Rubric 1 . TECHNOLOGIES AND PROJECTS

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MOBILITY ON DEMAND – VISION OF A FLEXIBLE FUTURE URBAN MOBILITY

Background: The present situation in megacities is characterized by traffic congestion, capacity limits of public transportation systems. In addition, environmental regulations due to potential health risks will have an increasing impact on urban transportation systems.

Aim: In this paper, we describe major technology trends in transportation and in information and communication systems which will influence urban transportation in future megacities. Based on these trends a vision of a sustainable urban transportation system is developed.

Method: In a first step, trends in urban development and the individual needs are analyzed. Digitalization of transportation and communication technologies offer new business opportunities for Artificial Intelligence (AI) based services.

Results: The intelligent combination of advanced transportation technologies in large buildings and AI based services enables a vision of "Mobility on Demand", representing a flexible and sustainable urban transportation in future megacities.

Conclusion: The vision "Mobility on Demand" illustrates the effective and flexible integration of individual transportation needs into public transportation systems. Depending on the standards of future individual vehicles such vehicles could be integrated seamlessly into the urban Maglev transportation system.

Keywords: Urban transportation, megacities, individual needs, linear drives, Maglev

INTRODUCTION

Today's situation of urban transportation in many large cities is characterized by road traffic congestion, especially by the individual traffic. An increasing problem is the lack of sufficient parking space in the downtown area of large cities. Air pollution presently attracts growing attention and already results in environmental regulations to limit hazardous emissions by vehicles powered by internal combustion engines (ICE). Among them NO_x and particulate matter are considered to have a negative impact on quality of life and health. Public transportation systems such as subway, express way and buses are already reaching their limit of transportation capacity, at least during several

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hours a day. In 2018, 55 percent of the world's population are residing in urban areas. By the year 2050, 68 percent of the world's is projected to be urban [1]. With an increasing influx of the population from rural areas this trend will continue during the next decades, and it is expected that at the end of the 21st century more than 90 percent of the worldwide population will reside in megacities, as illustrated in Fig 1.

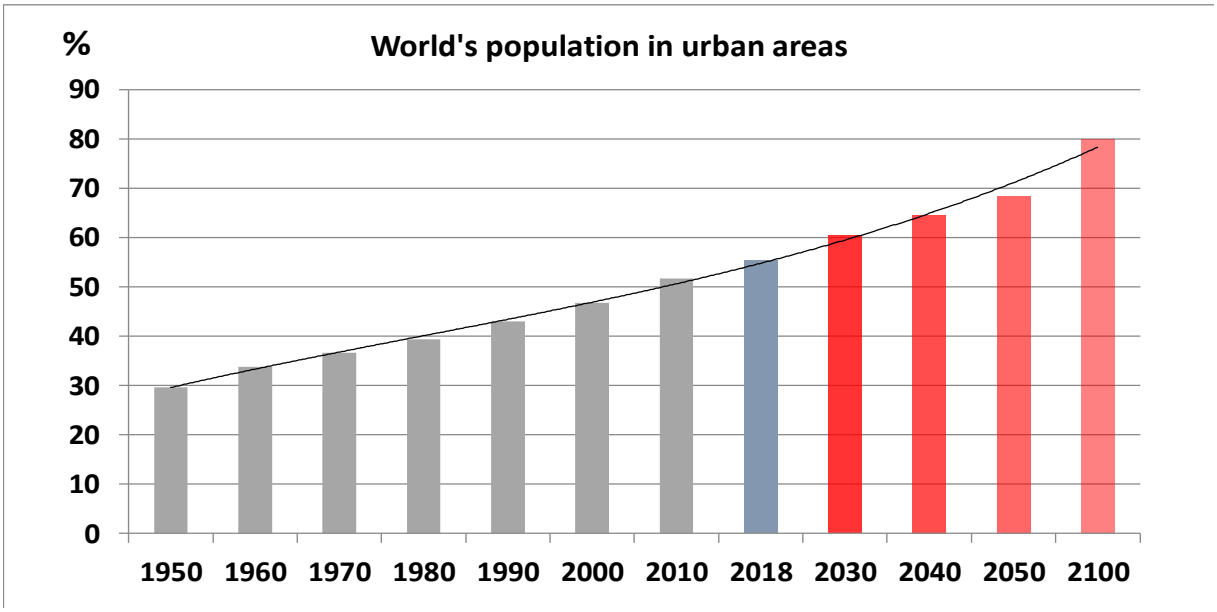

Fig. 1. Development of the world's population residing in urban areas [1]

This trend will lead to increasing costs of building ground and housing construction. Therefore, to utilize the available space in a most efficient way the housing construction will target to large buildings with a maximum use of the available area. In addition, energy efficiency, sustainability and comfort will become increasingly important in building construction. To keep pace with this development about two third of all cities worldwide have to be planned and constructed [2]. On the other hand, commuting traffic will increase with growing distance between working and living place. For comfort reasons short and flexible connections to long distance transportation systems become important. Short travel and transfer time are further personal needs, too. Avoiding potential conflicts of interests between personal needs and higher-ranking needs of the general public could be a challenge.

Presently common urban transportation systems in most large cities are operating at the limit of their transportation capacity. Expansion of these systems is restricted by limited available area, problems in public acceptance, increasing construction costs and municipal households. Therefore, innovative solutions are required to manage future urban transportation. In this paper, we investigate how advanced technologies of mobility combined with state of the art information and communication technologies can contribute to a sustainable and flexible urban mobility in future megacities.

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TECHNOLOGY TRENDS

Mobility

Due to environmental regulations electric mobility (e-mobility) is already penetrating the market of individual and fleet vehicles. However, almost all e-cars are powered by batteries whose capacity provides a rather limited range, even with the most advanced Li-ion technology. A major drawback of these batteries is the time required for re-charging, an exploitation process of the raw materials which is not sustainable. In addition, the long term supply of some important raw materials for the mass production of these batteries is still unknown. An alternative fuel is hydrogen for fuel cell powered e-cars. Hydrogen is generally available in abundance if generated via electrolysis. However, generation costs of hydrogen and the costs of fuel cell cars are not yet competitive to conventional cars. Research and development efforts in many countries are focusing on cost reduction of fuel cells and hydrogen generation. However, the trend towards electric mobility either powered by batteries or fuel cells will be irreversible.

Public ground transportation systems are based on rail-wheel technology which have a long history, and bus. Besides these conventional technologies more advanced systems, such as magnetic levitation (Maglev) trains have been developed and successfully tested. Some of them are in commercial operation. Examples are the Transrapid, developed in Germany and in commercial operation since 2002 in Shanghai/China. Other examples are the Linimo in Japan and the Rotem Ecobee in South Korea. All are Maglev systems, using the linear motor drive system for propulsion and the electromagnetic principle for levitation and guidance. They differ in the structural design of the levitation and the guidance system. Another system which is in preparation for commercialization is the JR Maglev. This system uses the electro-dynamic principle and onboard superconducting magnet coils for levitation and guidance.

Information and Communication

The last few decades experienced rapid progress in microelectronics, miniaturization and integration of a variety of functionalities into small devices accompanied by a dramatic increase in performance. A similar progress could be seen in the fields of software system development, data processing and communication technology, especially in wireless communication technology. A few decades ago, electronic devices managed and improved the performance of engines. Increasing wireless communication technology enabled navigation and infotainment features in vehicles. Today, embedded systems allow car-to-car communication and driver assistance, and algorithms based on artificial intelligence (AI) enable automated or autonomous driving. At many places around the world tests with autonomous driving are carried out. Besides comfort for driver and passengers this is considered as an improvement of safety in traffic in the near future.

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The intelligent combination of such embedded systems with advanced transportation technologies could contribute to a sustainable, efficient nd flexible urban transportation in future urban transportation. The challenge is an intelligent combination of information and communication technology with e-mobility technologies to cover personal individual transportation needs and higher-ranking requirements of public transportation. Wireless communication via smartphone could provide the missing link between personal transportation needs and public transportation systems. In the following the vision of "Mobility on Demand" is presented, illustrating how this could be realized.

INNOVATIVE TRANSPORTATION SOLUTIONS

Personal transportation by linear drive systems

Residential and office buildings in future megacities will be large-scale buildings, requiring efficient and flexible transportation inside the building complex. The innovative concept of MULTI [3] of thyssenkrupp is a disruptive re-invention of the elevator function which could revolutionize the personal transportation in building complexes. It applies the linear motor technology developed for the magnetic levitation train Transrapid to elevator cabins.

The cabins move in shafts in the same way as trains in rail systems. The linear motor system together with the fact that no ropes are necessary allows vertical as well as horizontal movements inside the building. Even various cabins can move in the same shaft at the same time. In addition this concept allows the use of new and lightweight materials substantially reducing the overall weight of the elevator compared to conventional ones. The functional concept of this MULTI system is illustrated in Fig. 2, and its implementation in a building complex in Fig. 3.

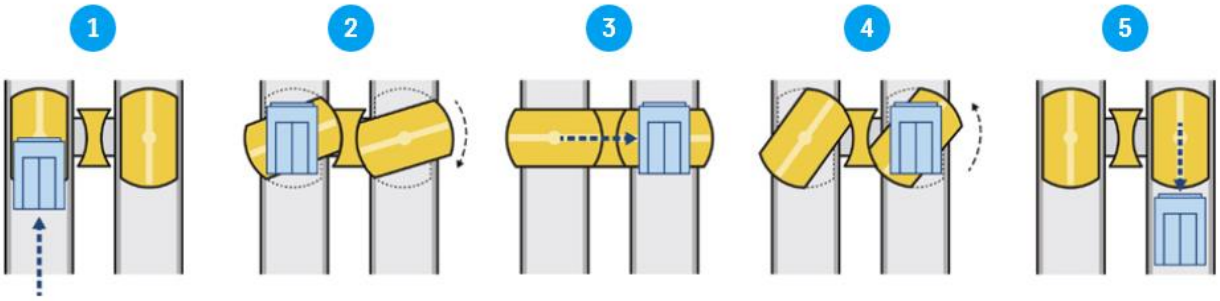

Fig. 2. Illustration of the functional concept of the MULTI system [3]

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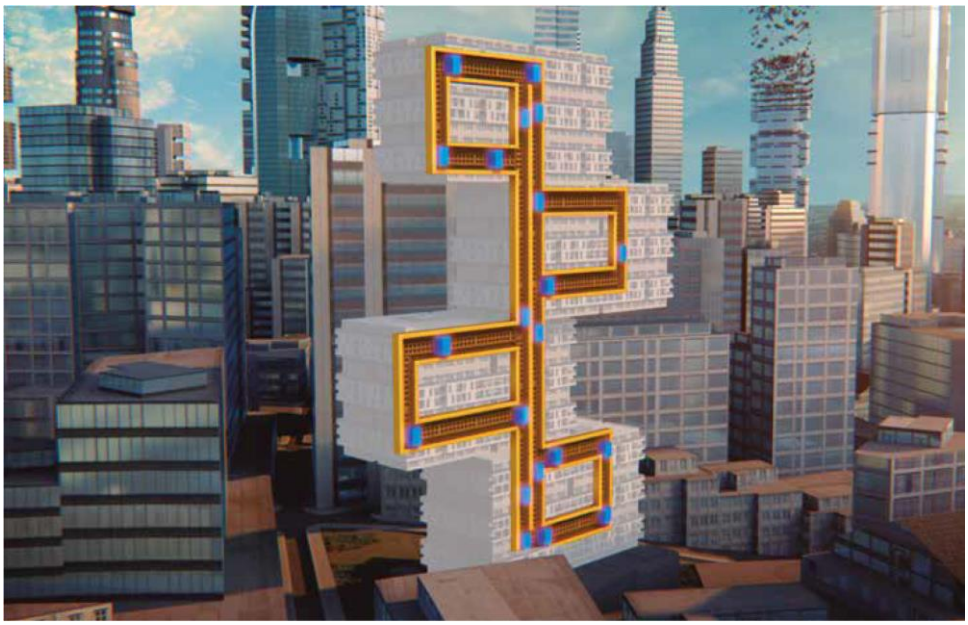

Fig. 3. Implementation of the MULTI system in a large scale building complex [3]

Urban Maglev systems for public metropolitan transportation

Several urban Maglev systems have been developed in Germany, Japan, China and South Korea. They are using different technologies and structural designs but their common principle is the electro-magnetic principle and the linear motor drive. Germany's high speed development Transrapid uses the attractive force of magnets beneath a guideway to lift the train up (bearing magnets for levitation) and long-stator coils for propulsion. The Transrapid operates at a speed up to 500 km/h. The structure of the Transrapid's bearing and propulsion system is illustrated in Fig. 4a.

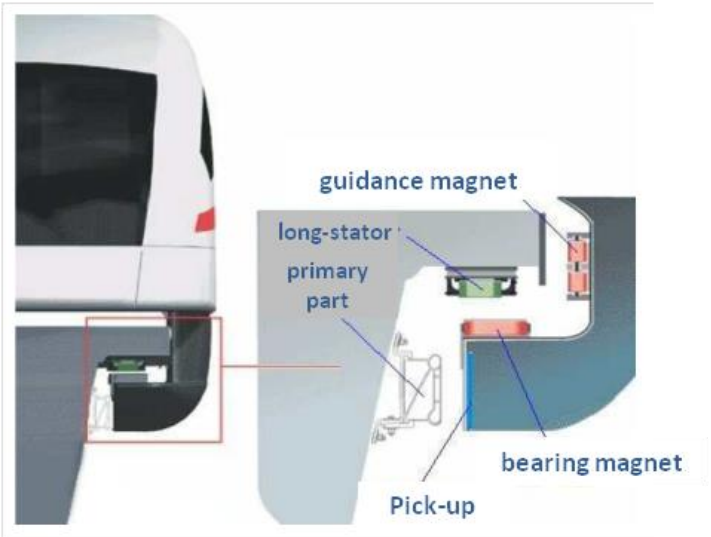

Fig. 4a. Structure of the bearing and propulsion system of TR08 [4]

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Fig. 4b shows the Shanghai Maglev Train (Transrapid) in operation.

Fig. 4b. The Transrapid leaving the station in Shanghai [5]

The Japanese Linimo uses the attractive force of magnets beneath a guideway to lift the train up, too. For propulsion a linear motor and short-stator coils are used. The maximum speed is limited to 100 km/h. The Linimo car in operation is shown in Fig. 5.

Fig. 5 The Linimo in operation [6]

The Ecobee urban Maglev train also uses the attractive force of magnets beneath a guideway to lift the train up. For propulsion a linear motor and a long-pole design is employed to reduce the magnetic drag forces. The designed top speed is 110 km/h.

R&D activities exist in many countries, especially in Eastern Europe and in Asia. Therefore, more advanced Maglev system designs for urban and long-distance transportation can be expected, and we focus on urban Maglev systems in general, with no restriction of the vehicle and guideway design. We even assume that in the future standardized small modular units could be developed which can temporarily be linked to other units, like in a chain.

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VISION OF "MOBILITY ON DEMAND"

Flexible transportation service on demand

The elements of this vision are the MULTI system for transportation inside large-scale building, urban Maglev systems for public transportation in cities and state of the art information and communication technologies. Combining these elements a flexible transportation service on demand can be realized. The transportation service process is performed in the following way: A person (the customer) planning his travel from his actual position "A" to a certain destination "B" communicates via a smartphone app to the central traffic coordination center (TCC) of the city, transmitting the information about his actual position "A", the destination "B" and his personal preferences and individual options. In the traffic coordination TCC center the most efficient route between his position "A" and the destination "B" is automatically identified, based on the locations "A" and "B", the customer's options and the availability of the urban transportation system. The result with detailed information about the transportation lines, the schedule including transfer times is sent to the customer. After approving the suggested traveling plan a cabin of the MULTI system inside the building is sent to the nearest location of the customer's position. The Maglev station close to the building and the next available urban Maglev train is informed about the arrival of the new passenger. The customer is continuously online informed via his navigation app on his smartphone about the status of his schedule. The concept of this vision is illustrated in Fig. 6.

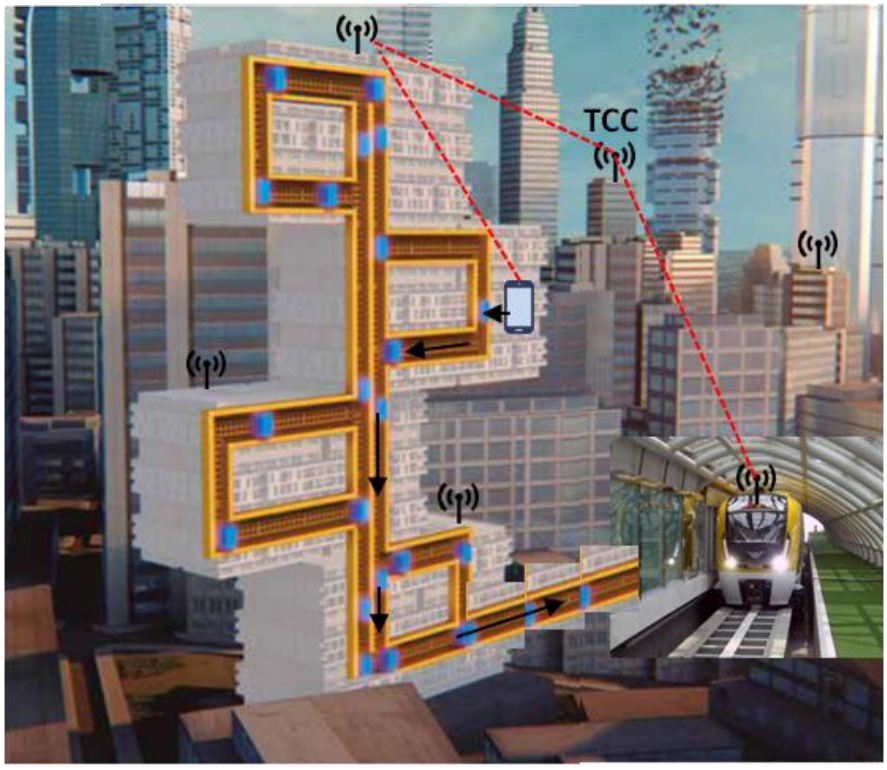

Fig. 6. Illustration of the flexible transportation system on demand

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Such systems provide most efficient personal transportation in terms of traveling time, connections and availability of transportation systems. Individual options and higher-ranking requirements of public transportation are combined in an optimum way.

The concept can even be extended to larger building complexes. The MULTI-system is not restricted to one single building, it could connect neighboring buildings, as illustrated in Fig. 7

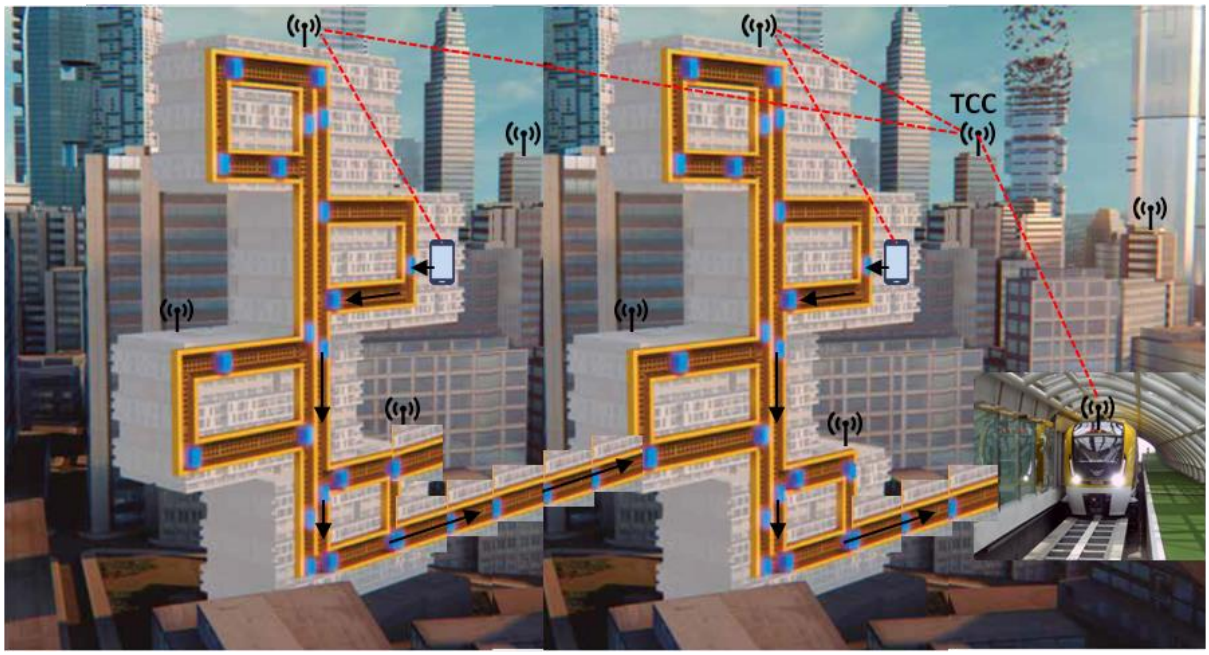

Fig. 7. Illustration of larger building complexes connected by MULTI-system

New business opportunities by Mobility on Demand

The idea of mobility on demand offers a new business opportunity for an organization “coordination center” which provides the service of transportation on demand. It overlooks and communicates with all participating transportation systems and building managers. Providing mobility on demand in future megacities 24 hours 7 days a week, satisfying individual personal needs and higher-ranking requirements of an efficient public transportation will be an important feature in a future sustainable and comfortable urban transportation. Energy consumption can be minimized and capacity of urban transporting optimized.

CONCLUSION

In the article, a vision of an urban transportation system in future megacities has been presented, which is based on an extrapolation of state of the art technologies in mobility and information and communication.

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The authors make it expressly clear that:

1. No conflict of interests has taken or may take place;
2. The present article does not contain any researches with people as the objects involved.

References

1. 2018 Revision of World Urbanization Prospects [Internet]. *United Nations | Department of Economic and Social Affairs*. [cited 2019 Jul 09]. Available from: https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html
2. Bauen für die Zukunft – Zukunft für den Bau, Heute für die Welt von morgen bauen. Fraunhofer Bau. Fraunhofer Institut für Bauphysik IBP. Fraunhofer-Allianz Bau, 2012 [Internet]. [cited 2019 Jul 09]. Available from: https://www.fraunhofer.de/content/dam/zv/de/institute.../fraunhofer-allianz-bau.pdf
3. Casting a glance into future mobility: thyssenkrupp shows ropeless MULTI at the German Pavilion of EXPO 2020 Dubai [Internet]. *Daily press*, 2019 11 Jul. [cited 2019 Jul 09]. Available from: https://www.thyssenkrupp-elevator.com/en/newsroom/press-releases-93760.html?id=2417166
4. Bühler G, Czainski R. *CPS for the high-speed magnetic levitation system of Transrapid TR08*, 2005.
5. MAGLEV BOARD [Internet]. Pics, Transrapid. [cited 2019 Jul 09]. Available from: https://www.maglevboard.net/en/pics#gallery4b25bb6ea4-27
6. MAGLEV BOARD [Internet]. Pics, Transrapid. [cited 2019 Jul 09]. Available from: https://www.maglevboard.net/en/pics/linimo-urban-maglev#gallery7f45cdb446-10
7. Paturi FR. Baumeister unserer Zukunft: Kühne Projekte der Forscher, Erfinder und Ingenieure in aller Welt. Econ Verlag; 1975. 227 p. (In German). [Internet]. ISBN 3-430-17379-5. [cited 2019 Jul 09]. Available from: https://isbnsearch.org/isbn/3430173795

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