Enterprise Asset Management and Digitalization of Rail Systems

Bringing benefits to rail operations and maintenance: combining the capabilities of a virtual twin with smart management and ISO 55001 for operational assets and services—all within a digital standard framework embedded into the railway production system.

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This whitepaper was developed by DB International Operations in collaboration with WSP and Dassault Systèmes.

Since the first passenger train ran nearly 200 years ago in the United Kingdom from Darlington to Stockton, getting goods to market quickly and providing safe, reliable and affordable passenger transport services have been the most important priorities for the railway. Globally, there is mounting pressure to do more with existing infrastructure—much of which was designed and constructed many years ago and is approaching end-of-life. Faced with budget limitations and rising expectations from passengers, stakeholders and shareholders, there is an increased need for infrastructure owners and operators to find efficient ways to extend the lifespan of existing assets and improve existing railway systems.

Ultimately, investment in rail infrastructure is needed to replace life-expired assets (including trains) and future-proof the railway environment for the benefit of users and owners alike. Digitalization will be key to ensuring these investments can deliver optimal outcomes in the areas of safety, operational quality and availability. To deliver continued, reliable services across the network, infrastructure owners and operators will need to adopt a holistic approach to ensure that replacement assets integrate seamlessly with existing ones.

Railway owners and operators are being faced with a myriad of emerging needs across a range of stakeholders. These expectations are typically over and above the core provision of safe, reliable and comfortable services and must be met to ensure that the railway delivers continued benefits for passengers and shareholders. Increasingly, stakeholders are seeking technology-enabled services, primarily for the benefit of passengers, including Wi-Fi enabled carriages, ticketing systems which are cyber-safe, and seamless fare integration with other networks. The increased political and social awareness of environmental issues means focus must also turn to the implementation of greener, low-carbon transport in the face of pressure to reduce whole lifecycle carbon impacts.

As more equitable access to the railway becomes more central to decision-making, Environmental, Social and Governance (ESG) principles guide business activity, particularly for governments and other buyers. The role of enhanced technologies is critical in addressing these pressures and it will be important for owners and operators to create conditions where existing networks can be agile in adopting newer technologies.

Some of the more holistic challenges that railway infrastructure owners and operators face, and that can be addressed by digitalization, include:

- How can operators deliver safe and reliable services while accommodating higher expectations from passengers for an enhanced experience?
- How does the rail industry attract new generations of users and workers, reduce travel time and deliver affordable services?
- Can owners and operators reduce waste in operations, make quicker repairs and eliminate unnecessary downtime?
- How is it possible to deliver cost-effective operations?
- How do owners ensure on-time performance?
- Can existing railway systems be transformed into modern ones?
- How can net zero targets be met with ESG compliance?

Enhancing profitability and customer satisfaction through resilient railway production systems supported by a digital standard framework

Through building on the fundamentals of standardized asset management, for example through ISO 55001 – Asset Management, and applying digitalization to the railway network system, owners and operators will have the opportunity to unlock additional value from existing infrastructure. By conceptualizing the railway network as a “production system” comprising four key processes—preparation for the customer train ride, asset management of infrastructure, delivery of customer services and customer information, and asset management of rolling stock—it becomes apparent that the key processes of the production system must be viewed as a whole if continued profitability and customer satisfaction are to be achieved. Establishing a digital standard framework which works hand-in-hand with the production system will enable data management across the four elements of the system and will play a crucial role in the successful and efficient delivery of rail operations and maintenance (O&M).

A strong foundation for data orchestration during the O&M of railway infrastructure is needed and will be based on the essential building blocks of:

- Data generation;
- Data distribution;
- Data processing; and
- Data storage to support each phase of the production system properly within O&M.

Traditionally, during the O&M of railways, data is collected and analyzed after the fact. By applying Smart Enterprise Asset Management (SEAM) and modernizing systems through digital adoption for railway O&M, teams can consolidate data analysis and data science processes into control room dashboards to detect malfunctions before they cause failures. This is predictive condition-based O&M. Digitalization enables faster production of critical data through automation and computing power, which allows users to develop a more timely understanding of situations and equips them with information to take faster, better-informed decisions in response. For example, the use of big data and data science supports improved awareness of asset health which, in turn, enables improvements to reliability and safety.

The availability of insights offered by enhanced and predictive data can also result in a reduction of O&M costs. This can be achieved through analysis and iteration of data that allow impacts to be better understood and assessed before potential issues cause damage.

Reflection: Rail infrastructure owners and operators are not yet operating at their full potential in terms of providing customers and funders with a safe, quality service that is demonstrably value for money. Digital Asset Management provides a system-wide approach that has the breadth, depth and whole-life focus necessary to help infrastructure managers to realize this potential. Through implementation and integration within the digital standard framework, a digital twin-of-twin system can steer, control and optimize operations and maintenance outcomes.

Using digital assets within the production system to generate data that can optimize outcomes

The impact on passengers (and owner/operator finances) of asset or equipment failures that result in train service downtime is significant. Alongside this, the cost of repairing ageing assets generally increases over time due to many factors, including higher labour costs, supply chain disruptions and the quality of manufactured parts.

Figure 1 illustrates the exponential cost of reactive and/or planned maintenance; the optimal navy line shows that front-end planning and investment in setting up digital twins with sensors, combined with the application of data science and analytical techniques for condition-based predictive maintenance, will result in long-term cost savings (an owner benefit). The upfront investment in digital twins would also result in increased reliability (a user and owner benefit).

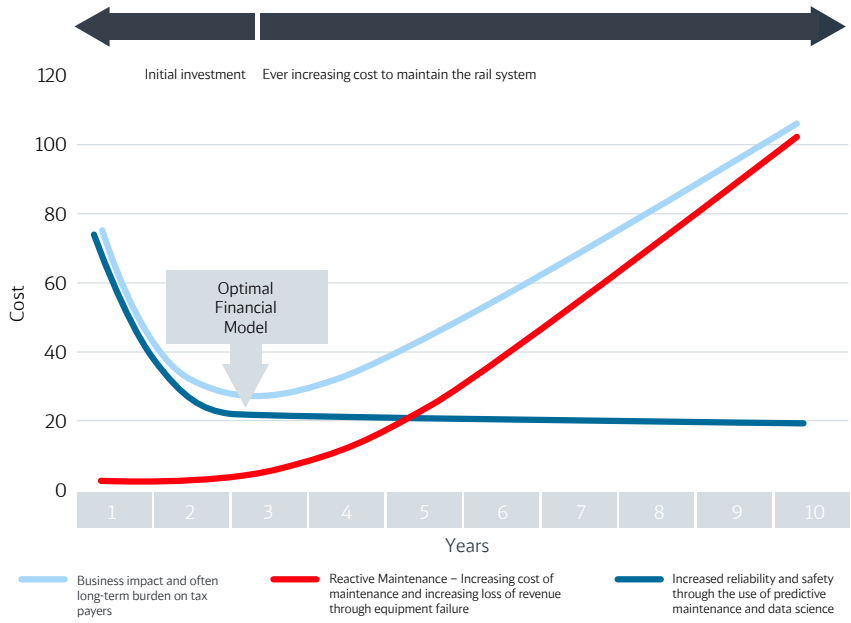

Figure 1 – Financial model scenarios with and without smart enterprise asset management

Digitizing existing assets can also generate significant value for railway O&M functions. The digital standard framework enables technicians to 'see' each asset via asset tags, including details such as its manufacturer specifications and part numbers.

As manufacturers move towards digitizing operations manuals as standard for new equipment, the digitization of older, paper-based manuals will enable field operatives to have real-time access to step-by-step maintenance instructions via digital tablets or smartphones.

When paired with parts look-up and ordering instructions, digitization in this manner means technicians will be able to order parts in real-time, shortening the time taken to restore assets to working order. The fingertip-availability of instructions also enables benefits to be realized through the consistent application of the instructions by all teams, regardless of their location.

Online and digital asset management allows a single point of truth to exist for O&M organizations, providing accurate, consistent and up-to-date information to all users, whether they are management or field operatives, relative to their job function. It allows visualization of data, through dashboards, to manage daily performance against key performance indicators and brings important information closer to the people who can make improvements the fastest.

For new projects, a Common Data Environment (CDE) and an integrated information model can support the engineering and construction stages by use of a model-based system-of-systems engineering (MBSoS). The MBSoS provides a comprehensive 360-degree view (in 2D or 3D) of the critical requirements and allows modelling and simulation that drive quality design solutions for the construction and O&M phases of the project. During the O&M phase, analysis of the enhanced data collected through digitalization can also help to inform better investment decisions and selection of more suitable products.

The deployment of digital tools can provide mitigation against some of the most common challenges facing railway infrastructure owners. A list of the headline challenges, together with their digital mitigations, is shown below in Figure 2.

Smart Assets can reduce the Impact of Common Challenges in Railway Networks

Common Challenges	Mitigation with Digital Tools	Time to Implement	Benefit vs Cost
1. Aging assets	IoT sensors for predictive failure detection	▼	★★★★ / $$
	Data science and analytics for asset health forecasting	▲	★★★★ / $$$$
2. Lack of Digital Skills	AR and VR for training, repair guidance and remote instructions	▼	★★★★ / $$
3. Labour shortages	Automation systems for operations and facilities	▲	★★★★ / $$$$
4. Supply Chain lagging behind in digitalization	Enterprise Asset Management / RFID tracking	▲	★★★★ / $$$$
5. Unplanned Service disruptions	Big Data Analytics IoT sensors (temperature, vibration, noise, etc.)	▼	★★★★ / $$
6. Increasing maintenance costs	Automation for routine repairs such as robotics	▲	★★★★ / $$$
7. Uncoordinated repairs	Digital Twin and a Single Pane of Glass view of asset condition	▼	★★★★ / $$$
8. Anomalies or unusual equipment operation	Machine Learning for early problem detection e.g., vibration, noise, temperature	▼	★★★★ / $$
9. Train Delays	Automated Passenger info alerts	▼	★★★★ / $$
10. Pollution, Noise, Vibration alerts	IoT Sensors linked to dashboards	▼	★★★★ / $$
11. Passenger Services	Integrated Fare Systems	▲	★★★★ / $$$$
12. Doors	Presence Detection	▼	★★★★ / $$
13. Heating / Cooling	Optimize air flow for passenger health and comfort	▼	★★★★ / $$
14. Elevators / Escalator malfunctions	Digital passenger alerts to Smart Phones, IoT sensors	▼	★★★★ / $$

Figure 2: Common challenges that can be mitigated through digital intervention

The benefits of virtual twins

Infrastructure owners and operators can benefit by undertaking digitalization from the earliest stages of a transit system project.

It is recommended that an integrated information model is built progressively during the engineering and construction phases of the project. This will allow the full value of benefits to be realized when the as-built virtual twin of the transit system is used during the O&M phase. By combining virtual simulation capabilities from the early planning and construction phases with the digital standard framework that is built up within the mobilization phase for the production system, an intelligent digital and automated rail system can be created for O&M.

A virtual twin, also known as a digital twin, is an intelligent digital replica of a physical asset, including processes and systems, with continuously enriched field data. Multiple teams are required to support virtual twins; this support will enable delivery of highly reliable and safe rail services using digital asset management and predictive maintenance methods based on modelling and data-driven decision-making within the digital standard framework. By combining digital asset management, virtual simulation capabilities and data sourced from real-time operations, an intelligent digital rail system is created.

In the overall context of the railway's production system, digitalization of asset information allows the production of enhanced data relating to assets that can be analyzed down to component level. This detailed and targeted information typically enables faster troubleshooting at a system or component level, making it is easier to track and understand how assets are operating and also to understand whether they are within a targeted range of operating parameters that supports reliable performance.

In a digital railway network environment, data and indicators can be tracked through visual tools, such as traffic light indicators, with red, green or yellow to show asset health in a consolidated network map. When O&M teams can visually understand the condition of each asset, it allows proactive repairs to be made to prevent larger-impact failures, which delivers the more desired financial outcomes illustrated earlier in Figure 1.

Figure 3: Control room digital network views (2D)

Further benefits of virtual twins include that they support lifecycle assessment (LCA) through enabling testing of multiple scenarios to optimize selection of assets, material, energy sources and their environmental impact throughout construction, operations, and maintenance cycles much faster than traditional methods. The virtual twins can also assist with stakeholder training, engagement or consultation including augmented reality (AR) and virtual reality (VR) as well as run optimal network planning simulations, safety inductions, repair simulations, remote repair guidance, visualizing of hidden utilities during excavation and repair works and many more use cases.

Digitalization strategy of the production system through a digital standard framework

For existing railway networks, developing a digitization strategy will involve setting goals and priorities, leveraging technology and establishing production systems by adopting standards such as ISO 55001 and ISO 19650 (Building Information Modelling) based on common data environments. For effective digitalization of the production system, a Digital Standard Framework with virtual twins of assets is needed, to enable real-time monitoring, gain faster insights from big data, and Internet of Things (IoT) sensors to shorten the time needed to troubleshoot and reduce the likelihood of unexpected issues occurring on the rail network. Our conceptual diagram of the production system and digital standard framework is illustrated in Figure 4.

The production system consists of four key processes as can be seen in Figure 5. These are:

1. Preparation for customer train ride;
2. Asset management infrastructure;
3. Customer train ride and customer information; and
4. Asset Management Rolling Stock.

To achieve the desired outcomes on a system-wide level, the planning, steering and execution needs to be considered for each of the key processes.

Developing the framework into a potential blueprint for steering and optimizing railway operations requires further consideration to be given to the four Production Resources which make up the physical assets of the railway system, namely workforce, railway infrastructure, rolling stock and consumables. Each should be given a clear RACI-responsibility (responsible, accountable, consulted, and informed).

Similarly, the Digital Standard Framework as depicted in Figure 4 provides a scalable, data-driven framework and applications for O&M that build upon the key processes. Effective data-orchestration (data generation, data distribution, data processing and data storage) across the four production resources will enable an increased ability to manage and optimize railway operations.

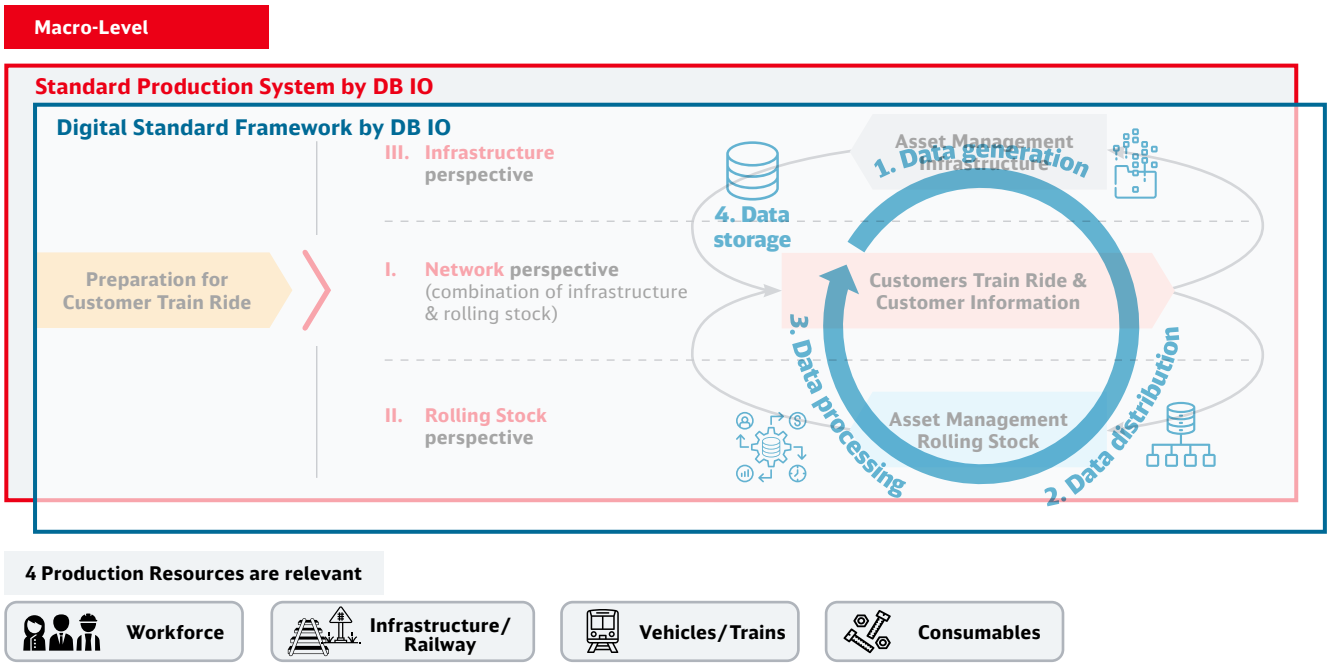

Figure 4: Digital Standard Framework by DB IO

Deep Dive: Smart Enterprise Asset Management Strategy

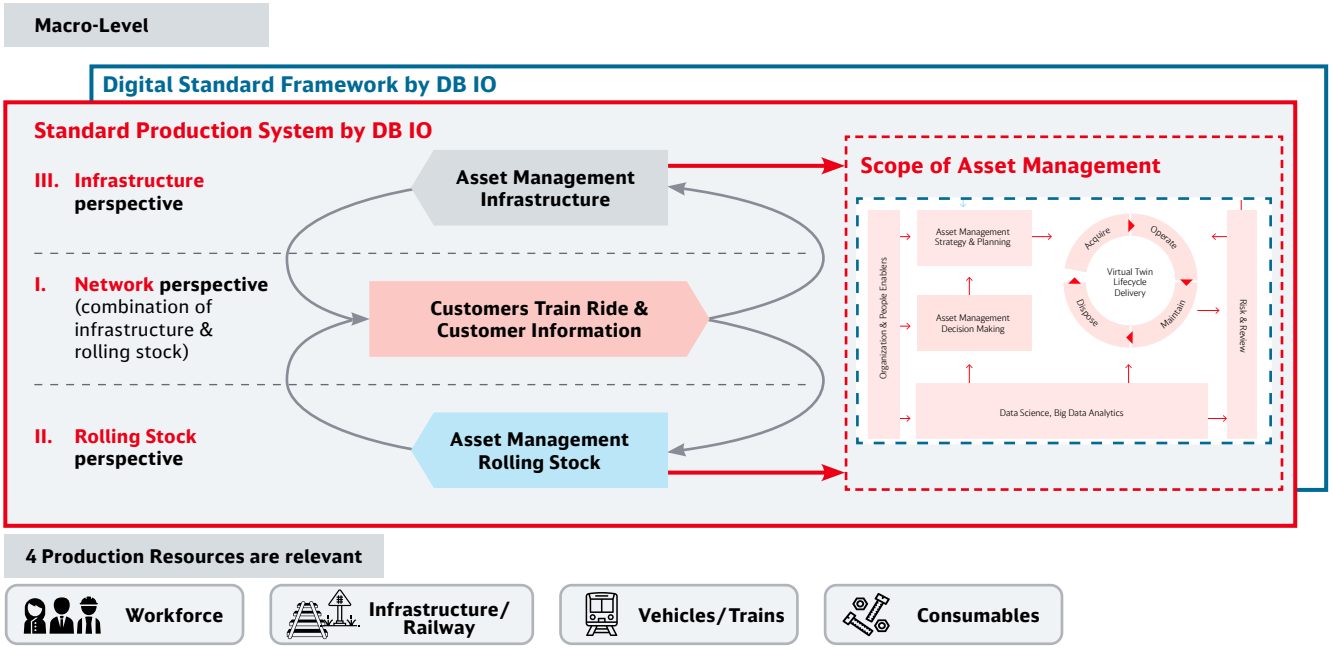

Figure 5: Production System and Digital Standard Framework by DB IO: expanded

Enterprise Asset Management is deployed at the organizational level to protect investments in assets, systems, resources and the inventory of critical assets.

At an operational level, infrastructure assets and rolling stock can be fitted with sensors that gather and share information to enable timely data-driven decision making for railway operations. This data enables control room operators to see alerts and to respond to operating conditions that are out of the norm (e.g. ice) to provide early warning for operations teams, dynamically. Trains that are equipped with sensors can provide data gathered across the overall rail system to support digital O&M. Typically, such assets are regarded as smart assets.

When enterprise asset management is combined with smart assets, railway owners can benefit from potential savings due to more targeted and generally less service interventions.

As the owner organization matures, tools such as the virtual twin can enable a wide range of tasks across the O&M spectrum of activities, including modelling of customer demand, maintenance schedules for planned and unplanned works and field teams' availability to propose interventions, re-routing of network traffic and provision of dynamic and accessible information for passengers.

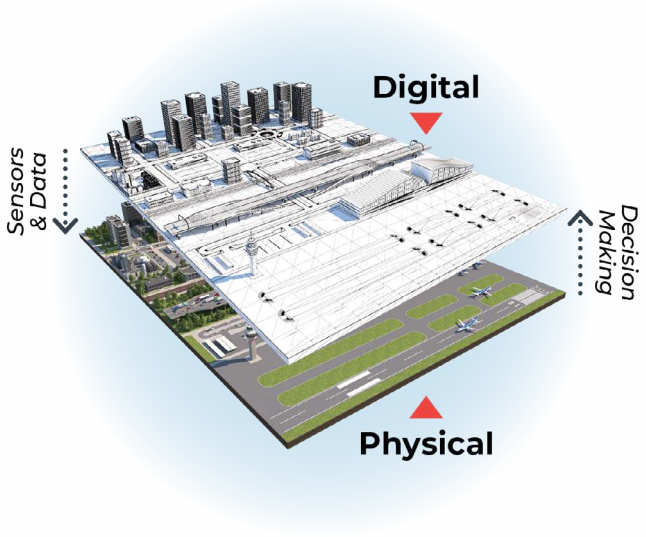

Figure 6: Virtual Twin for Railway Network (3D)

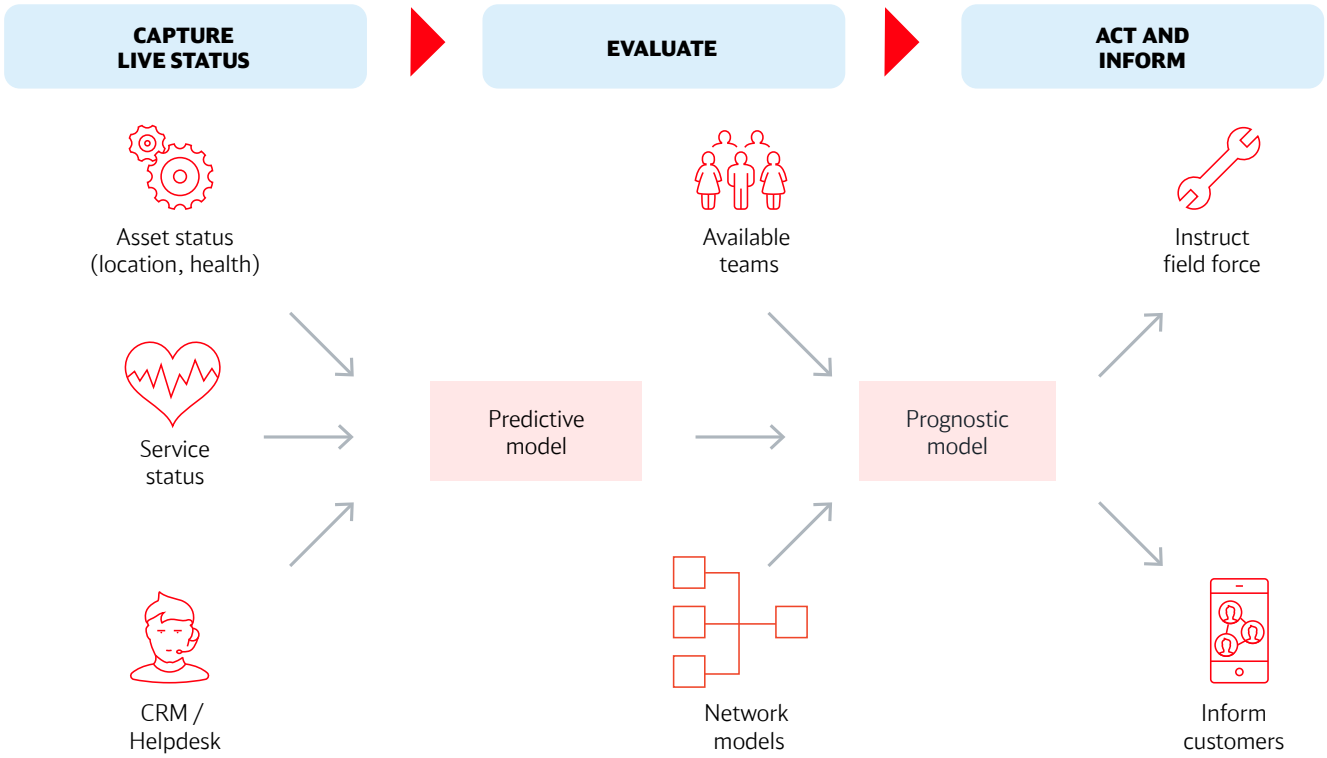

Figure 7: Integrated Smart (Digital) Enterprise Asset Management, courtesy of Institute of Asset Management

Implementing the Smart Enterprise Asset Management roadmap requires the creation of fundamental plans and policies from across the organization, such as:

- Asset Management Policy;
- Asset Management System Playbook;
- Asset Policies;
- Intelligent Infrastructure Roadmap;
- Asset Information Requirements;
- Cybersecurity Strategy;
- Asset Ontology; and
- Risk Management & Mitigation Plans.

To deliver improved rail services with existing rail operations and maintenance teams, it is important to establish alignment across all teams within the organization. Setting and leading the vision from senior levels within the business is a critical success factor in establishing a collaborative culture across operations teams. The shift towards smart (digitalized) assets and inventory management typically occurs over a two-to-five-year horizon, which allows sufficient time for staff engagement, goal setting, budget allocation, and design and implementation of digital architecture that will enable modernization of the underlying systems.

The data of virtual twins can also be leveraged to integrate with maintenance ticketing systems to facilitate prioritization of repairs, faster identification of the location of trouble spots and training for new O&M teams.

The integration with maintenance ticketing systems also provides a linkage between physical assets and operational history whereby data analytics can help to identify areas that are commonly failing or in need of routine repairs.

Figure 8: Virtual Twin for Railway Network (2D)

Virtual twins enable asset owners to better envision, design, build, operate, maintain and manage nearly everything in the built environment. These new capabilities allow teams to simulate conditions to improve design, apply data science, utilize predictive analytic capabilities and to see information more clearly through visualization for the entire project lifecycle (i.e. design, construction, commissioning, operation, and maintenance).

The outcomes can be far-reaching, such as lowering the costs of operation, achieving operational efficiencies continuous improvement and developing deeper learning of asset behaviour in the integrated railway network. Figure 9 captures the strategic value that virtual twins can deliver.

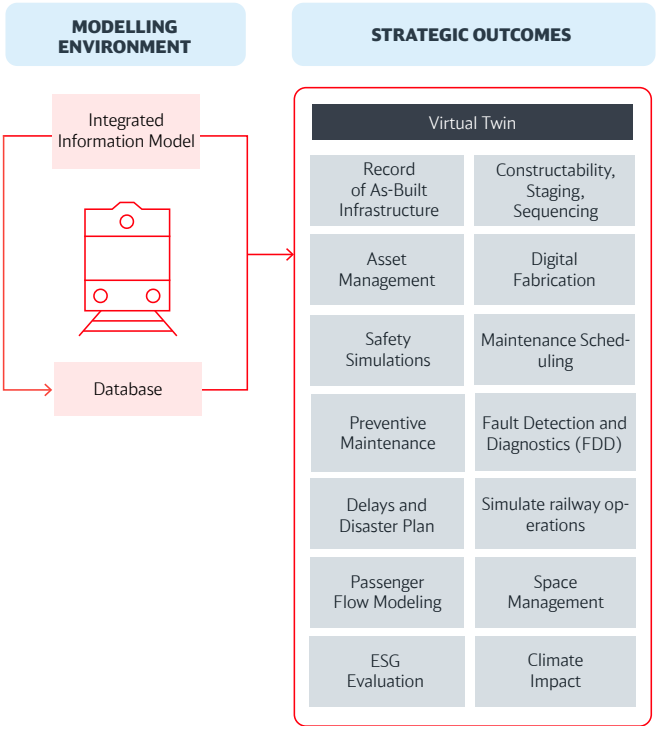

Figure 9: Strategic Value from Virtual Twins developed for Railway networks

Digital solutions to common railway challenges

Railway infrastructure owners and operators who pursue a strategy of digitalization can benefit from significant operational improvements and financial efficiencies in the reliability, safety, operations, maintenance and sustainability of railway infrastructure assets. The integration of virtual twins and Smart Enterprise Asset Management as a combined approach improves standardization and enables predictive capabilities, as well as faster turnaround times for repairs, throughout the lifecycle (e.g. design, construction, commissioning, operation, and maintenance) of assets and systems.

The application of digital technology within railway environments has evolved significantly over recent years. Best practices can be adopted progressively over time, which affords railway owners the scope to phase the cost of investment over several years. Examples of this approach can be found in the Calgary Transit, TGV, DB, SMRT, and Shinkansen operations, which have adopted automated data collection systems for track health; information from the rail assets is automatically collected using remotely operated rail cars fitted with sensors to collect valuable information for preventive maintenance, monitor asset health and optimize resources.

Related reading: Delivering Intelligent Integrated Digital Rail Systems and Operations & Maintenance

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