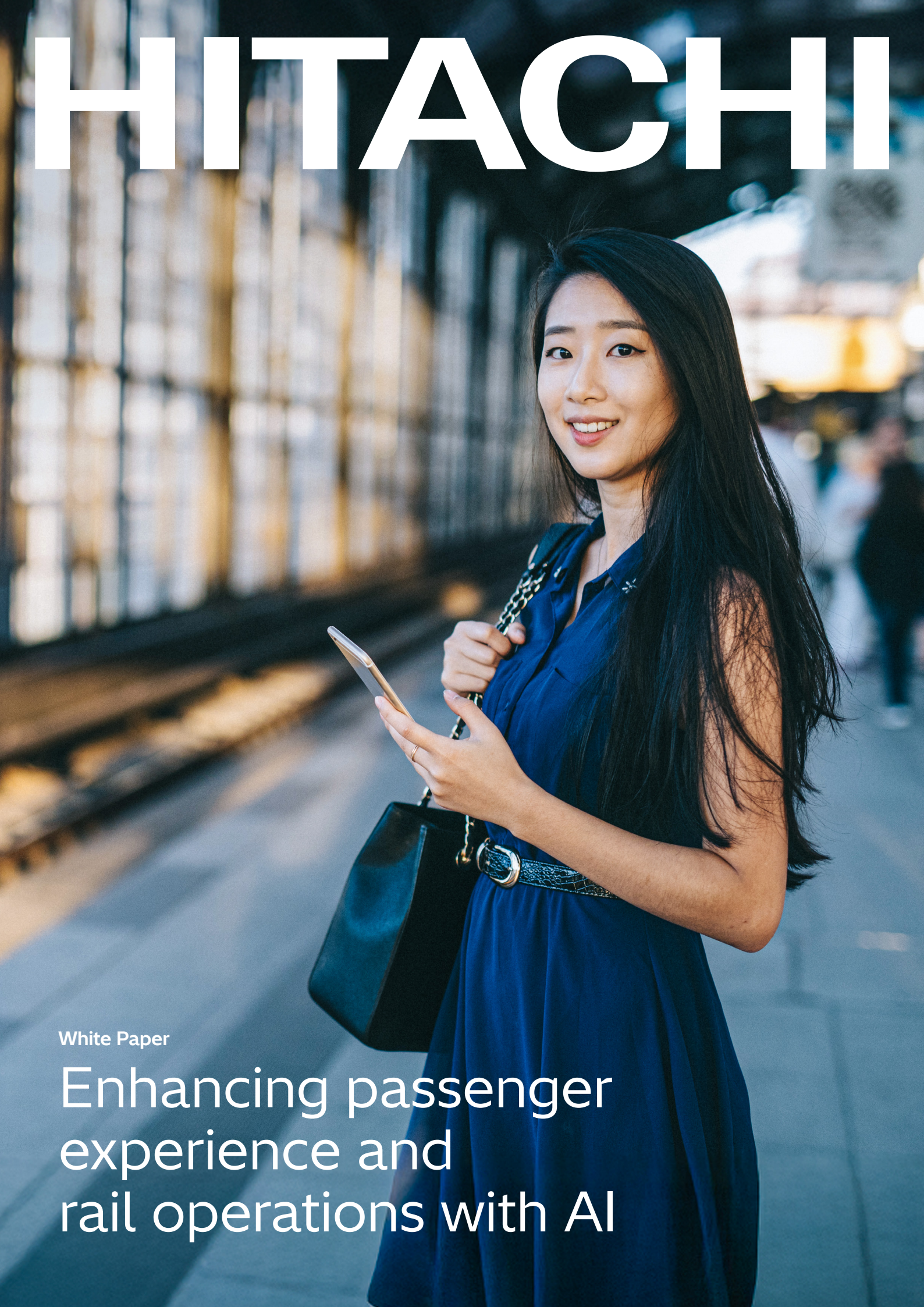
HITACHI



White Paper

Enhancing passenger experience and rail operations with AI

Contents

01

Introduction

How can rail operators take advantage of AI?

Artificial intelligence (AI) is now a fact of life. Generative AI tools such as OpenAI's ChatGPT and Microsoft Copilot have captured the public imagination with astonishing speed. Meanwhile, industrial applications of AI are transforming productivity from car making to aviation.

Hitachi Rail is committed to sharing the benefits of AI with its customers. To achieve this, the company is working in four main areas:

Perception AI: intelligent systems capable of identifying people and objects using computer vision tools. Hitachi Rail's DIVA (Distributed Intelligent Video Analytics) solution is an example of perceptive AI.

Agentic AI: the use of sophisticated reasoning to solve complex, multi-step problems – without the need for human intervention. Applications include long-term planning optimisation and decision-making support for operational efficiency.

Generative AI: the automatic creation of new content – such as text, images, video or audio – using existing data sources. Generative AI has multiple applications in the context of railways, from tailored passenger information and decision support to immersive simulations.

Physical AI: equipping trains with AI capabilities so they can interpret and interact with the real world. Applications include "Train as a Robot" using AI and sensors to enable everything from driverless operations to high-performance track monitoring.

The purpose of this white paper is to explore AI-enabled solutions in two specific areas.

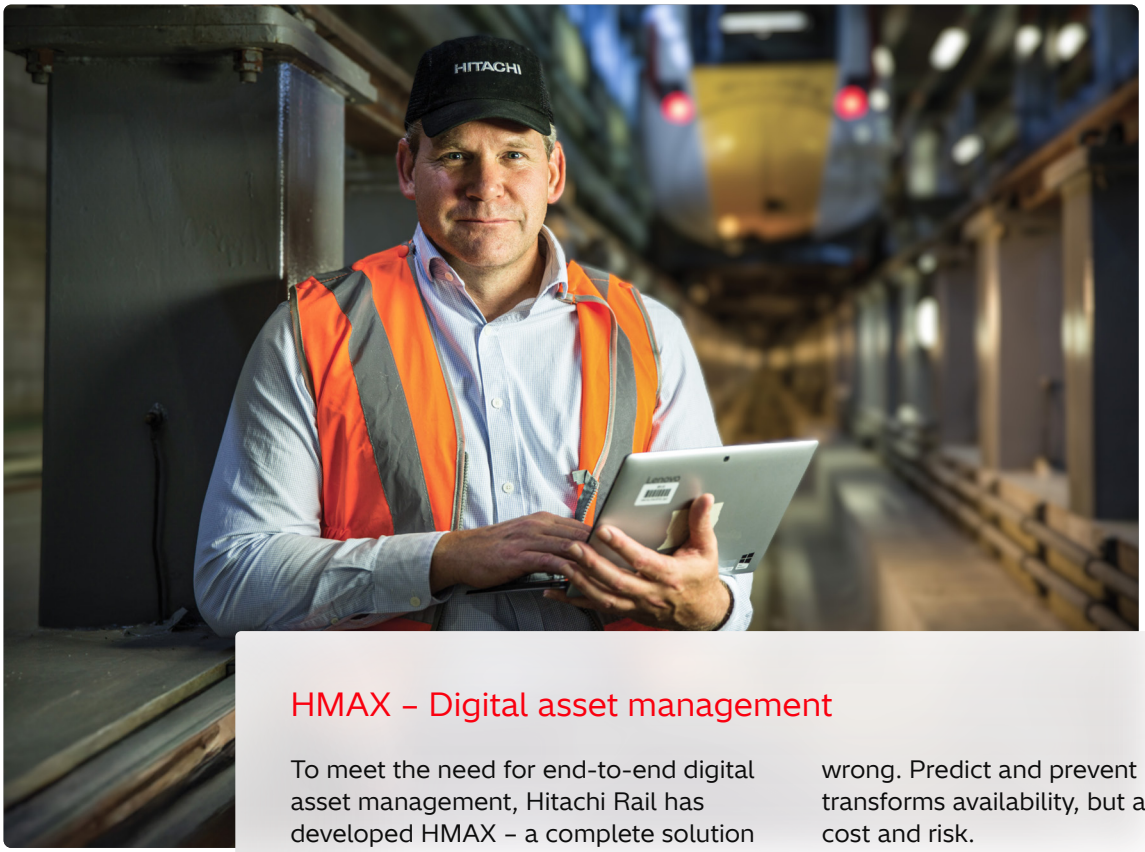
First, it examines the ways in which AI can be used to transform the passenger experience – including proactive passenger information. This is made possible by a brand new advisory tool that can be integrated as part of the Hitachi Rail Passenger Information Solution.

Next, it considers AI applications in the context of Operation Control Centres (OCCs) – the focal point of rail operations. The scope for AI-enhanced solutions is vast – with integration facilitated by Hitachi Rail's intelligent supervision solution.

Hitachi Rail has a long heritage in railway-specific AI innovation – in fact, the company's ground-breaking computer vision solution, DIVA, was one of the first applications of its kind for rail operators.

Today, we continue to build on that expertise – underlining the company's commitment to driving the sustainable mobility transition. This includes the company's powerful AI-enabled digital asset management platform – HMAX – which is powered by NVIDIA.

Hitachi Rail delivers a unique integrated framework to support operations and maintenance services in a consistent and harmonised environment combining HMAX and Hitachi Rail's control centre solution. Together, they offer a smarter, safer, and more responsive rail service for passengers, operators and maintainers. This enables the rail industry to enhance the passenger experience, optimise operations, and achieve cost efficiency.



HMAX – Digital asset management

To meet the need for end-to-end digital asset management, Hitachi Rail has developed HMAX – a complete solution for train operators and infrastructure managers. From rolling stock and signalling to track infrastructure and passenger flows, HMAX seamlessly integrates all operational data in a single platform – allowing customers to monitor and protect assets, maximise uptime and achieve cost savings. HMAX is powered by NVIDIA IGX, an industrial-grade edge AI platform, and the NVIDIA Holoscan sensor processing platform, to enable real-time data processing at the edge.

Unlike traditional preventive and reactive approaches, predictive maintenance is about anticipating faults – making it possible to intervene before anything goes wrong. Predict and prevent not only transforms availability, but also reduces cost and risk.

Hitachi Rail already delivers predictive maintenance tools – and has done for more than a decade. What is new (and made possible by AI) is the ability to improve the accuracy of predictions. This is achieved using algorithms that are capable of tapping into a vast array of both real-time and historical data, as well as a growing range of external data sources, such as weather and traffic reports. Meanwhile, the use of Large Language Models (LLMs) makes it easy for operators to query and explore their maintenance data. Predictive maintenance is part of Hitachi Rail's HMAX platform.

02 Passenger experience applications

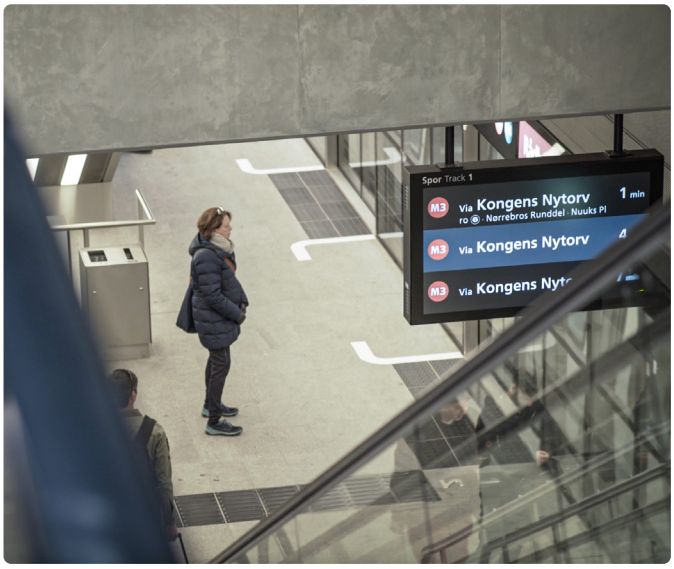
AI provides new ways to connect with passengers

Hitachi Rail is taking passenger information to the next level with a new AI-enabled advisory tool. A key feature is its ability to provide proactive and targeted information, so passengers can plan their journeys with confidence. Passenger information is generated automatically, from multiple data sources, reducing operator workload.

The advisory tool is part of the Hitachi Rail Passenger Information Solution (see box) and it can be deployed on the customer's own servers, or deployed as Analytics-as-a-Service on Hitachi Rail's cloud infrastructure. Interfaces and dashboards are tailored to customer requirements.

Proactive passenger information

Conventional passenger information typically deals with limited time horizons – minutes rather than hours. “Next train due” indications on platforms are an example. Information of this sort is vital – but it covers only one facet of the passenger experience.



What about the need for information before the journey begins? One of the major pain points for passengers is the lack of clarity around the anticipated status of train services on a given day in the future – perhaps several days away. Passengers want to plan ahead, but they lack the information needed to do so.

In the absence of reliable information from the operator, rumour and guesswork often fill the vacuum: “I’ve heard there’s going to be a strike next week,” or: “The trains are always delayed on Friday.” And even: “Someone just shared a picture of a flooded station on Facebook.” One of the limitations of conventional passenger information is that it rarely takes into account the impact of events that lie beyond the control of the transport operator.

Anticipating potential problems is only one part of the story. Another challenge is providing accurate real-time passenger information – particularly during a crisis. Passengers need to know what is happening and, more importantly, what action they need to take to complete their individual journey with the minimum of inconvenience.

Hitachi Rail’s advisory tool satisfies the demand for both advanced warnings and real-time information. Deploying the advisory tool makes it possible for operators to prepare for any eventuality and provide passengers with an early warning if disruption is anticipated, for any reason, hours or even days before it happens.

The solution works by correlating data from a wide range of internal and external sources. A generative AI model interprets the data, tailors it to the customer’s KPIs and internal rules (these are embedded in the solution), and then converts the result into concise, actionable information for passengers. In short, it provides public transport operators and public transit authorities with tools to deal with any scenario.

Datasets of all types can be used. The starting point is the customer’s own operational data. Historic train circulation data is an important part of this, because it reveals patterns that have the potential to repeat themselves. Other types of internal data provide additional granularity. These include everything from information about planned engineering works, to staff feedback and even metadata from video analytics systems.

Data from external sources is also enormously valuable. This includes information about large sporting events, music festivals, fairs or strikes that have an impact on daily routines and planning. Road traffic data (real time and historic) can also be included, along with meteorological data (rainfall, high winds and temperature extremes can all have a material impact on track and power supplies). Unstructured datasets also yield important insights – for example, news reports and validated user-generated content from social media platforms.

All of this can be correlated to generate proactive information – by date, by line and by station – to provide passengers with an advanced warning of potential disruption to their future journeys, giving them valuable time to adapt their plans.

Message authoring

Crystal clear messaging is of critical importance when communicating with passengers about disruption. But it presents a number of challenges. Running a passenger information operation is like working in a busy newsroom: raw information has to be gathered from multiple sources (not just from IT systems, but from people), checked for accuracy, and written up quickly in a way that passengers can easily understand. And the message is seldom static – each developing "thread" must be closely monitored and constantly updated. The workload can be phenomenal, particularly if the disruption involves several lines, stations or multiple transport operators.

Hitachi Rail's advisory tool is designed to transform the process of sourcing and writing passenger information. First, AI applications correlate data from multiple sources to interpret the situation – something they can do many times faster than a human operator. Moreover, AI can spot correlations and clues in the data that might otherwise be missed.

Second, Large Language Models (LLMs) are used to write the messages that passengers see and hear. This ensures accuracy, consistency and clarity of wording – key factors in winning passenger trust. In addition, AI provides fast and reliable tools for translating passenger information into multiple languages – a key consideration in cities that attract tourists and business travellers.

Channel management, versioning and targeting

Another challenge facing transport operators is making the best use of all the available channels of passenger communication. This is not necessarily easy to accomplish – particularly given the increasing number (and heterogeneity) of display systems, alongside and combined with digital channels and social media. Endpoints range from multimedia TFT LCD screens and LED displays on platforms and trains, to websites, mobile apps and social media platforms. All have their own specific visual characteristics and designated character counts. Passenger announcement systems, meanwhile, have their own unique characteristics.

Hitachi Rail's advisory tool uses AI to help operators make the best use of every available channel to reflect all passenger profiles – from regular commuters to tourists and passengers with specific communication needs. For any given event (a station closure, for example), written information for passengers is automatically versioned to satisfy the optimum display characteristics of each target system in terms of word count and format, and then repeated across all relevant endpoints – including audio. Extra detail can be provided via digital channels.

Moreover, this is achieved while retaining the overall consistency of the messaging that appears to passengers. This is a critical consideration: the essence of the message a passenger sees (or hears) on the platform, on the train, and on their mobile app, needs to be the same – even if some versions of the message are longer or shorter than others.

In addition, the advisory tool makes it easier than ever to target a message so that it has maximum relevance to the intended passenger audience. This is a matter of timing and geography. Because Hitachi Rail's Passenger Information Solution knows the topology of the network, it knows exactly where and when to activate a specific message – and when to deactivate it (e.g. suppressing an onboard message once the train is heading away from disruption). This minimises information fatigue induced by superfluous messaging.

Hitachi Rail's Passenger Information Solution

Reliable information is the bedrock of the passenger experience. High-quality, targeted information builds passenger trust, boosts ridership and drives social inclusion by easing the barriers to travel.

The Hitachi Rail Passenger Information Solution is purpose-built to achieve these goals. The solution makes it possible for operators to interact with passengers via a single, cybersecured platform that synthesises and delivers the right information to the right people at the right time – anywhere.

Operators can manage and deliver any type of content – from real-time information to interactive passenger assistance, infotainment and advertising. Critically, the solution is optimised for a multi-channel world with tailored output for all types of media, including passenger information displays on platforms and trains, public address, help kiosks and online via apps, the web and social media.

The solution acts as a single source of coherent and trustable information. This is a key driver in attracting more people to public transport – particularly in complex multimodal environments where disruption can have widespread repercussions.

One of the key features of the solution is that it is fully scalable, from a single transport hub to an entire nationwide network. Any mode of transport can be integrated. And it is easy to use, thanks to an ergonomic human-machine interface.

The Passenger Information Solution is part of Hitachi Rail's intelligent rail operations solution.

03

Operational applications

AI-powered workflows are a potential game changer

Operation Control Centres (OCCs) are at the heart of modern railway systems. The latest generation can monitor millions of control points – from CCTV to ticket barriers, signalling and alarms. Could the huge volume of data generated by these systems be used to create new business value?

Hitachi Rail is developing AI-enabled solutions and proofs of concept that allow operators to unlock the full potential of their data to deliver brand new capabilities in areas such as alarm management, decision support and training. These use cases are considered in more detail below.

Intelligent alarm management

Almost every asset supervised by an OCC is capable of generating an alarm. Certain situations can trigger a large number of alarms simultaneously – overwhelming the operator. This is sometimes called an alarm avalanche.

Alarm avalanches can be triggered for a number of different reasons – not all of which are emergencies. One example is a multiservice network fault: if a network node develops a problem, all the equipment behind it will generate alarms. Another example is when equipment connects and disconnects from the network – this can generate a mass of alerts, whether the assets are in failure mode or not. Meanwhile, a major incident (such as a power outage or natural disaster) will also generate a large number of alarms.

The problem is that the pattern of alarms generated in the three examples outlined above can appear similar to the control centre operator, at least at first glance. So what sort of incident is it? The operator needs a way to understand the root cause as quickly as possible so the correct procedure can be launched. Time is of the essence.

One of the key factors here is ergonomics; specifically, the interaction between the OCC operator and the systems under their supervision. Today, operators receive alarms via screens on their HMI (Human Machine Interface). These are sorted by time stamps, so the operator is shown all of the alerts, whether there is just one alarm or 50. The operator needs to interpret the pattern of alarms, and uses a keyboard and mouse both to interrogate the data and to launch a response.

OCC operators are highly skilled at interpreting and managing alarms. But could AI – trained on the customer's own data – help to make their job easier? An example of this would be the ability for the operator to interact with the system using natural language. This has the advantage of being more intuitive and potentially much quicker than using a mouse and keyboard. Another example would be AI alarm processing, with an interpretation of the likely underlying cause of an alarm avalanche. Instead of being confronted by dozens of alarms, the operator would only need to deal with one.

Work in this area is continuing. Hitachi Rail is developing an AI-driven application to help operators manage the deluge of alerts. The Unified Station Layout and Alarm List already include tools to filter, group and manage alarms so operators can get a clear understanding of what is happening, with help pages and online procedures. The solution is made possible by Hitachi Rail's intelligent rail supervision solution.

Decision support

Operation Control Centre staff rely on standard operating procedures to help them manage specific types of incidents, such as overcrowding and service disruption. Rules are typically set out in manuals which may be printed on paper, or delivered as web pages or pdf documents via the company intranet. In both cases, there are a number of drawbacks – particularly in a pressurised crisis situation.

First, the operator needs to find the appropriate manual (there may be more than one). Next he or she needs to pinpoint the relevant content, which means searching or using Ctrl F to find what is needed. With printed material, it can take even longer – particularly if the content is not indexed. Finally, and most importantly, the operator needs to launch the procedure described in the manual.

All of this takes time – and every mouse click and keyboard stroke eats up valuable seconds.

Hitachi Rail is developing a new solution to provide AI-enhanced decision support. This works by automatically providing the operator with details about the best procedure to follow the moment an incident is detected – eliminating the need to search through manuals. Taking this a step further, integration of a chatbot function provides operators with a way to get near-instant summaries and answers to complex procedural questions – something that cannot readily be achieved with conventional manuals.

In terms of execution, Hitachi Rail has already developed command and control workflows that link each step of the decision support process with the relevant subsystems (such as SCADA, CCTV and video analytics). All of this is made possible by Hitachi Rail's integrated supervision solution for rail operations.

Training and simulation

Staff training is a big responsibility for rail operators. In addition to coaching new recruits (it can take up to a year to turn a new staff member into a competent OCC operator) there is a need to refresh and upgrade the skills of existing workers.

One of the biggest pain points for trainers is creating simulations. Writing scripts for training exercises is time-consuming. It is also complex, because trainers need a full understanding of the logic underpinning the full range of OCC subsystems – everything from SCADA, ATS (Automatic Train Supervision) and CCTV to passenger information systems.

Hitachi Rail is inserting AI in its tools to transform the way that training and simulation exercises are created. Instead of laboriously writing out each exercise line by line (and specifying which subsystems will be involved, and how), trainers can put together any scenario they want – simply by using natural language prompts.

AI-scripted simulations can be as simple – or as complex – as trainers need them to be. An example of a simple exercise would be: "Simulate an escalator failure". A more complex example would be: "Simulate a power outage in a specified station and track zone resulting in unavailability of equipment within the zone."

The beauty of using AI for scripting is that complex multi-factor simulations can be created in just a few minutes – a job that would normally take hours. Trainers can easily specify any location, and include any combination of events, people and equipment they want in the exercise – without the need for specialised knowledge of the underlying subsystems.

A wider benefit of AI scripting is that it expands the scope and effectiveness of training activities. Eliminating traditional scripting constraints provides trainers with the freedom to experiment with a much wider range of scenarios than was previously possible. It also paves the way for tailored training – for example, creating scenarios on demand to meet the specific training needs of individual staff members.

Data queries and exploration

Rail networks are awash with data – but using this data to gain useful insights is seldom straightforward. There are now so many sources of data that answering a simple query can take hours of painstaking detective work. This can be a real constraint, especially in situations where operators need results – fast.

Hitachi Rail is developing an AI-powered tool that allows users to query data quickly and accurately via personalised dashboards and visualisations – eliminating the need to trawl through dozens of spreadsheets, emails, videos, manuals and reports.

There are multiple use cases for this type of capability – and there are no limits to the queries that can be answered. Which station is most crowded? What are the punctuality statistics for the last 24 hours? When was the peak hour? What are the total ridership figures for the past seven days?

An AI-powered dashboard provides answers to questions like these and many others, and it does so in seconds. The beauty of this technology is that it is intuitive and easy to evolve along the system life time. And everybody benefits, from traffic supervisors, station managers and maintainers to senior management.

Hitachi Rail's modular solution for railway OCCs

Operation Control Centres (OCCs) are vital to the success of metro, LRT and main line railway networks. Everything from signalling to passenger information and crisis management depends on seamless and coordinated OCC actions.

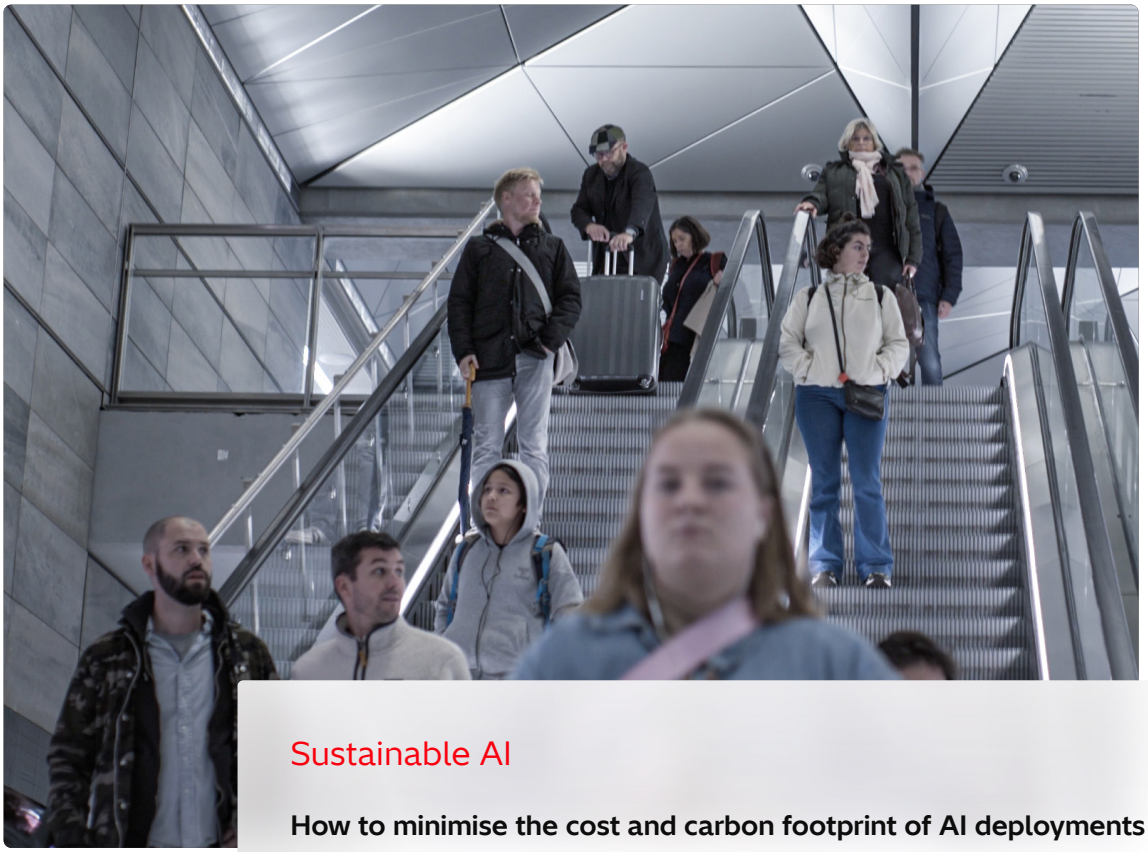
To get the most out of their OCCs, customers need a technology platform that provides reliable operations and full situational awareness, as well as training and simulation capabilities. And in a world where technology is constantly evolving, the ability to innovate and add new functionality is critical.

Hitachi Rail's answer to these challenges is a modular OCC solution that provides complete functional coordination, macro commands, real-time data exchanges, remote access and video analytics. Everything is supervised via a consistent user interface and cybersecured by design.

All critical subsystems – including third-party subsystems – are integrated via standard interfaces. These include signalling supervision, traffic management systems (TMS, ATS and ITMS1), power, station auxiliaries and tunnel ventilation command and control, monitoring and diagnostics, passenger information and entertainment, public address, CCTV and video analytics, access control and intrusion detection, and audio dispatch. Resources and applications can be easily adjusted to meet changing demands with no impact on performance.

As well as enabling fully-coordinated supervision, this solution leverages subsystem data to produce new value-added features. As an example, video analytics brings real-time passenger density computed from CCTV streams. This data is used in the solution for crowd control, passenger security, passenger guidance and timetable scheduling. Unattended luggage detection, trespassing detection, wheelchair detection and energy savings are additional features made possible by AI in the solution.

[1] Traffic Management System (TMS), Automatic Train Supervision (ATS), and Integrated Tram Management System (ITMS).



Sustainable AI

How to minimise the cost and carbon footprint of AI deployments

Integrating AI in passenger facing and operational systems has the potential to yield major benefits for transport operators. But the increased use of AI applications raises a number of important questions – not least ones about cost and carbon emissions.

Hitachi Rail is committed to deploying AI solutions that are cost effective for its customers. That means running AI on hardware that is affordable throughout the lifetime of the solution, and which is capable of delivering the required accuracy, performance, response time (latency) and power consumption. The key is working with customers to identify the right balance when selecting the technology mix.

Environmental impacts also require careful consideration. AI requires a lot of energy for processing and cooling. To put this in a global context, power consumption by data centres – the focal point for AI training and deployment – is expected to surge to 1,000TWh per year by 2026. This is equivalent to the combined electricity consumption of France and Germany.

So, how can rail applications of AI be made as energy efficient as possible? Hitachi Rail has extensive experience in this arena and the company's pioneering work on DIVA (Distributed Intelligent Video Analytics) underlines this capability. First, DIVA uses frugal algorithms to minimise electricity demand. Second, there is a focus on defining exactly the type of information required – and fine-tuning processing capacity to achieve the specified objectives. The same principles can be applied to minimise the carbon footprint and maximise the energy efficiency of any AI implementation – onboard or at the wayside.

[2] Electricity 2024. Analysis and forecast to 2025. International Energy Agency.