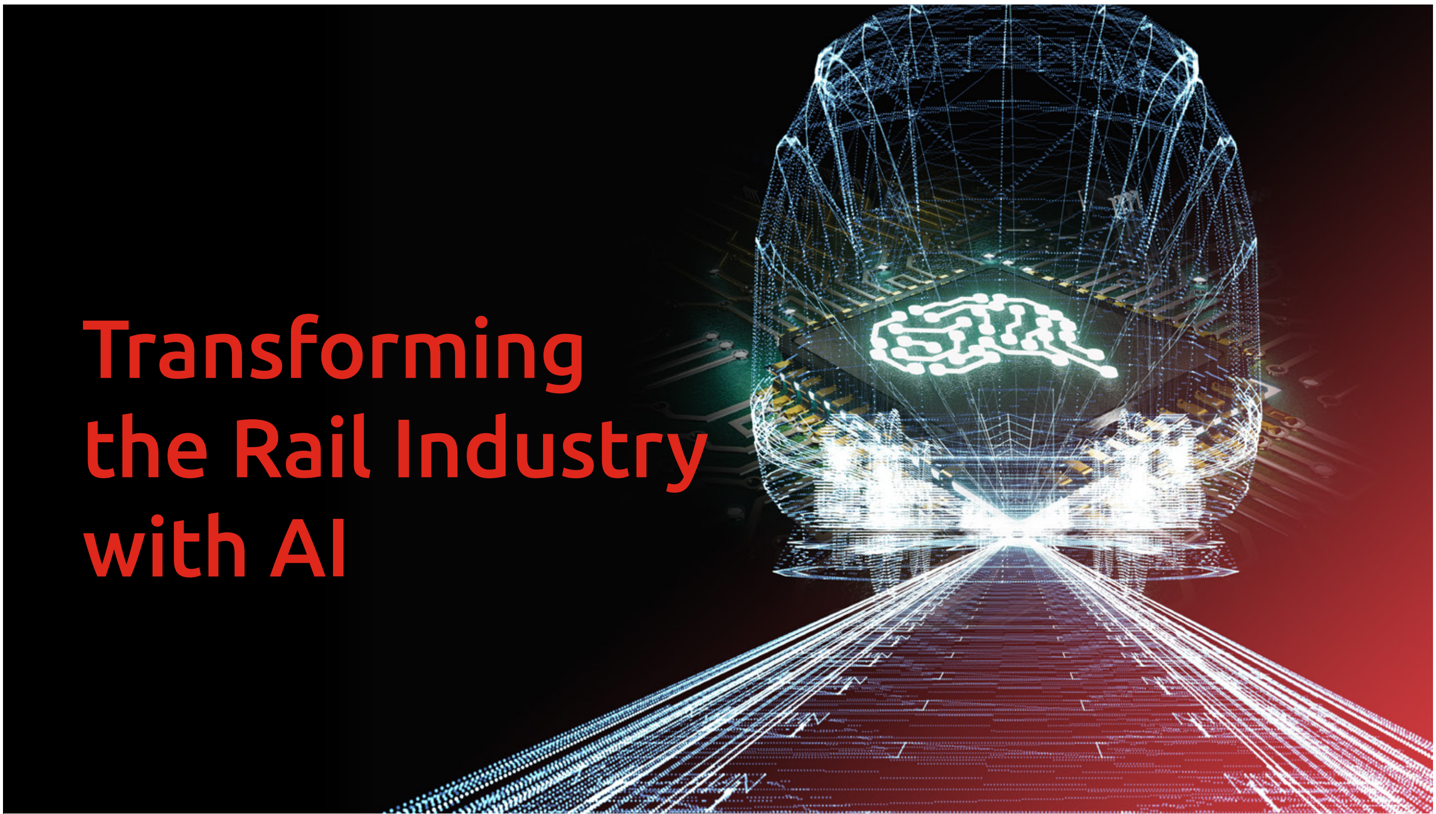


Transforming the Rail Industry with AI

AI accelerates railway digitalization to improve safety and operational efficiency

AI's pervasiveness helps the rail industry create new business opportunities, and deliver smarter and safer customer services

White Paper

Transforming the Rail Industry with AI

Introduction

Artificial intelligence (AI) continues to improve automation efficiency and accuracy in every industry. While analyzing and interacting with data in real time, AI can offload physical and logical work from humans while converting the work of many into streamlined functions for a few. This is particularly evident in today's AI-powered systems and applications as they continue to boost productivity and safety across many sectors, including transportation.

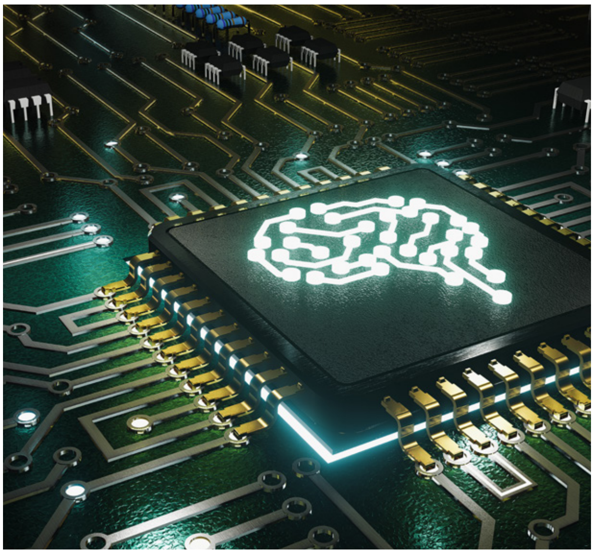
The rail industry has long needed modernization, and that need is quickly becoming critical. Consider the function of autonomous operation, which is made possible through AI. A 2020 study titled "Cost Analysis of Driverless Truck Operations" found that a balanced analysis (between optimistic and pessimistic forecasts) of driverless trucks determined cost savings of 29% to 45% compared to manually-operated trucks. One source noted a 15% to 20% drop in total cost of ownership for driverless trucks. Such cost advantages could dramatically upset the cost dynamics of cargo transportation, giving road-based solutions a significant advantage over rail. The article also states, "Having the flexibility to travel by [autonomous] car without owning one could change the riding habits of rail passengers in sparsely populated areas, affecting large swaths of [rail] systems."

However, the Association of American Railroads observes that technological modernization can benefit rail in many ways, including:

- *Fuel management:* Sensor data tracking factors from track grade to wind speed to train weight can inform real-time calculations to optimize fuel use and increase rail's cost advantages over road-based shipping alternatives.
- Train control: Visual systems analysis is only one of many input systems that can help automate safety systems and help slow or stop a train without the need for potentially fallible human involvement.
- Wayside-based preventative monitoring: Sensors near tracks can observe passing trains and help watch for potentially dangerous or costly conditions, such as component wear.
- Train-mounted monitoring: Cameras installed on or under trains can gather data about rail conditions, such as curvature and grade, providing live information for analysis that can inform safety and maintenance decisions.

AI can play a pivotal role in optimizing efficacy and value in all these examples. And clearly, the industry is getting the message. According to MarketsandMarkets Research, the global digital railway market is forecast to expand at a compound annual growth rate (CAGR) of 8.4% through 2024. Straits Research expects global IT spending in railways to increase at a 9.8% CAGR through 2026. Applications range from controlling energy-related emissions to having unmanned aerial vehicles (UAVs) monitor railway infrastructure. Again, in so many uses, AI is poised to play a key role in railway digitalization and modernization.

Contributing Trends and Factors



Railways could continue with legacy onboard and wayside systems. They worked for decades and continue to do so. However, the nature of competition and need for growth makes AI as attractive to railways as every other industry. Analysis firm McKensie released a Global Survey in late 2019 that showed very promising trends for organizations adopting AI, including "a nearly 25 percent year-over-year increase in the use of AI . . . an uptick in revenue in the business areas where it is used, and 44 percent say AI has reduced costs." Nearly one quarter of those surveyed realized AI-driven revenue increases of over 25 percent in service operations. Thus, AI stands to give railways an aggressive bottom-line boost. However, other complementary trends and factors also make AI adoption well-suited to railways.

Smaller Form Factors

Beyond reducing costs, a second possible contributing factor to the rise of AI within the rail industry is the change in computing form factors. Geographic real estate in the rail industry, especially on a train car, is limited, so the physical dimensions of computing infrastructure can be key. Unlike in prior times, when a single computer's footprint often occupied a large section of the system console, today's compute systems are powerful and much more space efficient — from palm-sized PC/104-based systems to server blades sharing a common compute chassis to virtualized cloud servers that consume zero local space.

More Data from the Masses

The amount of data produced in the rail industry continues to grow exponentially. Over time, large amounts of structured and unstructured information, also called "big data," flows from multitudes of devices and services, such as sensors, smart phones, servers, and databases. This volume of data gives the rail industry ample reason to use AI, which can deeply analyze how rail systems may improve efficiency, safety, customer approval, and profits.

The Internet of Things + M2M

Two device classes in particular generate notably large data amounts of data for AI analysis: Internet of Things (IoT) and machine-to-machine (M2M). Predictions for the number of IoT devices in global deployment by 2025 range from 21.5 billion to more than 75 billion. Many of these devices will be devoted to collecting and generating data, including logs, alerts, time stamps, and video — all information that could range from mundane to mission-critical for rail. M2M, a subset of IoT devices that communicate directly with other connected on-premises or cloud services, are also data-collecting devices. Vending machines, trackers, meters, and point-of-sale systems all fall under M2M, transmitting changes and information across a wired or wireless point-to-point network to a waiting server. The data is then processed and integrated into a larger system.

Boost from GPU

GPU-powered deep learning, in which the high degree of parallelism inherent to graphics processors helps accelerate learning in neural network systems, continues to gain importance in supercomputing and AI. By incorporating GPUs from NVIDIA or others into a compatible platform, rail companies can harness enough processing power to run a greater variety of AI-based workloads and applications — and run them at speeds more practical for near-real-time utility. For example, GPU-powered systems can use front-facing cameras and AI to track an oncoming train path and detect any possible obstructions or irregularities without human assistance, then take appropriate measures. This predictive and prescriptive function would replace manual inspections, which often take hours to complete, usually costing the rail company money and time.

Pandemic Push

The last contributing trend started in early 2020. The COVID-19 pandemic spread across the globe, disabling and then complicating travel in all affected countries. In many places, protective masks were mandated, especially for confined hubs like train stations. These locations could easily become overcrowded and facilitate COVID-19 spreading. By using AI, railroad stations can monitor station surveillance feeds and flag potential human-based hazards. This facilitates risk remediation, protection of the public and keeps the virus from spreading.

Potential AI Applications for Rail

Today, AI is a new, rapidly evolving technology. As breakthroughs continue, expect AI's prevalence and influence in the rail industry to grow. The following examples of current, fledgling AI applications within this market are only a beginning.

AI-Powered Customer Service

From chatbots running on social network services to AI-integrated call center systems to humanoid robots providing important travel information in high-traffic stations, AI will dominate how customers get their questions answered. AI-based technologies such as speech-to-text, natural language processing, and robotics will help provide answers in real time. Companies already employ these systems, in part to lower customer service costs and free staff to address other needs, but expect system accuracy, natural interactions with people, and customer satisfaction to improve continually.

Automation of Train Operation (ATO)

The International Association of Public Transport grades levels of rail autonomy on a scale of 0 to 4, where 0 has onboard attendants and a crew to manage the train and 4 is a fully automated train system running unattended without staff. This automation, wherein varying degrees of driving and operating responsibilities are transferred from a human crew (drivers and attendants) to an operational safety enhancement system, is already used in several countries. With improved and widely used AI-automated rail systems, future train transport will benefit from better rail synchronization thanks to real-time information and data exchange.

Biometric Ticketing

Detailed biometric ticketing based on technologies including body scans (i.e. facial, fingerprint, vein, and/or retina pattern recognition) and voice verification will help streamline onboarding processes while also bolstering security, especially during hectic passenger peak time. AI algorithms help accelerate biometric pattern processing and increase the accuracy of those scans. In turn, this processes patron traffic more quickly and helps alleviate congestion issues.

Crowd Control

Face and crowd detection video analytics help monitor ticketing and boarding locations, improving staff efficiency, security management, and traveler safety. For example, real-time, AI-enabled camera systems can help combat fare evasion problems, like tailgaters and other fraudulent ticket gate behaviors, while other systems can monitor crowding and face mask use.

Delay-Time Prediction

Delayed trains can be expensive for rail companies and annoying to customers. The rail industry is working on an AI-powered system to predict train delay time. By looking at historical data, AI can learn about past train delays and predict how long a delay is likely to last. Once collected and analyzed, this information is then delivered to rail operations and potentially to customers' mobile apps.

Freight Rail

The application of AI to the IoT will continue to improve how freight rail companies monitor their facilities, assets, systems, and shipments in real time. Beyond "where's my shipment?" customer scenarios, other metrics like network velocity, customer service, labor utilization, delay avoidance, and productivity will improve. The additional insight AI contributes to all these analytics will help rail companies and shipping customers while also benefitting partners, supply chain providers, and other connected industries.

Instant Information for Better Customer Service

AI can mine railway mobile app-relayed advice, suggestions, offers, and feedback based on customer location, context, and preferences. This analysis gives rail companies the opportunity to provide immediate assistance and re-accommodation in case of disruptions. These provider-specific mobile apps are personalized, interactive, and will be essential tools to the travel experience. On the other side of the customer service desk, employees can deliver exceptional in-person service with real-time knowledge to their customers, enabling fluid communication between patrons and the rail business.

Real-Time Rail Infrastructure Monitoring

Using AI, rail companies can remotely monitor rail systems and predict failures in real time. Traditionally, preventative maintenance work involved time-consuming and error-prone manual labor. In its place, AI uses specialized sensors to continuously monitor axle counters, track circuits, signals, and relevant subsystems. Analysis algorithms immediately detect flaws that could affect safety, cause delays, or create commercial bottlenecks. Once found, potential problems can be immediately remedied.

Stand Alone Switching

Soon, rail switches will be self-operating systems using AI to coordinate their operations via M2M communication. These switching stations would be unmanned and powered using a renewable energy resource, such as solar. With AI, rail systems could accurately schedule train paths without any human interaction, providing safety from human error and protecting business from delays.

Trading Floor for Train Routes

As with a stock exchange trading floor, AI can enable a real-time market for rail usage rights, letting supply and demand dictate fair pricing and optimal utilization among rail companies. This would be done with rail operators offering unused rail space to other parties, making transport management flexible and immediate.

…and more

There are dozens of other ways the rail industry can greatly benefit from using AI to run their systems, with many of these solutions still in development. From AI branches such as robotics to natural language processing to machine learning, the list of potential applications will continue to grow, as will the dependency on having the right hardware to support that software. The complexity of these applications will require the appropriate compute systems designed to process the rail industry's ever-increasing workloads.

AI and ADLINK: The AVA Series

Built and certified for the rail industry, the ruggedized, fanless ADLINK AI-based Video Analytics (AVA) Series is a line of graphics engine-focused commercial off-the-shelf (COTS) platforms designed to run today's and tomorrow's AI-powered applications. The AVA family leverages ADLINK's close relationship to NVIDIA to create solutions specially designed to help rail solution providers differentiate their applications and help clients achieve digital transformation. These solutions go beyond performance; they extend safety, reliability, and smarter functionality.

Variety within the AVA line allows integrators to pick the configuration best suited to their use cases. For example, the AVA-5500 is powered by 6th/7th Gen Intel® Core™ i7 Processors as well as a MXM 3.1 Type A/B module based on NVIDIA® Quadro® Embedded RTX 3000 via PCI Express x16. This CPU/GPU combination can drive a higher level of AI computing in applications such as predictive analytics and facial recognition. The system also offers market-optimized features such as four M12 Gigabit Ethernet ports, four M12 PoE ports, optional GPIO, and four lockable DisplayPort outputs.

As an EN 50155-compliant device, ADLINK's AVA-5500 follows strict guidelines, ensuring its certification for use in a variety of rail system environments. With the ability to operate at temperatures between -25°C and 70°C, the AVA-5500 also meets the rail industry's critical requirements for shock, vibration, and humidity.

Designed for both onboard and wayside deployment, the ADLINK AVA-5500 features a compact chassis (360 x 225 x 89 mm), making it a fully functional, Amazon AWS-approved edge computing system that can be integrated into any rail compute environment. With power consumption between 149W and 158W, the fanless AVA-5500's low power requirement is noteworthy, particularly when deployed in locations and vehicles where power is a limited and valuable commodity.

Reliability is a key system requirement in any industry, but especially in rail. The AVA-5500 provides several features needed to maximize uptime while also running at high efficiency. For example, ADLINK provides system board management for the AVA-5500 series through the company's own Smart Embedded Management Agent (SEMA), an intelligent middleware platform for system monitoring, control, and configuration. Currently, SEMA 3.0 provides several services for AVA-5500 remote management, including hardware monitoring, watchdog timer, runtime statistics, and failsafe dual BIOS.

The ADLINK AVA-5600 takes the features of the AVA-5500 in a slightly different direction. The two systems carry the same primary components (one notable exception being the AVA-5600's step up to RTX 5000 MXM graphics), but the AVA-5600 utilizes a 19" 2U chassis for rackmount deployment. The system's front panel features two 40-60W 12V power outputs, a 300W 3-pin power inlet, and reserved I/O for running Train Real-time Data Protocol (TRDP) over CAN bus. The NVIDIA Quadro RTX 5000 has a somewhat larger power profile than the RTX 3000 (110W vs. 80W), as well as supporting 16GB of Graphics SDRAM compared to 6GB, making this a better fit for more GPU-intensive applications.

The ADLINK AVA-RAGX rounds out the AVA Series by addressing the needs of deployment in space-restricted environments. Designed for even tighter spaces than the AVA-5500, the AVA-RAGX measures just 288 x 190 x 72 mm yet still offers the required I/O ports, including four M12 Gigabit Ethernet, two USB 3.1 Type A, four digital input and four output 24VDC-110VDC with 1.5kV isolation, HDMI, and M.2 slots for wireless connectivity. Beyond EN50155 compliance, ADLINK adds support for smart ignition control, which helps prevent data loss or corruption due to improper system shutdown. The system is powered by an NVIDIA Jetson AGX Xavier industrial module with 32GB of LPDDR memory, which blends an 8-core NVIDIA Carmel CPU with a 512-core NVIDIA Volta GPU into one compact part. The Jetson platform is specifically designed for AI computing at the edge, where low power consumption and high performance must be optimally balanced.

As edge compute systems designed for expansion and systems compatibility, the ADLINK AVA Series can accommodate rail-specific operations such as:

- Passenger information systems
- Railroad intrusion detection
- Train station surveillance
- Onboard video security
- Railroad hazard detection

In fact, the AI-based video analytics capabilities of the AVA-5500 were exactly what one European railway customer needed when deploying a solution to detect on-track obstacles. The system used input from optical radar, digital cameras, and a range of sensors to identify railway failures and other hazards. Real-time processing of these significant data loads was of truly vital importance. The AVA-5500's ruggedness, combined with its compact design and exceptional processing efficiency, allowed the customer to implement its detection solution quickly and without issues.

Conclusion

Artificial intelligence will create many new opportunities for one of the oldest transportation modes still relevant today. Not only does AI benefit rail businesses, it also benefits the passengers who rely on rail systems for travel, work, and commerce.

From mobile apps to in-train safety features, AI and high-performing systems, like the ADLINK AVA Series, will continue to help advance rail transportation. With its compute power, ruggedness, compact size, and reliability, the AVA platforms are an AI-ready solution that can help modernize the rail industry today.

ADLINK
LEADING EDGE COMPUTING

Building AI's Pervasiveness throughout Rail with AI-enabled Video Analytics Platforms

A line of EN 50155 compliant AI-enabled platforms offer rail solution providers with a high level of flexibility to select the configuration best suited to their use cases, and help them achieve railway digital transformation

AVA-5500

Rugged, fanless AIoT platform with NVIDIA Quadro GPU embedded for real-time video/graphics analytics

AVA-5600

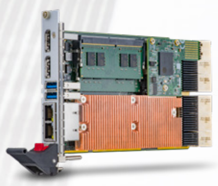
19" 2U rackmount rugged, fanless AIoT platform with high performance GPU for compute-intensive applications

AVA-RAGX

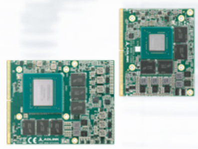
Compact, fanless AIoT video analytics platform with NVIDIA Jetson AGX Xavier for SWaP-constrained deployments

CompactPCI Platforms

Complete solutions consisting of high performance CPCI-S.0 processor/carrier blades, NVIDIA MXM GPU modules and CompactPCI systems



CompactPCI Serial Processor Blades



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