

Rail Asset Management | Whitepaper

AI and Railways: Taking asset performance to new heights

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AI holds transformative potential for the railway industry, offering improvements across various domains. One domain ripe for AI-enabled transformation is rail asset management. With the right mix of insight, expertise, and tools, their use of AI can become incredibly transformative – building a foundation that will reshape rail asset management.

Transforming rail asset management with AI

AI evangelists, data scientists, enterprise architects, business process owners, project managers, and developers already understand the value of AI. Meanwhile, other stakeholders might be less enthusiastic because adopting AI is considered challenging – requiring careful planning, cross-departmental collaboration, and significant organizational changes including shifts in work-flows, processes, and job roles.

Railway organizations are no strangers to this reality. However, they also know that resistance to such change – from cultural barriers to lack of stakeholder buy-in – can hinder successful implementation. The future of their industry relies on building a workforce that thoroughly under-stands AI's capabilities and limitations, clearly articulates business needs, and quickly adopts new technologies and innovations.

SAP commissioned a survey to unravel the true value of using AI in rail asset management. Conducted in December 2023, a series of in-depth interviews with key industry stakeholders uncovered insightful perspectives and findings on the following topics:

- Current business practices in AI adoption
- Areas of improvement for asset management
- Perceived value of AI and strategies for realizing them
- Business and IT skills necessary for effective AI-enabled practices
- Technology considerations for data management, integration, and protection
- Future rail industry vision for AI in asset management within the next 5–10 years



Staying on the right track to high-performing rail assets

High-performing rail assets are vital to achieving railway performance excellence. Railways face two unique asset management complexities:

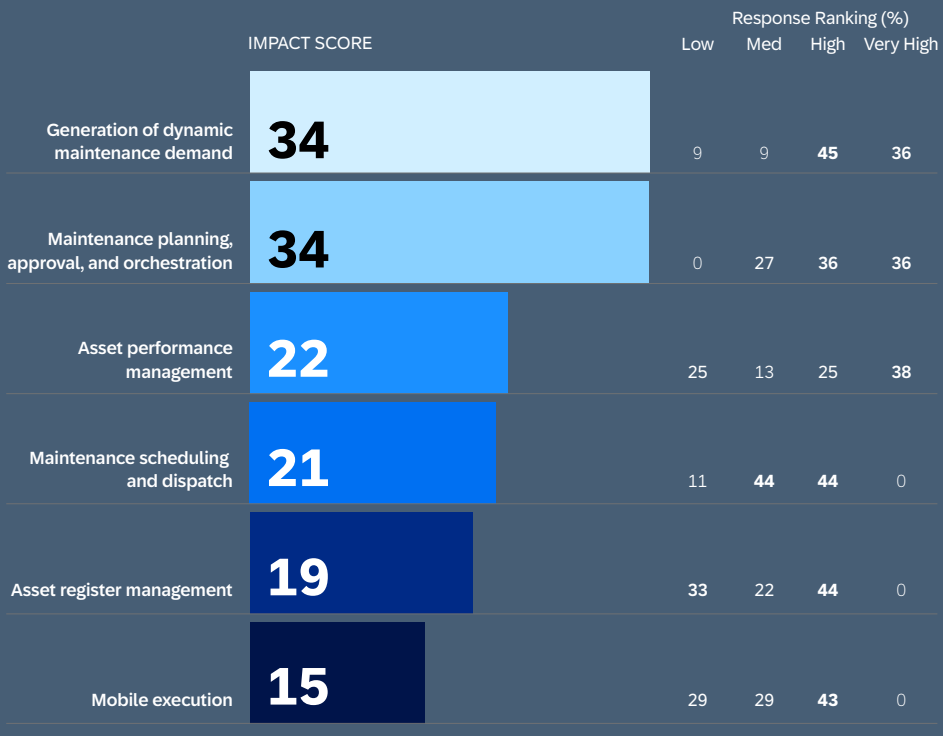
- **On-time delivery:** Freight and passengers get to their destination in good condition and within agreed timelines.
- **Capacity planning:** The utilization of rolling stock and network assets is maximized.

Stir in safety and an increasing number of government regulations that require compliance, and the overall picture becomes clear. There is a relentless drive to do more with less in an increasingly risk-averse private and public environment. Interviewed rail organizations consider AI as a key technology enabler to improve customer experience and asset utilization.

In our exploration, industry experts shed light on specific asset management focus areas and scenarios where AI is poised to make a significant impact (see Figure 1). The consensus is that AI will greatly enhance the generation of dynamic maintenance demand and maintenance planning, approval, and orchestration.

Asset performance management, maintenance scheduling, and dispatch and asset register management will also benefit significantly. Mobile execution is expected to yield medium to high benefits from AI.

Figure 1: Top rail asset management focus areas for AI-enabled transformation



Generation of dynamic maintenance demand

Dynamic maintenance demand results when the maintenance mix shifts from fixed preventive maintenance to condition-based, predictive, and prescriptive maintenance strategies. Leveraging AI-based visual inspections, operators can proactively identify potential issues and predict maintenance requirements more accurately.

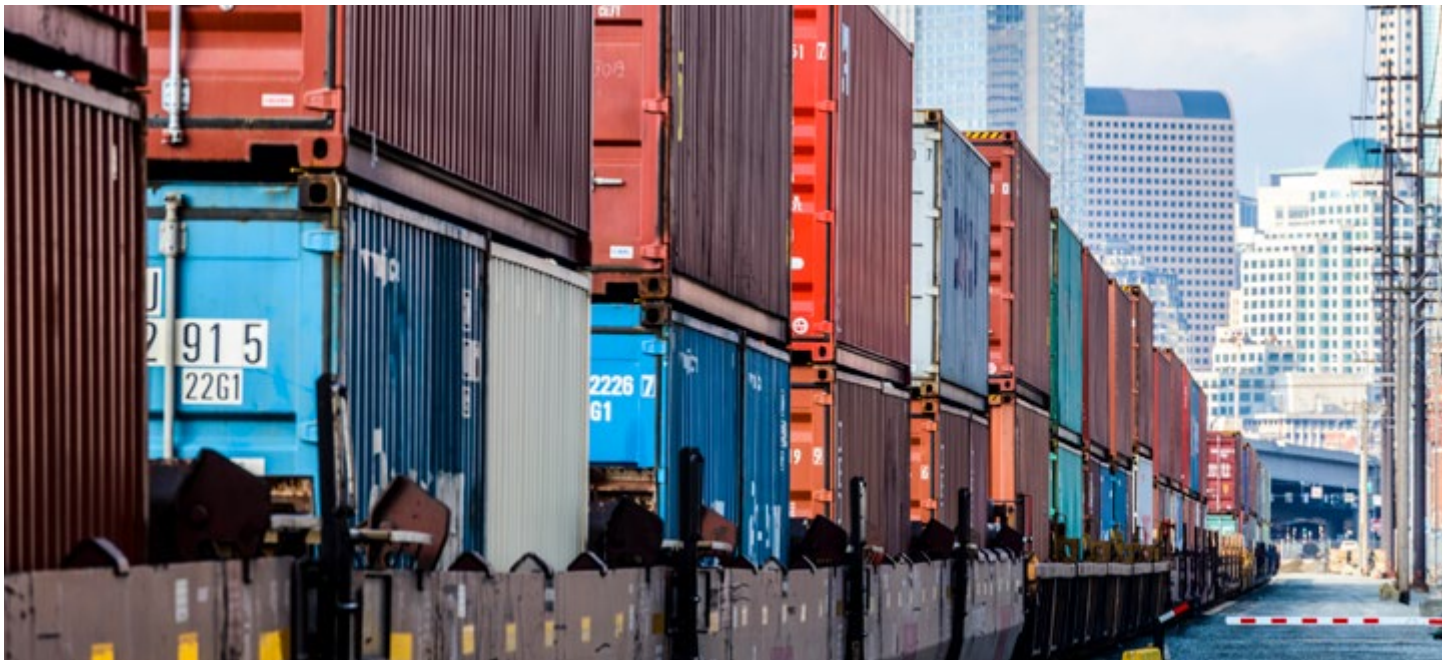
Among interviewed stakeholders, there is a prevailing consensus on the importance of AI capabilities – such as advanced image analysis techniques – in this process. They emphasized the opportunity to forecast and recommend maintenance actions in ways that enhance operational efficiency and extract valuable insights from data. Since such an improvement can be realized immediately, some respondents believe using AI in this capacity is a good entry point toward executive buy-in and organization-wide adoption of the technology.

> “High impact for me – that’s the main **low-hanging fruit.**”
>
> Specialist data science

Maintenance planning, approval, and orchestration

Maintenance planning, approval, and orchestration constitute essential components of effective railway asset management – encompassing long-term, medium-term, and short-term planning initiatives. Railways can streamline maintenance processes and optimize resource allocation by consolidating all work types into a single backlog and coordinating smoothly across supply chain, procurement, and finance operations. Inventory optimization further enhances efficiency by helping ensure the availability of necessary components and materials when required.

Respondents unanimously underscored the significance of AI in facilitating these functions, citing its ability to refine planning processes, accommodate evolving conditions, and improve overall operational effectiveness within the railway industry. Moreover, in recognition of escalating demand for inspections, overhauls, and replacements, they consider AI an opportunity to increase planning accuracy to maximize outcomes within available maintenance windows.





> The need to perform inspections, overhaul, and replacements is rising all the time, but the timeframes where you can physically change something are getting shorter. It's important that we have accurate planning and do the right thing at the right moment.

Railway principal consultant

Asset performance management

Asset performance management is a critical factor in efficient and safe railway operations. It requires a thorough understanding of each asset's significance and tailored strategies for maintaining it.

Railway operators can meticulously evaluate asset performance and prioritize maintenance efforts by using embedded, AI-enabled methodologies. They include risk and criticality analysis, reliability-centered maintenance (RCM), and failure mode and effects analysis. This approach closes the loop between maintenance strategy definition and execution, helping ensure alignment and optimization throughout the asset lifecycle. AI is also seen as a crucial component in the transition from preventive to prescriptive maintenance, enhancing the ability to predict and prescribe maintenance activities.

While surveyed stakeholders widely acknowledged AI's potential in predictive and prescriptive maintenance, their opinions on implementation readiness and effectiveness within their existing systems differed. Some respondents advocated for AI's high potential for streamlining maintenance processes and improving overall efficiency by enhancing their teams' understanding of equipment failure and ability to predict breakdowns. However, many were still concerned that the scope and readiness of their current technologies may be too complex to support these capabilities.

> "AI can really improve the way we understand the defaults we have. And if we understand them better, we can also predict when it's going to break, when the default will be too big for the train to go smoothly, and if we can adapt maintenance. Then, our operations are more efficient and less time-consuming because we already know exactly what we want to change how we want to change it."
>
> Engineer and research project manager



Maintenance scheduling and dispatching

Scheduling and dispatching are integral to the efficient functioning of railway operations that demand intelligent optimization and prioritization of tasks alongside capacity management and resource assignment. Among respondents, the perceived usefulness of AI in this domain ranked high.

The potential for AI to optimize schedules, manage train-related activities, and enhance traffic control is particularly promising. However, some respondents caution that this level of AI applicability may hinge on factors such as system integration and data maturity. Nevertheless, the prevailing sentiment underscores AI's considerable value in scheduling and dispatching, with one respondent succinctly affirming its centrality to their operational paradigm.

> "Good predictions – that's the part where you can really optimize things. With good scenarios and decisions, you can put money in the right places."
>
> Head of algorithms for operations



Asset register management

Although the perspectives of survey respondents varied, the majority agreed that AI can play a significant role in asset register management, especially during architectural transitions and data format transformations.

As part of a larger ecosystem, railway organizations must regularly exchange information and documentation across a network of manufacturers and service providers. Using a cloud-based architecture to build the central repository, they can leverage a digital twin of a physical asset during decision-making and enable cross-organizational collaboration.

Railway organizations can go even further by using the transformative power of AI. They can standardize processes, harmonize solutions, and facilitate data transformation from noncompatible formats in their business systems – all of which are too complex or time-consuming to be accomplished by hand. For example, chatbots can be embedded and trained to gather all that knowledge and offer real-time insights in the proper business context.

> “We are part of an ecosystem. We always exchange and collaborate with manufacturers that have their own data formats and service providers. AI will be very important and extremely relevant as it also has a huge chance to transform data from noncompatible formats.”
>
> Railway principal consultant



Mobile execution

Mobile execution in maintenance operations helps ensure field technicians have all the information they need to complete work orders efficiently and effectively. However, respondents' opinions on the importance of using AI in mobile apps vary.

Some stakeholders cited potential benefits, such as enhancing communication, facilitating knowledge transfer, and improving task efficiency for maintenance agents. Meanwhile, others expressed skepticism on whether AI has any real impact on the accuracy of that information. Yet, another subset of respondents took a longer-range view of the advantage of AI in mobile execution, sharing that the technology could allow the use of augmented reality (AR) and virtual reality (VR).

AR leverages a combination of computer vision and deep learning algorithms to detect objects, analyze shapes, and identify faults – providing invaluable assistance to agents in understanding the nature of faults and how they should be addressed. This advanced technological assistance can optimize maintenance processes and improve overall efficiency.

> "If we think about AR and VR (especially AR), it's based on computer vision and deep learning to detect different objects to analyze their shapes, the defaults, and so on. It can be useful for the agents to properly understand what the default is, how it must be repaired, and more."
>
> Engineer and research project manager





As evidenced in this business prioritization exercise, the level of AI integration into business processes varies based on the use case and its impact on users. In some applications, the use of AI is often smooth, enhancing user experience without explicitly stating its involvement.

Standalone AI applications – such as chatbots including GPT – act as valuable knowledge management tools. These tools can gather personalized information to prevent loss when individuals with specific knowledge leave an organization. Leveraging chatbots could also be critical in knowledge-intensive processes, providing a centralized source of information.

Opinions also paint a picture of separate, individual standalone AI applications that, over time, progressively become embedded in every part of the business processes. The vision is of an AI that comprehensively understands and embodies the entire business process.

> **Bottom line:** The consensus is that AI's impact is, and will be, substantial – unlocking previously challenging capabilities to improve decision-making across various business domains.

Showing the value

Interviewed rail organizations view AI as a key technology enabler of high-performing rail assets. They believe the technology is part of the next frontier to improve asset utilization, leading to a better customer experience. Respondents also identified additional value in greater operational efficiency and effectiveness, improved safety, higher employee satisfaction, and enriched knowledge retention.

According to survey participants, AI's contribution to the value drivers above can be attributed to the following key factors:

Extracting value from big data

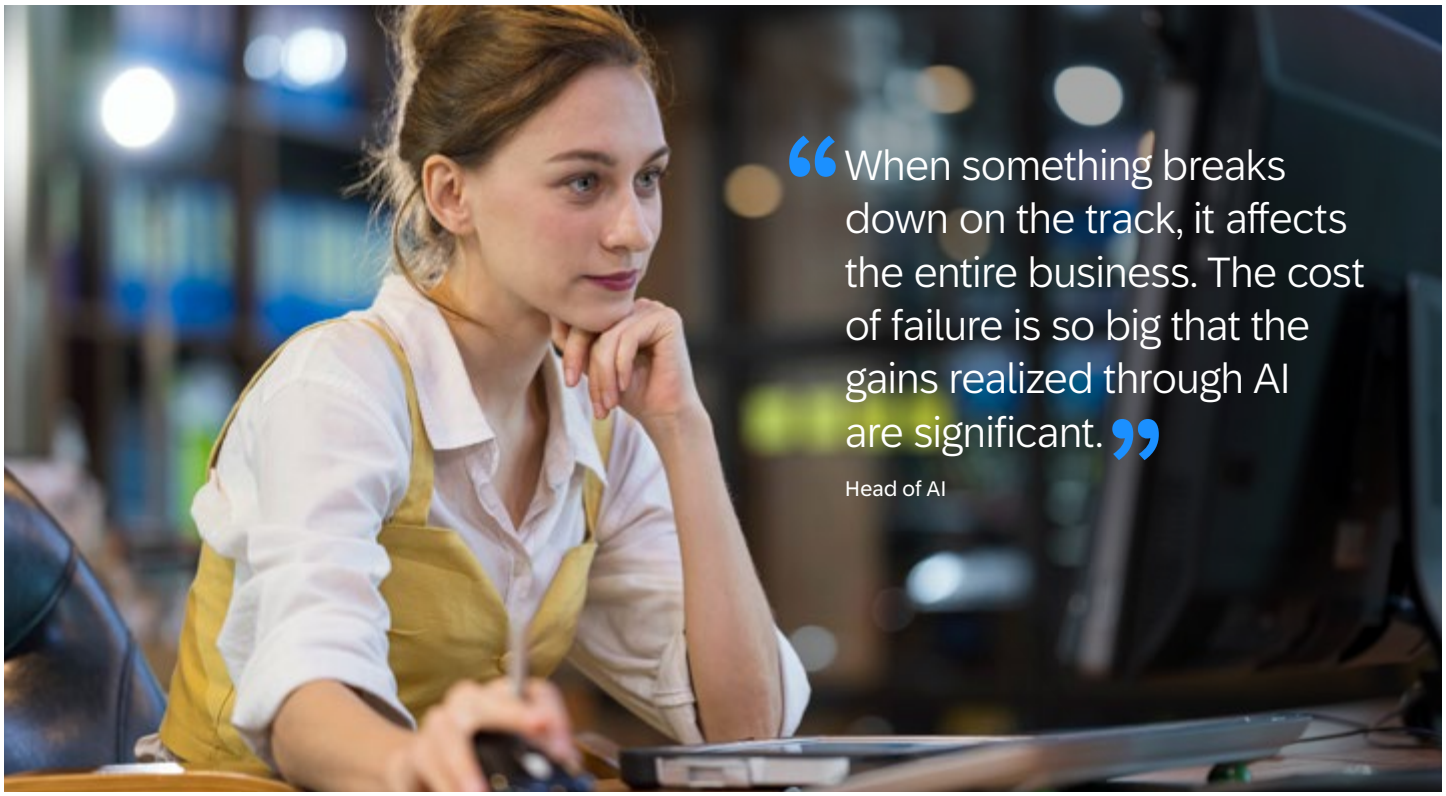
The exponential increase in available data – facilitated by an explosion of sensors and simple data storage options – has created a need for advanced tools to process and analyze vast datasets efficiently. This aligns with deep learning capabilities that generate substantial data, particularly in fields such as railway maintenance.

Exploiting the power of deep learning

Continuous advancements in deep learning technology serve as motivation for exploring and integrating AI into existing workflows. Innovation departments actively engage in AI research and proofs of concept to understand the limits and possibilities of these tools.

Knowledge retention

Maintenance agents play a crucial role in identifying specific needs for tools and technologies based on their practical experiences, contributing to the development of tailored solutions, and enabling knowledge retention.



Preparing to overcome barriers and challenges

The adoption of AI in railway asset management faces numerous challenges. But it's possible to overcome them and deliver successful AI implementations when organizations are well-prepared with the right blend of technology, compliance practices, and skilled talent.

Skills considerations

A solid understanding of AI is essential. Technology managers need to discern what is feasible, judge the limits, and bridge the knowledge gap between experts and practical implementation. Encouraging ongoing learning is crucial, as some companies may be operating with outdated knowledge. Openness to new technologies and a proactive approach to pushing for advancements are necessary.

The question of AI implementation is evolving rapidly, especially as the concept of democratized AI becomes more prevalent. Adapting to this technology requires a balance of enhancing existing roles and skills and adding new ones. Depending on the organization's approach, either building an internal core development team or leveraging existing roles with external expertise could be the strategy.

Exploring internal resources first is advisable, with domain knowledge being crucial. Hiring external support for specialized expertise or when internal resources are insufficient for larger projects is a common approach. The importance of exploring external collaborations – such as public tendering – is acknowledged, especially for large-scale projects or when specific expertise is needed.



Stakeholders participating in the survey mentioned the following skills as a high priority for their IT teams:

- Project management to keep developers on track and meet deadlines consistently
- Relevant programming knowledge, coupled with a comprehension of mathematics and statistics underlying AI models
- Effective communication to help ensure organizational decision-makers understand the costs involved in server usage, data acquisition, and industrialization
- Collaboration with consortiums and entities to reduce development time while protecting intellectual property protection

On the business side, interviewed stakeholders highly ranked skills, including:

- Solid understanding of AI to nurture a culture of openness toward technological advancements
- Awareness of limitations in existing processes, talent, and technology to discern the feasibility of desired business changes
- The mindset of a life-long learner with the willingness to engage in ongoing learning, role-specific training, and a guided user experience to bridge knowledge gaps

Social, technical, and environmental considerations

Scaling up AI capabilities from a proof of concept to a live, working deployment involves complex decision-making. Such determinations include choosing between on-premise and cloud solutions, determining algorithm placement, and creating maintenance and update protocols. Questions about the lifecycle of the AI model also inevitably arise – from algorithm ownership, knowledge retention, data sensitivity, and intellectual property protection to the use of external technology providers.

Like most digital investments, costs are another concern on various fronts. While finances and expenses can be negotiated, AI's social and environmental costs – such as data collection and algorithm training – often conflict with railways' public service focus, including job displacement and energy consumption.

To alleviate those fears, operators should include workers, where feasible, to be part of AI strategy definition and decision-making to address ethical concerns and ensure safety. Planning and cultivating an open mindset toward AI solutions are seen as essential for leveraging the technology's potential.



Risk considerations

While autonomous or automated systems are evolving, survey respondents agree that human involvement is vital, especially when human perception overrides AI outputs in critical situations.

Picking AI solutions that comply with railway industry standards and regulations is a multifaceted challenge. For example, security applications, such as systems accompanying drivers, must meet stringent safety integrity level requirements where AI performance is comparable to or better than human capabilities. The difficulty lies in aligning with authorized failure rates, which is critical in scenarios that could lead to catastrophic consequences. The regulatory landscape proves challenging due to varying safety requirements across different use cases.

To address compliance challenges, algorithms must be enhanced to improve performance with as few failures as possible. This includes categorizing use cases based on impact and safety considerations and collaborating with various entities to build trust in the AI scenarios.

In summary, successful AI implementation demands a harmonious blend of five key factors:

- Technical proficiency
- Effective communication
- Proactive project management
- Adaptability to evolving technologies
- Strategic approach to internal and external collaboration

Realizing the promise of AI with a relevant, reliable, and responsible partner

The convergence of AI and railway operations presents unprecedented opportunities. As AI advancements capture the imagination of innovators worldwide, rail asset management stakeholders are increasingly exploring how AI solutions can revolutionize their systems – making them smarter, more responsive, and ultimately, safer and more eco-friendly.

Many leading railways worldwide benefit from SAP investments in the next generation of AI-powered startups. At the forefront of this transformative wave, our vast solution portfolio offers partnership and innovation that redefine how businesses, including railways, operate. With SAP Business AI technology, organizations can catalyze transformative change by deeply embedding AI capabilities into their processes and analytics.

SAP Business AI also holds significant relevance to rail asset management due to its integration within SAP applications and alignment with the dynamic, time-sensitive nature of enterprise asset management. The technology helps enhance efficiency and effectiveness in tasks such as maintenance planning, scheduling, and resource allocation through features such as notifications, recommendations, and predictions.

This human-centered approach empowers railway personnel to control decision-making processes while leveraging AI capabilities to streamline operations and improve outcomes. By adhering to clear AI design principles outlined and enabled by SAP, rail organizations can optimize performance while ensuring operational transparency, simplicity, and impartiality.

Across SAP and our global partner ecosystem, AI capabilities in rail asset management are evolving quickly, supporting use cases including:

- Asset performance management:
  Use machine learning for insights into equipment failure modes and probable causes.
- Intelligent warehousing and logistics:
  Simplify setup processes using AI to automatically derive slotting rules from product data.
- Generative AI assistant:
  Revolutionize how users interact with SAP business systems, making every touch point count and every task simpler.
- Visual operations intelligence:
  Automate and optimize tasks associated with computer vision-based asset tracking, inspection, and management.
- Intelligent Asset Management powered by Generative AI:
  Find the most relevant information from equipment, installation, and maintenance manuals by using generative AI.





SAP also offers a comprehensive AI foundation within the SAP Business Technology Platform. It facilitates the development, training, and deployment of AI models underpinned by enterprise-grade safety and security measures. Access to such an integrated suite of AI capabilities allows rail organizations to industrialize AI innovation, ensuring deployment at scale to drive positive business outcomes.

Learn more

Join us on the journey by connecting with your local SAP representative and exploring the value of embedding AI into your supply chain and asset management processes with technologies such as SAP Business AI solutions.

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