Environmental Benefits of Transrapid

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Rolf Hellinger & Juergen Nothhaft
Siemens AG, Industry Sector, Mobility Division, Erlangen, Germany

ABSTRACT: Based on the experiences in Shanghai Maglev Transrapid project, the paper will present the environmental benefits of a Transrapid system for regional and long distance applications. Aspects, like energy efficiency, local air pollution, noise emissions, electromagnetic fields, shock and vibrations and land take, will be discussed. When doing so, it is important to look at the basic conditions, too: Trip times have to be considered as well as the carriage capacity of the transportation system. Moreover safety aspects, availability and competitive life cycle costs are relevant [1]. In all these aspects the Transrapid offers substantial benefits for both, the passengers and the operators of Transrapid lines.

1 CHALLENGES OF MOBILITY

The population growth and the urbanization worldwide makes Transport of an increasing number of passengers and goods over increasing distances necessary in short time. Mobility is a human basic need. The real challenge is to solve the current and future mobility problems in an effective, economic and environmentally friendly way [1].

1.1 Population growth and climate change

World's population has grown in the last 60 years 2.7 times and the United Nations expect a growth of further 1/3 by 2050 (Figure 1) [2].

The population growth is accompanied by a climate change as said by the Intergovernmental Panel on Climate Change (IPCC) in its latest assessment report in November 2007 [3]. This development has led to changes in temperatures and average sea level (Figure 2). The climate change corresponds with a depletion of natural resources and an increase of environmentally harmful emissions. Due to human activities the global greenhouse gas emissions had an increase of 70% between 1970 and 2004 alone (Figure 3, [4]).

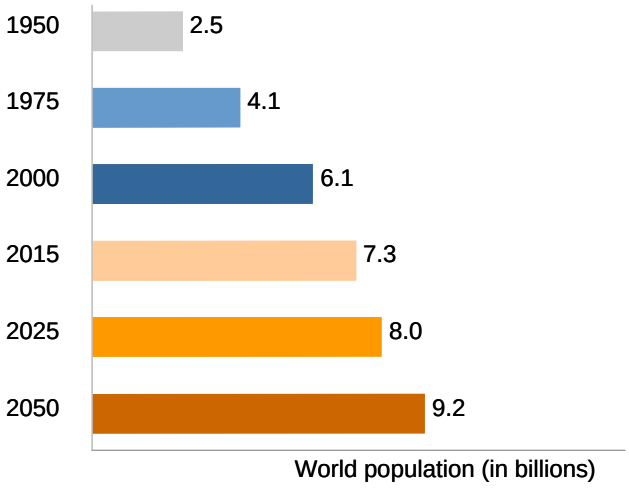

Figure 1. World Population growth 1950 – 2050 [2]

The growth of world population and the spread of the urbanization calls for attractive, environmentally friendly and economic transportation solutions in order to ensure the competitiveness and appeal of urban regions in the long term.

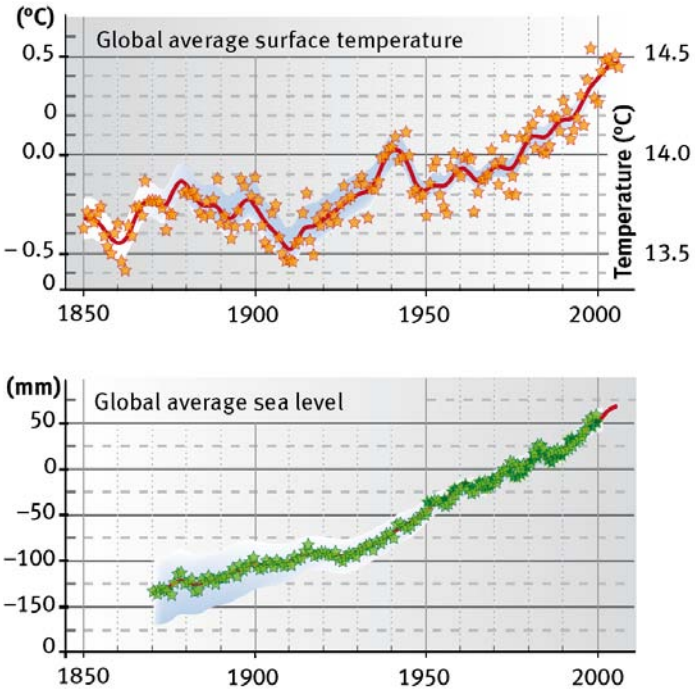

Figure 2. Development of the global average surface temperature and global average sea level 1850 – 2005 [3]

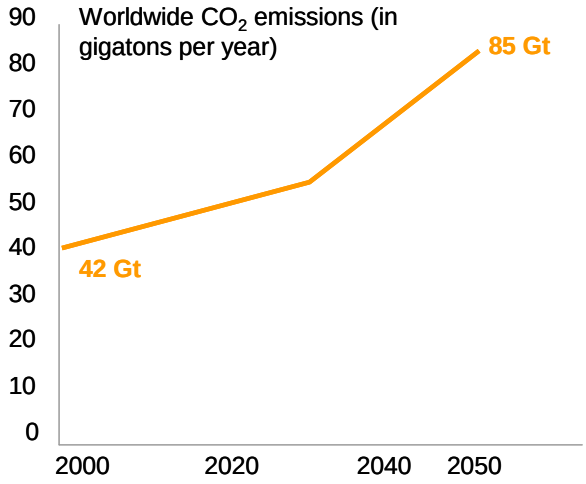

Figure 3. Worldwide CO_2 emission 2000 – 2050 [4]

1.2 Environmentally friendly mobility

The transport of goods and persons can be fulfilled by different carriers. Of course, all carriers have their individual application areas. For freight transport in a distance up to 1000 km usually
– Lorries,
– Trains and
– Inland waterways
are used.

For passenger transport up to 1000 km
– Cars,
– Trains and
– Airplanes
are applicable.

The figures below compare the CO_2 emissions for freight and passenger transport on typical distances (Figure 4 und Figure 5).

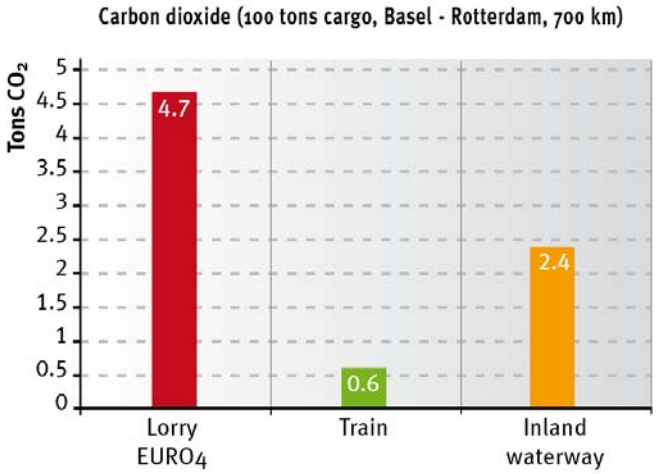

Figure 4. Freight transport CO_2 comparison [3]

Figure 4 shows that concerning typical freight transport CO_2 emissions of rail are almost eight times less than lorries and four times less than inland waterways.

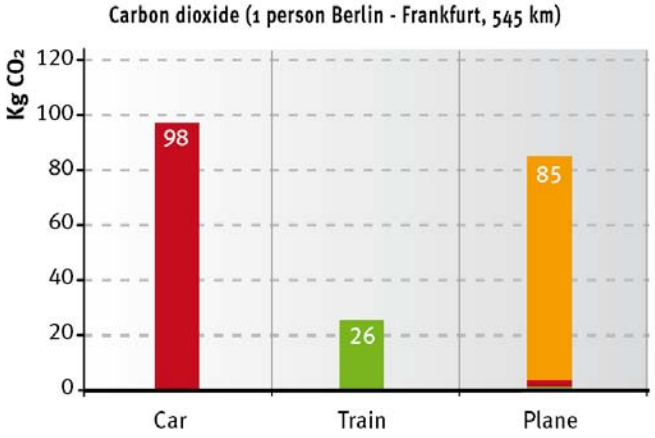

Figure 5. Passenger transport CO_2 comparison [3]

Concerning passenger transport the rail is four times more efficient than the car and three times more than the plane on average (Figure 5) (car: one person, train and plane: average degree of utilization).

Attractive and clean railways are the key transportation solutions for a clean and worth living future.

2 WHAT MEANS TRANSRAPID?

The modern high speed trains are already economical and environmentally friendly systems for fast passenger transport.

The Transrapid system has been developed as a railway solution for long distances and short trip times. Due to its high acceleration values over the whole speed range, Transrapid is an excellent solution for high value regional transport, too.

The development of Transrapid had to attain the following goals:

1. Comfortable:
   - Short trip time due to high acceleration and high velocity
   - Punctual due to high availability
   - Barrier-free access to the vehicles
2. Safe:
   - Fully automated operation
   - Protected against derailing due to wrap-around vehicle design
3. Eco-friendly:
   - Energy-efficient due to better aerodynamics
   - Silent due to contact free technology and flat surfaces
   - Less vibration due to magnetic levitation
   - Easy integration into existing landscape
4. Economical:
   - Less maintenance due to contact-free technology
   - Fewer tunnels and bridges due to high gradeability
   - Propulsion power adaptable to the line topography

The comfort, safety and economical goals were achieved as shown by the world's first commercial Maglev system in Shanghai.

3 ENERGY EFFICIENCY

The challenge of a high speed surface system is the train resistance and the energy consumption.

The train resistance of high speed systems is dominated by the aerodynamic resistance. The aerodynamic resistance depends mainly on the cross sectional area and the smoothness of the surfaces. The cross sectional areas of modern high speed trains and Transrapid vehicles have nearly the same dimensions. Only the need of pantographs and bogies for high speed trains does not allow such smooth surfaces as for the Transrapid vehicle. At high speed trains the pantograph effects 5-8% and the bogies 20-35% of the aerodynamic resistance of the train.

Due to this, the aerodynamic resistance of the Transrapid vehicle is less than the aerodynamic resistance of a modern high speed train (Figure 6).

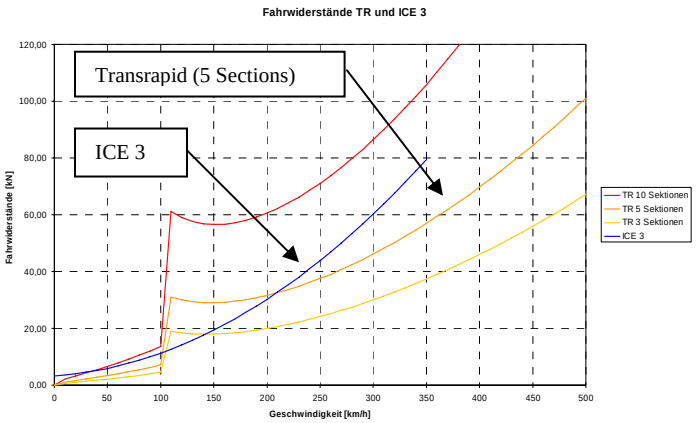

Figure 6. Aerodynamic resistance of Transrapid and ICE 3

The Transrapid vehicles have light weight design and the propulsion power is wayside installed along the track. The specific weight of Transrapid vehicle is with 0.564 t/m² 26% lighter than a modern high speed train [6].

The Transrapid allows, like other modern railway systems, the energy recovery of the braking energy [5]. This is shown with innovative active front-end converters on the Transrapid test facility in Emsland, Germany.

4 EMISSIONS

4.1 Local air pollution

Transrapid is an electrical high speed railway system. The required energy is supplied by a stationary power supply system fed by the public power grid. This means, Transrapid does not produce any exhaust emissions.

While Transrapid has an electrical braking system (based on the synchronous machine respectively the eddy current brake and a contactless levitation and propulsion system), it does not produce respirable dust either.

4.2 Noise emissions

Noise emissions of transport systems are unavoidable. A study of the European commission shows the percentage of citizens who are highly disturbed when exposed to rail, air and road traffic noise [3] (Figure 7).

The gentle rail systems have advantages by electrical propulsion and electrical brake systems. The acoustic sources are the rolling contact between wheel and rail as well as the aerodynamic noise of the carbody, the bogies and the pantographs. A further noise source is the mechanical brake with braking shoes and brake discs.

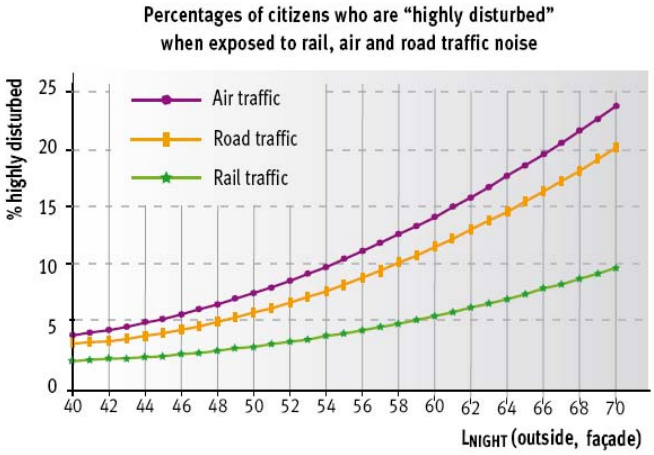

Figure 7. Percentages of citizens "highly disturbed" when exposed to rail, air and road traffic (L_{NIGHT}: constant noise exposure level) [3]

As already explained regarding the aerodynamic resistance, Transrapid is designed with smooth surfaces. Compared with other high speed trains, Transrapid has no wheel – rail contact and produces therefore no rolling noise.

A noise comparison between the different railway systems shows, that Transrapid has clearly lower noise emissions at 200 kph than an interurban train at 80 kph [6] (table 1).

Table 1. Measured noise emissions (peak level) at 25 m distance [6]

Sound level in dB(A)	100 kph	200 kph	300 kph
Freight train	88 – 92		
Interurban train	89 – 91		
Intercity train		90 – 95	
ICE		82 – 84	87 – 91
Transrapid		79	86

This means Transrapid lines can be routed in cities like interurban railways and there is no need for noise control measures minimum up to 200 kph.

4.3 Magnetic fields

The electromagnetic system Transrapid has to bridge a levitation air gap of approximately 10 mm. The electrodynamic maglev systems usually have to bridge air gaps of 100 mm. Due to the flux density in the air gap B_m

$$B_m \sim 1/\delta^2$$

is proportional to the square of the air gap δ, the electrodynamic systems need 100 times of the magnetic fields from Transrapid.

Magnetic continuous and alternating fields in the passenger compartment of Transrapid are lower than the magnetic fields of other railway systems (Figure 8).

The magnetic fields inside the vehicle and near the guideway are in the same dimension we are exposed in the household and due to this, Transrapid is absolutely safe for people with heart pacemakers.

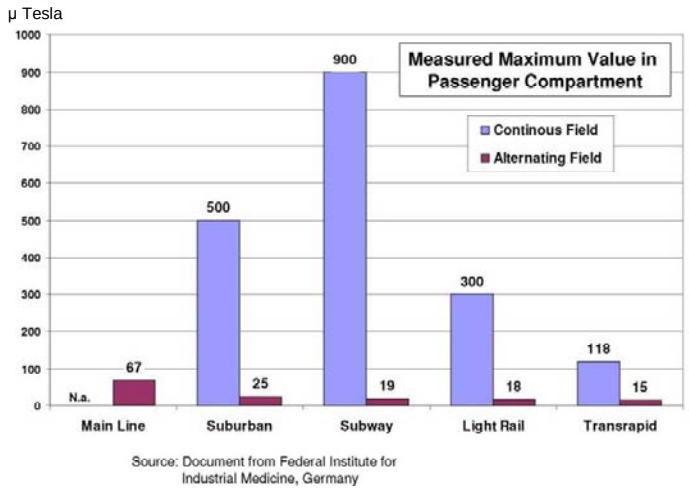

Figure 8. Magnetic fields: measured maximum values in passenger compartments [7]

4.4 Shock and vibrations

In normal operation Transrapid has an absolute advantage concerning shock and vibrations for its surrounding area.

Due to the levitation magnets, the Transrapid vehicle load is distributed over the whole length at both sides of the vehicle. Therefore the area load is with 0.67 kg/cm² very low. In comparison, a wheel – rail system with four axles per wagon has a concentrated load on the wheel – rail contact of 5000 kg/cm² (Figure 9).

The area load allows line routing near respectively in buildings with low shock and vibrations.

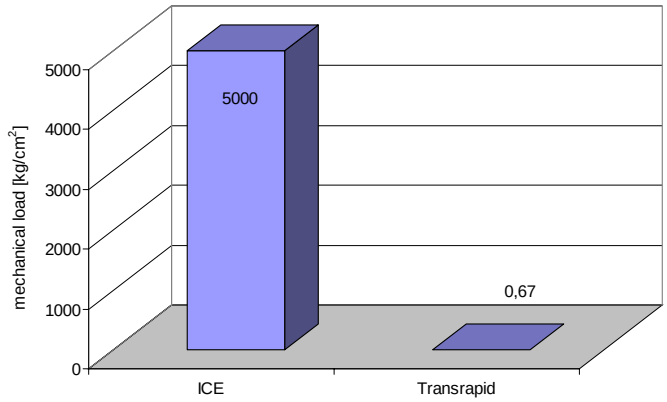

Figure 9. Mechanical area load of Transrapid vs. concentrated load of a wheel- rail system

4.5 Land take

Transport infrastructure has negative influence by the actual space requirement, as well as fragmentation and degradation of the natural or urban landscape.

A comparison of capacities of urban transport modes show that rail has the highest capacity (Figure 10).

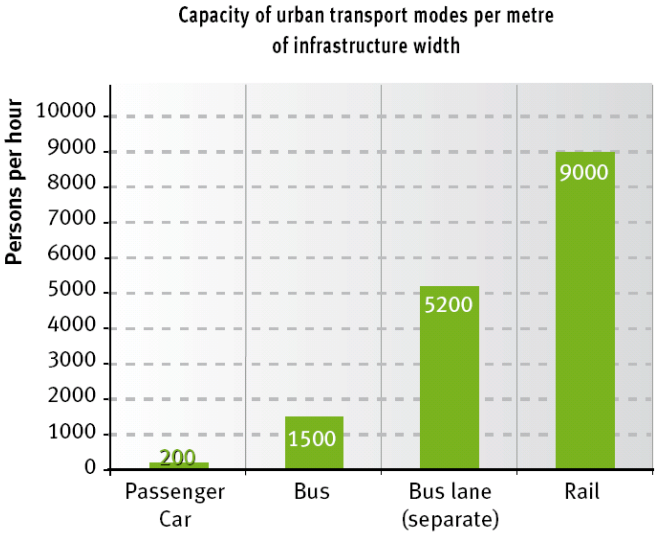

Figure 10. Comparison of capacities of urban transport modes per meter of infrastructure width [3]

This advantage comes from the efficient traffic management under urban conditions with many trains having high carrying capacity per hour.

Due to the contactless technology, Transrapid allows a high gradeability of up to 10%. This allows a flexible alignment with a lower number of tunnels and bridges (Figure 11 and 12).

The Transrapid system can be aligned at-grade or elevated. Especially the elevated alignment has safety and environmental advantages: the safety advantages are no crossing traffic and no possibility for animals to climb the guideway; the environmental advantage is the track is no barrier for water or animals.

Figure 11. Picture of the new rail track Köln – Rhein-Main (Photo: Arge Mittelstand NBS)

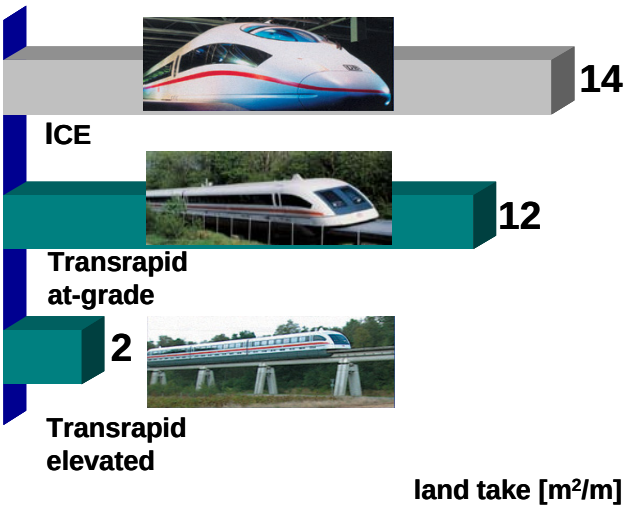

Figure 12. Land take of the guideway in m² per m track length

5 CONCLUSION

Transrapid has been developed by a strong look at the comfort, safety, environmental and economical concerns.

Regarding the environmental interests, the Transrapid takes all advantages of a high speed railway system. The Transrapid has additional assets concerning energy efficiency, local air pollution, noise emissions, shock and vibrations and land take.

The competitiveness of Transrapid and its attractiveness towards operators and passengers is still increasing and will accomplish transportation solutions which are highly efficient and environmentally-friendly.

6 ACKNOWLEDGEMENT

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7 REFERENCES

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