Transrapid International

A joint company of
Siemens and ThyssenKrupp

High-Tech for “Flying on the Ground”

Maglev System Transrapid

Driving Without Wheels –
Flying Without Wings

The maglev system Transrapid is a track-bound transportation system for passenger and high-value cargo traffic at high speeds. It is the first fundamental innovation in railroad technology since the construction of the first railroad.

The non-contact technology of the maglev system Transrapid - electronics are used instead of mechanical components – overcomes for the first time the technical and economic limitations of wheel-on-rail technology.

In operation, the Transrapid is quieter, more cost-efficient, and consumes less energy than any other railroad system. It is virtually impossible to derail and comfortable at all speeds. The guideway of the Transrapid consumes less space and can be flexibly aligned to fit the existing landscape.

The maglev system Transrapid is the transportation technology of the future. It is ready for revenue operation and the advantageous system characteristics of this new railroad technology "Made in Germany" give it the lead throughout the world.

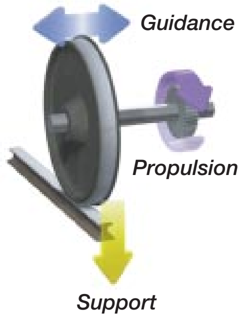
Essential system characteristics of the Transrapid maglev system are:

- *the non-contact and non-wearing levitation, guidance, and propulsion technology which is independent of friction*
- *the synchronous longstator linear motor integrated into the guideway*
- *the high standards of safety and comfort in all types of applications, from high-speed regional traffic at 200 to 350 km/h (125 to 220 mph) to superspeed intercity traffic at speeds of up to 500 km/h (310 mph)*
- *the high acceleration and braking power*
- *the flexible route alignment of the guideway due to small curve radii and high grade climbing ability (10%)*
- *the low noise emission at all speeds*
- *the low specific energy consumption and low operating costs*
- *the minimal land consumption of the guideway for both at-grade and elevated versions*

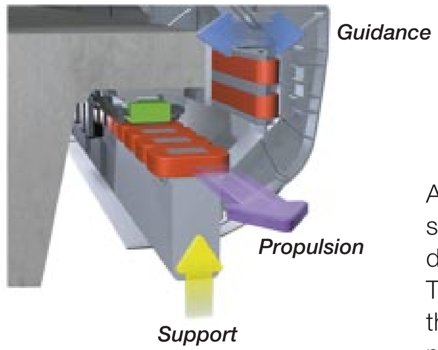
Electricity and Electronics – *Instead of Mechanics*

The Transrapid maglev system has no wheels, axles, transmissions, and overhead wires. It doesn‘t roll, it hovers. The wheels and rails of the railroad are replaced by non-contact, electromagnetic support, guidance, and propulsion systems.

Wheel-on-rail

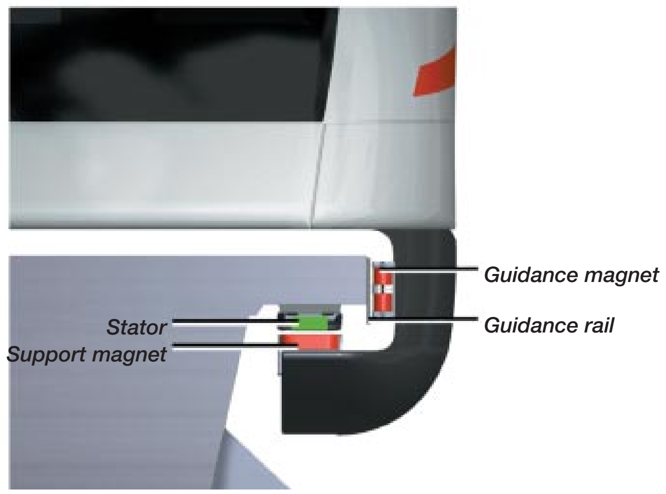


Electromagnetic levitation



Support and Guidance System

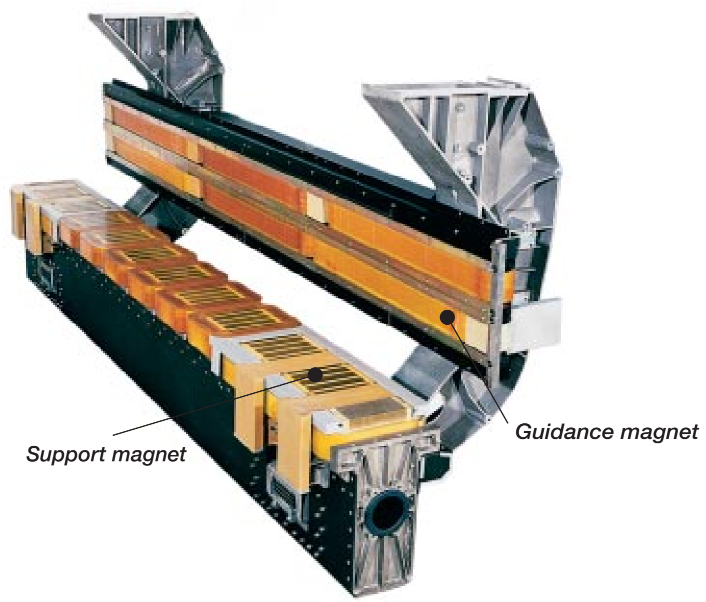
The non-contact support and guidance system of the Transrapid maglev system functions according to the principle of electromagnetic levitation. It uses the attractive forces between the individual, electronically controlled electromagnets in the vehicle and the ferromagnetic reaction rails which are installed on the underside of the guideway. The support magnets pull the vehicle up to the guideway from below, the guidance magnets keep it laterally on track. The support and guidance magnets are arranged on both sides along the entire length of the vehicle.

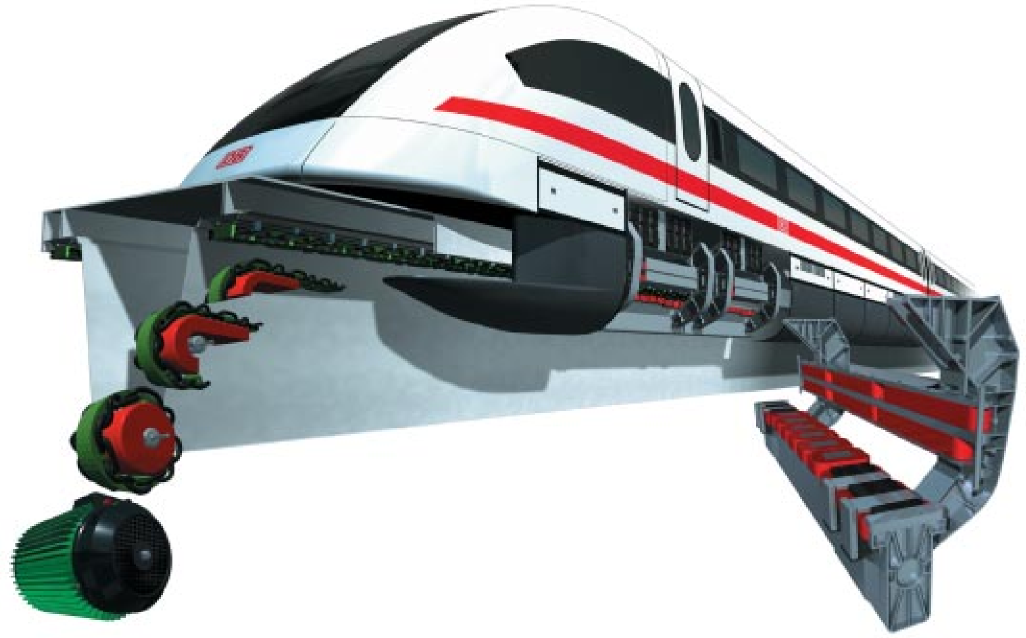


A highly reliable, fully redundant electronic control system ensures that the vehicle hovers at an average distance of about 10 mm (3/8 in) from its guideway. The distance between the top of the guideway and the underside of the vehicle during levitation is 150 mm (6 in), enabling the maglev vehicle to hover over objects or a layer of snow.

The design of the Transrapid support, guidance, and propulsion systems is modular, failure tolerant, and equipped with automatic diagnostic systems. This ensures that the failure of individual components does not result in a disturbance of operation.

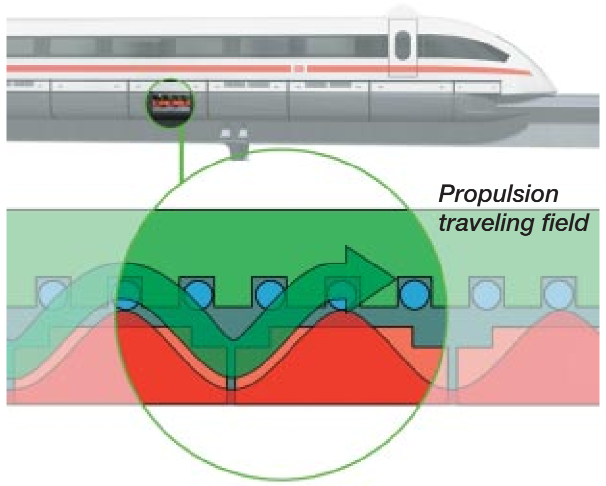
Support and guidance module





Propulsion System

The synchronous longstator linear motor of the Transrapid maglev system is used both for propulsion and braking. The function of this non-contact propulsion and braking system can be derived from the functional principle of a rotating electric motor whose stator is cut open and stretched along both sides of the guideway. Instead of a rotary magnetic field, the motor generates an electromagnetic traveling field. The support magnets in the vehicle function as the rotor (excitation portion) of the electric motor.



In contrast to the conventional railroad, the primary propulsion component of the Transrapid maglev system – the stator packs with three-phase motor winding – are not installed in the vehicle but in the guideway.

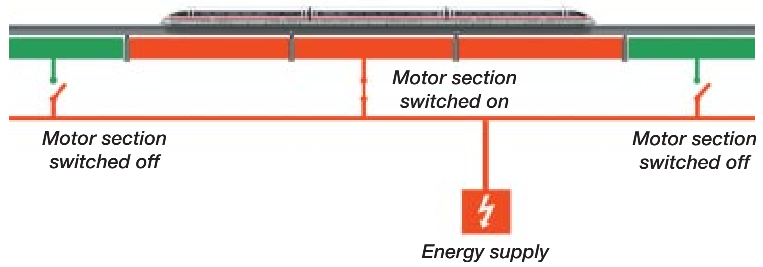
By supplying alternating current to the three-phase motor winding, an electromagnetic traveling field is generated which moves the vehicle, pulled along by its support magnets which act as the excitation component. The speed can be continuously regulated from standstill to full operating speed by varying the frequency of the alternating current. If the direction of the traveling field is reversed, the motor becomes a generator which brakes the vehicle without any contact. The braking energy can be fed back into the public network.

The longstator linear motor in the guideway is divided into individual motor sections which are only supplied with power as the vehicle passes.

The location and the installed power of the substations depends on the requirements on the propulsion system. In sections where high thrust is required, e.g. gradients, acceleration, and braking sections, the power of the substations is higher than on level sections which are traveled at constant speed.

And because the primary component of the propulsion system is installed in the guideway, Transrapid vehicles need not carry the entire motor power for the peak requirements, as is the case with other types of vehicles.

The support and guidance system is supplied with energy without contact via the linear generators integrated into the support magnets. No overhead wires are required for the Transrapid. In the event of a power failure, energy is supplied from on-board batteries which are charged by the linear generators during travel.



Technology Made for the Times – and Comfortable Travel

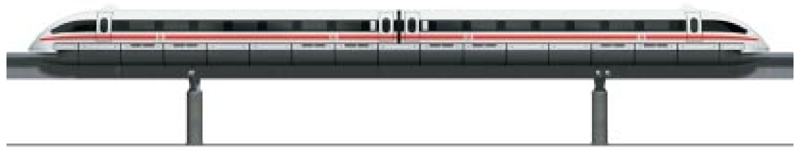
Transrapid – Vehicles for Passengers and High-Value Cargo

The Transrapid vehicles are flexibly configured to fit the requirements of the most diverse applications. The vehicle sections are built using lightweight, modular structures and can be combined into trains with two to ten sections depending on the application and traffic volume. In addition to passengers, the Transrapid can also carry high-value cargo in specially designed cargo sections. These can be used for dedicated high-speed cargo trains or added to passenger trains for mixed service.

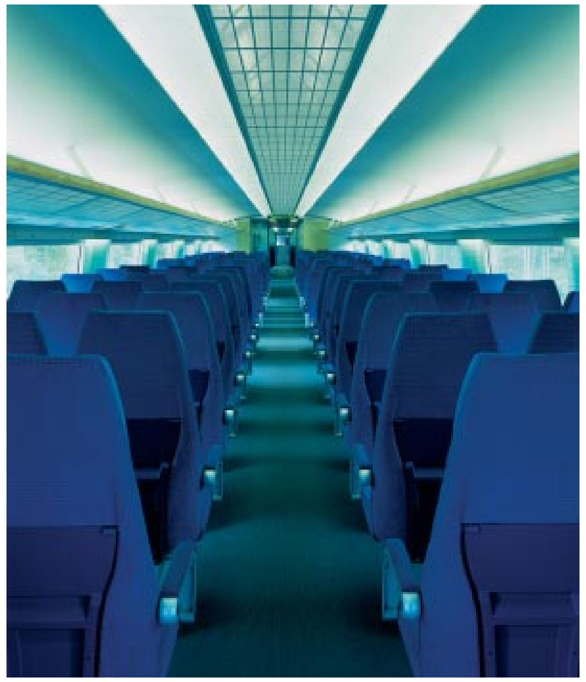
Together, the vehicle body and the maglev undercarriage form a vehicle section. Each vehicle section has four levitation chassis which serve to transmit the forces for propulsion, support, guidance, and braking. To ensure optimum traveling comfort, the levitation chassis are connected to the vehicle body via a self-leveling air spring and pendulum suspension. All moving mechanical elements between the vehicle body and the magnets are mounted on vibration-dampening rubber/metal elements. A support and a guidance magnet or a support and a brake magnet are mounted to a pair of levitation frames to form a single magnet module.

Standardized fastening elements are used for the interior furnishings of the vehicles. These furnishings are modularly designed so the requirements of the operator can be met in an economical and flexible fashion.

Airport shuttle:
2 or more sections



Long distance:
up to 10 sections



The on-board equipment is supplied with power without contact (as are the support and guidance systems). Near stations and in low speed areas, the on-board power is supplied by power rails mounted to the guideway.

The Transrapid vehicles can be designed almost exclusively under aerodynamic aspects. Therefore, there is little air turbulence when a Transrapid vehicle passes by. The pressure distribution along the vehicle and its impact on oncoming vehicles has been calculated using methods developed in the aeronautical and aerospace industries and confirmed by measurements at the Transrapid Test Facility (TVE). Travel comfort is not affected when one vehicle passes another because the vehicle body is pressure-sealed.

Technical Data

Length	end section		27.0 m
	middle section		24.8 m
Width			3.7 m
Height			4.2 m
Maximum operational speed			500 km/h (310 mph)
Empty weight, passenger vehicle	per section	approx.	53 t
Empty weight, cargo vehicle	per section	approx.	48 t
Useful payload, cargo vehicle	per section	approx.	15 t
Seats, passenger vehicle	end section	max.	92
	middle section	max.	126

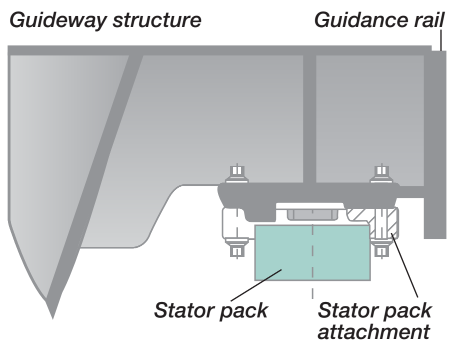
The Best “Way” –
Precision on Every Level

In conventional railroad systems, the function of the track is limited to supporting the loads from the vehicle and guiding it along the route. By comparison, the Transrapid‘s guideway has the propulsion system integrated into it and together with the vehicle, they form an integrated system. To achieve the best possible ride comfort, the requirements of the guideway in terms of fabrication, equipment, availability, and service life are especially high. Whether at-grade or elevated, whether concrete or steel construction, the Transrapid guideway meets all of these requirements. The precision of the functional surfaces is ensured by integrating the entire process – from initial layout of the route to manufacture of the guideway components to final installation and commissioning on site – using the most modern, computerized equipment and techniques. The single or double track guideway of the Transrapid maglev system consists of individual guideway beams made of steel or concrete in standard lengths from 6.2 m - 62 m (20.3 ft - 203.4 ft). The guideway can be installed at-grade or elevated depending on the local situation. The track center-to-center distance of the double track guideway is 4.4 m up to 300 km/h or 5.1 m up to 500 km/h (14.4 ft up to 185 mph or 16.7 ft up to 310 mph). The clearance envelopes are 10.1 m and 11.4 m (33.1 ft and 37.4 ft), respectively; the track gauge is 2.8 m (9.2 ft).

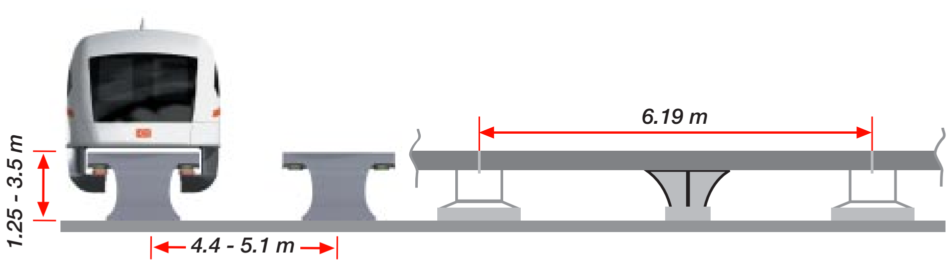
Elevated Guideway

Elevated guideway is especially appropriate in areas which should not be separated for ecological or agricultural reasons and/or where existing traffic routes should not be effected by the new line. Variable column heights of up to 20m (65 ft) and standard beam spans of up to 31 m (102 ft) allow flexible adaptation of the guideway to the topography. Elevated guideway is mounted on discrete foundations with columns architecturally suited to the surrounding infrastructure. In areas with poor soil conditions, elevated guideway can also be utilized near to the ground (without columns) which is often more economical than using at-grade guideway with its continuous foundations.
The use of elevated guideway causes little or no disturbance to the original landscape and consequently there is practically no impact on ground and surface water.

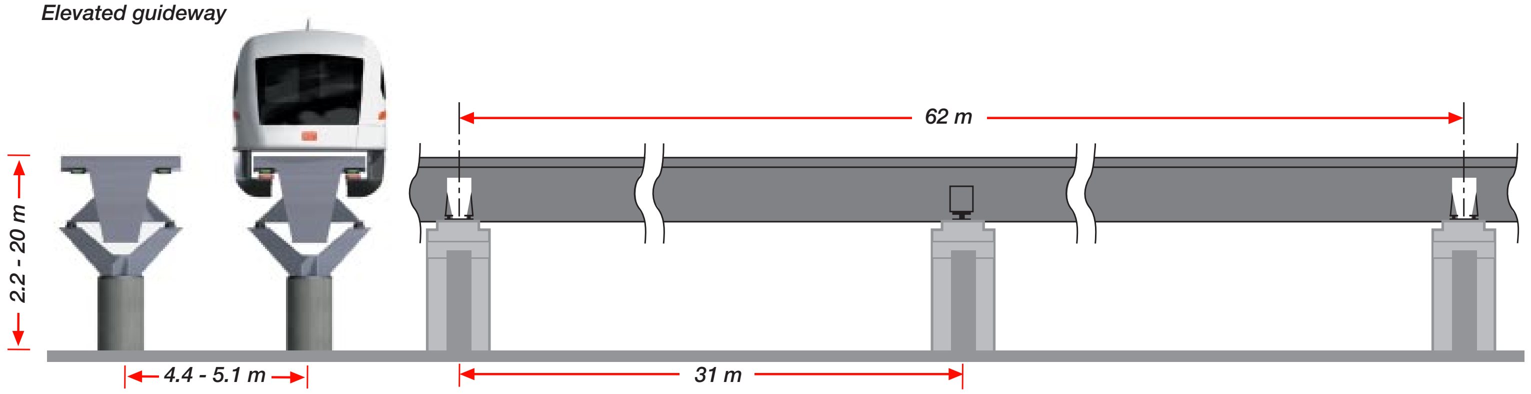
Guideway equipment



At-grade guideway



Elevated guideway



At-Grade Guideway

The guideway is installed at-grade mainly where it can be collocated with existing traffic routes (roads, railroads) as well as in cuttings, tunnels, and on primary civil structures such as bridges and stations. Specific features are the standard beam spans of 6.2 m (20.3 ft) and gradients of 1.25 m to 3.5 m (4.1 ft - 11.5 ft). At-grade guideway is mounted on continuous foundations and is typically fenced-in to improve safety.

In the straight position, the vehicle can cross the switch without speed restrictions, in the turnout position, the speed is limited to 200 km/h (125 mph) (high speed switch) or 100 km/h (62 mph) (low speed switch).

In parking and maintenance facilities, tracks can also be changed using a transfer table. These operate by laterally moving a straight length of guideway (with the vehicle sitting stationary on top) to access multiple tracks.

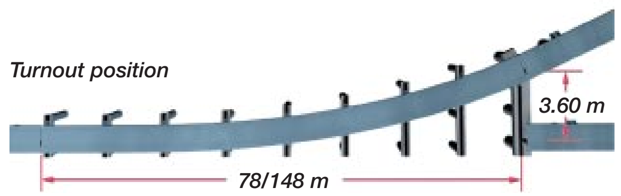
Switches

The Transrapid maglev system changes tracks using steel bendable switches. They consist of continuous steel box beams with lengths between 78 m and 148 m (256 ft - 486 ft) which are elastically bent by means of electromagnetic setting drives and securely locked in their end positions. This function is electronically controlled and safeguarded.

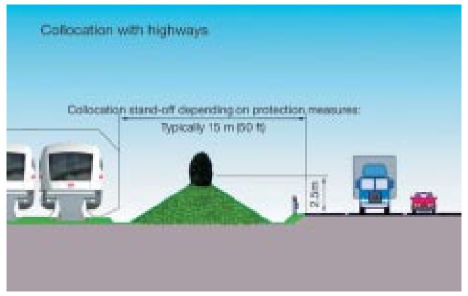
Bendable switches can be designed as two-way or three-way switches, either at-grade or elevated.

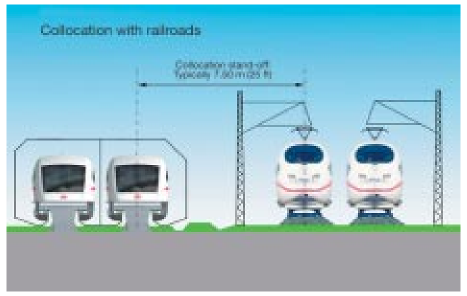
Straight position

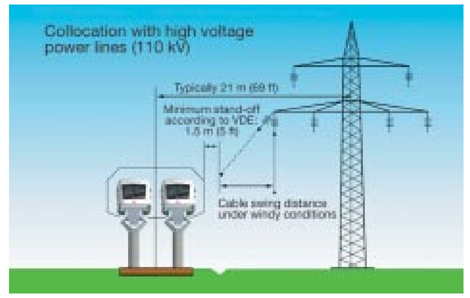
Turnout position



The Best "Way" –
Precision on Every Level







Substructures

The amount of ground work required for the guideway foundations depends on the local soil conditions. Typically, flat foundations are sufficient. Pile foundations are necessary only where local soil conditions are difficult. In all cases, the foundations lie approx. 30 cm (12 in) below the surface to minimize effects on water run-off and small animals. There are also passages for small animals below the at-grade guideway.

Cross-sectional area	tunnel length > 150 m (492 ft)		
for a speed of:	250 km/h 155 mph	400 km/h 250 mph	450 km/h 280 mph
double track tunnel	70 m^2 753 ft^2	180 m^2 1938 ft^2	225 m^2 2422 ft^2
single track tunnel	36 m^2 388 ft^2	85 m^2 915 ft^2	120 m^2 1292 ft^2

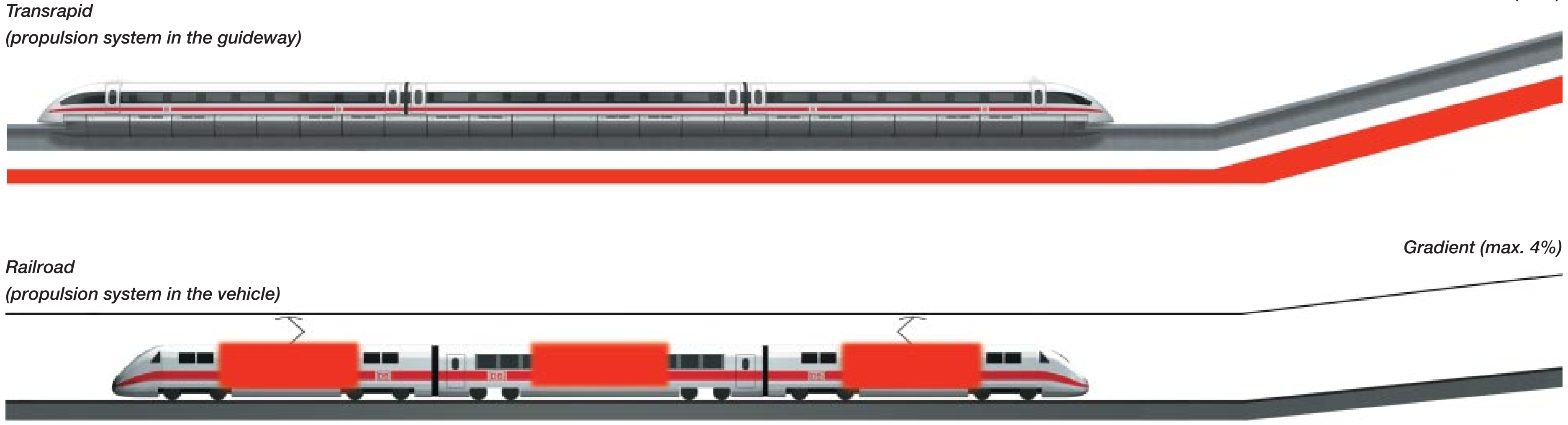
Tunnels

With its flexible route alignment parameters, the Transrapid guideway can be adapted to a great extent to the landscape. Therefore, tunnels are seldom necessary, even in hilly and mountainous terrain. Even when they are required, the tunnel cross-sections necessary for the Transrapid are smaller than those of railroads. This is due to the smooth, aerodynamic shape of the vehicle and small clearance envelope.

Typical tunnel cross-sections for tunnels longer than 150 m (492 ft) and vehicles with 2 to 8 sections are shown in the table:

Route Alignment Parameters

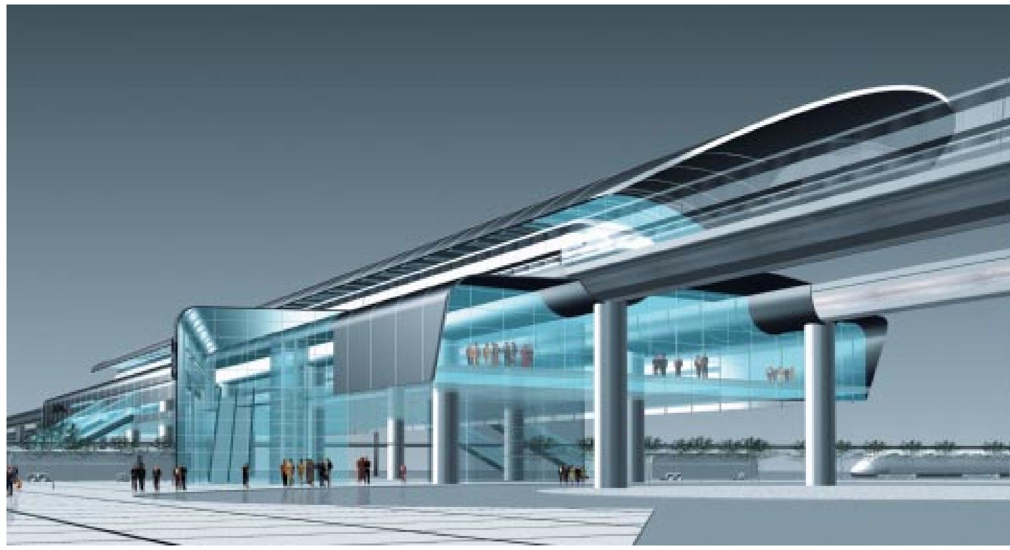
Two features of the Transrapid maglev system allow it to have extremely favorable route alignment parameters. These are the active guidance of the vehicle along the guideway and the propulsion system (motor) in the guideway. With these, gradients of 10% can be climbed and curves with tight radii and cants of up to 16° can be traveled without difficulty.
These favorable parameters also allow the guideway to be flexibly adapted to the landscape without massive earthworks and it is often possible to collocate it with existing traffic routes, thus saving precious land and cost.



Interconnection with Other Transportation Modes and Routes

For maximum convenience and customer satisfaction, the stations of the Transrapid maglev system are always interconnected with the other available transportation modes (rail, road, air). They are multi-modal in nature, conveniently located for passenger and service access, and allow simple transfer to other modes for travel on to more distant destinations. Depending on the station and its location, these may include long distance rail, suburban/light rail, buses, taxis, subways, private cars, and/or airplanes. In this way, the Transrapid service is integrated into the overall transportation network to provide maximum benefits and transportation performance to the community.

Acceptance and economic efficiency of the maglev system depend on the accessibility of its stations. Therefore, when planning the route, care is taken to ensure close proximity to all available systems, not just to roads. Road traffic can only be effectively relieved if car drivers can conveniently transfer to the Transrapid system and thereby reach their destination. And this requires quick, reliable, and economical access to major roads and the availability of sufficient park-and-ride facilities.



The Best System –
Innovation for More Safety

Despite the high speeds of up to 500 km/h (310 mph), you are safer on board the Transrapid than in any other means of transport. The vehicle virtually cannot derail because it wraps around its guideway. And since grade crossings are not allowed, nothing can get in its way.

Collisions between Transrapid vehicles are also ruled out due to the technical layout of the system and the section-wise switching of the ”guideway motor“. The vehicle and the traveling field of the guideway motor move synchronously, i.e. with the same speed and in the same direction. Additionally, the section of the longstator linear motor in which the vehicle is moving is only switched on as the vehicle passes.

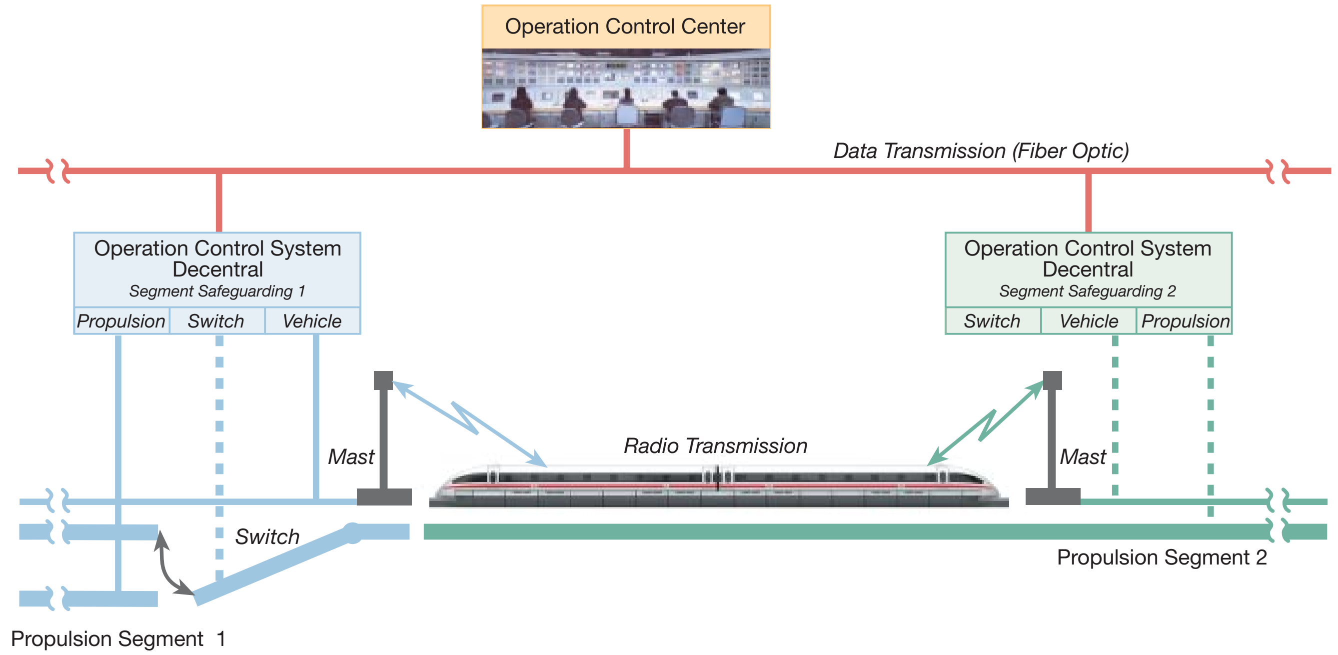
With regard to fire protection, the Transrapid meets the highest requirements of the relevant standards. There are no fuels or combustible materials on board. Only PVC-free materials that are highly inflammable, poor conductors of heat, burn-through-proof, and heat-proof are used in the vehicles. As an additional safety precaution, the vehicle sections can be separated by fireproof doors.

Other important elements of the safety concept are:

- automatic train protection
- passive protection equipment to prevent damage to the guideway structure and violation of the vehicle’s clearance envelope
- automatic inspection of the guideway
- protection of the passengers during boarding and exit in the stations by means of platform doors and gap bridges

Even if the power from the public grid fails while the vehicle is running, only the propulsion system (motor) is lost. The vehicle levitation system and all on-board equipment are supplied from on-board batteries, so the vehicle continues to levitate and move forward with its existing “momentum”. If the next station is too far away, the vehicle will be automatically braked to a stop at the next available auxiliary stopping area. These areas are set up for this purpose along the route and convenient access is provided for support services, should they be required. Under these circumstances, the vehicle is braked using eddy current brakes located in each section, also supplied from the on-board batteries. The eddy-current brakes slow the vehicle down to 10 km/h (6 mph), upon which the vehicle then sets down on its skids and stops.

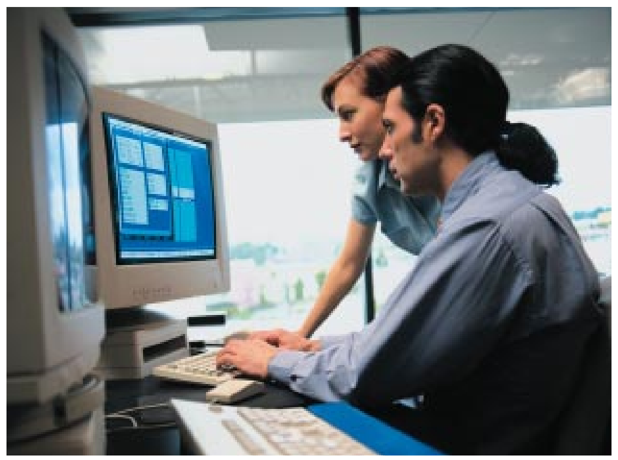
Even in the rare case of a significant technical failure in the Transrapid system, the vehicle will always be brought to a stop automatically at an auxiliary stopping area. If a fire is reported, the vehicle also automatically stops at the next auxiliary stopping area as a precaution. If necessary, the vehicle may be quickly and conveniently evacuated there.



Operation Control System

The operation control system of the Transrapid maglev system is characterized by central automatic control of the operation according to programmed trip schedules in conjunction with decentral monitoring and safeguarding of all routes and vehicle movements. The conventional tasks of the train driver, i.e. the proper control of driving and braking operations according to the train’s location, are completely replaced by the Transrapid operation control system.

The equipment for safeguarding operation are located in the vehicle and in stationary facilities. A highly reliable, line-of-sight radio transmission system is used to exchange data between the two. The specific arrangement of the radio masts along the route ensures that the two redundant antennas on the vehicle can always receive signals from two separate radio masts at all times.



The vehicles are securely located using digitally encoded flags mounted on the guideway and the vehicle‘s speed limit is constantly supervised. The automatic shut down of the propulsion power and the activation of the vehicle‘s eddy-current brakes are primary safety functions of the operation control system when a speed limit has been exceeded. Additionally, the distance between adjacent vehicles along the route, operation of the guideway switches, the passenger protection equipment in the stations, as well as many other functions and processes are controlled and safeguarded by the operation control system.

The elimination of safety responsibility by the operating personnel during revenue operation and the certified, high safety standard for signal technology in the Transrapid equipment guarantee a high level of safety in the entire system.

Additional tasks of the operation control system include documentation of the vehicle operation and providing up-to-date information for both the operating personnel and passengers.

A Comparison of Economic Efficiency –
Good Reasons for New Ways

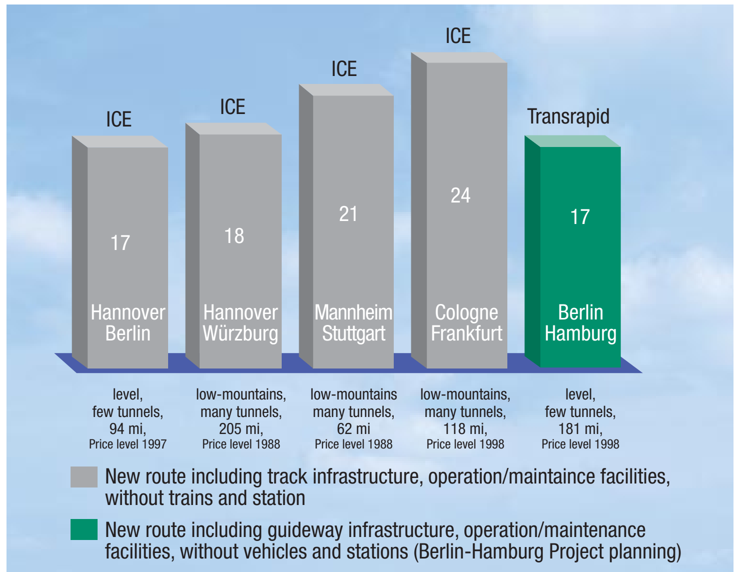
Investment Costs

The manufacture and construction of the guideway infrastructure are a significant portion of the overall Transrapid maglev system investment costs. Despite the higher performance of these routes though, the investment costs for Transrapid maglev routes are comparable to those for high-speed rail.

A comparison of the infrastructure investment costs favors the Transrapid maglev system even more when the route passes through difficult terrain. Here the flexible route alignment parameters of the Transrapid (small curve radii, high grade climbing ability, standard elevated guideway, etc.) can be used to adapt the guideway to the surroundings instead of the other way around. The need for expensive civil structures such as bridges and tunnels can therefore be reduced significantly.

The high average speeds of the Transrapid translate into short trip times. They also result in smaller vehicle fleet sizes than comparable high speed rail systems because fewer vehicles are required to handle the same volume of traffic. Fewer vehicles mean lower investment costs, both for the vehicles themselves and for the maintenance and parking facilities required for the route – they may also be smaller.

Guideway Infrastructure Investment Costs for German ICE and Transrapid Routes (cost in million € / double track km)



Operation and Maintenance Costs

The operation and maintenance costs of the Transrapid maglev system are lower than those of comparable transportation systems. In general, the operation and maintenance costs fall into three categories – personnel, maintenance, and energy consumption. The following applies to the Transrapid:

- The smaller vehicle fleet requires fewer operating and maintenance personnel as well as fewer spare parts and materials.
- With its fully automatic operation, the personnel requirements are lower in general compared with other transportation systems.
- The non-contact technology reduces mechanical wear and tear (vehicle operation causes neither misalignment nor wear of the guideway structure, equipment, and surfaces).
- Most mechanical components which may wear have been replaced by non-wearing electronic and electromagnetic components.
- The vehicle loads on the guideway are distributed (no point loading) which result in lower static and dynamic loads over the entire speed range and consequently, less stress on the guideway.
- The specific energy consumption (per seat) is lower than comparable transportation systems at equivalent speeds.

Maintenance

Central and decentral maintenance facilities for the vehicles are located along the route, depending on the operational requirements.

They are laid out and equipped to allow quick replacement of faulty components and modules which can later be repaired on- or off-site.

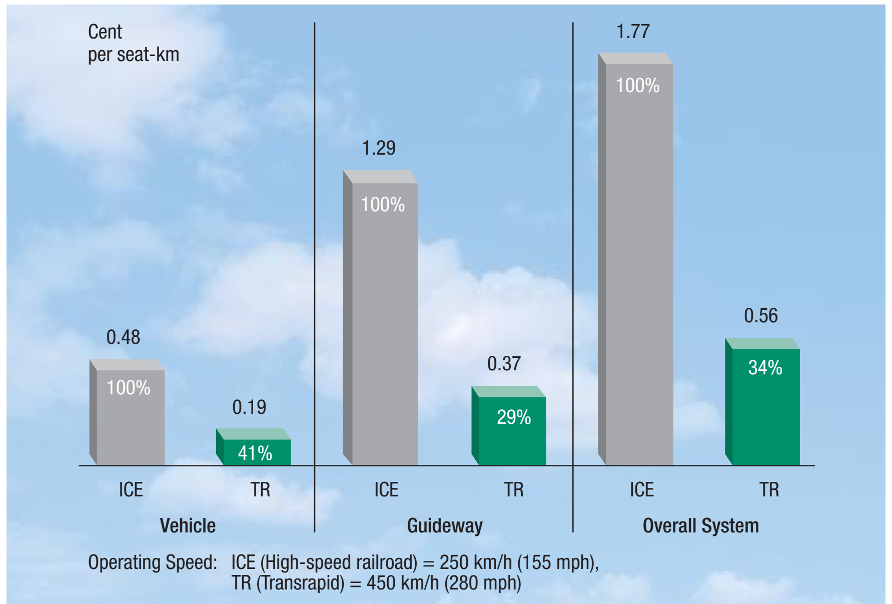
Due to the non-contact and non-wearing technology, maintenance of the guideway and the guideway equipment is primarily restricted to the conventional civil structures, unless damage occurs through external influences which cannot be foreseen.

The guideway is inspected and monitored from the guideway itself by means of a special maintenance vehicle which is equipped with modules for various activities, such as:

- dimensional measurement systems for detection of changes to the guideway, in particular to the stator packs, guidance rails, and beam bearings
- an optical inspection system with digital image processing to check and monitor the condition of the guideway components and surfaces

An access road along the guideway is not required for maintenance purposes.

Overall System Maintenance Costs



Where the Air is Clean –
An Environmentally Friendly System

Environmental Compatibility

The development and introduction of a new transportation system like the Transrapid maglev system makes the most sense when it is also has ecological advantages and can contribute to a reduction in pollution caused by traffic.

Positive environmental characteristics of the Transrapid:

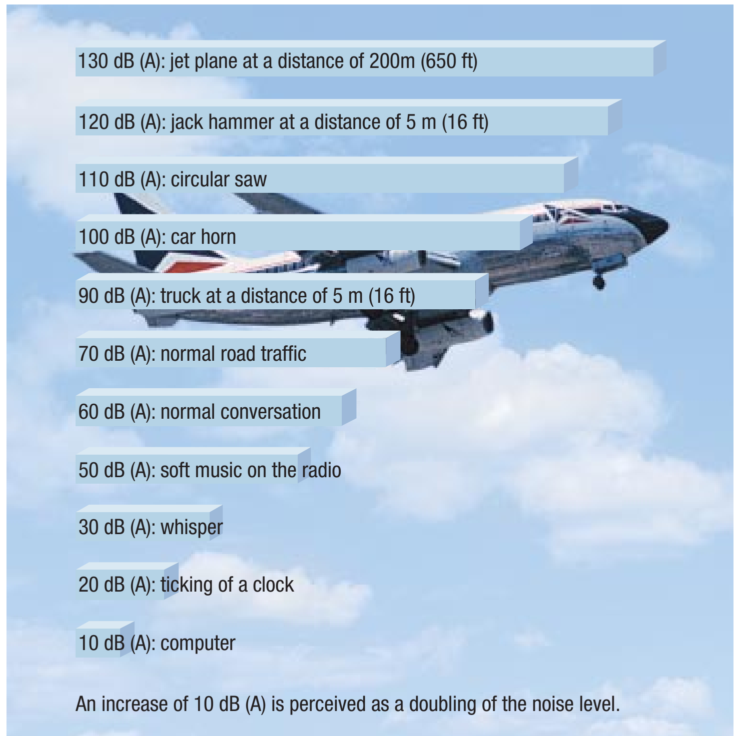
- ***No rolling or propulsion noise due to the non-contact technology.***
- ***No emission of combustion gases or other pollutants along the route.***
- ***Independent of the type of primary energy.***
- ***Low land consumption of the elevated and at-grade guideway.***
- ***Continued use of the space under the elevated guideway, e.g. for agriculture.***
- ***No division of the landscape, developed structures, or biological habitats through use of the elevated guideway.***
- ***No impairment of game movements with the elevated guideway and uninhibited passage for amphibians and small animals under the at-grade guideway.***
- ***Few embankments and cuttings and thus minimal disruption of the landscape.***
- ***Ability to adapt to the topographic conditions with the various guideway types and flexible route alignment parameters.***

Noise Emission

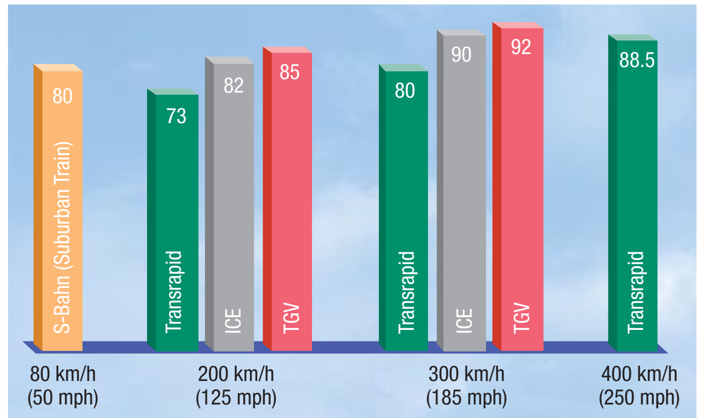
Sound can be unpleasant or even painful but also as something so beautiful that we expose ourselves to it voluntarily (concerts, sporting events). Whether or not a sound is pleasant or deemed as noise depends on the personal assessment of each individual. Such a subjective sensation cannot be measured objectively.

However, sound levels can be measured, i.e. the pressure variations generated by a source of sound in the air. Sound pressure levels are measured in dB (A). This international measuring unit imitates the sensitivity of the human ear. The scale ranges from 0 dB (A) (audible threshold) to 130 dB (A) (pain threshold).

Everyday Noise



Pass-by Level at a Distance of 25 m (82 ft)



Between the thresholds of audibility and pain, the human ear's range of sensitivity to acoustic pressure is wide. To be able to capture this range between the values 0 to 130 dB (A), the decibel scale is logarithmic.

An increase of 10 dB (A) is perceived as a doubling of the loudness of the noise.

Compared with other transport systems, the Transrapid is extremely quiet. There is no rolling or propulsion noise. At speeds up to 250 km/h (155 mph), the Transrapid hovers almost soundlessly through cities and metropolitan areas.

Due to the non-contact levitation and propulsion technology, the noise emission of the superspeed maglev system at speeds above 250 km/h (155 mph) is mainly determined by aerodynamic noise.

The pass-by noise levels of the Transrapid have been measured at the Transrapid Test Facility (TVE). The levels for elevated guideway compared with other rail systems are shown above. For at-grade guideway, the levels are even lower.

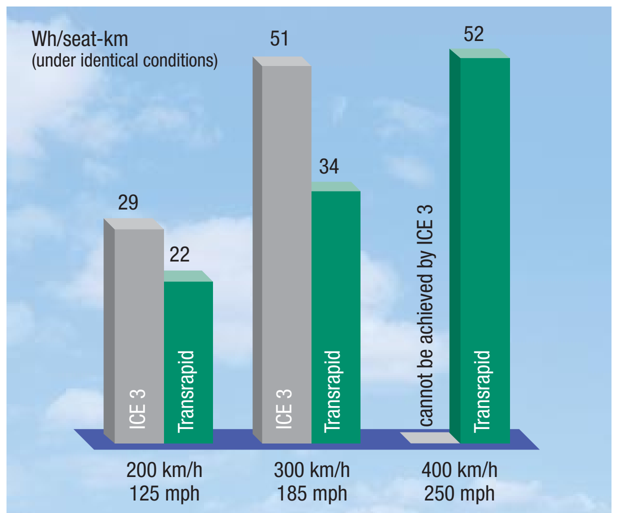
Where the Air is Clean – An Environmentally Friendly System

Energy Consumption

The favorable energy consumption figures of the Transrapid system are a result of the use of modern power electronics, the lack of electromechanical energy conversion using friction-based elements for propulsion and on-board power supply, the high efficiency of the synchronous longstator motor with excitation by the vehicle's support magnets, and the favorable vehicle data, e.g. the low mass of approx. 0.5 t per seat and the low running resistance of approx. 0.2 kN per seat at 400 km/h (250 mph).

When compared at equivalent distances, the specific primary energy consumption of automobile traffic is three times higher and air traffic five times higher than the Transrapid.

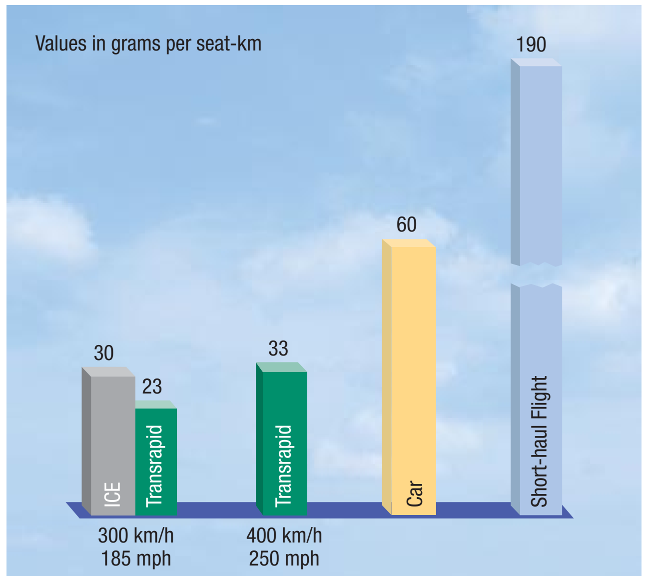
Specific Energy Consumption per Seat



CO_2 Emission

Lower energy consumption also means lower CO_2 emission. The CO_2 emission depends on the primary energy consumption, the method and raw materials used to generate the energy, and how it is distributed.

Typical CO_2 emission values per 100 seat-km (62 seat-miles) are shown below:



The Transrapid maglev system is supplied from the public electricity network. The German ICE is supplied from Deutsche Bahn's electricity network which has lower CO_2 emissions per watt-hour (Wh) than the public network.

Land Consumption in Comparison (m^2/m)

Land Consumption

The Transrapid maglev system requires the lowest amount of space and land for the guideway infrastructure and related facilities in comparison with other transportation systems.

The space required for standard, elevated, double track guideway for the Transrapid including substations and wayside equipment is approx. 2.1 m^2/m (6.89 ft^2/ft).

The space required for standard, at-grade, double track guideway including substations and wayside equipment is approx. 12 m^2/m (39.37 ft^2/ft).

An access road along the guideway is not required after construction has been completed – neither for safety reasons nor for maintenance of the guideway and wayside equipment. The land is therefore returned to its original condition.

At the Transrapid Test Facility (TVE), most of the original construction road has therefore been removed. The road has been retained though in certain areas at the wish of the owner to improve access for test work and for the local farmers to improve access to their fields (located under and surrounding the guideway).

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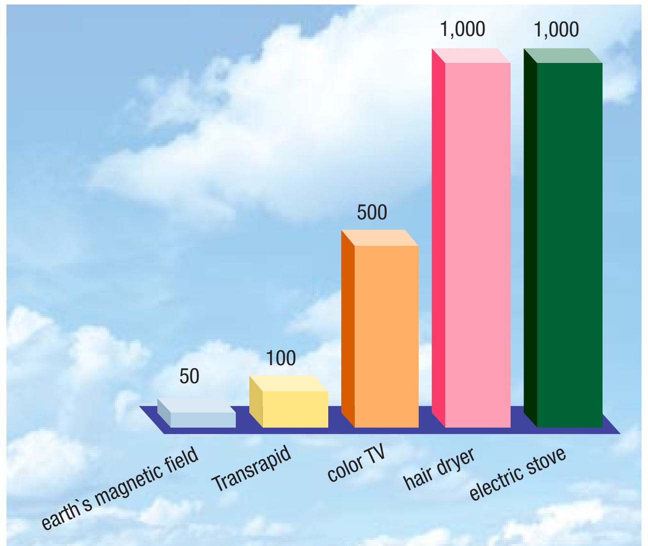
Magnetic Fields

The impact of magnetic fields produced by the Transrapid maglev system on passengers and the environment is extremely small. It is in fact, comparable to the earth's residual magnetic field and thus far below the field intensity produced by many common household appliances. A hair dryer, a toaster, or an electric sewing machine are surrounded by far stronger magnetic fields than those occurring in the passenger compartment of the Transrapid vehicle. The magnetic fields along the guideway are even weaker.

The electromagnetic fields generated in the longstator motor, the support and guidance system, and the radio transmission system have been measured by various experts including the *Forschungsgesellschaft für Energie und Umwelttechnologie* (Research Association for Energy and Environmental Technology) on behalf of the *Bundesanstalt für Arbeitsmedizin* (German Federal Office for Occupational Medicine). Over the entire frequency range, the electromagnetic field intensities are 20 to 1,000 times lower than the admissible limits in the Bundes-Immissionsschutzverordnung (German Federal Immission Control Act). Thus adverse effects on pace-makers or magnetic cards (e.g. credit cards) are ruled out.

Magnetic Field Strengths [µT]



Aerodynamic Effects

The air flow surrounding the Transrapid has been extensively studied at the Transrapid Test Facility (TVE) with the following results:

- There are no perceivable aerodynamic effects under the elevated guideway over the entire speed range.
- Aerodynamic effects comparable to gentle wind can be detected when the Transrapid vehicle passes over the at-grade guideway. Small pebbles on the ground directly under the vehicle and guideway are not disturbed.
- The air flow velocity along the vehicle at a distance of 1 m (3.3 ft) and a speed of 350 km/h (220 mph) is smaller than 10 km/h (6 mph).

Vibration

When the Transrapid passes by, vibrations are passed from the guideway into the ground via the foundations. These vibrations are subject in Germany to the Federal Immisson Control Act. In accordance with DIN 4150, vibration severity is measured in KB and takes account of the duration and intensity of the influence (similar to the assessment level for sound immission).

Measurements at the Transrapid Test Facility (TVE) have shown that the vibrations at a distance of 25 m (82 ft) and a speed of 250 km/h (155 mph) (a typical speed in urban areas) are below the "threshold of feeling" for human beings. At a distance of 50 m (164 ft), no vibration is perceivable at any speed.

Weather Influences

A tremendous advantage of track-bound transportation systems is that they are relatively unaffected by the weather. This also true for the Transrapid maglev system. Its non-contact technology functions even under extreme weather conditions.

- The propulsion components of the Transrapid maglev system are protected underneath the guideway from snow and ice.
- If more snow or ice collects on the guideway than the specifications allow, a special vehicle will clear the guideway. Clearing is made easier by the smooth upper surface of the guideway.
- Cross winds and gusts have little effect on the Transrapid because of its active control and guidance system. Wind velocities of up to 30 m/s (67 mph) have no effect on operation at all. At the Transrapid Test Facility (TVE), it has been proved that the vehicle can be operated without difficulty at speeds up to 350 km/h (220 mph) with wind gusts up to 150 km/h (94 mph).

Attractive Trip Times – On All Connections

The Transrapid is versatile and suited for many applications. As a fast link between a city center and its outer-lying airport, as a fast regional system in metropolitan areas, or as a fast and cost-effective link between city pairs. As part of a sophisticated and powerful inter-modal network in which all transportation systems are connected in a sensible way. And not only for high-speed passenger service but also for high-value goods that require urgent delivery.

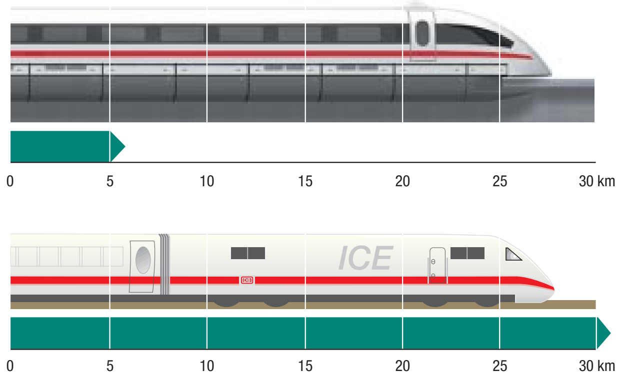
Modern airports are often located far outside of cities. Frequently, the journey to or from the airport takes as long as the flight itself. A Transrapid city-to-airport link can shorten overall travel time significantly. Available capacities can be better utilized with the traffic volume being handled in an optimal fashion. For such a link, the Transrapid can cover a distance of about 30 km (19 miles) in less than 10 minutes.

The Transrapid is not only fast, but it can also accelerate quickly to high speeds. 300 km/h (185 mph) can be reached after a distance of only 5 km (3 miles). Modern high-speed trains require more than 28 km (18 miles) and at least four times as long to reach the same speed. The Transrapid maglev system can therefore be used to advantage not only for long distances but also for short and medium distances in metropolitan areas with short intervals between stops.

Modern high-speed railroads generally run at speeds of up to 300 km/h (185 mph) on specially designed and built routes.

The non-contact levitation and propulsion technology of the Transrapid maglev system allows cost-effective operation at considerably higher speeds (500 km/h / 310 mph). Consequently, for medium and long distances (up to about 800 km / 500 miles), Transrapid trip times are much shorter than for high-speed rail and similar to those of airplanes.

Acceleration to 300 km/h (185 mph)



Distances to Destinations using Transrapid (in hours)

Travel Speed

Its extraordinary dynamic performance, high average speed, and a propulsion system which can be tailored to the landscape and conditions, allow Transrapid trip times comparable to those of airplanes for medium and long distances. Even intermediate stops increase the trip time by just a few minutes.

Transrapid – a Joint Project of Siemens, ThyssenKrupp and Transrapid International.

With the Transportation Systems (TS) division, Siemens is one of the leading partners to the international railway industry. As single source supplier and system integrator, TS combines comprehensive know-how in its fields of competence Automation & Power, Rolling Stock, Turnkey Systems and Integrated Services – from operation control systems to traction power supplies to rolling stock for mass transit, regional and mainline services. Forward-looking service concepts and extensive experience in project management complement the portfolio. Components supplied for the Transrapid: propulsion system, power supply, operation control system, communication systems and conductor rails.

ThyssenKrupp has decades of experience with locomotive and wagon building and played a significant role in the successful development of the ICE. Based on the know-how acquired, ThyssenKrupp realized the necessity to overcome the technical and commercial limitations of the wheel-on-rail technology. With the proof of function of the longstator magnetic levitation technology and the leadership in the development of the system, ThyssenKrupp laid the foundation for the Transrapid system which is now being implemented. Components supplied for the Transrapid: vehicles, propulsion components and guideway equipment.

To complete the partnership for the Transrapid system, Siemens and ThyssenKrupp have established Transrapid International as a joint company for systems engineering, system integration, marketing, and maintenance support.

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