



Edge AI Computing in Smart Railway:

Driving the Future of Efficiency and Safety

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Table of Contents

1. Overview and The Trends of Smart Railway

2. Use Cases of Edge AI Computing in Smart Railway

- 2.1 Passenger Information System (PIS) in Smart Railway Solution
- 2.2 Environmental and Disaster Warning for Safe Train Operations in Smart Railway Solution
- 2.3 Train Operation and Passenger Safety Management Solution

3. Portwell Applies Extensive DMS Experience to Deliver High-Standard Edge Computing Solutions for Railway Applications

Smart Railway

Edge AI Computing in Smart Railway : Driving the Future of Efficiency and Safety

In recent years, the global smart transportation market has experienced remarkable growth, driving technological advancements and urbanization. According to market forecasts, the smart transportation market is expected to reach a valuation of USD 300 billion by 2032. Europe, with its long-term investments in modernizing and upgrading railway infrastructure, demonstrates significant investment potential in the smart transportation sector and is poised to maintain a leading position. Meanwhile, the Asia-Pacific region, driven by supportive policies, is experiencing rapid growth in smart transportation infrastructure, with significant momentum expected over the next decade. Global urbanization continues to fuel this growth as increasing urban populations demand efficient transportation systems, which are critical to economic competitiveness. Key markets, including smart roads and Smart Railway, are leveraging AI and edge computing to enhance efficiency and safety, driving the digital transformation of transportation worldwide.

As Global Trade and Population Grow, Smart Railway can use AI, IoT and Big Data to Provide Sustainable Transportation Solutions

Rail transportation is an efficient and eco-friendly mode of transit, offering significant potential to address challenges such as urbanization, population growth, traffic congestion and environmental protection. Compared to road transport, railways can move millions of passengers and large volumes of freight across countries and continents in a cleaner and more compact manner. As global trade expands and freight demand rises, smart railway technologies can optimize train scheduling and route planning, significantly enhancing transportation efficiency. This plays a vital role in shaping national economies and finances, driving global economic growth in the 21st century. With urbanization and population growth, Smart Railway use AI, IoT and big data to enhance operations, safety, energy efficiency and

sustainability. IoT integration and smart city initiatives have revolutionized the industry, enabling intelligent ticketing, passenger entertainment, analytics and dynamic route planning. These advancements boost competitiveness, open new business opportunities and provide benefits like improved supply chains, asset monitoring and predictive maintenance.

The Primary Drivers of Growth in the Smart Railway Market will focus on Security and Safety , Rail Communication, Networking and Smart Ticketing System

Smart Railway represents an advanced technological solution designed to efficiently manage railway operations by rapidly sharing data across various railway infrastructure components, including Passenger Information System, Smart Ticketing Systems, Rail Communication and Networking System, Rail Analytics and Security Safety System. These solutions rely on cutting-edge technologies such as the Internet of Things (IoT), cloud computing, data analytics, big data, global positioning systems (GPS), artificial intelligence (AI) and machine learning (ML) to enhance operational accuracy and efficiency.

By integrating software solutions with railway assets, Smart Railway optimize resource utilization from tracks to trains, addressing the increasing demand for transportation while improving safety. Factors such as sustainability, regulatory requirements, demographic shifts (e.g., traffic growth and aging populations), economic pressures (e.g., limited public funding and price sensitivity), technological innovations and mobility demands are expected to drive significant increase in the railway sector. These trends will profoundly impact all aspects of the smart railway market value chain, transforming everything from passenger services to backend operations.

The smart railway market is driven by integrated solutions, including passenger information systems for real-time updates, operations management for efficiency and safety monitoring to ensure security. Communication networks connect trains to central systems, while smart ticketing enhances convenience. Analytics and asset management further optimize operations and extend lifespans, creating a robust and innovative ecosystem. The seamless integration of these solutions establishes a robust foundation for the smart railway ecosystem, driving continuous market growth.

Key Considerations for Edge AI Computing in Smart Railway Include Durability, Real-Time Monitoring and Secure Data Transmission

Smart railway systems rely on edge AI computing to integrate with railway hardware and

enable edge-cloud collaboration. This ensures coordinated operations, efficient resource allocation and improved user experiences while driving digital transformation.

Key Technologies for Edge AI Computing in Smart Railway:

1. Environmental Adaptability and Durability



Edge computing hardware for railways must exhibit high environmental adaptability and durability to operate reliably in harsh railway environments. Certified by standards such as EN50155 and EN50121, these devices are designed to handle extreme conditions, including vibration resistance (using M12 waterproof connectors), wide temperature ranges and high durability. They maintain stable performance in high temperatures, humidity and vibration-prone environments.

2. Real-Time Data Processing and Low Latency



Edge AI computing in railways requires robust processing capabilities for real-time monitoring and decision-making. Devices must support standards like PoE, GbE and USB, with multi-channel PCIe and USB interfaces to connect various sensors and devices. High-throughput I/O interfaces, such as 10GbE, 25GbE, or higher Ethernet ports, are essential to handle the large volumes of data generated by multiple sensors and cameras, ensuring fast and simultaneous data processing and transmission.

3. Energy Efficiency and Continuous Operation



Railway edge computing equipment must operate efficiently over extended periods with low power consumption, even under unstable power conditions. These devices should support a wide range of voltage inputs to adapt to the variable power environments in railway systems, ensuring uninterrupted operation during power fluctuations. Additionally, fast boot capabilities are crucial to minimize downtime, enabling the system to quickly recover from brief outages or reboots.

4. Security and Data Protection



Reliable network connectivity is vital for railway applications, particularly when multiple edge computing nodes collaborate. Industrial-grade edge devices must support GPS, 4G, 5G and Wi-Fi interfaces to mitigate signal instability or interruptions and ensure data synchronization. Given the public safety implications of railway systems, edge devices must incorporate robust security measures to protect against cyberattacks, ensure data integrity and safeguard sensitive information with encryption technologies.

Use Cases of Edge AI Computing in Smart Railway

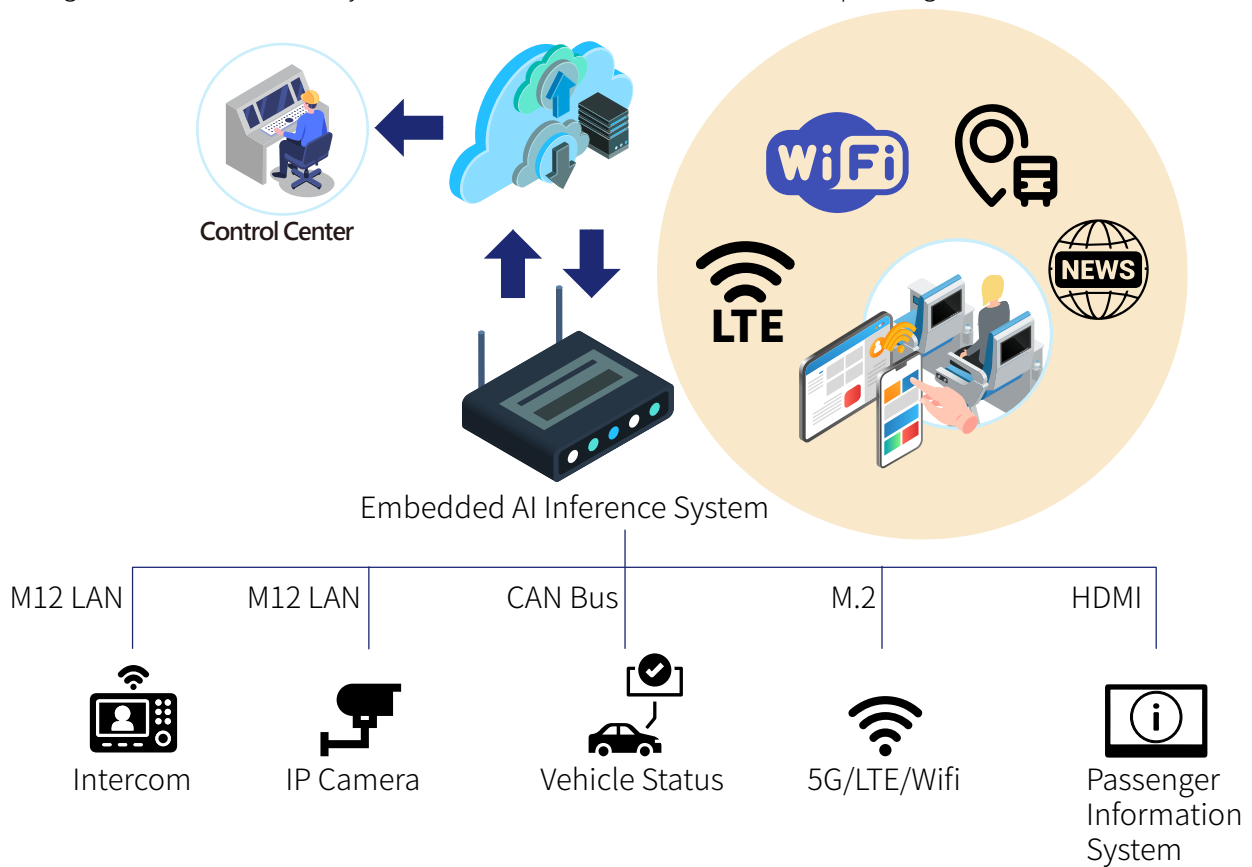
Passenger Information System (PIS) in Smart Railway Solution

The development of Smart Railway is closely linked to the evolution of Passenger Information System (PIS), which has grown beyond simply providing travel information to become critical for enhancing passenger experiences and improving operational efficiency. Driven by modern digitalization and smart city initiatives, PIS delivers essential updates such as real-time weather, train speed, arrival times and service reliability. This enhances safety and comfort for passengers while improving transparency and responsiveness for railway staff. As global transportation systems advance, PIS has become an indispensable part of the smart railway ecosystem, playing a vital role in digital transformation and sustainable development by integrating advanced information delivery with system optimization.

Edge AI computing drives the transformation of PIS by enabling real-time data processing directly on devices, reducing latency and ensuring stable performance even in low-bandwidth environments. It enhances multimedia broadcasting by analyzing passenger preferences, flow and crowding in real-time to deliver personalized content. Additionally, edge AI computing optimizes railway data management and decision-making by analyzing passenger behavior and operational data, allowing operators to adjust strategies, reduce delays and improve energy efficiency. These intelligent systems support digital transformation and meet the demands of modern smart transportation.

Passenger Information System (PIS) in Smart Railway Solution

Integrate visual and audio systems with stable Wi-Fi/LTE to enhance passenger satisfaction



Environmental and Disaster Warning for Safe Train Operations in Smart Railway Solution

With global climate change triggering more frequent extreme weather events such as flooding, heavy rain and other environmental variables, railway infrastructure faces unprecedented safety challenges. During heavy rain or floods, obstacles like fallen trees or landslides are more likely to invade tracks. In regions like the Pacific Ring of Fire, frequent earthquakes exacerbate track wear and displacement risks. Traditional manual inspection methods, while useful, are often insufficient in extreme environments due to limited accuracy and slow response times. In such dynamic and complex conditions, industrial computing technologies with real-time monitoring and intelligent detection capabilities have become critical for ensuring railway safety.

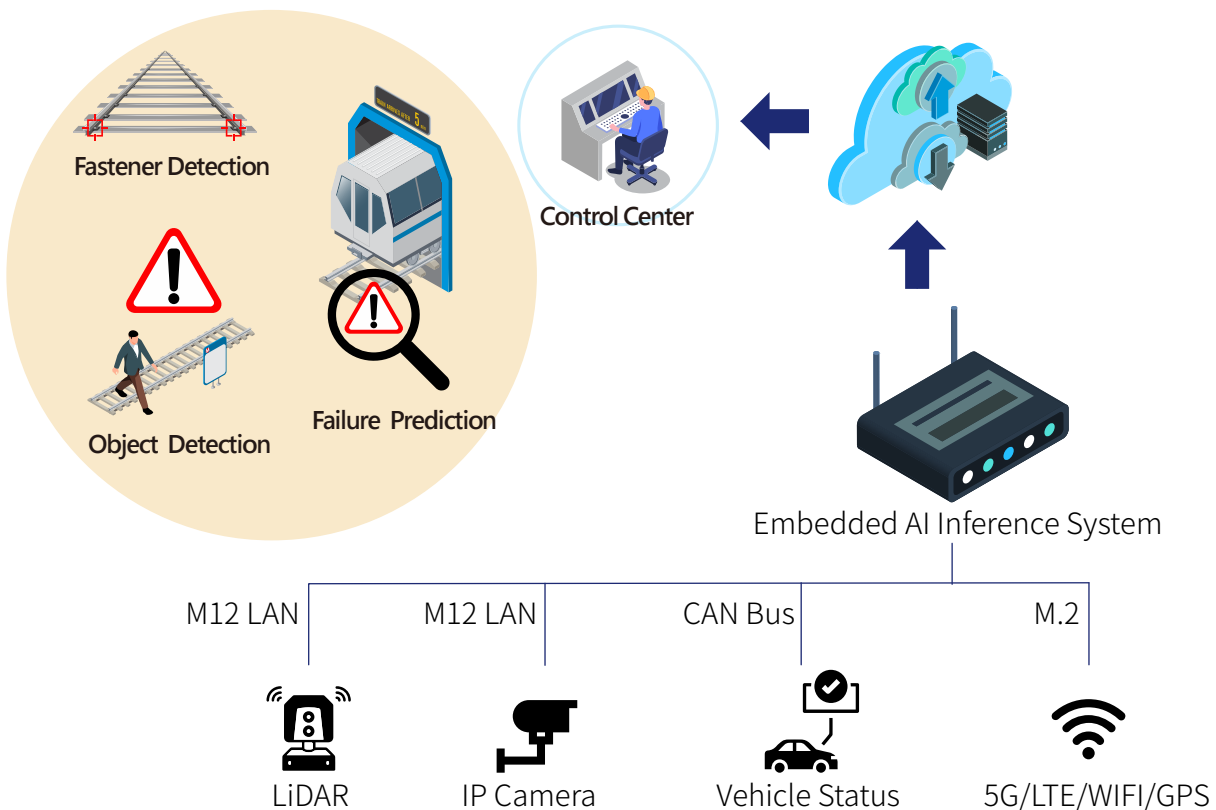
The introduction of edge AI computing addresses these challenges by enabling real-time, local processing of large datasets without reliance on remote servers. This reduces latency issues associated with data transmission. By equipping train front ends with LiDAR sensors and cameras, these systems continuously scan tracks and surrounding areas during operation,

generating precise 3D maps. Machine learning algorithms analyze the data to detect risks such as fallen trees or other intrusions, accurately identifying their locations and issuing immediate alerts to operators. With edge AI's real-time inference capabilities and efficient data handling, these systems perform reliably even in adverse weather or low-light conditions. Detection models can be continuously optimized for diverse environmental conditions, enhancing the accuracy of obstacle detection and accident prevention.

Intelligent monitoring technology not only improves the efficiency and accuracy of obstacle detection but also serves as a vital pillar for addressing climate change challenges and protecting railway safety. During extreme weather events like storms or snowfalls, these systems rapidly identify potential risks and assist operators in taking timely protective measures, significantly reducing the likelihood of accidents. Moreover, the system's real-time processing and efficiency enhance operational stability while reducing dependence on manual inspections, thereby lowering maintenance costs. Whether in responding to emergencies, natural disasters, or routine railway operations, this technology provides long-term stability and safety for railway systems.

Environmental and Disaster Warning for Safe Train Operations in Smart Railway Solution

Real-time detection of track intrusions to reduce train accident risks



Train Operation and Passenger Safety Management Solution

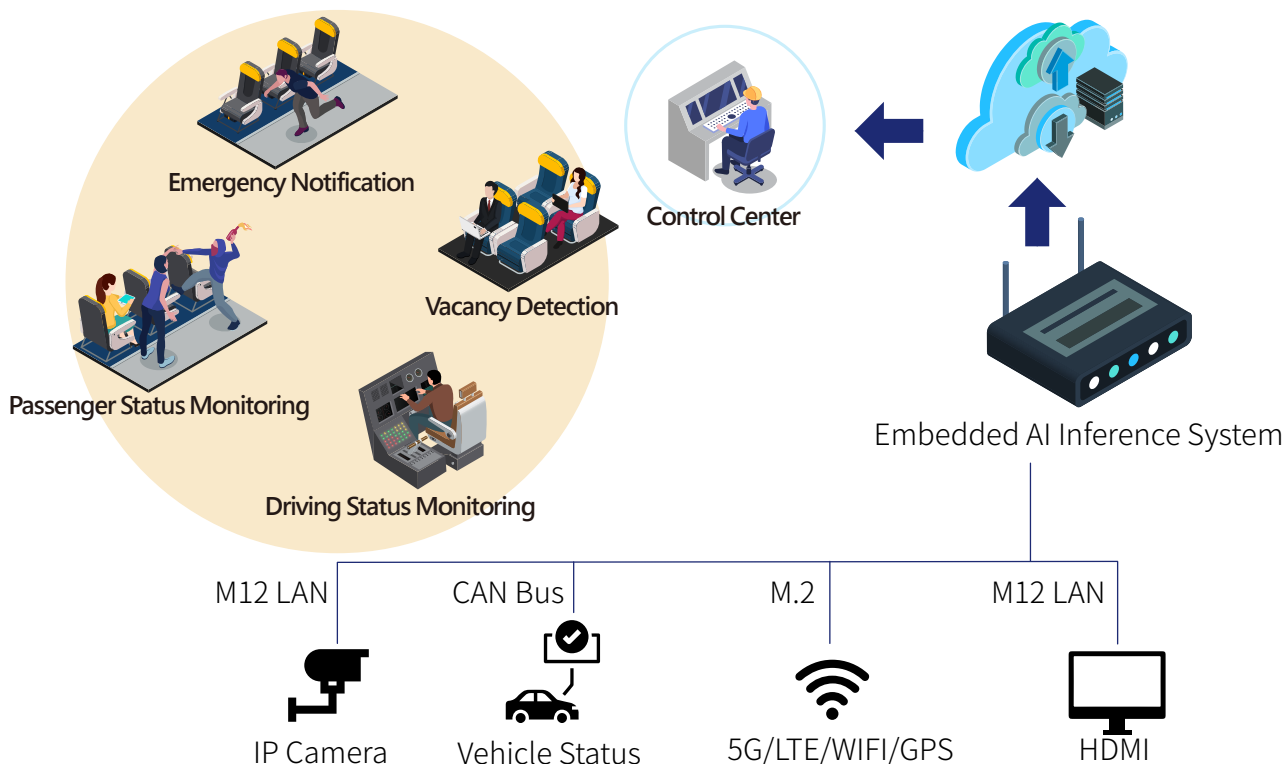
In modern railway systems, train operation and passenger safety are key priorities. As technology advances, intelligent solutions like driver behavior analysis systems have replaced traditional methods, ensuring real-time monitoring of drivers' mental and physical states to prevent accidents and maintain stable operations.

Edge AI computing plays a critical role in this application by enabling real-time data processing to quickly analyze driver behavior patterns. Using high-resolution cameras and advanced machine learning algorithms, the system can accurately detect abnormal driving behaviors. For example, AI-powered image learning establishes normal driver behavior patterns, such as focused attention, hand movements and body posture. When anomalies like prolonged inactivity, gaze deviation, or unnatural posture are detected, the system triggers alerts and notifies the control center for emergency intervention. These algorithms also self-adjust based on real-time data to enhance detection accuracy and reliability.

Additionally, edge AI computing enables real-time passenger behavior analysis through AI vision technology, detecting agitation, suspicious activity, safety violations, or emergencies. The system alerts management for immediate action, enhancing safety while reducing maintenance and security costs. Vacancy detection systems further improve convenience by displaying carriage occupancy, helping passengers find seats easily. These intelligent systems provide efficient monitoring, automated reporting and actionable insights, ensuring Smart Railway operates safely and efficiently, even in complex environments.

Train Operation and Passenger Safety Management Solution

Monitor and analyze driver or passenger activities to ensure passenger and operational safety



As smart railway systems evolve, AI, IoT and edge computing drive operational efficiency, enhance passenger experiences and accelerate transportation digitization. Portwell, as a leading railway solutions provider, is dedicated to supporting your business in advancing global growth and sustainability as a trusted long-term partner.





Portwell, Inc. Headquarters

No. 242, Bo'AI St., Shu-Lin Dist,
New Taipei City 238, Taiwan
Tel: +886-2-7731-8888
Fax: +886-2-7731-9888
E-mail: info@portwell.com.tw
www.portwell.com.tw

Americas

American Portwell (Fremont, CA)

44200 Christy St., Fremont, CA 94538, USA
Tel: +1-510-403-3399
Fax: +1-510-403-3184
E-mail: info@portwell.com
www.portwell.com

Japan

Portwell Japan, Inc. (Tokyo)

〒112-0011 4-27-10, Sengoku, Bunkyo-ku,
Tokyo, Japan
Tel: +81-3-6902-9225
Fax: +81-3-6902-9226
E-mail: info@portwell.co.jp
www.portwell.co.jp

Portwell Japan, Inc. (Osaka)

〒532-0004 Ste.501 Nippo Shin-osaka Dai-2
Bldg, 1-8-33 Nishi-Miyahara, Yodogawa-ku
Osaka Japan
Tel: +81-6-4807-7721
Fax: +81-6-4807-7720
E-mail: info@portwell.co.jp
www.portwell.co.jp

Europe

European Portwell

Schillingweg 3, 2153 PL
Nieuw Vennep, The Netherlands
Tel: +31-252-620790
E-mail: info@portwell.eu
www.portwell.eu

KIOSK Embedded Systems GmbH

Am Technologiepark 8-10,
D-82229 Seefeld
Tel: +49-8152-3962-500
E-mail: info@portwell.eu
www.portwell.de

Portwell UK Ltd.

Office TH2
Trident House, Trident Park Basil
Hill Road, Didcot, OX11 7HJ, UK
Tel: +44(0)1235-750-760
Fax: +44(0)1235-750-761
E-mail: info@portwell.eu
www.portwell.eu

China

Shanghai Portwell

(201612), Room 1303-1, Building 33, No.258,
Xinhuan Highway, Songjiang District,
Shanghai
Tel: +86-21-5771-2505
Fax: +86-21-5772-2965
E-mail: info@portwell.com.cn
www.portwell.com.cn

Korea

Portwell Korea, Inc.

O-BIZ Tower 1901, No.126,
Beolmal-ro, Dongan-gu, Anyang-si,
Gyeonggi-do, Korea, 431-060
Tel: +82-31-450-3043
Fax: +82-31-450-3044
E-mail: info@portwell.co.kr
www.portwell.co.kr

India

Portwell India Technology Private Limited.

3rd Floor, Jeet Dynasty, Old Madras Rd,
next to Gopalan Signature Mall,
Nagavarapalya, Benniganahalli,
Bengaluru, Karnataka 560093, India
Tel: +91-80-4168-4255
E-mail: enquiry@portwell.in
www.portwell.in



www.portwell.com.tw