Predictive maintenance solutions help railway operators maximize operational readiness. Benefits include:

- **Increased fleet availability**  
  The automated, real-time pantograph inspection system maximizes fleet availability of rail cars without the need to take trains out of service.

- **Enhanced safety and security**  
  The inspection monitoring system helps minimize safety risks and high-voltage incidents to maintenance staff and removes the need to access the top of railcars for inspection.

- **Reduced Maintenance Costs**  
  Automated reporting helps identify more predictable and optimized maintenance scheduling with fewer service delays.

- **Increased Return on Investment**  
  Consistent inspection monitoring protects service continuity and customer revenue while decreasing costs and threat to service reputation.

- **Fewer Teardowns**  
  The solution reduces teardown of damaged overhead contact lines by using more accurate and reliable technology for pantograph monitoring.

### Overview

The global rail market is booming, as densely populated cities seek more efficient transportation strategies to respond to population growth, safety and security concerns, and shrinking operating budgets. Meanwhile, constraints to existing rail networks make accommodation of next-gen passenger and shipping demands more difficult. New, innovative railway operations approaches are needed.

Global climate change is also pushing national and local governments to call for more sustainable solutions such as rail electrification. This will help improve energy consumption and decrease carbon emissions by diesel rail engines. Cities want to take advantage of new technologies like artificial intelligence (AI) to provide real-time analytics to help increase operational readiness, safety, and efficiencies—all in pursuit of capturing better return on investment.

Intel-powered smart railway solutions combine integrated hardware and software to consolidate different use case applications at the edge of networks. When rail operators use existing in-vehicle computers and accelerators, Intel-based solutions digitally connect railcars and operators to help create a safe, efficient, and convenient railway fleet.

### Customer Challenges

The global trend toward green energy and renewable energy solutions such as electric railcars also increase demand for equipment used by electric railcars, such as pantographs. The increased need for this equipment makes managing operational budgets and predictive maintenance more challenging for railway operators.

Pantographs, a primary component of railway electrification, are the apparatus mounted on the roof of an electric railcar collect electricity from overhead transmission lines to power the rail cars. The electrical discharges created from this equipment can accelerate the wear and tear on these parts. Electrical sparks can also interfere with continuous train operations, such as train delays or unscheduled maintenance. These events further exacerbate growth and operational readiness challenges.

Traditional train operators rely on manual inspection of this equipment, which is often inefficient, costly, inaccurate, and conducted infrequently. Unexpected service delays caused by defective or damaged pantographs decrease financial performance, increase maintenance costs, and shorten the life of railcars and their associated technologies. Growing constraints on operating budgets create a need for a new predictive maintenance solution.
Intel and its global ecosystem of partners have collaborated on a Pantograph Catenary Monitoring System (PCMS) solution. This fully automated pantograph inspection system for predictive maintenance offers advanced accuracy and measurement technology for helping to detect damaged pantographs and catenaries. Using a combination of 3D laser triangulation, Artificial Intelligence (AI), Machine Learning (ML), and advanced software algorithm processing at network edges, the system helps accurately detect and measure pantographs for damage. The system can then alert rail operators to schedule maintenance.

This Intel-based system helps decrease unscheduled maintenance and increases rail fleet availability. PCMS identifies pantograph damage, such as deformed bows, damaged graphite plates, cracks, and missing parts. The system also identifies abnormalities to catenary components like arcing and broken or loose dropper wires. Finally, PCMS identifies potential risks caused by foreign objects, such as bird or animal nests and other unwanted things.

How the Pantograph-Catenary Monitoring System Works

PCMS systems are activated when a moving train activates a light beam from either a train-mounted or wayside system. Once started, the system takes precise train speed and direction measurements before automatically detecting and identifying the components for a specific railcar. A co-located LED array illuminates the pantograph head as it passes through a defined area and a set of sensors, typically 3D cameras capture stereoscopic L/R images of the pantograph and store it in a database for analysis. The system retrieves the captured images, and uses advanced Intel-based image processing technologies analyze each image before generating a report. Rail operators automatically receive notifications when a damaged pantograph, catenary, or foreign objects are detected. The detection of damaged parts triggers a notification containing the exact train route and location data.

Additional benefits include:

- Maximized fleet availability with fewer unexpected maintenance costs
- Minimized safety risks to maintenance staff, with reduced need to access the top of rail carriage or power car
- Enhanced access to consistent data from fully-automated pantograph inspections
- Reduced risk of line teardown and other power line maintenance

PCMS is flexible and designed for deployments across two railway operator scenarios:

1. Train-mounted pantograph monitoring system
2. Wayside pantograph monitoring system
Intel-Based Architecture for Real-Time Insights

Historically, sensor and camera data processing occurs in the cloud, and it can be challenging to maintain rail network uptime with real-time access. For systems overly reliant on shipping data to the backend data center, network bandwidth is overwhelmed by large data sets. Data sources such as high-quality video streams of stations and railcars. Latency issues can also cause connectivity failures and delays impacting safety, security, and efficiency.

When railway operators try to take advantage of their railway sensor networks, they often find their data is siloed or hard to access in real-time. Disparate sensor and camera providers can also cause proprietary bottlenecks. A lack of nodes that bridge the divide between endpoint and cloud can make it challenging to unlock the end-to-end visibility needed to drive insights across the railway network. The data collected and reports generated are only as useful as their timeliness, relevance, and reliability.

Intel’s PCMS solution leverages device data at the network edge. Data pre-processed at the edge delivers real-time information to rail operators. The system is also more easily upgradeable and compatible with new applications and services by using end-to-end Intel-based components and software. Rail operators receive a better return on investment and can potentially lengthen the life of railcar equipment and infrastructure.

Intel ingredients comprise the PCMS system architecture. For example, the train-mounted architecture includes Intel-based data collection modules, such as sensors and cameras to capture the current state of the pantograph. The system connects a set of data processors and uses a data switching exchange. At the same time, an onboard diagnostic host server facilitates onboard wireless connectivity with the on-ground server or cloud-based servers.
End-to-End Solution Portfolio

Intel’s partner ecosystem offers solutions that power the latest workload consolidation technologies, such as containerization and hyper-converged infrastructure. Intel-based devices can perform multiple functions, maximizing the value of each network asset. By using solutions based on industry-standard Intel processors, rail operators can integrate a wide array of devices that work together to provide a holistic view of their network.

Advances in intelligent rail technology enable operators to manage railways and meet a growing set of challenges actively. Intel and its ecosystem offer unique components and solutions to deliver the future of smart railway technology. Modern railway operators implementing Intel-based railway solutions across passenger and freight train infrastructure can help achieve better safety, operational readiness, and efficiency objectives.

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