Strategy

- Virtual modeling of physical assets
- Real-time monitoring and simulation
- Predictive analysis capabilities

Integration with maintenance systems

- Infrastructure planning
- Maintenance scheduling
- Performance optimization
- Risk assessment

Global Railway Operation's Applications

Deutche bahn's OptiMa

- Real time genetic algorithm & Ant colony Optimisation
- Reduces network delays through dynamic train path adjustment

Siemen's Valero

- Real time data for optimisation
- Blends human expertise with AI precision

Bombardier's Rail Star

- Historical data & weather trends into proactive scheduling adjustments.. To minimise disruptions

Hitachi's STOS

- Takes holistics view , merging real time data with network simulations and advanced algorithms
- to optimise not just train paths but also passenger comfort & energy efficiency.

Similarly, Global Players like **SNCF** (France), **JR** (Japan), **KORAIL** (S.Korea) & **Alstom**'s Predictive Maintenance & Real time Optimisation (PMRTO)

The Cure: Open AI/ML as the Engineer:

SimPy accurate:

- Real-time Train Simulation through simulations of train movements,
- considering crucial factors like track layouts and passenger loads.
- informed decisions, smoother operations, and reduced delays.

TensorFlow's Dynamic Path Optimization:

- further enhances this efficiency.
- It employs advanced algorithms, such as genetic algorithms and ant colony optimization to dynamically craft optimal train routes,
- ensuring fluid network flow and timely arrivals.

Reinforcement Learning (RL) tools like Open AI Gym and Ray RLlib:

- For freight operations, redefine scheduling.
- They adaptively adjust freight timetables,balancing efficiency with passenger train priorities.

Revenue Management & Customer Experience

Smart Pricing Systems

- Dynamic fare adjustment
- Demand prediction
- Market segmentation
- Revenue optimization

Enhanced Customer Services

- Real-time journey updates
- Personalized travel recommendations
- Automated booking systems
- Integrated mobility solutions

Sustainability Initiatives

Green Technology Integration

- Energy-efficient operations
- Circular Economy adoption
- Waste reduction strategies
- Sustainable maintenance practices

Environmental Impact

- Reduced carbon footprint
- Optimized resource utilization
- Sustainable infrastructure development

Harnessing AI-powered Predictive Analytics & Maintenance

Unlike the present system of carrying out maintenance in a periodic manner,

- Proactively detect potential failures, optimize maintenance schedules, and enhance overall operational efficiency

- Predictive asset maintenance system to continuously monitor the condition of equipment and generate the required alerts.

- Reducing the cost of maintenance & cut down the load on maintenance of assets.

Predictive maintenance use cases for the railroad industry

- Wheel and Track Condition Monitoring
- Fault Detection in Rolling Stock
- Predicting Component Failures
- Optimizing Maintenance Scheduling
- Weather-Induced Maintenance Alerts
- Energy Consumption Optimization
- Predictive Signal and Communication Systems
- Preventing Catenary and Power Failures
- Track and Infrastructure Maintenance

Railway Maintenance & Monitoring

1

"CTM – Infrastructure diagnostics with scheduled trains" monitors the track surface – OHL for headline

2

Sensor technology on track bed detects imminent wheel bearing damage ("check points")

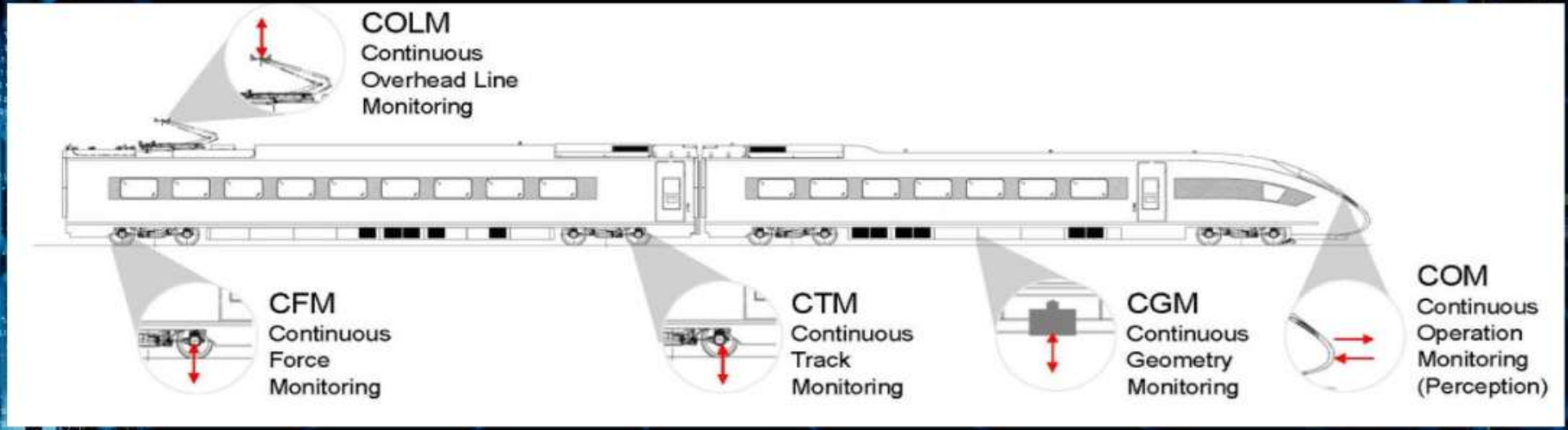
3

"Land-side" platform for on-board diagnostic systems

4

Switch drives, switch heaters, railroad crossings, signals, etc.

Predictive Maintenance



CTM – Continuous Track Monitoring

CTM system enables you to continuously record the condition of your rail infrastructure.

The systems can be mounted in or on any rail vehicle.

Rail Monitoring Systems

Optical Rail Profile measurement during train movement

Round wheel measurement during regular train operation

Acoustic Wheelset Bearing monitoring

OHL – Overheadline Monitoring

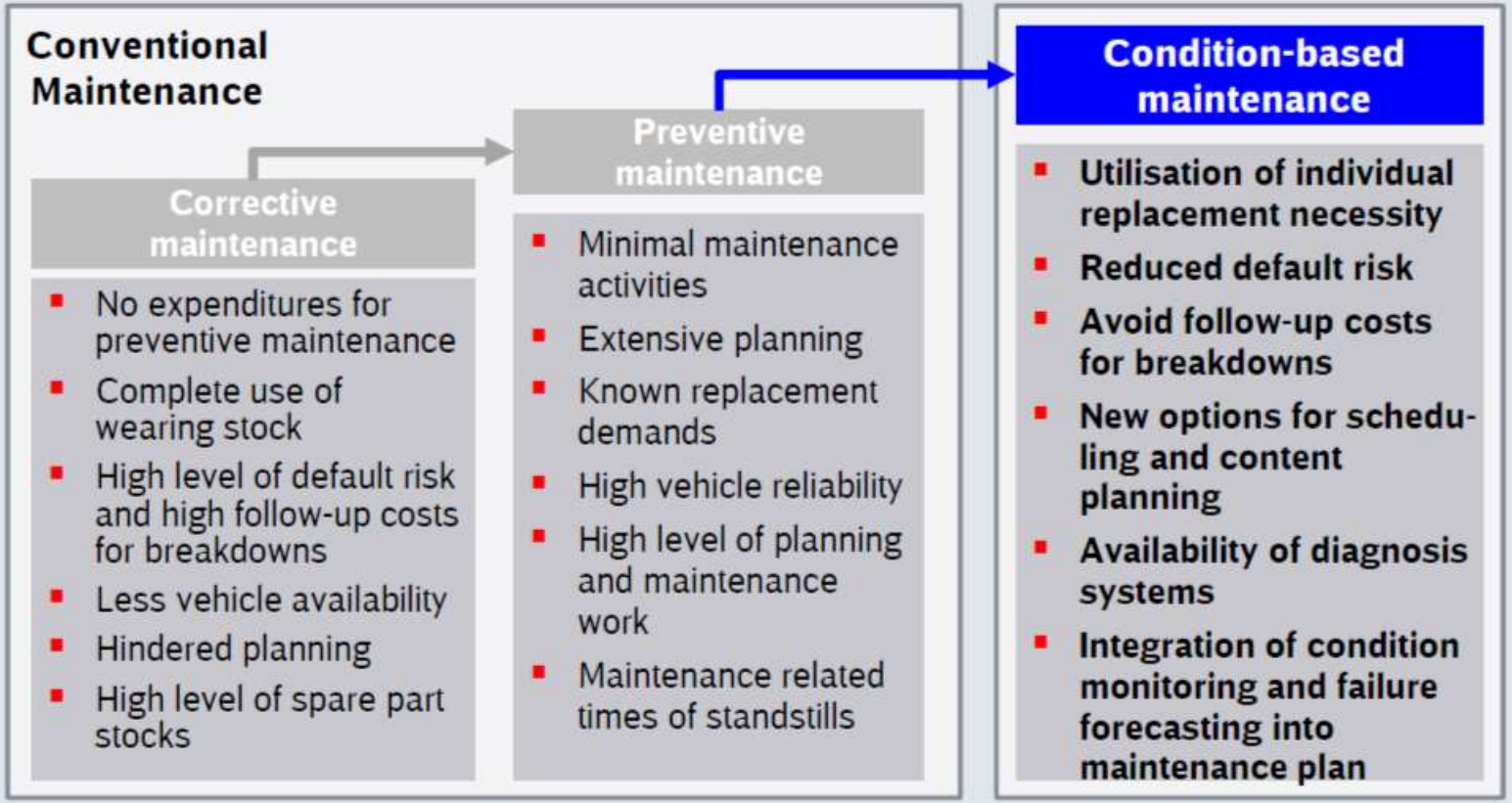
Force Measurement System (FMS)

- Contact pressure measurement between catenary and pantograph

Contact Wire Scanner (CWS)

- Measurement of catenary position relative to track

CBM – Condition Based Maintenance



Development challenges and solutions:

1. **Data Quality Enhancement**: Implementing data loggers to automate and accurately capture train movements, reducing human error and ensuring high-quality data.
2. **Customized Model Development**: Rigorously testing and evaluating algorithmic models specific to Indian Railways, focusing on predictive accuracy, robustness, and ethical alignment. Continuous adaptation is essential for long-term effectiveness.
3. **Cyber security Focus**: Strengthening data privacy and protection measures to safeguard against cyber threats in the AI/ML infrastructure.
4. **Bridging the Skill Gap**: Collaborating with Centers of Excellence at IITs and IISc to develop a skilled workforce capable of managing AI/ML complexities in railway operations.

Indian Railways : CRIS Implementation

Current Infrastructure

- National **RDBMS** deployment
- Centralized data management
- Real-time monitoring systems
- Integrated operations platform

Future Roadmap

- Enhanced AI integration
- Expanded digital services
- Advanced analytics implementation
- Cross-platform integration

Future Railway Systems: iIOT5.0

Advanced Technologies

- Human-centric AI systems
- Emotional intelligence integration
- Open source platforms
- GDPR-compliant systems

Innovation Pipeline

- Prescriptive maintenance evolution
- Advanced automation systems
- Integrated mobility solutions
- Smart infrastructure development

Strategic Recommendations

Short-term Goals

- AI system implementation
- Staff training programs
- Infrastructure upgrades
- Data collection improvement

Long-term Vision

- Full automation capability
- Integrated mobility solutions
- Sustainable operations
- Enhanced passenger experience

'...The best way to predict the future is to create it.'

Peter Drucker

Thank You