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A circular logo with a dark grey center containing the text 'Stations 360°' in white. The center is surrounded by a white ring with four small black tabs pointing outwards.

Stations  
360°

# Digital Stations

The digital heart of mobility

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## What to expect

Stations are at the center of the digital mobility transition. No longer simply buildings whose sole function is transportation, they are evolving into socio-technical systems in which operational technology (OT) and information technology (IT) work closely together in a secure environment. In the same vein, digital stations aren't simply stations equipped with digital technology. They are interoperable platforms that connect data, processes and people in real time.

The entire stakeholder ecosystem benefits. Station users experience safer and cleaner stations. Rail operators benefit from greater efficiency and availability. And station management benefits from data-driven processes, which improve efficiency and availability and lower costs.

This white paper describes the architectural principles, governance principles, use cases and KPIs that are crucial for scalable and commercially viable implementation. It shows how stations are becoming smart hubs – with operational excellence, tangible quality and urban relevance, the three dimensions of the digital station:

- **Operational excellence:** Energy efficiency, system availability and process stability.
- **Tangible quality:** Safety, cleanliness, wayfinding and accessibility.
- **Urban relevance:** Integration into urban mobility, energy flows and local value added.

This white paper provides a **concrete, scalable frame of reference and decision-making framework** – and shows how digital investments can be directed in a targeted manner and measurably translated into operational and economic added value. Digital stations are becoming the heart of multimodal mobility systems – efficient, sustainable and tangible. In other words, modern platforms that users, rail operators and station management rightly want.

# 1. From service to system intelligence

## Quick wins to scalable stations

Digital transformation often gets off to an unspectacular start. Deutsche Bahn (DB) launched a WhatsApp service for the first time in 2017. The service allowed station visitors to report messes. Messes were cleaned up without delay, and the person who reported them received real-time feedback. What started out small grew into a successful model. The service is now used at several hundred DB stations.

As this example shows, digitalization doesn't necessarily have to be complex or expensive. A smart combination of existing systems is often enough to noticeably improve the everyday experience of passengers and staff.

But station digitalization doesn't stop at individual services. It encompasses the entire structure – from operational technology (OT), sensor technology and communication systems to cloud-based platforms and AI applications in the world of information technology (IT). This connectivity gives rise to a new understanding of the system: The digital station as an ecosystem in which data, energy and mobility coalesce.



[3] DB InfraGO employees are installing a security camera on the platform

# 2. What is a digital station?

## Connecting data, operations and services

A digital station is more than just a station with Wi-Fi and monitors. It's a socio-technical system that combines physical infrastructure, data intelligence and human decision-making processes. It comprises various technical dimensions in their entirety and in their interdependence.

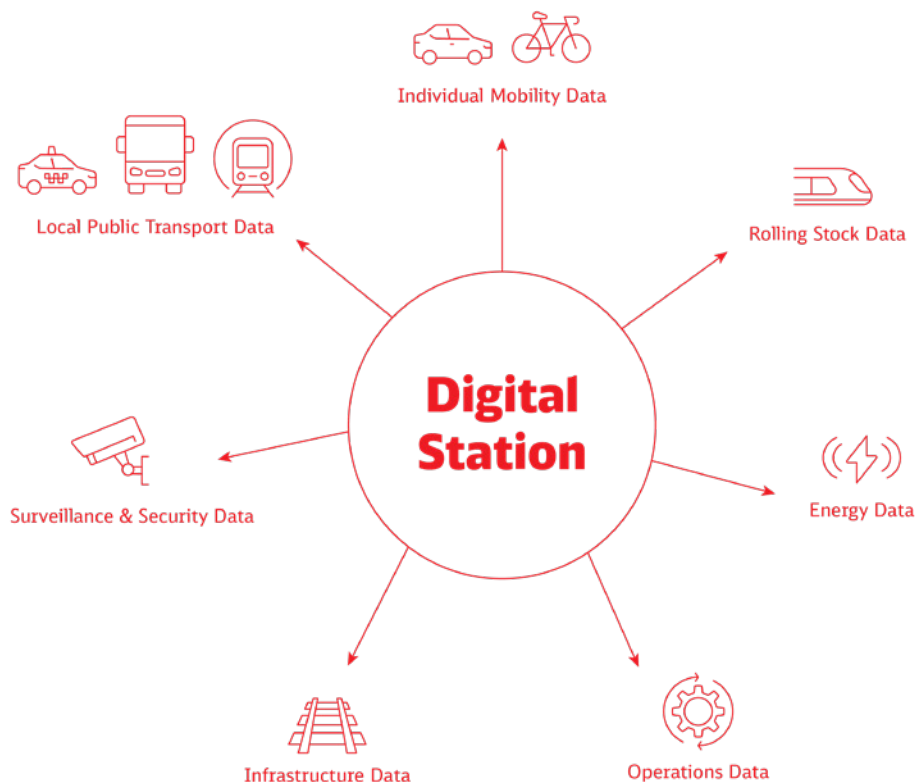
The system reacts in real time, learns from data patterns and continuously optimizes itself.

At their core, digital stations are about the safe, secure and efficient convergence of IT and OT – i.e. data platforms, sensor technology and rail operations technology. Stations become a living data and service platform that understands and can react to the condition of the infrastructure, space utilization and passenger behavior.

Vision of the digital station:

- **Operational excellence:** Enhanced efficiency, reduced energy consumption and predictable servicing.
- **Tangible quality:** Safety, cleanliness, wayfinding and comfort.
- **Urban relevance:** Integration into urban transport, energy supply and the economy.

The result is a station that not only manages traffic, but also intelligently manages mobility, data and energy.



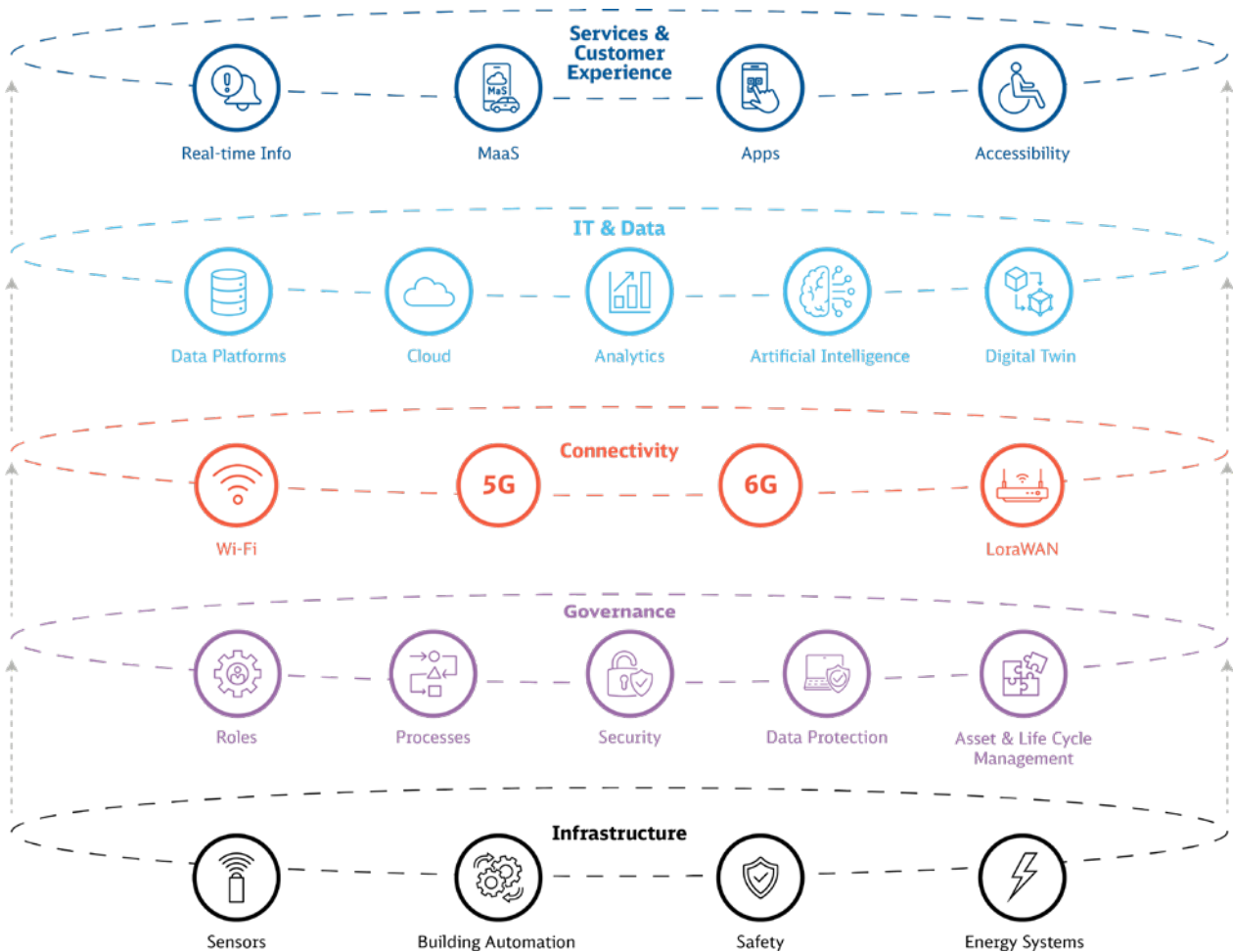
[4] Figure 1: Digital station – station data types

# 3. Architectural principle

## The layer system

Digital excellence is based on clearly defined and harmonized layers. The layer system is the basis of digital station architecture:

- 1. Infrastructure layer (OT layer):** Physical systems and equipment such as energy supply, elevators, escalators, platforms and tracks. Standards: CENELEC EN 50126/28/29.
- 2. Governance layer:** Roles, processes, security, data privacy and asset management.
- 3. Connectivity layer:** Secure data transfer between OT and IT, with prioritized data paths and redundancies.
- 4. IT and data management layer:** Cloud platforms, data analysis, AI, digital twins and interface management. Standards: ISO/IEC, ETSI.
- 5. Service layer:** Passenger information, digital interfaces (e.g. rail operator's app), routing, perceived safety, retail, comfort and convenience.



[5] Figure2: Schematic IT architecture principle – the digital station layer system

Digital excellence is achieved when the station levels – the physical infrastructure, data and connectivity layers, and service and customer experience level – are connected by clear interfaces, standardized data models and secure communication paths. This creates a consistent link between the digital and real customer experience; the station is experienced as the digital heart of the city.

The biggest challenge is that two worlds with different development systems need to be combined. Operational technology (OT) is designed for stability, safety and long life cycles. Systems such as elevators, signaling and electrical power systems are robust, standardized and in use for decades. Information technology (IT), on the other hand, is characterized by short innovation cycles, modular architecture and a high degree of agility.

While OT focuses on maximum availability and operational reliability in accordance with the **safety first** principle, IT aims for continuous optimization and rapid adaptation. This tension between robust continuity and dynamic digital development is at the heart of IT/OT convergence.

Successful smart station concepts bring both worlds together in terms of technology and organization – through clear

responsibilities, uniform data and security architectures, and defined governance structures. The **guiding principles** of this architecture system are:

- API-first and standard data models (e.g. ETSI/CENELEC) for interoperability,
- Security by design and zero-trust architecture for maximum operational security
- Human-in-the-loop, where technology sets priorities but humans always make the final decision.

It is this interaction among technology, security and human responsibility that unlocks the full potential of digitalization in the station ecosystem – from predictive maintenance and energy optimization to a seamless, data-driven passenger experience.

One example of this is the *bahnhof.de* project from Deutsche Bahn. Sensor-monitored elevators send their status to the operations center and registered users are proactively sent information about elevator statuses. If an elevator is out of order, an alternative route can be identified in good time and displayed in DB Navigator.



[6] *Hamburg Main Station and its digital twin*

# 4. Station categories and scalable digital strategy

Different stations have different requirements. Uniform architecture nevertheless allows for different maturity levels. The category model enables resource-saving, scalable digitalization.

### Local node (small station)

Focus on basic digitalization: Energy and condition monitoring, accessibility and basic services.

Objective: Quick success, low complexity, measurable added value.

### Regional connector (mid-sized station)

Selective integration of central systems: Energy, security and information management.

Objective: Enhanced efficiency and consistent customer experiences.

### Metropolitan hub (large station)

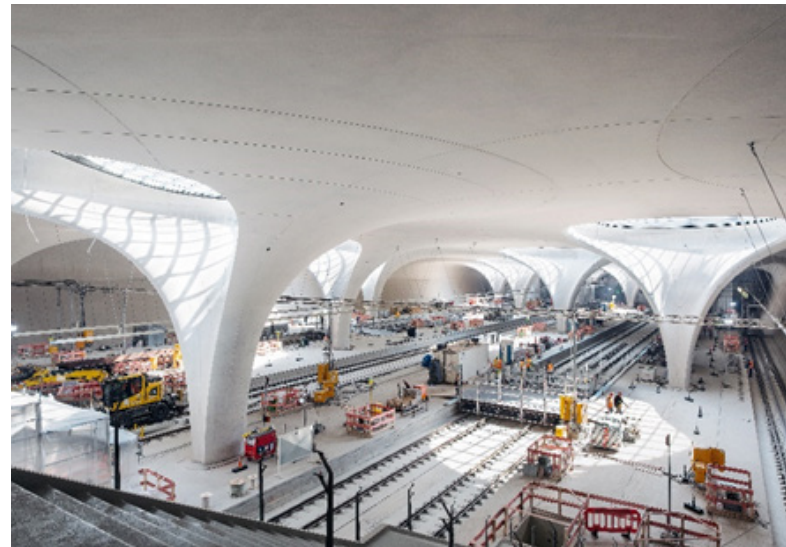
Full integration of all layers: Data platform, real-time monitoring, AI-assisted management, commerce ecosystem. Objective: Urban mobility and data hub – the mobility heart of the city



[7] Zorneding Station



[8] Magdeburg Main Station



[9] Stuttgart Main Station



[10] Berliner Main Station

# 5. Data-driven energy and sustainability management – efficiency as a system principle

Digitalization and sustainability are two sides of the same coin, especially when it comes to supplying power to modern train stations. Digital stations use data to precisely control energy flows and optimize the use of resources. Smart grids and sensor networks record energy consumption in real time and enable forecasting and optimization of energy requirements. Adaptive control systems adjust lighting, heating and cooling as required, reducing energy consumption without compromising comfort. Energy dashboards link technical systems, operating processes and planning data and support load management and predictive servicing for an efficient energy supply.

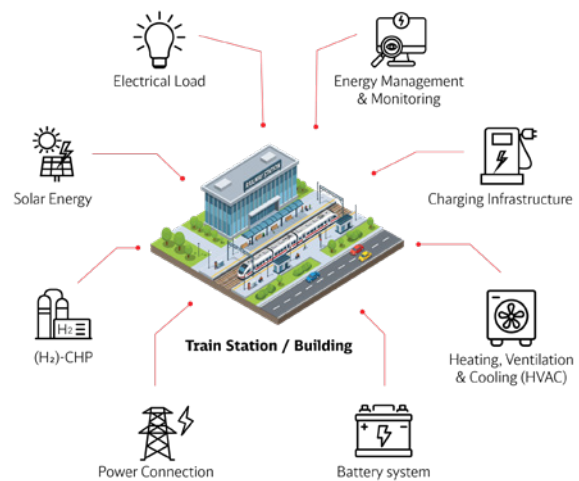
Deutsche Bahn's green station concept integrates digital technologies as a key enabler of sustainable and efficient infrastructure. A building management system (BMS) coordinates renewable energy sources such as photovoltaics, geothermal energy and solar thermal energy with building systems (heating, ventilation, lighting and hot water) and water management. This automates operating processes, maximizes efficiency potential and enables partial energy self-sufficiency.

Real-time monitoring and public feedback mechanisms make power generation and consumption and any supplying of surplus energy back to the grid visible to passengers. This increases transparency and raises awareness of sustainability measures.

The use of modular, prefabricated timber construction, especially for small green stations, is supported by digital design processes and BIM-compatible workflows. This enables efficient replicability, lower resource consumption, shorter construction time and optimized construction management.

Since 2025, all DB stations, maintenance facilities, office buildings and other stationary facilities in Germany have been supplied with 100% renewable electricity. Deutsche Bahn has introduced an energy management system certified in accordance with DIN EN ISO 50001 to continuously monitor and optimize energy use

By combining digital control, renewable energy systems and modular construction concepts, green stations are a scalable, data-driven model for a sustainable rail infrastructure that combines eco-friendly objectives with reliable and efficient station operation.



[11] *Energy Dimensions*



[12] „Green Station“ – Lutherstadt Wittenberg Hbf

# 6. Governance, cybersecurity and data privacy

When digitalization at stations fails, it's often not because of sensors or software. It's usually because of factors related to daily operations, such as unclear responsibilities, security requirements and trust.

Clear rules and security mechanisms are required so that all players can participate in a shared data ecosystem:

- **Data interoperability:** Standardized data models, APIs, version control and quality assurance.
- **Security by design:** Segmented networks, one-way OT IT communication, SOC monitoring.
- **Zero trust:** Every data flow is checked; no system is automatically trustworthy.
- **Privacy by design:** De-identification, local pre-processing, GDPR-compliant storage.
- **Human-in-the-loop:** People remain the decision-makers; systems provide analysis and set priorities.

Here is an example. Data privacy is relevant day to day because many value-added applications (video analysis, flows of people and feedback systems) **can legally be accepted** and used only if de-identification, purpose limitation and GDPR-compliant processing are incorporated from the outset. Without privacy by design, for example, apps in use cases like these often have to be taken back out of operation despite their benefits. Security therefore becomes the trust anchor in digitalization.



[13] *Software app tracking blurred people inside train station*

# 7. Three perspectives

## An ecosystem of passengers, operators and owners

### The visitor perspective: Safety, cleanliness and experience

Above all, passengers expect reliability, especially when it comes to safety, cleanliness and wayfinding. AI-assisted video analysis, sensor technology and real-time information systematically help ensure these basic needs are met. Improvements to passenger information systems have a particularly high impact on customer satisfaction. In Germany, their effect is around three times higher than traditional structural renovation measures.



[14] Real-time information: Pilot project for the occupancy of S-Bahn cars at the S-Bahn Berlin. The occupancy rate is measured with a light sensor and displayed in real time

Passengers experience the digital transformation of stations primarily through a greater sense of safety and noticeably better cleanliness. Sensor technology, video analysis and real-time alerts enable early detection of safety-critical situations and messes. Measures are implemented faster, more transparently and more consistently, and stations are perceived as well-maintained and reliable places.

A good example of intelligent frequency management in the station area is the FQM project Munich Central Station – supplemented by numerous other implementations at heavily frequented stations in Germany. Counting lines, cameras and sensors record flows of people in real time and link them to operating data. This makes it possible to:

- Identify bottlenecks at an early stage
- Develop measures for visitor flow management and queue management
- Use space more efficiently

The project shows how OT data (such as data from cameras and counting systems) and IT components (analysis dashboards, Power BI and iBMS connections) merge to form an integrated basis for decision-making, creating a self-learning system for more efficient, safer and predictable station operations. Another approach is the use of LiDAR technology, as demonstrated in a pilot installation by the Brussels Metro.

### The rail operator perspective: Efficiency and availability

Rail operators benefit from data-driven processes due to shorter downtimes, automated vehicle readiness control and predictive servicing based on AI-assisted forecasts. Diagnostics data is used to proactively report malfunctions and increases vehicle availability.

Digital vehicle readiness control combines video, sensor and vehicle data to automate readiness control processes. One model project in this field is our technical vehicle readiness control systems, which shorten downtimes, reduce delays and improve operational stability for rail operators.

### The management perspective: Transparency and control

Station management uses dashboards, digital twins, and station security and service centers for real-time management of operations, security and service. In addition, digital commercial services such as Wi-Fi portals, voucher systems and location APIs create new revenue potential and involve retail and city partners.

As of 2025, the new generation of station operations centers unites safety, service and operating data centrally and evaluates it in real time – a first. Incidents captured by video, sensors and alert systems flow into an integrated situation report and form the basis for operational decisions. Station operations centers enable:

- Early detection of safety risks and messes
- Prioritized management of security and cleaning crew deployment across locations
- Transparent tracking and evaluation of measures.

As the central operational deployment system of digital stations, station operations centers shorten response times, give people involved more confidence in their actions and ensure that measures for passengers are implemented quickly, consistently and reliably, especially during peak times and when disruptions occur.

# 8. KPI framework and implementation roadmap

In order to effectively implement the described architectural principles, use cases and governance approaches, stations need a consistent management model that makes progress measurable and enables gradual scaling.

A powerful KPI framework measures progress in all three dimensions:

<i>Dimension</i>	<i>KPI</i>	<i>Description</i>
<i>Operational excellence</i>	<i>System availability (%)</i>	<i>Availability of critical OT assets</i>
<i>Operational excellence</i>	<i>Energy (kWh/m<sup>2</sup>, kWh/passenger)</i>	<i>Energy consumption per area and user</i>
<i>Tangible quality</i>	<i>Cleanliness SLA (%)</i>	<i>Time until completion of reported tasks</i>
<i>Tangible quality</i>	<i>First-time-right info (%)</i>	<i>Accuracy of real-time information</i>
<i>Urban relevance</i>	<i>Transfer rate (%)</i>	<i>Percentage of seamless intermodal transfers</i>
<i>Urban relevance</i>	<i>Local revenue index</i>	<i>Measure of economic activity</i>

[15] *KPI Framework*

How can the transition from digitally isolated elements of an existing infrastructure that evolved over time to a connected, stable and integrated customer journey characterized by operational excellence, tangible quality and urban relevance succeed?

The pathway to smart stations follows a step-by-step, user-centric approach that combines technological, organizational and cultural dimensions.

## Implementation phases

### 1. Define the vision and baseline with a user-centered approach

Analyzing the status quo and developing a shared vision for the future of the station – with a focus on customer value, operational efficiency and data value.

### 2. Build a use case portfolio with quick wins

Identifying and prioritizing use cases that create measurable added value for passengers and operators – from energy and system monitoring to smart passenger information.

### 3. Implement data and interface architecture (API-first)

Developing an interoperable, modular data foundation based on open standards and secure communication paths.

### 4. Test pilot projects (thin slice) in all layers

Testing and validating iteratively throughout the entire layer model – from infrastructure to the service experience.

### 5. Initiate change processes with the workforce

Involving employees through training, new role profiles and a culture of digital responsibility.

### 6. Scale by station category and lessons learned

Adapting solutions to different types of stations – from small to main stations – incorporating the results of tests during the pilot phases.

### 7. Monitor KPIs and continuously improve

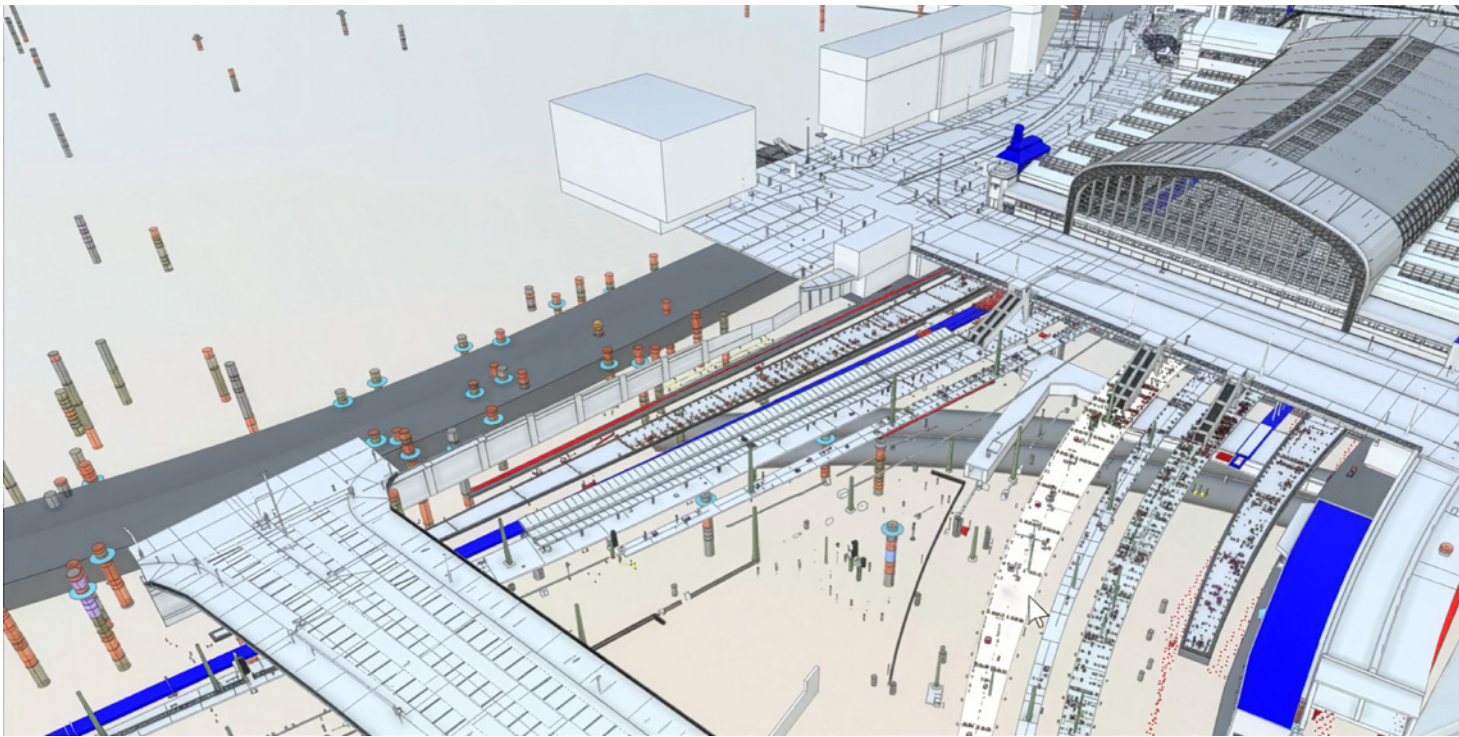
Establishing a standardized monitoring and evaluation framework to measure progress, system maturity and customer satisfaction.

# 9. Conclusion

## The station as a self-learning system

Station digitalization is not an end in itself. It lays the foundation for harmonious interaction between people, machines and data – for safe, efficient and sustainable mobility.

The digital station is a self-learning system that combines operational excellence, tangible quality and urban relevance in a consistent framework. It is not a place. It is a digitally connected system that thinks, learns and reacts – the true heart of modern mobility.



[16] *BIM Modell incl. indicated Data Points / GIS2BIM, Hamburg Main Station*



# 10. Stations 360°

## Holistic consulting solutions for train station ecosystems



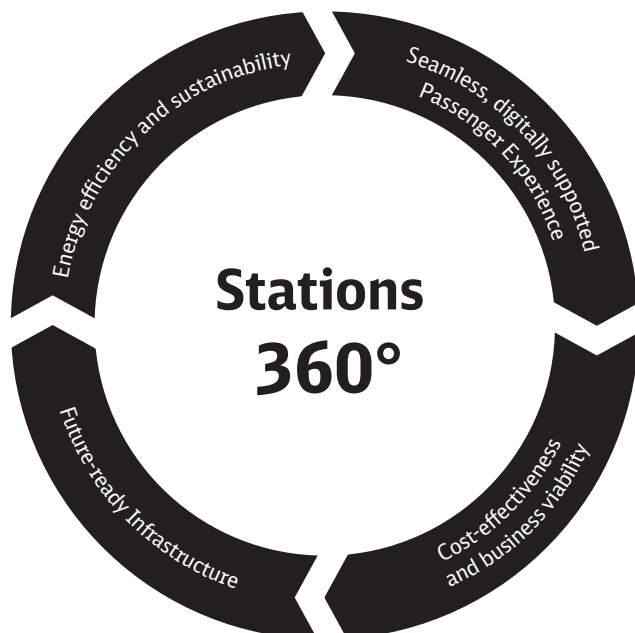
[17] Station in bright sunlight

As the world moves towards more sustainable and efficient means of transportation, train stations are evolving beyond mere points of transit. They are becoming vibrant landmarks that reflect the cultural heritage of their surroundings and serve as inclusive social hubs. Stations 360° embodies this vision by delivering customized consulting services that set new global standards for train stations and mobility hubs.

### Core Components of Stations 360°

The Stations 360° framework consists of four complementary components that together form a comprehensive approach to modern railway station development:

- 1. Seamless Passenger Experience:** Focuses on creating intuitive journeys through digital services and smart technologies that respond to passenger needs and optimize station operations.
- 2. Business Viability:** Explores sustainable financial models and revenue opportunities beyond traditional ticket sales, positioning stations as community hubs with diverse offerings.
- 3. Future-Ready Infrastructure:** Addresses the physical design and technical requirements for adaptable stations that can evolve with changing urban needs and transportation patterns.
- 4. Energy Efficiency and Sustainability:** Encompasses resource-conscious design principles and systems that reduce environmental impact while improving operational efficiency.



[18] Visualization Stations 360°



### The Expertise behind Stations 360°

As part of DB E.C.O. Group, **DB Engineering & Consulting (DB E&C)** plays a key role in shaping sustainable and efficient rail infrastructure worldwide. DB E.C.O. Group unites Deutsche Bahn's expertise in engineering, construction, operations, and environmental solutions, ensuring integrated, future-proof mobility. With a strong commitment to quality, safety, and innovation, DB E&C delivers cutting-edge infrastructure solutions, supporting projects from concept to completion.

**inno2grid**, also part of DB E.C.O. Group, specializes in integrating energy management and mobility solutions. Through cutting-edge technologies and sustainable practices, inno2grid transforms transportation hubs into smart, efficient, and environmentally friendly spaces.

Stations 360° adapts and applies the principles and methodologies of the Future Station initiative on a global scale. This integrative approach ensures that train stations worldwide are optimized for transit and serve as catalysts for regional development and community engagement.

As we look ahead to a more interconnected and sustainable future, train stations will play a pivotal role in urban development. By integrating TOD principles with advanced digital and sustainability solutions, these stations can transform into vibrant, multi-functional spaces that enhance mobility, stimulate economic growth, and elevate the quality of urban life.

Stations 360° drives this transformation through comprehensive consulting services, leveraging the expertise of DB E&C and inno2grid.

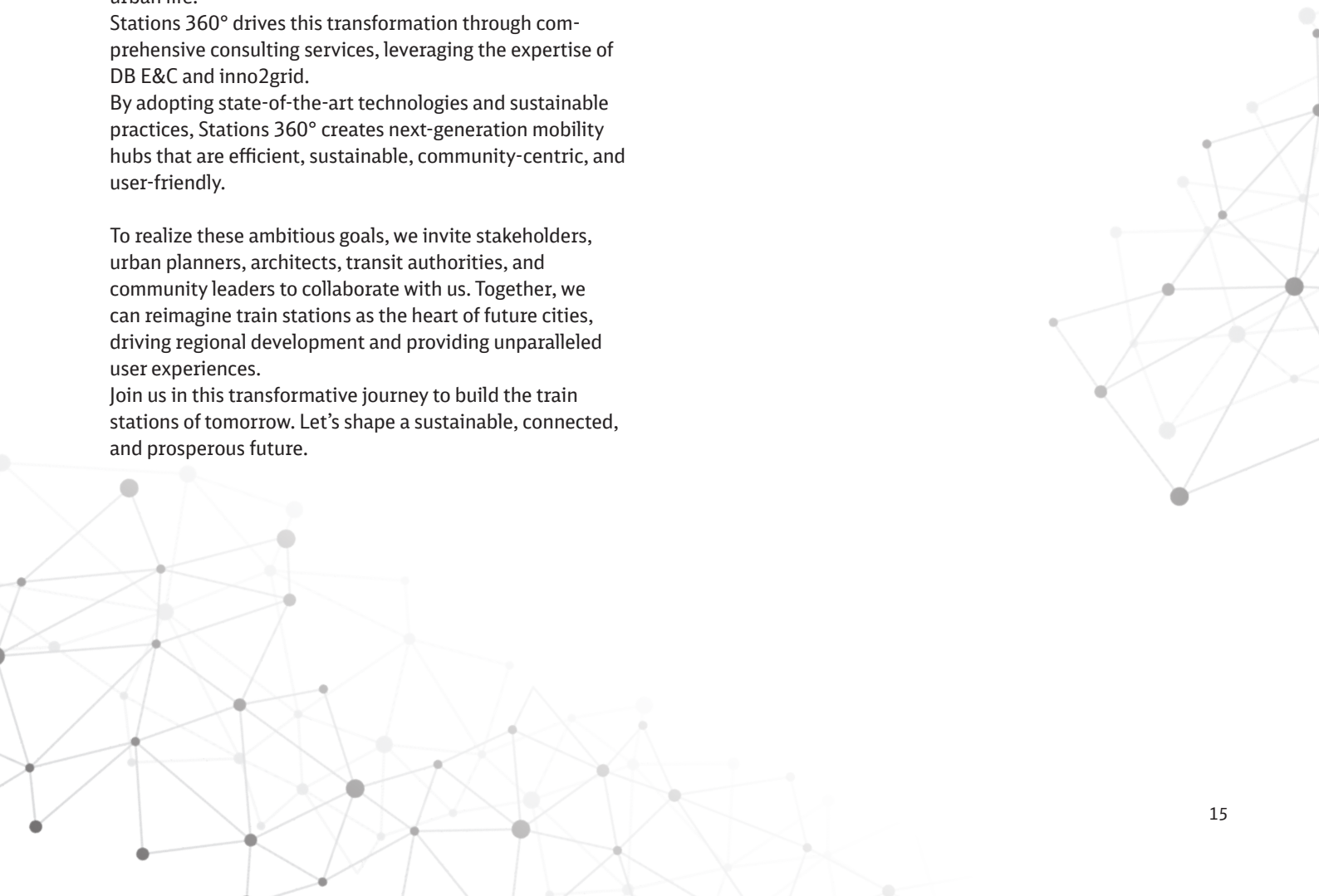
By adopting state-of-the-art technologies and sustainable practices, Stations 360° creates next-generation mobility hubs that are efficient, sustainable, community-centric, and user-friendly.

To realize these ambitious goals, we invite stakeholders, urban planners, architects, transit authorities, and community leaders to collaborate with us. Together, we can reimagine train stations as the heart of future cities, driving regional development and providing unparalleled user experiences.

Join us in this transformative journey to build the train stations of tomorrow. Let's shape a sustainable, connected, and prosperous future.



[19] *Msheireb station – Central station of Doha Metro Network*



## Imprint

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