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Passenger Information Plus – The Development of a Leading Innovation

Fahrgastinformation Plus – Die Entwicklung der wegweisenden Innovation

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Abstract

The new Passenger Information Plus (PI+) is the most visible innovation of the new X-Car vehicle generation developed and built by Siemens Mobility in Vienna for the metro of "Wiener Linien" (WL). It provides passengers with route guidance information even before they arrive at the next station, including current connections. Orientation in the traffic network of WL is made much easier by dynamic information in the network plan and door-selective indications. The article describes the first ideas in the design process of the new vehicles, the joint development of the system with WL and the technical implementation up to the test runs and gives an overview of the functionality of the system.

Zusammenfassung

Die neue Fahrgastinformation Plus (PI+) ist die sichtbarste Innovation der von Siemens Mobility in Wien entwickelten und gebauten X-Wagen der neuen Fahrzeuggeneration für die U-Bahn der Wiener Linien. Sie ermöglicht den Fahrgästen eine Information zur Wegeleitung bereits vor Ankunft in der kommenden Station inklusive aktueller Anschlussverbindungen. Die Orientierung im Verkehrsnetz der Wiener Linien wird durch dynamische Informationen im Netzplan und türselektive Anzeigen deutlich einfacher. Der Beitrag schildert die ersten Ideen im Designprozess der neuen Fahrzeuge, die gemeinsame Entwicklung des Systems mit den Wiener Linien und die technische Umsetzung bis zu den Testfahrten und gibt einen Überblick über die Funktionalität des Systems.

1 Challenges

Growing metropolises like Vienna rely on an attractive range of public transportation options to reduce carbon emissions and traffic jams and better utilize the available space in the city. As more passengers use public transportation, a powerful overall system is required, especially in the metro network. To modernize and expand its fleet, Wiener Linien GmbH & Co KG relies on the new "X-Cars" from Siemens Mobility Austria GmbH.

The X-Car is the third generation of metro vehicles that were commissioned by Wiener Linien (WL) in 2017 and are produced at Siemens Mobility's factory in Vienna (*Figure 1*).

The order includes 34 six-car trains with an option for an additional 11 trains. The first pre-series vehicle was manufactured in 2020 and given to WL to undergo a rigorous test phase. When passenger service starts in the second half of 2022, the vehicles will be operated in semi-automated mode (GoA2). Starting in 2026, fully automated operation (GoA4) is planned for the U5 Line.

The "Passenger Information Plus" (PI+) system was jointly developed by Siemens and WL and is making its world debut with the X-Car. Innovative processing of digital data makes it possible to provide a new type of real-time passenger information that makes the metro network easier to navigate, while at the same making operations faster and more efficient.

2 Passenger Information Plus

2.1 Route guidance as a service and convenience for passengers

Until now, passengers on metros, trams, and buses have primarily received abstract, static information and occasional dynamic information that doesn't cover all aspects of comprehensive (route) guidance and passenger orientation in the public transportation system. There's no thorough, consistent guidance for travelers. As a result, passengers exiting a train often remain standing on the platform near the vehicle doors while they try to figure out which way to go

to find their connecting trains. This frequently leads to congestion and even bottlenecks, and not just during rush hours, that have a negative impact on the passengers' subjective feeling of comfort and on passenger flows. The pandemic is another reason for passenger crowding to be avoided as much as possible.

Prior to arrival at the next stop, the new Passenger Information Plus offers passengers route guidance for the next station, including all connecting trains. Relevant, location-specific information on where stairways, elevators, exits, and connections are located is displayed above each door and in multiple languages if appropriate. Before arriving at the station, passengers already know which direction they need to go after exiting the train, which results in shorter exit and transfer times. Passenger Information Plus also provides other useful information. Unlike the apps already available on mobile devices, this information is always in the passengers' field of vision. They can orient themselves "in passing" without having to first open an app and obstruct other passengers while they look at their smartphones.

The idea for this development arose during the design process as way to replace the backlit, static network map previously used in vehicles with a digitalized solution. The design team working on the problem consisted in large part of public transportation users living in Vienna. This meant that a lot of practical experience and suggestions for improvement were already accumulated during the early phase, and it continued to serve as the foundation for defining the requirements for the new Passenger Information Plus.

When developing this type of system, it's essential that the transportation operator be actively involved so they can respond to all the operational details and take existing graphical definitions and data sources into account. For Passenger Information Plus, this was done in close collaboration with WL. In this case, the operator was mainly in charge of the graphical configuration and defining the specific use cases in the WL network; they also participated in the implementation and acquired the station data.

Figure 1: „X-Car": The new X-Car from Siemens

2.2 Design aspects

The goal of passenger information is to avoid unclear situations and prevent uncertainties in orientation. Passengers should have access to correct, consistent, and situation-dependent information at all times.

WL visually separates route guidance from advertising. In the station area in particular, passenger information isn't combined with advertising formats. This principle was also applied to the design inside the metro vehicle interior: Advertising monitors are separate from passenger information screens in the X-Car. Internationally standardized graphical symbols and colors are prioritized in areas where textual notifications could create barriers. Pictograms that are comprehensible worldwide take the place of text and reduce barriers.

The individual metro lines are assigned numbers and colors that are used in the station design. Many elements in the stations bear each of the line colors, making orientation in the station easier (*Figure 2*).

WL has clear design rules that were also implemented in Passenger Information Plus. The dynamic display options created new options in areas where specifications didn't yet exist: for example, when it came to visually highlighting the current line. As a result, PI+ also revealed new possibilities for the future visual design of passenger information.

2.3 Features of Passenger Information Plus

Inside the vehicle, monitors are installed above each pair of facing doors that provide passengers with dynamic information that differs depending on which side is used to exit (*Figure 3*).

The most important information is displayed at the top and is the same on both sides of the vehicle. The header, or "Quick Info," shows the current metro line, end station, direction of travel, and the next station with high-priority train connections. The color scheme of each metro line is now also used inside the vehicle as a visual continuation of the route guidance system.

As the usual operating phases are repeated – preparation for departure (doors close) – departure – mid-journey – stop at station (doors open) – the information on the exit side dynamically changes to reflect the current situation and is represented in different images on the monitors. The monitors on the "non-exit side" display a dynamic network map.

2.4 Dynamic network map

In the metro vehicles previously deployed, a backlit printed map above the doors show the metro map and two central rapid urban rail lines. PI+ also displays the metro map on the non-exit side. The current line is highlighted and the position of the train as it approaches the

Figure 2: Wiener Linien control system": WL control system with color-coded metro lines

next station is depicted in an animation. This tells passengers their exact, real-time location in the metro network. Because an expansion of the metro network is planned and space on the map is limited, the contents of the current printed map were divided into two maps, which allowed more rapid urban rail line connections to be added. A crossfade between the two maps occurs during the approach to the station that allows transfers to the rapid urban rail line (*Figure 4*).

2.5 Route guidance and transfer information (exit side)

The operation control system in the WL metro stations provides information relating to boarding, alighting, transferring, and faults. At this time, on-board passenger information about transfer options is acoustic only. Passengers don't receive directional information for transfer op-

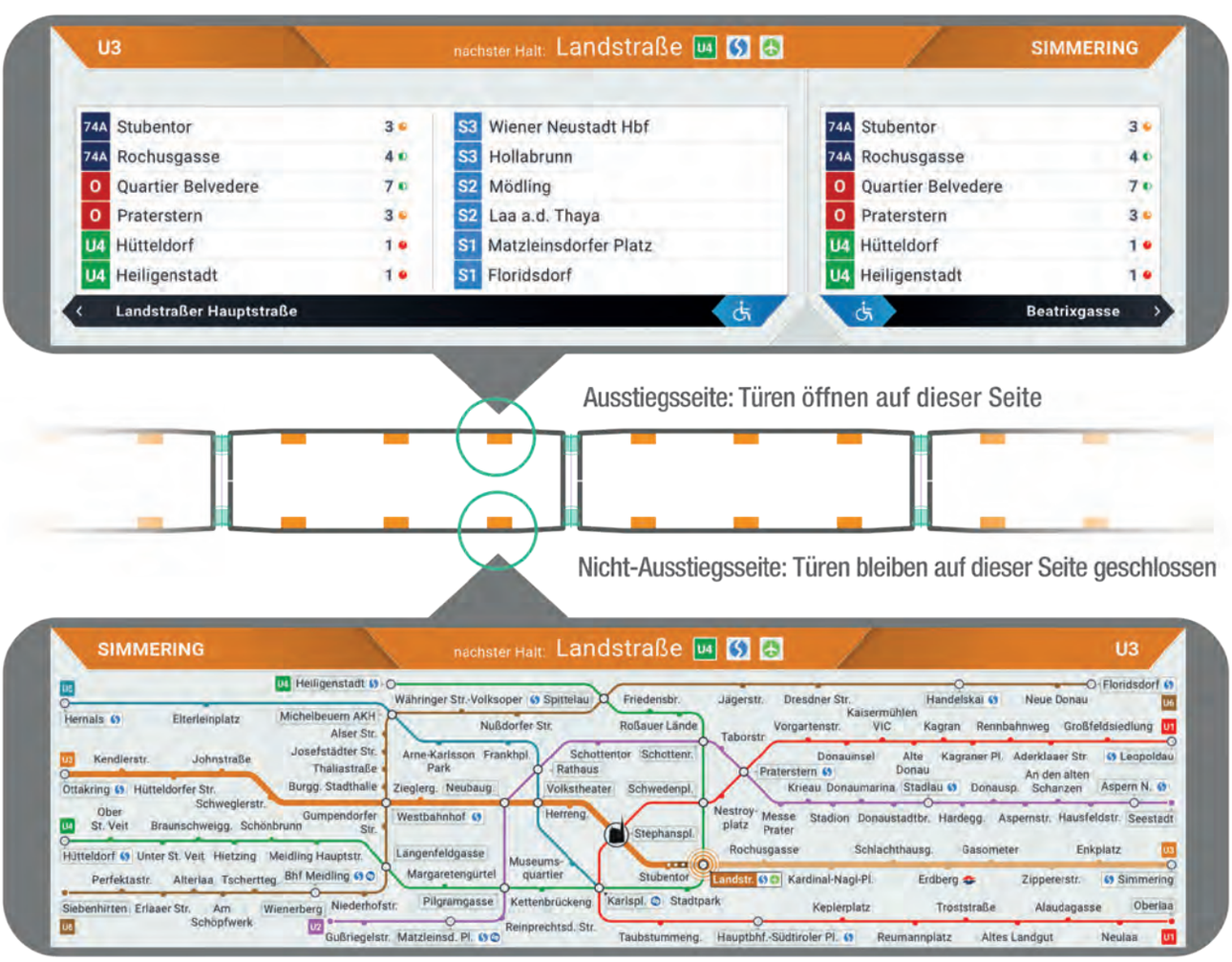

Figure 3: On-board PI+ monitors": Visualization of the positions of PI+ monitors in the vehicle and dependence of display on exit side

tions, elevators, or exits until they're on the station platform.

With PI + , this information that was previously only available on the platform is brought inside the vehicle. The greatest innovation is door-specific guidance. Unlike conventional systems, the monitor above each door displays information specific to that door and the vehicle's location with respect to the station. What's crucial here is not just the particular station where the train is located but also the location of the vehicle doors within the station. In mid-journey, passengers can already learn their route to the exit, elevator, or transfer connection and whether they'll need to go left, right, or straight ahead when they exit the train (*Figure 5*).

Passengers are shown the following information about the next station:

- Route guidance to exits and information on structural design (accessibility): People who need elevators – like the elderly, people with limited mobility, and people with strollers – are shown the shortest route to the elevator, which differs for each station and each vehicle door.
- Connecting trains and the time remaining until their departure are displayed at each exit, with time-dependent color indications showing the likelihood of their being reached before they leave the station.
- Operational and fault messages are displayed that could affect subsequent routes (for example, closed elevators, discontinuation of a line, and delays).

To prevent passengers from waiting until they're exiting the train to view the information on the displays and blocking the flow of traffic in the boarding area, a minimized guidance display containing only essential information is shown when the doors open and in the station (*Figure 6*).

In the event of faults or deviations in operation, this information is quickly

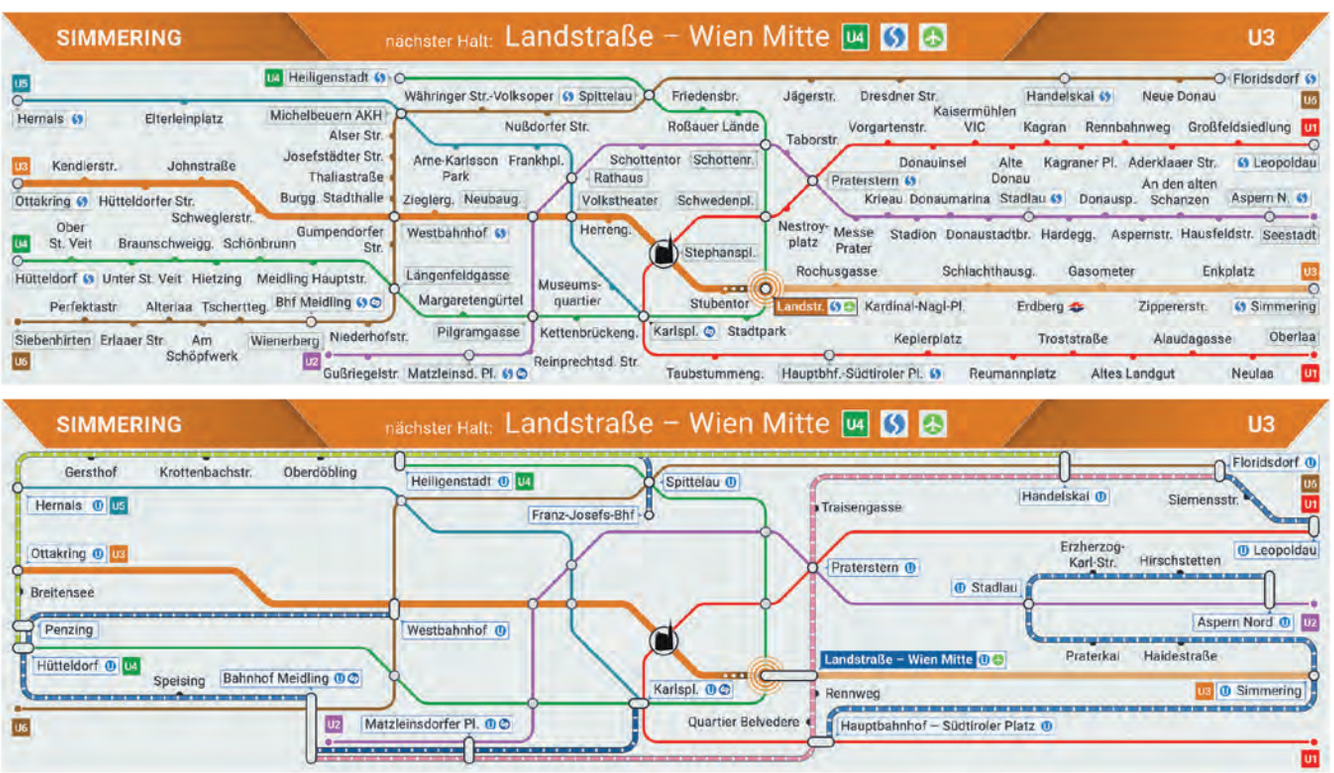

Figure 4: Dynamic network map: Crossfade between metro network map and rapid urban rail line map when approaching a rapid urban rail line transfer connection

Figure 5: Route guidance and transfer options": Display of route guidance and transfer information during the approach to the next station

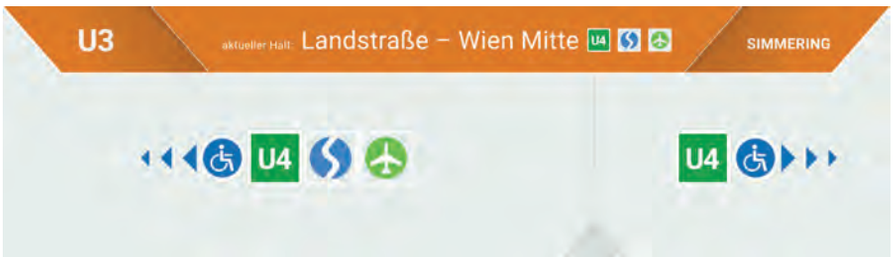

Figure 6: Minimized route guidance": Minimized route guidance during passenger boarding and alighting

Figure 7: PI+ monitor": Monitor for displaying Passenger Information Plus content above each passenger door

and conveniently displayed on the monitors to indicate whether the deviation affects the ongoing trip profile. Barriers that might hinder accessibility when exiting the next station are also displayed. For example, if one of two station elevators is temporarily out of order, this can be indicated in the vehicle prior to its arrival at the station, because the information is accessed via a real-time interface. This includes not only the elevators on the platform but also throughout the entire trip chain in the station. The elevators are linked together and connected to the exit: If all the elevators are out of order, passengers can decide to continue on to the next metro station if necessary.

The monitors also provide information about the exit side and issue a visual door-closing warning. If necessary, a "Tür gestört" ("Door out of order") notice is also displayed.

The text is displayed in German and English, either simultaneously if space allows or using a crossfade.

3 Technical implementation of Passenger Information Plus

3.1 In the train

In the vehicle, a monitor displaying Passenger Information Plus content is installed above all 36 passenger doors. The monitors angle in the 42" ½ cut stretch display format are antiglare and feature an extra-wide viewing in order to make the best use of the available installation space for displaying information (*Figure 7*).

Each of these monitors has a client computer that processes the screen content for each door based on the information provided by the train server, and they display this information in a Chromium browser.

3.2 Tasks of the train server

The train server is part of the "TrainIT" system developed by Siemens Mobility. The trainset has two train servers for redundancy purposes. TrainIT is the central on-board network that serves as a data hub for all the subsystems relevant to passenger information, including CCTV, interior and exterior displays, acoustic passenger information, passenger frequency counters, emergency call points, infotainment, and Passenger Information Plus, as well as the track-side connection via broadband wireless. The TrainIT system enables a standardized exchange of process data between the individual subsystems and guarantees data synchronicity in the train. This makes it possible, for example, to control and synchronize the specific times for loudspeaker announcements on the train and train displays (interior displays and PI + monitors) via a central data source using "train state" signals. Relevant signals from vehicle control systems (including trip progress, train position, and stations) are also linked. Exchanges of data between the vehicle control networks and TrainIT always occur via the security gateway, which is a type of firewall between these two networks.

The PI + server application runs on the train server. This application is programmed in Java and is the central control element of Passenger Information Plus on the vehicle. The application processes data from the data sources listed below and uses it to generate door-specific display images for the 36 monitors distributed throughout the train.

Communication from the server application to these monitors is via an Ethernet network and switches installed in the vehicle.

The Passenger Information Plus server application accesses and interconnects the following data sources (*Figure 8*):

- Data from the vehicle control system: Data transferred from this on-board interface provides PI + with information

on, among other things, the identity of the current line, the next station, the end station, information for precisely locating the vehicle, information on the status of the vehicle doors and of the platform edge doors at the next station, and fault information.
- All of the real-time information that's displayed on the PI + monitors on the train during the journey comes from WL. This data contains departure information (actual amount of time until the next departure and timetable data) and operation information (faults), including line and station faults and elevator faults. The train accesses the data every 30 seconds in order to display the route guidance information relevant for the next station. This means that passengers always have the latest information on transfers and accessibility at the next station. If it isn't possible to transmit real-time data, the system accesses stored static information on transfer connections. If the connection to the train server is interrupted, a static map of the metro network that's stored locally in the monitors is displayed. The train server fetches the real-time data from the track side via the broadband wireless system, making it possible to use a narrow bandwidth.
- Passengers on the train can obtain information on specifics of operation, unscheduled stops in stations, and temporary closures of exits and platforms directly from the control center. A separate data path in the broadband wireless system is used between the control center and the train.
- Offline data – including WL's timetables and infrastructure data like digital station maps that contain the layout of service facilities like elevators, escalators, and stairs – are stored in the train server or the PI + application in a database. This data can also be updated via the broadband wireless system.

3.3 Central system administration on the track side

A PI + trackside application provides the following centralized, Web browser-based functions for acquiring and managing the offline data necessary for the system:

- Importing basic data on lines, stations, and stops (platforms)
- Acquiring and managing the station data from station data acquisition that's necessary for door-specific route guidance. Door-specific route guidance requires precise information on the position of platform elements (stairs, escalators, and elevators) on the platform and on the transfer options and exits available there. Station-specific data is necessary because stations have different architectures, including different platform lengths. This data first has to be acquired for the system in digital form. As part of this acquisition and because of the different station architectures, the functions of the station acquisition tool were modified and expanded in a combined process. The station acquisition tool is designed as a Web application that can run in a browser on laptops and tablets, which is important for on-site data acquisition in the stations. The data acquired is always immediately saved on the track-side PI + server.
- Station, line, and exit closures
- Editor for making changes (including colors, shapes, station names, notification text) to the network map
- Loading and managing graphics that are transferred directly to the train and displayed on the PI + monitors.
- Logging the content displayed in PI + .
- Providing (release) information for use on trains, including the possibility of defining a period of validity for this information.

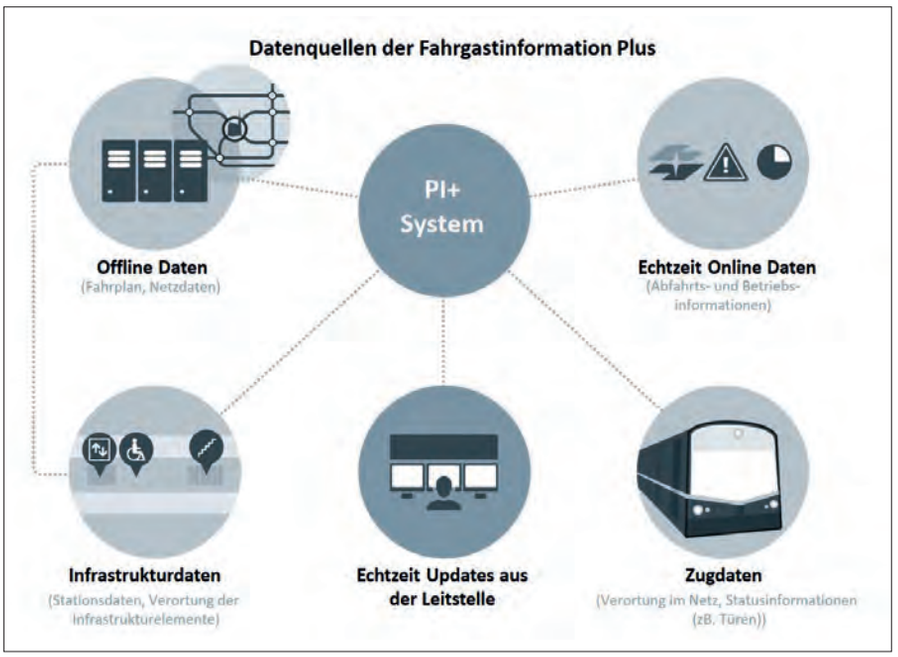

Figure 8: Data sources for Passenger Information Plus": Data sources for Passenger Information Plus

The PI + track-side application is also programmed in Java and installed on a Debian Linux server with access to a central database server (MS SQL). Track-side client access is programmed in Angular and accessible via a Web browser in the WL network. An overview of all the elements of PI + is provided (*Figure 9*).

4 Testing the system

As a part of agile software development, each software sprint is followed by developer tests, and after an integration phase, by system tests in Siemens Mobility's software laboratory. Using the devices and simulation programs that are available there, it's possible to simulate part of the train and generate a virtual trip. This means that the software is already thoroughly tested before it's used on an actual train. Among other things, the software laboratory's setup for Passenger Information Plus includes six monitors installed on the integration test bed (*Figure 10*).

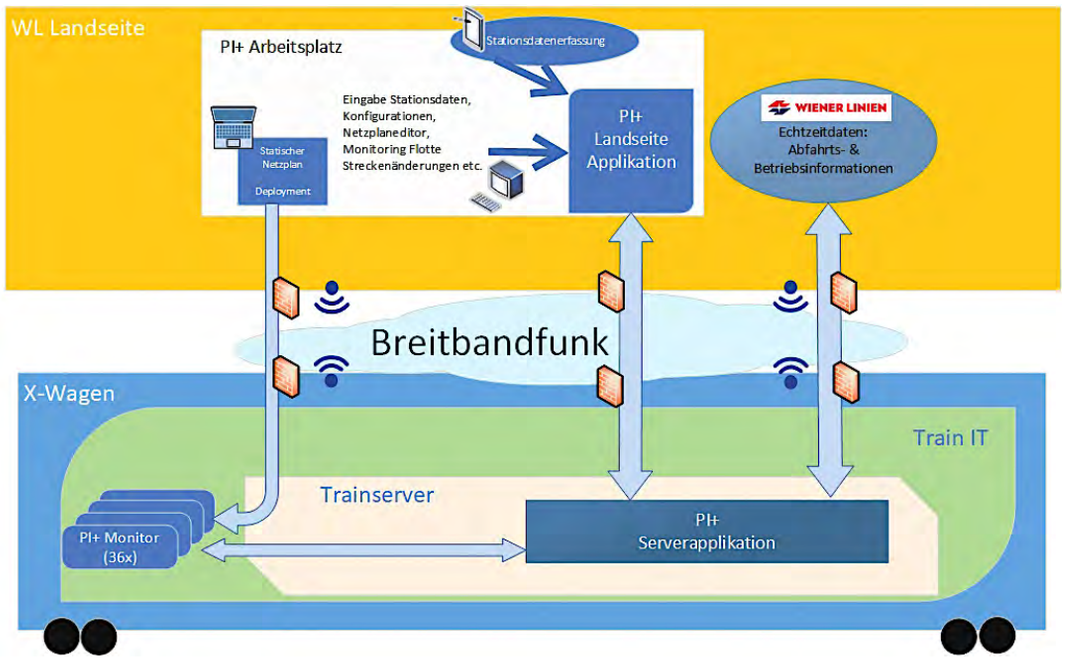

Figure 9: UBX elements of Passenger Information Plus": Train-side and track-side elements of Passenger Information Plus

These pairs of monitors display door-specific images of the virtual beginning, middle, and end of the train. A system test bed is also installed in the testing laboratory that contains all 36 train monitors, making it possible to verify the door-specific images and test all the other system functions. The system test bed is also connected to the trackside elements of PI + (real-time data interface and PI + track-side application).

To test the system's functioning on the train and verify that platform elements are displayed in the correct locations on the door-specific displays, a series of night-time test runs was required away from operations. Acquiring and verifying station data – especially in the case of complex node stations – for the purpose of ensuring that passengers aren't given incorrect information was a resour-

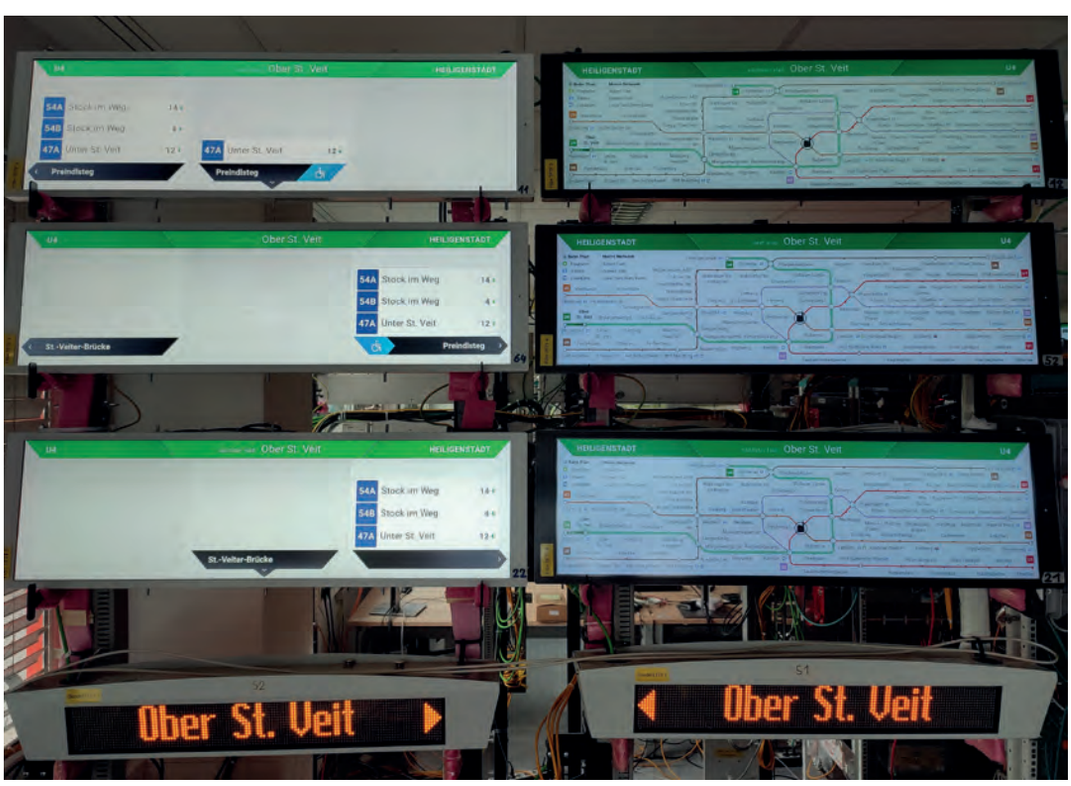

Figure 10: PI+ Laboratory configuration": Passenger Information Plus test setup in Siemens Mobility's software laboratory

ce-intensive process. Day trips to verify the correct display of departure data and various operational messages completed the successful system testing.

5 Summary and outlook

The new Passenger Information Plus system supplies passengers mid-journey with straightforward guidance and makes it easier for them to orient themselves. Those who benefit most are people who travel infrequently, non-locals, and people with limited mobility, like those with strollers or wheelchairs and the disabled. PI+ is protected by an international process patent and – thanks to the rail infrastructure and the vehicles working closely together – displays the precise, location-specific, and real-time information that is currently needed on monitors above each door. The targeted route guidance it provides optimizes passenger.

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(Sources of figures: 1 to 10, autors)

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