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## Integrated The themed magazine for IT systems in public transport

# Hobility: networked thinking

low software is transforming local transport



## **Integrated IT systems** for complex fleets

Textbox 18, TextfeldThe mobility transition is in full swing and public transport has a key role to play in this. The expansion of services and rising passenger numbers on the one hand and cost increases on the other pose major challenges for transport companies. In order to sustainably reduce emissions, more and more transport companies around the world are opting for electric buses and therefore contributing to liveable cities. However, the increasing electrification of bus fleets increases the complexity of planning and operations. Comprehensive digitalisation of processes is essential in order to make this complexity manageable and enable the growth of public transport. Optimisation helps transport companies to make better use of scarce resources and increase their efficiency at the same time. Whether Basler Verkehrs-Betriebe, DB Regio Straße, Stadtwerke Bonn Verkehrs-GmbH or Verkehrsbetriebe Biel – despite their very different requirements, these companies are united by their trust in IVU.suite.

IVU is a leading IT specialist in the development of integrated standard products for public transport. We support complex fleets worldwide by offering fast, convenient and environmentally friendly mobility for everyone, both now and in the future.

**IVU**. SYSTEMS FOR VIBRANT CITIES.



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## **Project Bus System 2027** paves the way for a carbonneutral future –

## Introduction of the IVU.suite at Basler Verkehrs-Betriebe





asler Verkehrs-Betriebe (BVB) are the backbone of public transport in the trinational metropolitan region of Basel. With a fleet of around 120 trams and just as many buses, more than 1,300 employees ensure their services run smoothly every day. One of BVB's particular strengths is that its buses and trains not only connect the Basel region, but also travel as far as France and Germany. This cross-border mobility makes BVB an indispensable part of the international transport network.

The canton of Basel-Stadt is setting new standards for Switzerland: with its ambitious climate targets, the net-zero target is expected to be achieved by 2037. In addition, BVB has received the political mandate to operate its entire bus fleet with 100 per cent renewable energy by 2027. In 2018, BVB therefore launched the visionary Bus System 2027 project to convert its entire bus fleet to battery-electric buses. This will make BVB a lighthouse project in Switzerland. If everything goes according to plan, public transport operations in the region will be virtually climate-neutral from 2027.

Converting an entire fossil fuel bus fleet of this size to electric drive requires an enormous step towards digitalisation. To ensure operations run smoothly, an extensive charging infrastructure is essential: for this very reason, a brand-new depot fitted with modern infrastructure is currently being built in Basel. BVB has faced a particular challenge here, as space is at a premium in urban areas. This is why the new Rank depot is being built on the same site as the existing depot. As the old facility is being completely dismantled, two temporary facilities have been created for interim operations during the construction period – each with a new depot and charging management system for e-mobility.

Unlike many transport companies, BVB is also taking its own approach to the electrification of its bus fleet. Instead of gradually expanding the e-bus fleet, the fleet is being converted in two stages. During the first stage, which has already been implemented, services are operated using two provisional depots. Half of the bus fleet – 65 vehicles in total – is already electric. In the second stage in 2027, the entire bus fleet will consist of electric vehicles and will be operated entirely from the new Rank garage.

However, the conversion of the vehicle fleet is only one part of the Bus System 2027 project. Operating an e-bus fleet is much more complex than operating a diesel fleet. The development of an intelligent charging management infrastructure is therefore a central component of the project. This allows the vehicles to be charged at an ideal time and with the exact amount of energy required, depending on the outside temperature, battery condition and expected traffic volume. The digital depot management system also ensures that drivers find the right parking space. At the same time, the switch to e-mobility is also changing work processes. Here, BVB also relies on digital systems for personnel planning and dispatch.

By implementing all of these measures, BVB is investing in a state-of-the-art operation and preparing itself optimally for the future.

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#### Three questions for Bruno Stehrenberger

## Electromobility makes public transport even more sustainable – but why is the changeover so complex?

It often seems that switching to electromobility just means buying new buses. If you take a closer look, everything changes with the switch to electromobility. It starts with the infrastructure, which has to be completely redesigned, and affects job profiles, processes and the entire production method. The world has changed since we've switched from fossil fuels to electric drive. There are always two sides to this for transport services. On the one hand, transport service employees appreciate the advantages of electromobility, while on the other hand, of course, the operating process has to be planned much more precisely: when we drive a diesel bus, we know in the morning how far we can get with a full tank. Electromobility requires much more precise planning and this only works with the appropriate digital support.

#### Is it worth the effort to switch to electromobility?

For me, the main difference to diesel buses is that they are far more sustainable. With our electric buses, we will save an average of 10,000 tons of CO2 per year over the 14 years we operate them. This is equivalent to the emissions of 3,500 cars on our roads. The effort involved in switching to e-mobility is therefore definitely worth it.

### How can digitalisation make the complexity of electromobility manageable?

Digitalisation supports our processes in many ways. With depot management, we are able to control and charge a complex fleet of electric buses in such a way that we can drive out every day without any errors. The depot management system helps the drivers to recognise which vehicle is being picked up each morning, which route it is travelling on and at what time. When the vehicle returns in the evening, the driver can see whether the bus needs to go to the car wash or maintenance workshop or where the vehicle should be parked for charging. The charging management system ensures that our vehicles leave the depot in a condition that allows them to fulfil their mission. Since 2020, we have worked closely with IVU who has helped us to keep the management and handling of our entire bus fleet under control, from the planning stage right through to production.

 Electromobility requires much more precise planning and this only works with the appropriate digital support.

BRUNO STEHRENBERGER DIRECTOR | BVB





Photos: IVU Traffic Technologies AG

**Bruno Stehrenberger** is a certified production manager (ZFU) who has been Director of Basler Verkehrs-Betriebe since 2019. His responsibilities include the general management of BVB in the areas of transport, technology, infrastructure, finance, human resources and corporate staff.



Employees: **1,350** Buses: **130** Trams: **120** Passengers: **115 million per year** 





## **IVU.**suite FOR THE E-MOBILITY OF TOMORROW



The future of mobility is electric. For transport companies, there is a great deal of work to be done: determining requirements for power grids, planning charging stations, adapting routes to ranges, integrating charging times, monitoring states of charge and infrastructure, taking load limits and electricity prices into account, planning charging processes and scheduling them in real time while learning from the data. The IVU.suite maps all work processes relating to the deployment of electric buses. We provide a suitable solution for every task – either on a modular basis or as a complete system. With the IVU.suite, transport companies establish an end-to-end digital workflow for the planning, deployment and operation of mixed bus fleets. From batterypowered electric buses to combustion engines and fuel cell buses – regardless of the manufacturer – all functions are available in a single interface. This makes the changeover easy, especially for operators of mixed fleets. Thanks to standardised open interfaces, every IVU module can also be connected to third-party systems.



#### Integrated user interface

Whether diesel bus or electric bus – the IVU. suite displays all the essential information for dispatch in a single interface. This gives dispatchers an overview of the entire fleet at all times.



## Proven standard interfaces

Connected via CAN bus, the on-board computers of the IVU.box family receive all relevant data on battery and state of charge directly from the vehicle – without needing to install additional hardware.

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#### **Detailed monitoring**

Accessible at any time: the current state of charge for each vehicle and the status of the charging infrastructure. Dynamic icons in both the map and the table display signal when action is required.

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#### Comprehensive logging

IVU.suite records all operational events during a vehicle working, such as traffic conditions or the development of the battery health, and automatically creates vehicle-specific forecast models using this data.

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#### Accurate operating forecast

IVU.suite automatically determines the remaining range and calculates how many trips are still possible in the currently planned vehicle working, depending on the time of day, occupancy rate or weather.



#### **Smart charging**

IVU.suite automatically analyses the charging status of the vehicle and determines the best possible charging time. This avoids consumption peaks and saves costs in the process.



Flexible working in public transport – the shortage of skilled labour is a challenge, especially for transport companies. There is often a lack of personnel to ensure public transport services run according to plan. At the same time, employees' needs must be taken into account. Transport companies are tackling this problem with lateral entry, job sharing and integrative measures. Digitalisation plays a decisive role, as IT solutions facilitate planning and implementation. The result is reliable public transport for the future. he shortage of skilled labour will remain a key issue for transport companies in the coming years, which will be exacerbated by demographic change. Increasing numbers of baby boomers are increasingly retiring. The Association of German Transport Companies (VDV) predicts that 4,000 to 6,000 bus drivers will retire each year until 2030. At the same time, public transport is becoming increasingly important as a central pillar of the mobility transition.

Digitalisation cannot fully compensate for the shortage of skilled workers, but it can help transport companies to attract and retain skilled workers and make efficient use of existing resources. The recruitment of new employees will increasingly have to take place internationally. This brings challenges, such as achieving a professional language level. IT solutions such as the IVU on-board computer can help train drivers, even those with limited language skills, on board vehicles within a short period of time. Digital support makes it possible to communicate with the control centre and passengers in their respective languages

Employee satisfaction is a decisive factor in attracting new target groups to work in public transport. This also includes flexible working time models that do justice to employees' new lifestyles. IVU's modern scheduling too allows for various working time models to be considered and automatically created optimal

duty and shift schedules. Duty swap and holiday swap exchanges enable more self-determination and flexibility and thus increase the attractiveness for drivers. This helps to adapt schedules to changing living conditions and to allow a greater number of working time models to accommodate employees.

While recruiting and retaining staff are medium-term measures to counter the staff shortage, the daily challenge is to cover all journeys with the available staff. Intelligent algorithms help to build better services. This makes it possible to provide more services for passengers on the road and rail with the same resources and employees.

The strategies to combat the shortage of skilled labour affect all areas of the company: the training teams reassess qualifications, the HR department develops new contract models and recruitment strategies, and the operations teams ensure good communication and respond to the needs of employees. Digitalisation forms the basis for these new models, meaning that the IT department plays a crucial role in introducing new tools and ensuring employee acceptance. The shortage of skilled labour will be with the industry for years to come – time to get everyone involved!



## Interview with **Anja Wenmakers** from Stadtwerke Bonn Verkehrs-GmbH



Anja Wenmakers studied law and is a state-certified interpreter and translator. She has worked for Stadtwerke Bonn since 2005. In 2014, she was appointed the role of procurator and took over the management of SWB Bus und Bahn and SWB Mobil in 2017. In 2025, she was appointed Man-

aging Director of Stadtwerke Bonn.



Employees: **2,560** Length of bus routes: **663 km** Length of tram routes: **125.36 km** Passengers: **92 million per year** 

Resilient public transport is essential for a sustainable mobility transition. In order to provide passengers with an attractive service, qualified and sufficient staff are needed. On the other hand, there is a shortage of skilled labour. What measures are you taking at Stadtwerke Bonn to overcome this disagreement?

The mobility transition will only succeed with committed and qualified employees. We are aware that the shortage of skilled labour is a key challenge. That is why we at Stadtwerke Bonn are focussing on a comprehensive package of measures. We continuously invest in our training programmes, supported by the VDV Academy, in which I am a member of the Executive Board. We offer systematic training for career changes. In addition to traditional recruiting channels, we are also building partnerships with international employment agencies and offer language courses and integration support.

We position ourselves as a strong and positive employer brand with fair remuneration and a high level of job security. We also continuously invest in improving working conditions, for example through ergonomic workstations, air-conditioned vehicles and technical assistance systems

#### How do you manage to promote employee satisfaction on the one hand and reduce organisational complexity on the other?

Flexible working time models are an important key to increasing the attractiveness of jobs, especially in shift work. The scheduling software supports us in scheduling our employees.

We plan shifts in a needs-oriented, fair and transparent manner, take into account the individual wishes of our em-

ployees and optimise staff deployment at the same time. We are also testing new working time models in close consultation with the works council and place a strong focus on regular feedback meetings with our employees

#### The transport industry is undergoing a digital transformation. What role does digitalisation play at Stadtwerke Bonn and where will the journey take us in the coming years?

For us, digitalisation is not an end in itself, but a key tool for improving our service, streamlining processes and creating a new mobility offering. Our passengers benefit from digital real-time information, mobility apps and the option of contactless payment. On the operational side, we are looking into the use of driver assistance systems and even autonomous driving in the long term. By analysing our traffic flows, we are able to adapt timetables and routes in line with demand - with the aim of making our vehicles more efficient and climate-friendly. For us, digitalisation also includes predictive maintenance in order to adjust maintenance intervals and reduce downtimes based on real-time data. For example, the buses' tyre profiles are automatically checked as soon as they enter the hall via a sensor threshold. When communicating with drivers, we are increasingly focussing on digital options to make processes simpler and more flexible – always as a supplement to personal communication.

## Made in Germany Deployed internationally



## DB

With over 561 million passengers, **DB Regio Straße** is the largest bus operator in Germany. DB Regio Straße relies on IVU.suite to provide a single system for all planning and scheduling in all operating regions.

Regio

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The Belgian transport company **De Lijn** operates more than 3,200 buses and around 400 trams in Flanders, including the famous Kusttram along the Flemish coast. With the IVU.suite products, De Lijn was able to set up a demand-orientated operations management system.



#### With around 2,400 vehicles, **PostBus**

transports around 135 million passengers across Switzerland every year. The company relies on the standardised solutions of IVU.suite for all planning and scheduling tasks. Utrecht

Paris

Birmingham

Madrid

Hanover

Frankfurt am Main

Aachen

Olten



### Metro

**Metro Copenhagen** has more than 20 years of experience in the operation and maintenance of driverless metro lines in Copenhagen. For efficient 24-hour operation on all metro lines, the transport operator relies on IVU.suite for timetable planning and vehicle scheduling.

#### **IESWE** VERKEHR

**ESWE Verkehr** transports around 60 million passengers a year with its bus fleet, which consists of 290 buses – 120 of which are electric. ESWE uses the IVU.suite to manage all electric buses in an integrated manner – from route planning to depot and charging management.

### SWIENER LINIEN

**Wiener Linien** relies on IVU products for all its vehicles. With fleet control and dynamic passenger information from IVU.suite – for urban transport by tram and bus.

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Since 2021, **Autolinee Toscane**, a wholly owned subsidiary of the French company **RATPDev**, has been responsible for all public transport in the central Italian region. The transport company relied on IVU.suite right from the start to plan and deploy vehicles and personnel efficiently

## Interview with **Dr Arne Schneemann** from DB Regio Straße

With the high-performance rail replacement service (SEV) for the Riedbahn, DB Regio has set new standards in terms of quality and service. This level would not have been possible without sufficient drivers. How did you manage to recruit hundreds of drivers in such a short space of time?

Recruitment was no easy task given the existing shortage of skilled labour. We therefore made a conscious decision to advertise intensively for drivers not only throughout Germany, but also in other European countries.

We are proud that we were able to recruit around 400 staff from 14 European countries for the Riedbahn replacement service and thus also attract additional skilled workers to the tight labour market in Germany. An attractive overall package was key to this success. In addition to standard market pay, the main plus points were accommodation in free flats close to the place of work and comprehensive onboarding.

In contrast to traditional scheduled services in urban or interurban areas, rail replacement transport is clearly limited in terms of location and time. The general refurbishment of the railway network means that further operations on a comparable scale are to be expected. How flexibly can drivers react to these requirements and what measures do you take to ensure the long-term loyalty of your drivers?

We have learnt a lot from the recruitment and onboarding of many drivers from abroad.

We can see how important the support was after arriving in Germany and on site, for example from integration managers. These services were crucial in determining whether foreign skilled workers chose DB and wanted to stay for the long term. Multilingual training courses and registration in the respective national language on the on-board computers of the buses were also very well received by the drivers and ensured confidence in their work. The entire DB Regio bus group benefits from the experience gained in recruiting and the onboarding tools used during the Riedbahn SEV. These can be transferred to upcoming replacement services for corridor refurbishments and scheduled services.

The planning and implementation of a high-quality SEV is complex. Digital systems can provide crucial support here. To what extent can IT help to carry out time-limited transport operations efficiently and to a high quality with non-local personnel? And how can software contribute to communication between staff with different native languages?

In the Riedbahn SEV, we were able to use IT and digital features in the new buses authorised for this purpose to an unprecedented extent in replacement services. Both drivers and passengers have benefited from this. This has demonstrably contributed to the high quality of transport.

One of the keys to punctual replacement transport lies in the route knowledge of the drivers, most of whom are unfamiliar with the area. In addition to instruction journeys, IT-supported routing via an integrated navigation device is an important support during operation. The use of IT for our passengers has set new standards in replacement transport with information on arrivals, connections and delays in real time, automatic stop announcements and destination displays. Only with comprehensive digitalisation of the workplace were we able to create the conditions to deliver a high-quality, complex replacement transport on the Riedbahn with many drivers from abroad onto the road.



Employees: **ca. 11,500** Bus companies: **29** Number of buses: **11,800 including buses from contractors** Passengers: **561 million per year** 



#### Dr Arne Schneemann studied

business administration and completed his doctorate at the Karlsruhe Institute of Technology (KIT). He joined the DB Group in 2010. Since 1 December 2023, Dr Arne Schneemann has been a member of the Management Board of DB Regio AG.



Photo: DB Regio – Straße

## In conversation with **Christine Maier** from Verkehrsbetriebe Biel

The shortage of skilled labour poses major challenges for many transport companies in Europe and makes it difficult to offer passengers a reliable service. How is Verkehrsbetrieben Biel tackling these challenges?

It is important to find new employees, but it is even more important to retain them. Attractive employment conditions are crucial for this. It is not only the salary that plays a role here, but also further training opportunities, holidays and loyalty bonuses.

Corporate culture is also essential; it characterises the way we treat each other and the way we work together. We have worked intensively on this in recent years and will continue to endeavour to strengthen our shared 'DNA'. For example, we have integrated our values more strongly into our appraisals and pay particular attention to the 'values fit' of new hires. Managers are central to our corporate culture, which is why we have invested heavily in their training in recent years.

We are also working on our image. We show how varied and exciting our professions are. We emphasise that working in public transport is not only fun, but also meaningful.

#### Good communication, for example between drivers and the control centre, is essential for smooth operations. Can digital solutions help to break down language barriers and thus support smooth operations?

In the event of an incident, such as an accident or traffic jam, personal communication between drivers and the control centre is still the most important channel for us. Since the introduction of digital radio a few years ago, the quality has improved significantly. But there is still the challenge of language – especially for us in Biel – with bilingualism. Digital solutions play an important role in providing customer information in the event of a fault. Text modules help with fault information and route suggestions for customers. The fully digital process for vehicle faults is particularly noteworthy: from recording with standard texts and photos to forwarding to the workshop and ordering materials from the warehouse – everything is handled digitally. This helps to avoid errors and improve quality – and not just because of the language.

## The mobility revolution is shaping change in the transport industry. What priorities do Verkehrsbetrieben Biel have for the next five years and what role will digitalisation play in this?

Digitalisation is of central importance to us. We have defined four priorities for this: firstly, Biel and the surrounding agglomeration municipalities are planning a comprehensive expansion of services as part of the 'Public Transport Concept 2035'. One of our priorities until 2027 is to help shape this in a customer-friendly and cost-effective way.

Secondly, we will electrify our entire bus fleet by 2031, with the first step being realised by 2027. This conversion will ensure the planned growth in supply. A modern fleet also opens up new technical and digital possibilities, such as driver assistance systems or continuous vehicle monitoring for proactive fault avoidance.

The third focus is a new depot for our larger vehicle fleet. We are planning a comprehensive energy management system there, taking into account our buses, cable cars and the use of second-life batteries. We are also thinking about automation processes, such as automated parking, to counteract the shortage of skilled labour.

We have digitalised a great deal in recent years, for example by introducing ERP, IVU.pad or Office 365. What is key here is that the new tools have to be used. The fourth focus is therefore on training our employees to get the best out of digitalisation.



Christine Maier studied industrial engineering, specialising in mechanical engineering, and has been Director of Verkehrsbetriebe Biel since 2021. Prior to that, she worked for Swiss Federal Railways (SBB) as Head of Business Development for Passenger Transport/Operations in Bern.



Employees: 240 Vehicles: around 60 buses Route: 229.2 km Passengers: 18 million per year

## **Optimisation** in the course of time

Dr Andreas Löbel and Prof Dr Ralf Borndörfer on algorithms and digitalisation

VU uses state-of-the-art optimisation algorithms and has been able to draw on the expertise of the renowned Zuse Institute Berlin (ZIB) during the development of these mathematical optimisation methods. This makes it possible to quickly create duty and vehicle working schedules that fulfil all legal and operational requirements. This frees up resources that can be used to offer more services, for example. At the same time, duties are more balanced and employees are more satisfied – an important factor for staff retention. Thanks to optimisation, dispatch managers can react directly to disruptions or construction sites and adjust duty schedules and vehicle workings in a matter of seconds with only minimal changes.

#### Duty and vehicle working optimisation

The IVU.suite planning products make it possible to efficiently coordinate services and vehicle workings. Vehicle working optimisation always finds a needsbased and cost-minimised solution for the number of trips to be planned. The powerful optimisation core automatically creates routes according to individual



requirements – for example, taking charging cycles and charging slots into account. The powerful optimisation core automatically creates routes according to individual requirements – for example, taking charging cycles and charging slots into account – and minimises the number of vehicles required. The integrated depot optimisation enables the best solution for load planning, parking space allocation and assignment of vehicles to rotations.

Duty schedule optimisation then ensures that all vehicle rotations and activities are optimally covered. Thanks to powerful optimisation algorithms, it can compile thousands of service elements, staffing specifications and qualifications into an optimal duty roster within a few minutes. With the help of variants and adjustments, planners can also react quickly to changes at short notice, with duty rosters being changed as little as possible. In regional transport in particular, the roster and duty rota must be created simultaneously. Transport companies can achieve the best possible results in this environment too with integrated duty schedule and vehicle working optimisation. The system starts with a timetable and creates an optimised

and coordinated schedule and duty roster based on it. The allocation of duties and vehicle workings to the vehicle and staff depots can be specified – even when allocating areas of the timetable to external contractors.

#### Automatic Personnel Planning (APD)

IVU.suite uses APD to optimise personnel allocation. The system defines duty sequences and assigns the appropriate employees to them. Depending on operational requirements, it ensures fair allocations or balanced working time accounts, for example. APD also automatically takes qualifications, holidays, further training and requests into account – thus increasing the flexibility of the driving personnel.

In addition to day-to-day operations, optimisation also supports business decisions, such as when applying for tenders. This makes it possible to strike a balance between an attractive offer for drivers and operational efficiency. Optimisation can also be used to calculate scenarios for routes that have not yet been won and use them as the basis for an efficient service, so as to stay one carriage length ahead of the competition.





Dr Andreas Löbel (IVU) and Prof Dr Ralf Borndörfer (FU Berlin and Zuse Institute Berlin) in conversation about the future of optimisation in public transport.

## " Al and optimisation are not opposites, they complement each other.

The successful cooperation between IVU Traffic Technologies and the Zuse Institute Berlin in the development of intelligent algorithms for optimisation has now been in place for many years. How did this co-operation originally come about? Which topics were at the centre of attention at the beginning?

LÖBEL: Ralf and I studied together in Augsburg and were taught by Prof Martin Grötschel. We have always been interested in how maths can influence and improve the real world. When Prof Grötschel moved to the Zuse Institute in Berlin in 1991, he also focussed on traffic. After completing our diploma thesis, we followed him to the institute in 1992. One of our first tasks was to develop a vehicle working schedule for the Telebus – a bus system for people with restricted mobility in Berlin.

BORNDÖRFER: Right from the start, our aim was to develop algorithms that would improve public transport. It was particularly important to us that the planning results were directly applicable without having to make any additional adjustments.

LÖBEL: At the time, IVU had a customer with very specific requirements for an optimisation system for vehicle working scheduling. That was the beginning of our collaboration and the development of a close partnership that has now been successful for around 30 years. The first customer was followed by further projects, including optimisations for vehicle working scheduling and duty scheduling for bus and rail customers.

## How have the requirements of transport companies changed over the last 20 years?

LÖBEL: Over the years, the focus of optimisation has changed significantly. In the past, the main focus was on reducing the use of resources in order to achieve the same or even better output at the lowest possible cost. This primarily involved the more efficient utilisation of vehicles and personnel. Today, the shortage of skilled labour poses a completely new challenge: the limited capacities must be planned in such a way that transport continues to function stably and offers drivers attractive services for a long-term commitment. This issue will become even more important in the coming years, as many employees are retiring and it is likely to be difficult to recruit enough new staff.

BORNDÖFRER: The tasks have become more complex and the requirements for optimisation have become much more detailed. At the beginning of the 2000s, we started optimising the circulation of classic diesel buses for transport companies. The complexity has increased with the optimisation of railway companies and reached a new peak with the use of electric buses.

#### Keyword e-mobility on the road: what are the challenges in optimising electric buses?

LÖBEL: The scheduling of electric buses is extremely complex. In contrast to diesel buses, which start with a full tank, are in use all day and only return to the depot in the evening, electric buses have to be recharged more frequently. Their range depends on many factors, such as battery condition, weather conditions and vehicle utilisation. Initially, we tried to adapt one of our tried-and-tested planning procedures. However, this did not work for various reasons. In the end, we were able to benefit from other problems relating to services and thus develop algorithms for optimising the scheduling of e-buses.

#### We live in the age of artificial intelligence (AI) – provocatively asked: can AI take over the entire optimisation process?

LÖBEL: Artificial intelligence and optimisation should not be seen as opposites. All AI processes are essentially optimisation, and conversely, AI can obtain the information needed for optimisation in a comprehensive manner. If the question is whether all problems can be solved effortlessly with a single method, then the answer is no, "there is no free lunch". You still have to use the appropriate method in each case. But with AI, the spectrum of possibilities expands. For example, you could use machine learning to automate very detailed parameter recording for vehicle circulation planning. However, the actual planning will still be carried out using integer optimisation in order to achieve the same quality of results.

BORNDÖRFER: AI is usually divided into three areas: descriptive, predictive and prescriptive. Descriptive AI analyses data in order to understand what is going on. Predictive AI attempts to predict the future on this basis. Prescriptive AI uses this information and forecasts to make decisions. This is exactly what optimisation does. AI and optimisation are therefore not opposites, but complement each other.

#### What topics do you think the transport industry will be dealing with in the next five to ten years and how can applied maths support this?

LÖBEL: Over the next five to ten years, the transport industry will increasingly benefit from the availability and utilisation of large amounts of data. This data will make it possible to significantly extend the planning horizon. While planning to date – with the exception of train planning – has mostly been carried out on a daily basis, mathematical algorithms will soon be able to enable cyclical, integrated vehicle working and duty scheduling, for example for electric buses, for an entire weekly period.

BORNDÖRFER: In the future, predictions will be possible in "true" real time, and intermodally. However, this is not always easy. Let's take the example of a park & ride terminal: if a free parking space displayed on departure is no longer available on arrival, this leads to frustration. The same applies to local transport if,

for example, suggestions from planning systems cannot be used during disruptions or major events such as football matches. Thanks to ever more comprehensive data and improved control options, we will be able to better control transport systems in real time and organise them intermodally. This will significantly increase the efficiency and reliability of transport.

#### Optimisation has always been an interplay of algorithms and computing power. What opportunities do quantum computers offer?

BORNDÖRFER: Quantum computing is a fascinating research topic with great potential. Algorithms already exist for certain problems that could run much faster on quantum computers. However, we still face technical challenges, such as susceptibility to errors and the handling of input and output. In the short term, we should not expect any 'quantum leaps' in the transport sector, but in the long term, quantum computers could offer revolutionary opportunities. However, it will be years before we see practical applications.



## **The complete solution** for public transport



Well-developed public transport is the environmentally friendly alternative to private transport. Digitalisation plays a decisive role here.



Founded: **1976** IPO: **2000** Employees: **over 1,000** Customers: **500 worldwide** Locations: **17** 

The mobility transition is essential to counteract climate change and ensure a sustainable future. Well-developed and modern public transport offers an environmentally friendly alternative to private transport. Growing electric bus fleets reduce CO2 emissions and improve the quality of life in cities. Cashless payment systems facilitate access to public transport, while artificial intelligence supports operations by analysing data. On-demand services and intermodal transport complement conventional services. Autonomous driving will play a much greater role in the future – in large conurbations, for example, for underground trains or in suburban areas with small vehicles. Digitalisation will play a key role here

### Questions for **Bastian Dittbrenner** Head of Public Transport Division

#### The increasing switch to electromobility is also making planning and operation more complex. How can digitalisation simplify processes in depots and on the track?

As electromobility becomes more widespread, the complexity for transport companies is also growing. Digitalisation is the key to overcoming these challenges. Intelligent planning and integrated depot and charging management ensure efficient control of processes in the depot. Smart load and charging management reduces peak loads and takes dynamic electricity prices into account. This results in an optimised interplay of deployment planning and charging times and also keeps an eye on electricity costs. Battery-friendly charging is also crucial for extending the service life of the batteries and maximising efficiency.

#### Resource shortages and a lack of skilled workers are leading to cancellations and thinned-out timetables for transport companies, which is affecting passengers and the image of public transport. How can IT solutions help here?

Although transport companies are experiencing a slight improvement, the issue of a shortage of skilled labour remains highly topical, especially with the impending wave of baby boomer retirements. Digital solutions cannot solve the shortage of skilled labour, but they do help transport companies to make the best possible use of available resources. IVU.crew, for example, supports the efficient planning and management of personnel resources, while IVU.pad offers drivers a mobile tool that makes their daily work easier and improves communication. More attractive duty rosters, duty swap and holiday swap exchanges enable more self-determination and flexibility for drivers. This is how modern employers react flexibly to a dynamic labour market.

#### Artificial intelligence is increasingly penetrating our working and living environments and is also influencing public transport to varying degrees. How is IVU prepared for this?

Al alone will not be able to completely solve complex planning and operating processes in the near future, but it can support, simplify and automate them. IVU has always been a leader in optimisation and automation. The use of Al algorithms enables a wide range of exciting applications. Through more precise planning and scheduling, transport companies can increase their performance with the same use of resources. With IVU.data, we have created a tool that collects and processes data to provide Al algorithms with a better basis. We will continue to stay on the ball in terms of Al technology and work closely with our customers. In this way, we are constantly improving our algorithms, testing them with customers in practice and then incorporating them into our products.

#### The demands on the world of work in transport companies are increasingly changing. Is <neo> IVU's answer to the need for even simpler and more flexible use of its integrated software?

The world of work in transport companies is subject to constant change. Younger generations are calling for an even stronger focus on user-friendly and easy-to-learn software. With <neo>, we provide the answer and rely, for example, on web-based solutions that impress with an intuitive user interface and clear design. Ease of use and full performance take centre stage. However, smaller companies often require a reduced range of functions. With IVU.plan.essentials and IVU.fleet.essentials, we also offer these companies the opportunity to digitalise their processes to a greater extent.

## REACHING OUR GOAL TOGETHER

From winning the licence to launching the first vehicle, there is a lot of work to be done. IVU stands by its customers as a reliable partner throughout and helps them to keep an eye on all requirements and optimally fulfil their tasks even after the start of operations.

With IVU solutions, transport companies achieve more: they establish a consistently digital workflow and integrate all areas of operations, from planning to driving personnel. Whether they use the complete IVU.suite or individual products, all data remains in one system. This ensures efficiency – on the road or rail as well as in the control centre. We know the tasks of transport companies are as individual as the routes they operate. That's why the IVU.suite contains everything needed for the successful operation of buses and trains. A standard system for everyone – and therefore quick and easy to implement.

We do not leave our customers in the lurch. Whether it's configuring interfaces, implementing projects quickly, hosting the IVU systems or providing technical support – together we find customised solutions for every need so that buses and trains run reliably.



### **IVU.**integration

In a networked world, software products never exist in a vacuum. IVU.integration ensures that all systems work together optimally and that data flows smoothly – from correct timetable printouts and the connection of on-board computers and external products to evaluations and statistics.



### IVU.xpress

Every transport company has its own identity and its own approach. With the IVU.xpress implementation process, the IVU.suite can be put into operation quickly and efficiently in any environment. This ensures a predictable project process – from the start of the project to the system design and the final roll-out.



### IVU.cloud

With IVU.cloud, IVU takes over the entire technical management of the IVU.suite – from hosting and maintenance to the installation of updates Highperformance, highly available, secure and reliable: IVU.cloud remains fully scalable, for example for new routes or lines. This ensures flexibility.



## IVU.suite

The IVU.suite is IVU's standard solution. Thanks to its modular structure, it can also be customised precisely to individual requirements. Exactly what is needed is always used.  Sustainable efficiency is based on consistent data flows. Integrated IT systems make it easier to optimise vehicle and personnel deployment and reduce emissions.



## IVU.service

Successful IT projects are based on trust. IVU places great value on this. Whether urban or regional transport, IVU accompanies customers through the entire project – and beyond. After successful commissioning, Customer Service are on-hand to ensure that all vehicles always reach their destination.



## IVU.consult

The IT consultancy IVU.consult supports transport companies in the targeted planning, implementation, and optimisation of software. From consulting to the complete takeover of services: IVU.consult GmbH's customers benefit from its expertise in the processes and special features of IT systems in public transport.



### IVU.solutions

The standard software IVU.suite fulfils the requirements of transport companies all over the world. To this end, IVU.solutions develops customised software solutions, such as interfaces to third-party systems or the development of supplementary modules that are precisely tailored to the needs of individual transport companies. Head office IVU Traffic Technologies AG Bundesallee 88 12161 Berlin

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