



TSB more mobility

TSB

Transport System Bögl



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TEB – *Moving megacities*

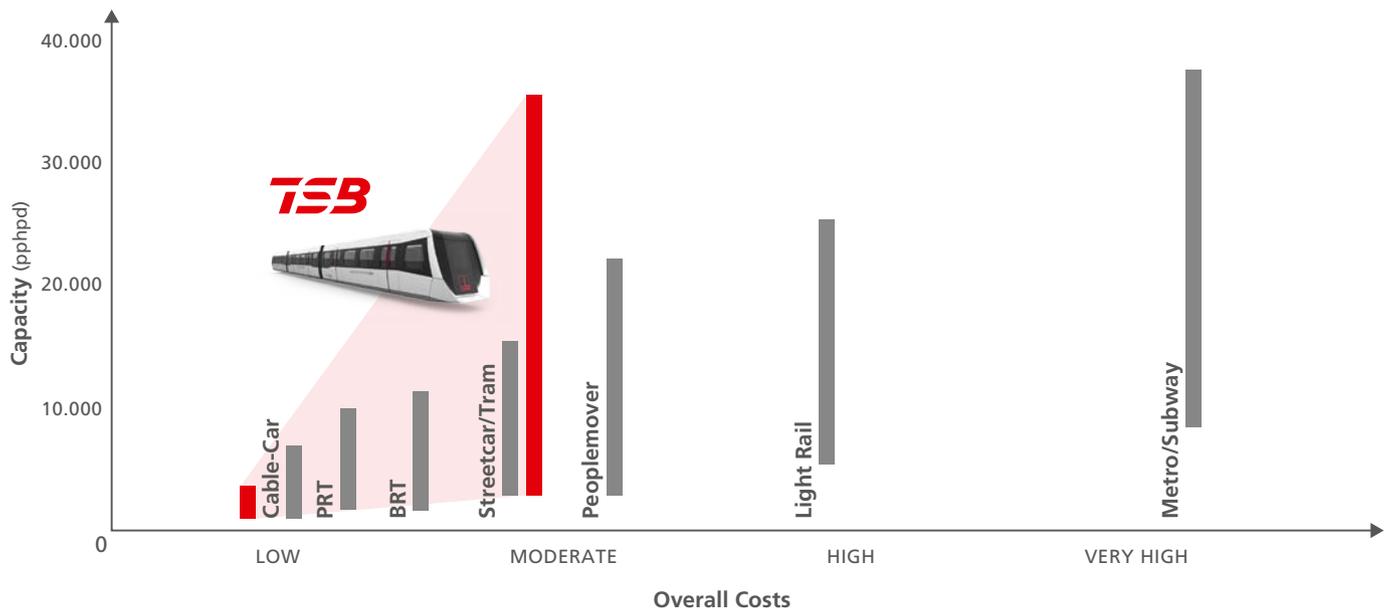
Cities are growing and urbanization is accelerating throughout the world. Over 5.6 billion people will be living in metropolitan areas and their surroundings by 2035. Such growth brings with it higher building density and more traffic, noise, and air pollution. Smart public transportation concepts are therefore needed to meet the challenges of big cities and link neighborhoods together efficiently and with almost zero noise. With the Transport System Bögl, we have developed

a public transportation system that is ready for the future. Thanks to maglev technology, this system is quiet, flexible and reliable while also saving space and lowering emissions. And with variable routing, the Transport System Bögl can be integrated into any urban landscape or existing traffic infrastructure. From planning and the manufacturing of tracks and vehicles to on-site assembly and system operation, we deliver an efficient turnkey system that redefines the future of mobility.

More tomorrow, today

Due to increasing building density, city centers, suburbs, exhibition grounds, industrial areas and airports are growing closer together. The consequence of this is that more people want to travel reliably and flexibly in less space. There is enormous traffic density on the roads, and existing bus and trolley systems are already failing to meet frequency and capacity needs in many places. The Transport System Bögl relies on advanced maglev technology. The magnets installed in the running allow to levitate the vehicle and at the same time ensure guidance on the track. For locomotion, a linear

motor is built into the running gear that can accelerate the TSB up to 150 km/h (93 mph). A major advantage of maglev technology is the nearly silent propulsion and high reliability regardless of weather conditions. The running gear of the TSB lies protected inside the track so that movement is not impaired by snow or ice. These characteristics make the Transport System Bögl a superior solution for constructing or expanding local transport infrastructure, especially in densely populated urban regions and surrounding areas.









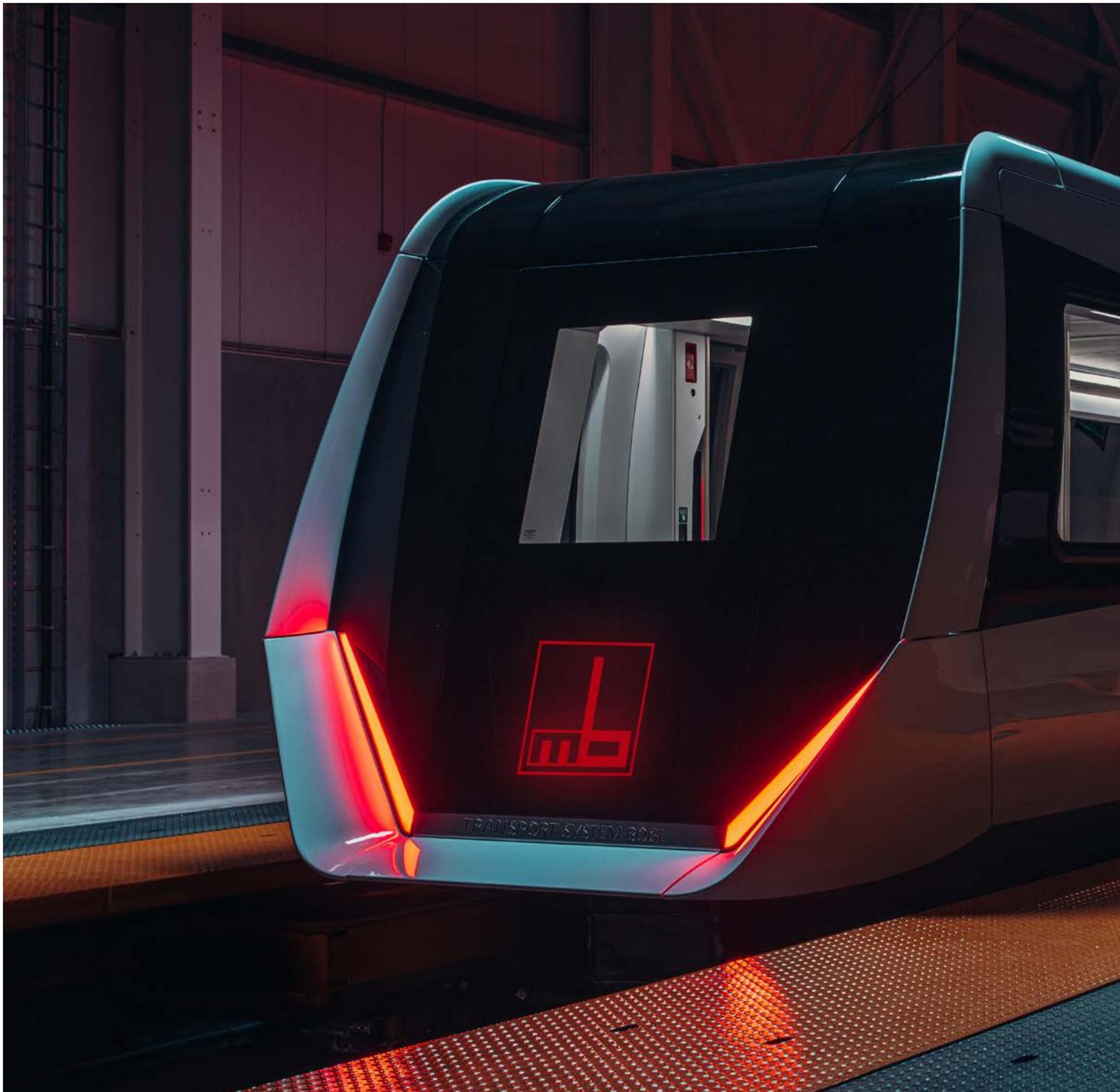
Rethinking public transportation

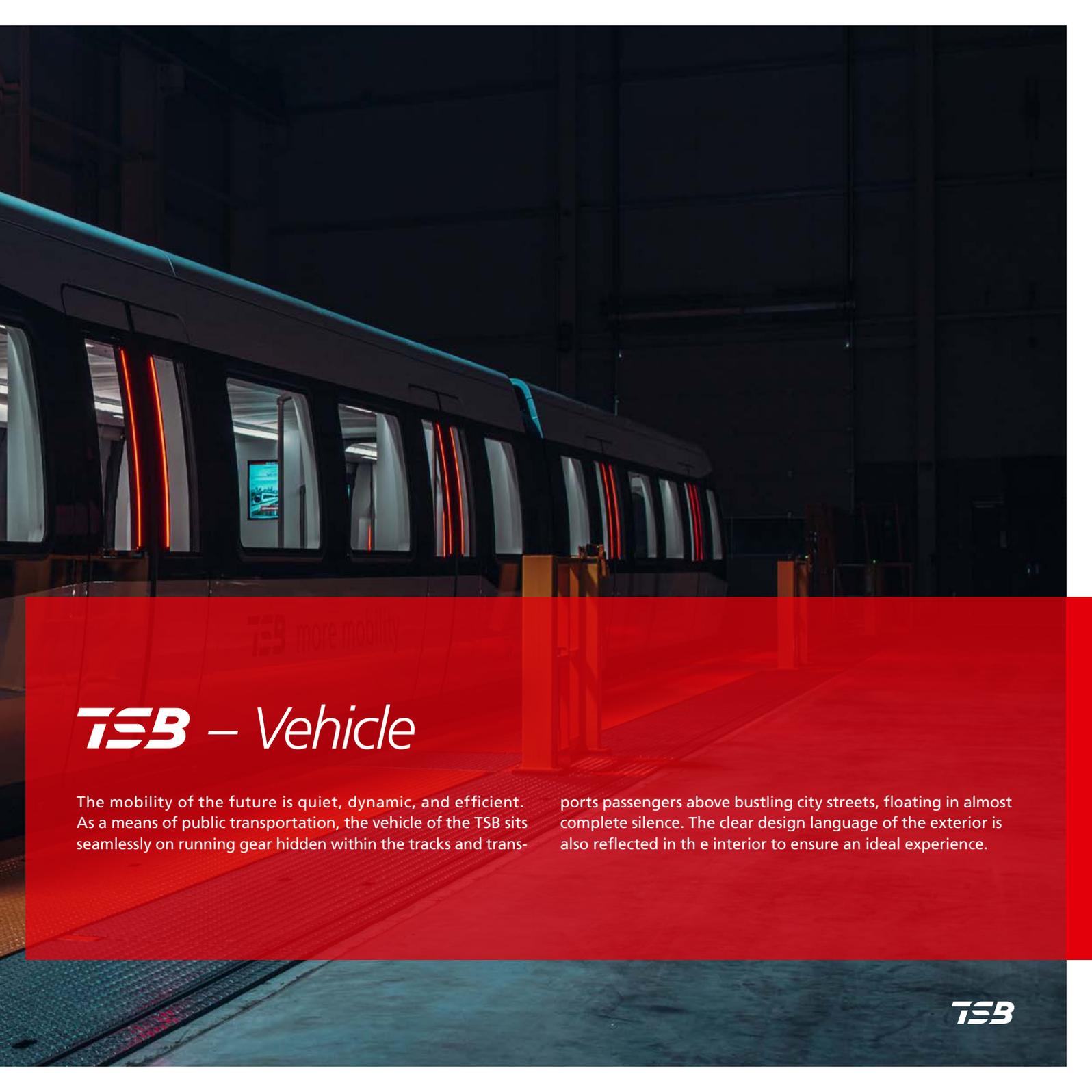
As a future-oriented maglev transportation system, the Transport System Bögl is capable of fulfilling many of the needs that metropolitan areas must deal with in the future. It can bring over 35,000 people per hour per direction to their destination at an investment cost far below that of conventional subway systems.

With speeds of up to 150 km/h (93 mph), the Transport System Bögl is virtually noise-free in urban areas, and their surroundings and can easily handle various passenger loads thanks to a high cycle frequency of up to 80 seconds' train headway. The track length can range from one kilometer (0.50 miles) to over 50 kilometers (30 miles).

Advantages of the Transport System Bögl

- Hardly any wear on the vehicle and track
- Driverless operation (GOA4) with high timetable flexibility for optimal capacity utilization
- System at ground level, in tunnels, or elevated with up to 10% gradeability and a horizontal curve radius of 45 m (148 ft)
- Implementation as turnkey project: planning; production of track, vehicle, and operational control system; construction; operation





TSB – *Vehicle*

The mobility of the future is quiet, dynamic, and efficient. As a means of public transportation, the vehicle of the TSB sits seamlessly on running gear hidden within the tracks and trans-

ports passengers above bustling city streets, floating in almost complete silence. The clear design language of the exterior is also reflected in the interior to ensure an ideal experience.

Design meets functionality

The exterior design of the Transport System Bögl vehicle is designed for optimal standing area and aerodynamics. The car body is made of lightweight aluminum. The TSB deliberately stands out from the conventional design language of trains, trolleys, and buses. It features interior com-

ponents that appear to float and a novel lighting scheme that enriches the feeling of floating in silence. Modern standing and seating areas combined with vibration-free transport ensure maximum comfort. The interior spatial design sets new standards for this vehicle class.

General

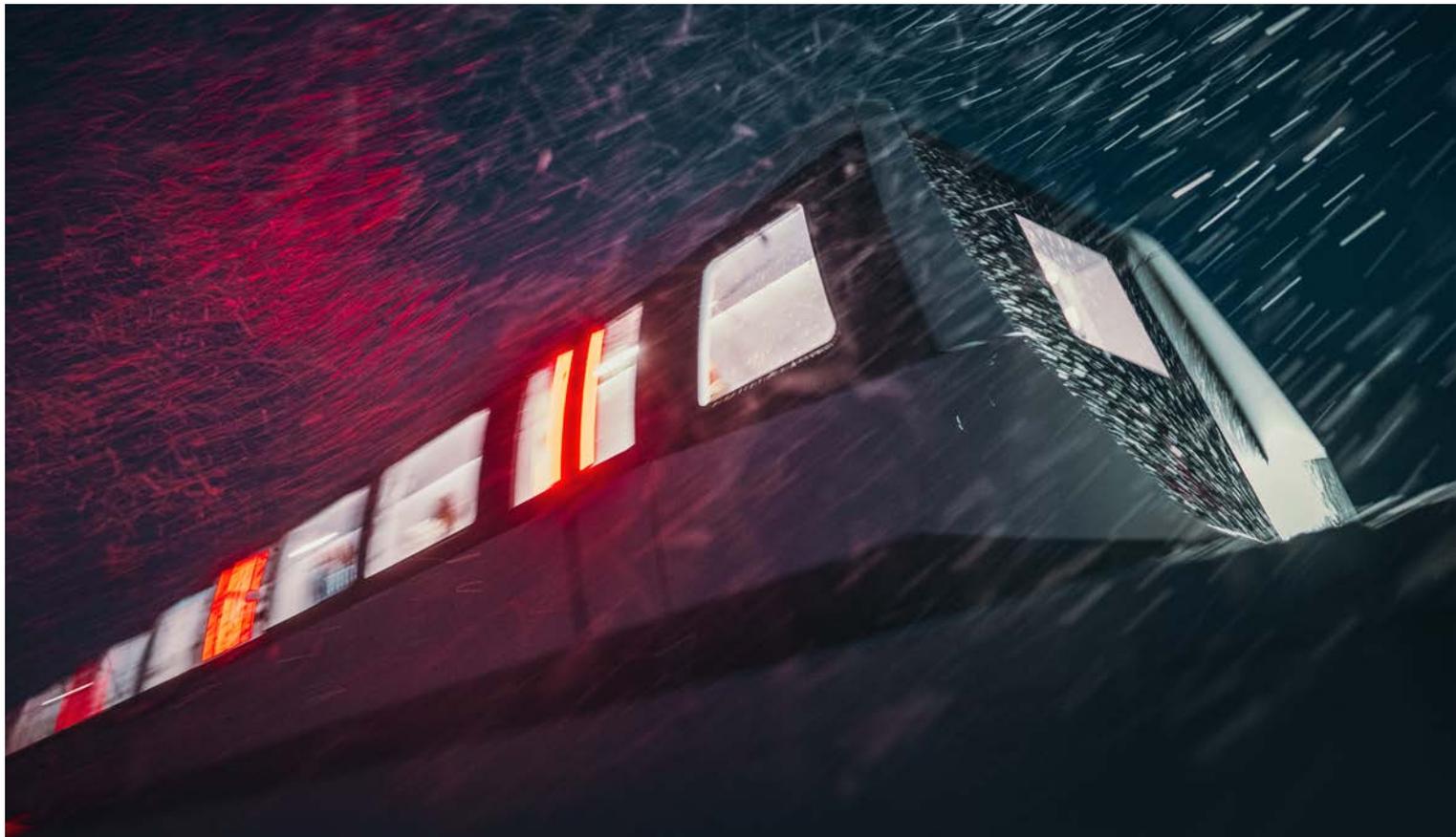
- Automatic driverless passenger transportation system with asynchronous short stator linear drive
 - Electromagnetic levitation system with combined carrying and guiding function
 - Vehicle made up of two to six powered cars
-

Vehicle data per car

| | |
|---------------------------|----------------------|
| Length | 12 m (40 ft) |
| Width | 2.85 m (9.35 ft) |
| Power distribution system | 750 V DC |
| Unloaded weight | 18.5 t |
| Payload | 9.5 t |
| Max. capacity | up to 127 passengers |
| Headway | min. 80 s |

Technical data

| | |
|------------------------------|--|
| Maximum operating speed | up to 150 km/h (93 mph) |
| Acceleration/deceleration | 1.3 m/s ² (0.13 g) |
| Maximum grade | 10% |
| Min. horizontal curve radius | 45 m (148 ft) |
| Max. superelevation | 8° |
| Overall capacity | up to max. 35.000 pphpd (passengers per hour per direction) |



12 m (40 ft)





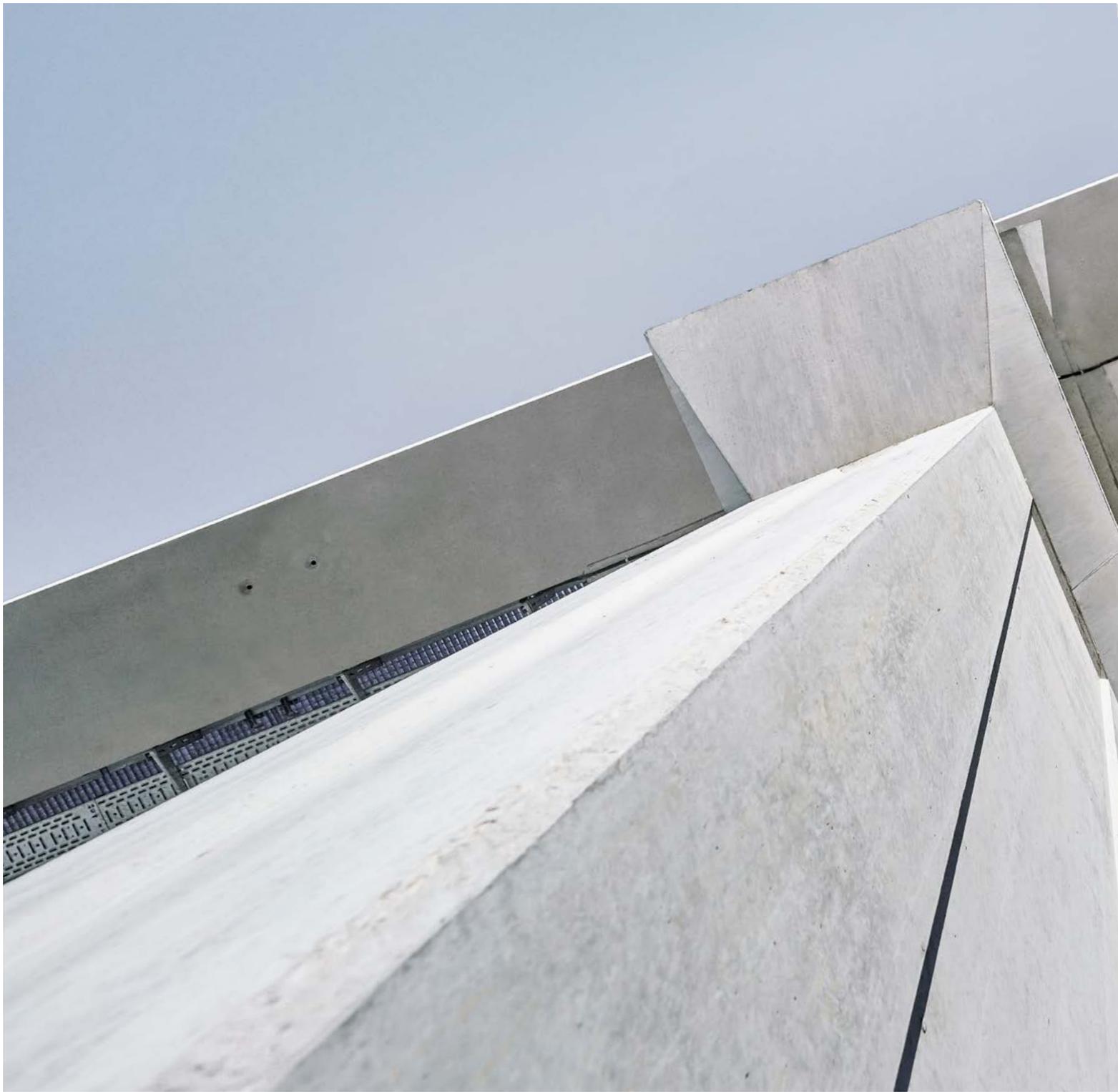
Comfort redefined

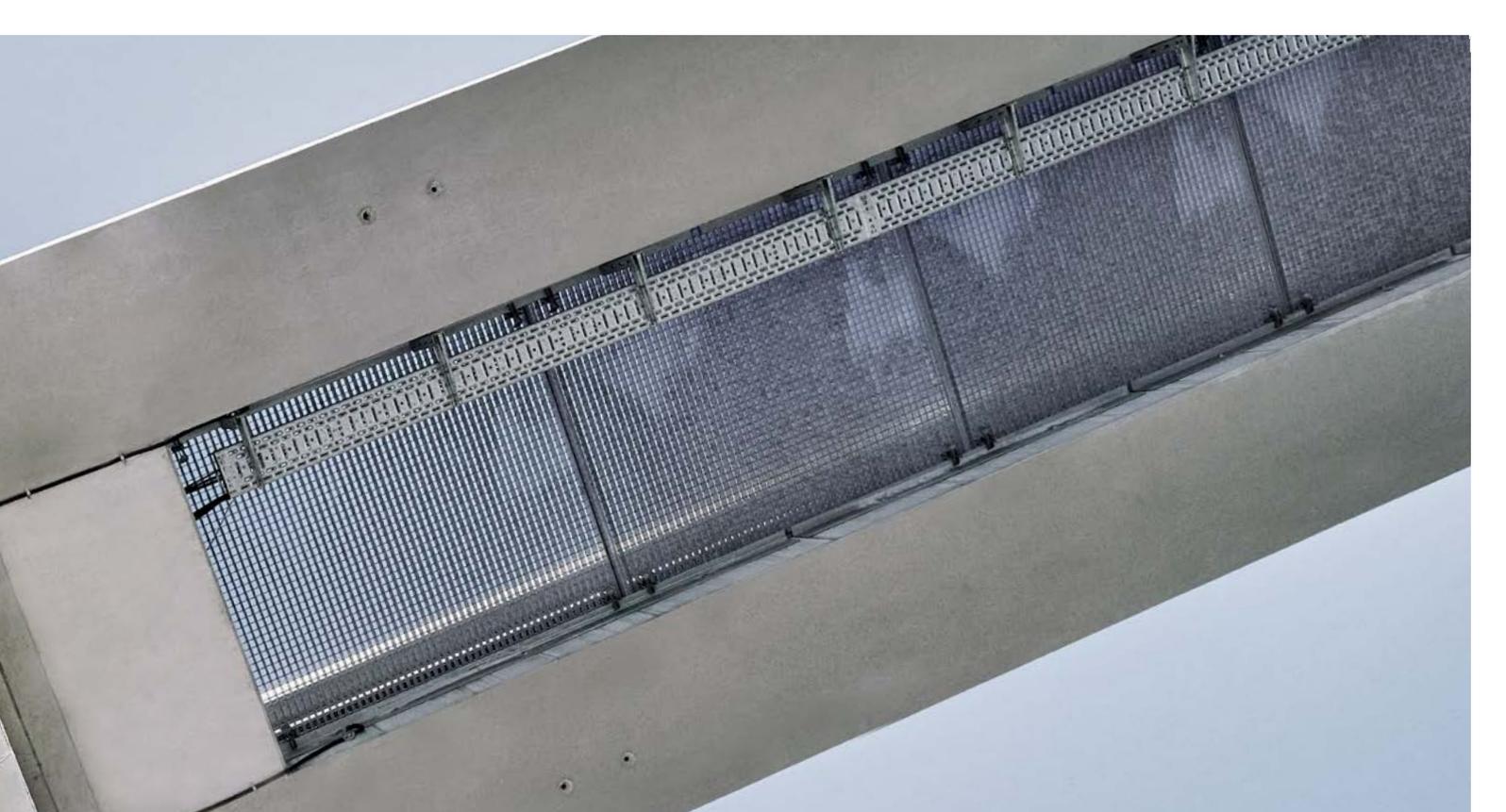
The Transport System Bögl offers passengers standing areas or comfortable seating areas depending on car variant and furnishings. The interior design emphasizes high comfort and efficient use of space.

This is aided by lighting strips whose color temperature adjusts to the available daylight. A powerful and particularly quiet air conditioning system creates a pleasant atmosphere inside the sections.

Details on interior design

- Ergonomic standing areas
- Customizable layout with up to 37 seats
- Powerful and silent air conditioning system
- Floor covered with non-slip natural rubber
- Monitors, passenger-counting devices, cameras, loudspeakers, and emergency intercoms





TSB – Track

Transportation systems of the future can be seamlessly integrated into existing mobility structures. Large cities have been built with multi-lane roads aboveground and a slew of supply lines and subway tunnels underground.

This presents a challenge for urban infrastructure. The track of the Transport System Bögl is specifically designed for this purpose and is thus capable of seamlessly fitting into the urban landscape of major cities.

Smart integration into urban landscape

The Transport System Bögl can be easily integrated into new or existing infrastructure systems. The visually appealing track adapts seamlessly to any urban environment and eliminates the need for disruptive overhead lines. The track can be built on the ground, underground, or elevated. Expensive primary support structures are therefore unnecessary.

The guideway is industrially manufactured at our main plant in Sengenthal, Germany in a standardized and efficient manner. Worldwide transport is available using standard shipping containers. The simple frame construction method of the track allows for quick on-site installation. This not only results in significantly lower construction times, but also lower space requirements thanks to the narrow design of the guideway. Since the weight of the TSB vehicle is evenly distributed on the track because of the maglev technology, the track is very low and lightweight compared to wheel

rails where the load is concentrated. Future public transportation projects can thus be implemented quickly and economically while also conserving resources.

Advantages of the track

- Industrial production of fully-equipped standard segments
- Quick assembly of industrially manufactured track profiles
- Narrow primary support structure – H 1.2 m (4 ft) / L 23.5 m (77 ft) – for seamless integration into cities and urban areas
- Flexible use due to various routing options – elevated, at ground level or in tunnels
- Visually appealing track route for urban use without overhead lines
- Short construction times; less annoyance for local residents
- Optimum solution for distances ranging from one kilometer (0.5 miles) to over 50 kilometers (30 miles)







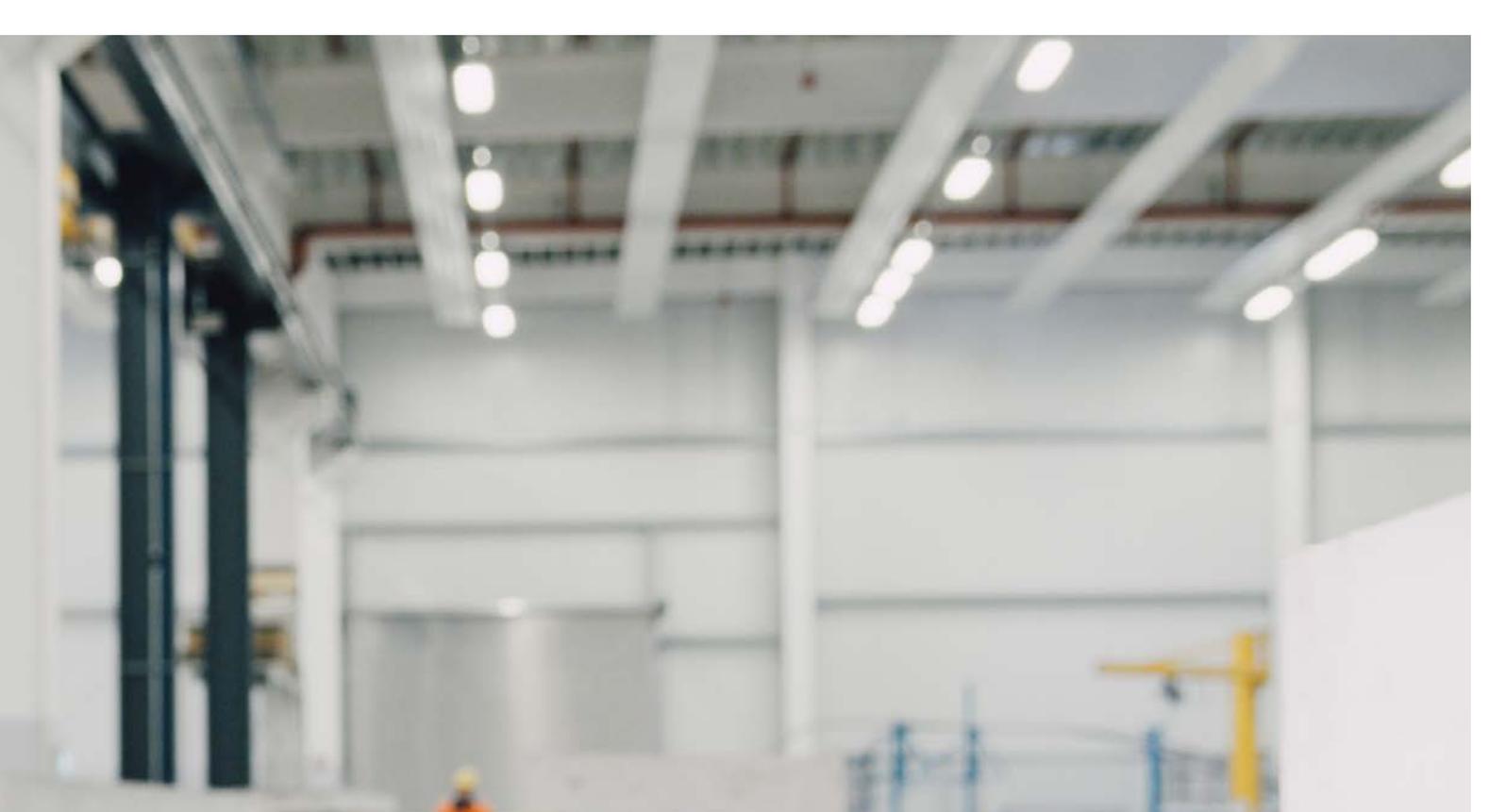
A flexible way to connect people

The Transport System Bögl can be implemented in no time. Thanks to variable routing with industrially manufactured subsegments, track routes are equally flexible, customizable and cost-effective. The Transport System Bögl can handle inclines of 10% and an horizontal curve radius of 45 meters (148 ft) at a cant of 8°.

Thanks to the elevated mounting system, the TSB can be optimally integrated into the urban infrastructure. Any free space available under the guideway can also be used for alternative purposes. If the Transport System Bögl is used to transport people to and from airports or exhibition grounds, it can be elevated along the median strip of existing traffic routes. Hence it can be adapted to the given infrastructure without the need for additional space.

The built-in electronics are based on standard trolley technology and thus easy to maintain for experienced operating personnel. The linear motor ensures reliable transport in all weather conditions.





TSB – *From a single source*

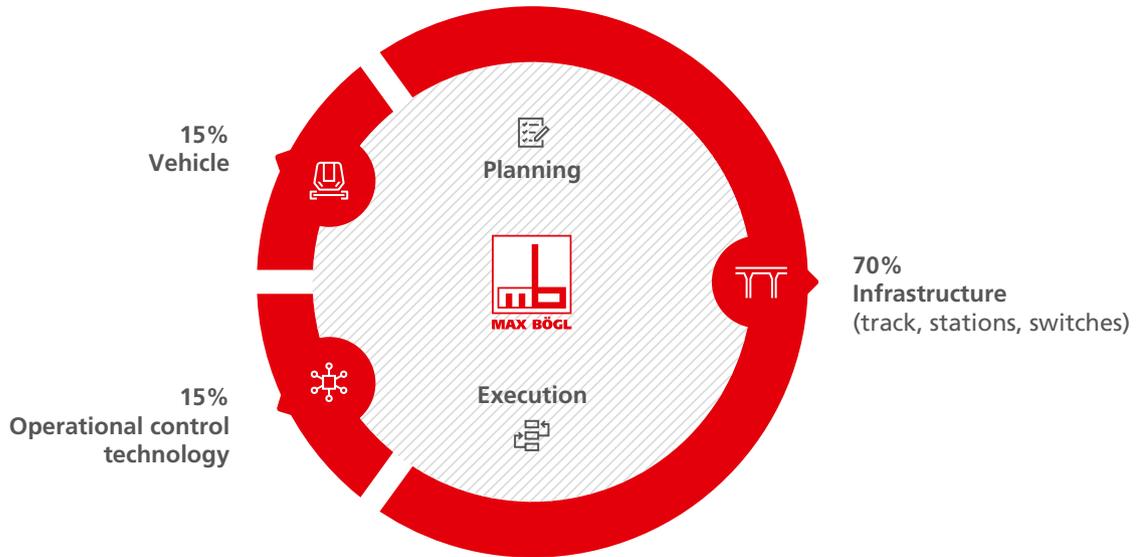
Complex infrastructure projects can be very cost-effective if most of the individual work is carried out by a single source. As the full-service provider of the Transport System Bögl, we are able to implement all processes in a standardized and coordinated manner – from planning and the industrial manufacturing of guideways and vehicles to the application of structural measures and implementation of our own operational control technology.

We are a professional construction company which relies on sound expertise and longstanding experience in infrastructure projects. In 2010, our engineers began working with maglev technology and since then we have thoroughly tested the Transport System Bögl with over 125,000 individual trips and over 85,000 kilometers (52,800 miles) on our test track at our headquarters in Sengenthal.

Premium quality production and assembly

The Transport System Bögl and its individual components, track, and vehicle, are produced and assembled in Sengenthal. The concrete segments of the track are cast in flexible form-works and then machined with sub-millimeter precision using a CNC grinding machine. With the help of expert personnel and state-of-the-art technology, the running gear and car bodies are assembled here to form the TSB. The magnet unit – the heart of the vehicle – is also assembled during this

stage of production. A smart digital storage system ensures the availability of components for each individual production step. The individual components are then loaded into standard shipping containers and delivered for use around the world. As a turnkey solution, the Transport System Bögl is the most cost-effective option for public transportation. This is in large part due to its narrow and efficient track system that is serially produced yet flexibly routable.



Distribution of investment costs in an average overall project



Efficient operational control technology for automatic driving

The operational control system of the Transport System Bögl includes components and functions for safeguarding, monitoring, and controlling operation. It links the vehicle, guideway switch, station and power supply subsystems to form a complete system that is ready for operation and allows fully automatic operation with short train headway times. All subsystems can be completely controlled and monitored from the control center. Core functions are the safety features, which meet the highest safety integrity level (SIL 4) for railway standards, and a high-availability data transmission system. The data transmission system includes a multi-redundant fiber-optic network infrastructure on the track and a two-channel radio system covering the entire route. This means there is a continuous and redundant connection between the vehicle and the control center. Each subsystem comes with

a safety controller that can automatically establish a fail-safe state in the event of a critical malfunction. The mobile vehicle safety computer is equipped with a locating system, determines the position block-independently and computes the braking distance with meter accuracy. The local safety computer at the guideway switch reports the locked switch position to the central computer. This eliminates the need for signaling on the route itself. On a technological level, this matches the highest ETCS Level 3 (European Train Control System). Besides fully automatic operation, the automation system also enables energy-efficient driving. When a vehicle brakes and feeds back its energy, the smart automation system can start a vehicle at the same time so that the braking energy is absorbed directly by the starting vehicle.





Max Bögl – Mobility of tomorrow

The metropolitan areas of the future are facing great challenges. The solution requires innovative, sustainable, and flexible mobility concepts. The Transport System Bögl can be integrated into new or existing transport infrastructures in an extremely flexible and virtually silent manner. To do so, we use maglev tech-

nology to ensure a reliable and low-emission form of transportation. As turnkey partners, we help city planners and mobility managers meet the challenges they face in passenger transport. Together we can create cost-effective public transportation routes that will significantly shape the mobility of tomorrow.





2018



Signing the licence agreement including supply of the 3.5 km long demonstration track

2019



Production of the guideway elements and a three-section vehicle

2019



Qualification of local staff for construction and operation

2019



Delivery of system components via rail and air freight

TSB – Demonstration track in Chengdu, China

A long-term licence agreement with the Chinese partner company Xinzhu Road & Bridge Machinery Co., Ltd. was concluded by Max Bögl in 2018 to ensure the successful introduction of the TSB on the Chinese market. A 3.5 km long demonstration track has been in operation in Chengdu, the capital of Sichuan Province, since the beginning of 2020. The first track section was completed just nine months after supplying the first guideway structures. The aim of the demonstration track is to convince Chinese customers of the technology and performance of the TSB and provide the evidence needed for approval in China.

The guideway structure required for the construction of the track was produced at the Group's headquarters in Sengenthal and transported by train in over 650 containers to Chengdu on the new Silk Road. The Antonow AN-124, one of the world's largest freight planes, transported the series production vehicle to Chengdu, 7,500 km away.

Following the overall commissioning of the demonstration track in 2020, the three-section TSB vehicle set a new record for medium-low-speed maglev trains there in February 2021 with a top speed of 169 km/h. This was another major step towards having the first operational track in China as well as in Germany.

2020



Commissioning of track nine months after construction commenced

2020



Delivery of series production vehicle

2020



Operation of a three-section vehicle on a 3.5 km long track

2021



Speed record for public transport maglev trains 169 km/h (February 2021)

TSB – Feasibility study of the German Federal Ministry for Digital and Transport

The Transport System Bögl, developed by Max Bögl, was the focus of a feasibility study commissioned by the German Federal Ministry for Digital and Transport (BMDV) on the use of new public transportation technology in February 2020. To assess and evaluate the sustainable local transport system, the TSB was compared with the classic railway-based public transportation systems – trams, the underground metro system and rapid transit. In the second part of the study, the possible use of the TSB at Munich Airport was investigated as a specific use case.

At the end of 2021, the feasibility study concluded that the TSB is ideally suited as a cost-effective and quickly realisable alternative to classic railway transportation systems and is the better alternative in many applications. The low emissions due to the quiet and needs-optimised drive mode stood out in particular as advantages of the system.

Equally, the TSB can be built faster and more cost effectively than conventional systems under difficult topographical conditions and with demanding route layouts thanks to its gradeability, which is up to 10 per cent higher than other systems. In addition, the study concluded that the possible use of the TSB to develop and connect the airport infrastructure in Munich was worthwhile in order to make passenger transport routes sustainable, efficient and comfortable.

Another study by the Münchner Verkehrs- und Tarifverbund (MVG) transport network, together with the counties and the state capital, certified in 2021 that the TSB is economically viable for several extension and tangential connections of the Munich underground rail network. This means that the Transport System Bögl provides a further innovative and climate-friendly mode of transport that satisfies the growing demands of public transportation systems through its ability to be implemented quickly.

Gefördert durch:



Bundesministerium
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aufgrund eines Beschlusses
des Deutschen Bundestages

Supported by:
The Federal Ministry for
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based on a resolution by
the Bundestag



Read the complete feasibility study for
alternative transportation systems in
railway-based public transportation systems:

<https://www.bmvi.de/SharedDocs/DE/Artikel/E/magnetschwebebahn-studienergebnisse.html>

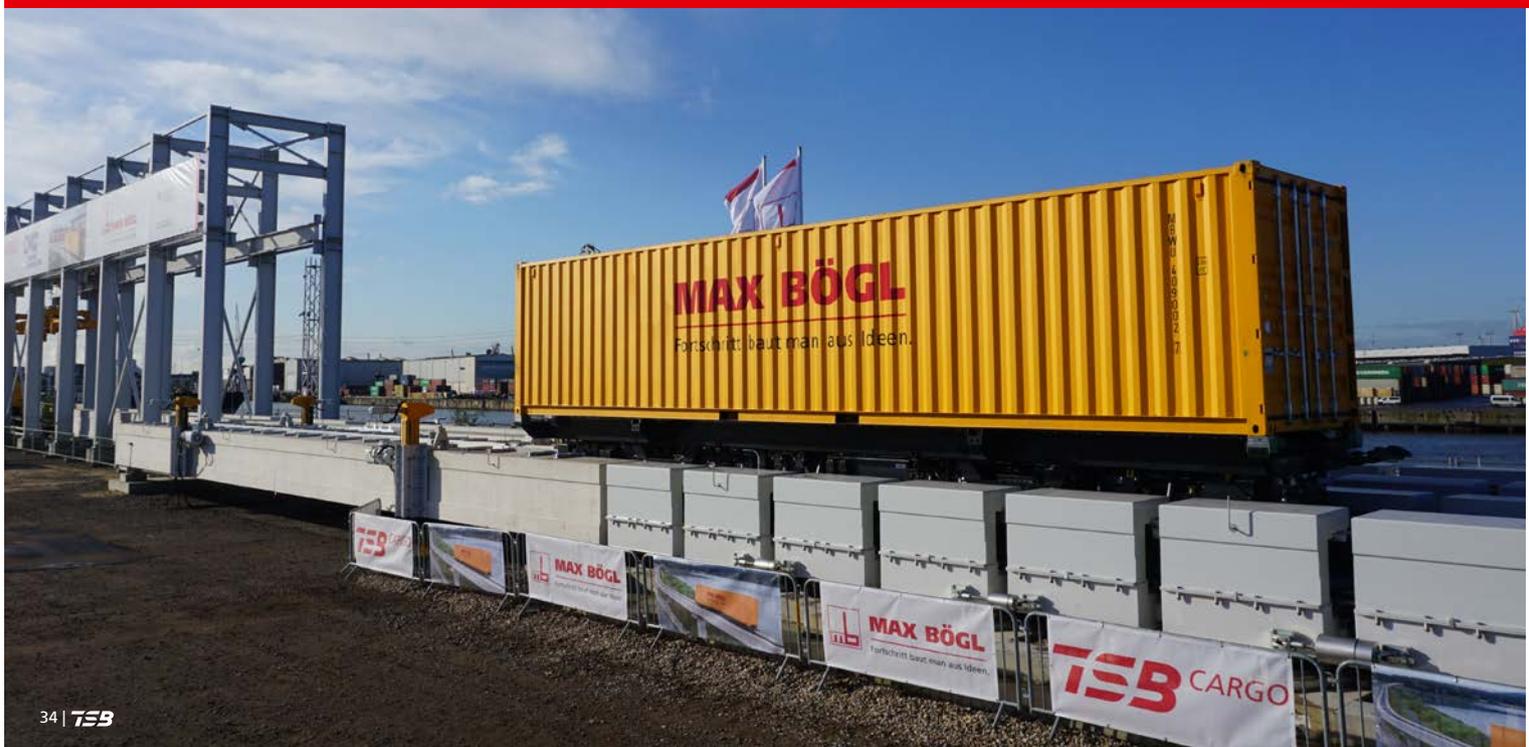
| Criteria | TSB | Tram | Underground train | Rapid transit train |
|----------------------------|------------|------|-------------------|---------------------|
| Flexibility | ✓ | ✓ | ✓ | ○ |
| Capacity | ✓ | × | ○ | ✓ |
| Energy consumption | ✓ | ✓ | ✓ | ✓ |
| Fine particulate emissions | ✓ | ✓ | ✓ | ✓ |
| Noise emissions | ✓ | ○ | ✓ | ○ |
| Automatability | ✓ | × | ✓ | ○ |
| Extendability | ✓ | ○ | × | ○ |
| Networking | ○ | ✓ | ○ | ✓ |
| Vehicle maintenance | ○ | × | × | ✓ |
| Infrastructure maintenance | ✓ | ✓ | × | × |
| Benefits | ✓ | ✓ | ✓ | ✓ |
| Vehicle costs | × | × | ○ | ○ |
| Infrastructure costs | ✓ | ✓ | × | × |
| Eligibility | ○ | ✓ | ✓ | ✓ |
| Legal framework | ○ | ✓ | ✓ | ✓ |

✓ Positive ○ Neutral × Negative

TSB Cargo – Demonstration system in Hamburg

The TSB Cargo was first presented to the international community of experts at a specially created demonstration circuit under real conditions at the ITS World Congress in Hamburg in October 2021. In an area of the Cruise Center Steinwerder in the Port of Hamburg, Max Bögl demonstrated the performance and reliability of the TSB Cargo on a track measuring around 120 m – including fully automated

driving, switching between tracks via points and container transfer to other transport modalities such as trucks. With the project taking four months from the planning stage to the commissioning of the demonstration circuit, the integrated planning approach and the modularised construction for the infrastructure demonstrated their advantages.





The German Federal Ministry for Digital and Transport (BMDV) funded the project to develop and test an alternative technology for reliable, environmentally friendly, sustainable and efficient freight transport. Possible fields of application are being investigated together with the Port of Hamburg in a feasibility study.

Gefördert durch:



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und Verkehr

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the Bundestag

aufgrund eines Beschlusses
des Deutschen Bundestages



Environmentally friendly concrete

The Max Bögl group of companies has been using Bögl environmental concrete for years as part of the sustainable production of high-quality reinforced concrete components. The concrete is characterised by short transport routes, the use of regional materials and the reduction of the proportion of cement in the concrete. This means the construction material has on average a **39 per cent smaller CO₂ footprint (kilogram of CO₂ per cubic metre of concrete)** than traditional concrete, meaning that its ecological composition and processing makes a positive contribution to reducing CO₂ emissions in the construction industry.

The environmental concretes developed by Max Bögl don't just boast excellent durability; the component cross-sections can also be reduced to an optimum. This ensures significantly lower consumption of raw materials when compared to traditional construction methods. Long-lasting, certified and sustainable building products are thus created in ultra-modern production facilities using the latest technologies, which are always produced using state-of-the-art techniques thanks to the excellent performance of Bögl environmental concrete.



Innovations are making history

Thanks to our own future-oriented innovations for the core issues of our time – urbanization, mobility, renewable energies, and infrastructure – we at the Max Bögl Group are implementing solutions for the megatrends of our globalized world. Based on long-standing experience and expertise in high-precision precast concrete construction, we have been able to establish ourselves as an important leader in the development of innovative products, technologies, and construction

methods. With around 6,500 highly qualified employees at more than 40 locations worldwide and an annual turnover of over 2.0 billion euros, the Max Bögl Group is one of the largest construction companies in Germany. Ever since its founding in 1929, the company has been known for its innovative strength in research and technology – from tailor-made custom solutions to complete and sustainable construction engineering solutions.

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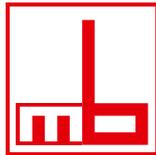
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MAX BÖGL

Progress is built on ideas.