



# Comparison of Trends in Development of City Structures and Development of Urban Transportation

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## ABSTRACT

This paper discusses trends in the development of future cities and the emerging new requirements to urban transportation. Trends in urban transportation will be investigated to conclude whether they are coherent with the visions of future cities or are able to fulfill the requirements. Origin and history of cities will be discussed to better understand the current status of city structures before future visions are presented. Same will be done for urban transportation.

**Key words:** Mobility, Sustainable cities, Sustainable transportation, Urbanization

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## INTRODUCTION

One of the oldest continuously inhabited cities in the world, with evidence of settlement is Jericho. Its origin is dated back to 9000 BC and was located near the Jordan River in the West Bank of the present-day Palestinian territories. During the Younger Dryas period of cold and drought, permanent habitation of one location was not possible. However, the area that would become Jericho was a popular camping ground for Natufian hunter-gatherer groups, who left a scattering of crescent microlith tools behind them. Around 9600 BC the droughts and cold of the Younger Dryas had come to an end, making it possible for Natufian groups to extend the duration of their stay, eventually leading to year round habitation and permanent settlement. Evidence of a genuine civilization, pyramids included was found Norte Chico in Peru, dated back to 3500 BC. This is the site where the oldest traces of a civilization are found in America, although the area is an agronomical no-go area, where hardly anything grows. Keeping this fact in mind, it is fascinating that approximately 25 large ceremonial/ residential sites have so far been found in this area, of which Caral has become the most famous. In Europe, many settlements can be found that date back to 8000BC to 3000BC: Chur in Switzerland, Varna (Bulgaria), Hallstadt (Austria) or Bratislava (Slovakia) are only some

examples to be named. Settlements in Europe developed into municipal towns in Europe around 1100 AD.

It was in 2008 when the United Nations announced that 50 percent of the world's population lives in urban areas, a milestone in demographic history (Bremner, Haub, Lee, Mather, & Zuehlke, 2009). News reports on the subject frequently rephrased this development slightly to say that half of the global population now lives in cities and illustrated articles with photos of Mumbai, Shanghai, or New York. These cities are what the UN terms mega-cities; urban areas of 10 million people or more. The distinct impression was created that a majority of people lived in very large cities. However, only about 5 percent of world population lives in the largest cities or, more properly, metropolitan areas. The fact that over half of the world's population live in places termed 'urban' is a notable development. But, at the same time, it is useful and important to know just how the term "urban" is defined. In most countries, a large part of the urban population actually lives in rather small towns and villages. In its most recent urbanisation estimates and projections, the UN Population Division recognised that when urbanization is discussed, the focus is often on large cities, cities whose populations are larger than many countries. The great variation in the urban definition and the size of places deemed urban is readily apparent. The development and growth of cities provided the essential basis for the development of labour. That was also

the most fundamental of all contributions to enhance productivity and to boost economic growth. It is with the beginning of industrial revolution and the appearance of factories when people started to settle more and more around the factories and forming bigger cities. It was the initial growth of cities that prompted the need for transport improvements to meet the requirements of the urban dwellers. The invention of the wheel was driven by the demand to overcome the tyranny of distance. By extending the area over which food could be distributed, cities were able to expand (Bairoch, 1991). It was the further growth of cities that gave rise to the demand for technological innovation in infrastructure, water supply and public hygiene. Those innovations in turn allowed the industrial era to exploit the economies of scale and the further division of labour enabled by the invention of the factory system.

Cities are complex organisms. Policies take a long time to have any significant effect on this organism. One obvious reason here for is the durability of the built environment; a city seems to be a project for generations. As the society is changing, also life in cities is changing and requirements of citizens will change by time. Analyses of cities have mostly focused on structural elements, such as labour or infrastructure. However, the ability to address people's basic needs is getting more and more into the spotlight. Kelly (2010) distinguished between three basic needs, namely material and psychological needs as well as the broader environment. Quality of life in cities is much determined by the ability to provide a basis to address these needs.

### TRENDS IN CITY STRUCTURES AND URBANIZATION

On each of our five continents city structures differ significantly and have different functions. A city of three million inhabitants, which in Europe is regarded as a big city, seems to be only a small village with a rural area and no perspectives for young people in Asia. Old cities have grown over time, leading to a different city structure than new cities which were planned of even future projects for cities that are designed. The different development path of these cities has also influenced the development of transportation infrastructure. While in European cities the city centre is usually the old town with pedestrian zones, in some cities in North America the city centre might be planned for cars to enter. Projects for future cities seem to have the intention to minimize the need for individual transportation. Sustainability issues play a key role in the planning of future cities. One example is Masdar city projected in the United Arab Emirates. Environmental concerns and the intention to plan a sustainable city have influenced the whole planning process, e.g. orientation of buildings or minimization of the need for air conditioners. Also transportation planning is influenced: no private automobiles are permitted. All public means of transport shall be powered by electrical engines, electricity shall be provided by solar energy. Masdar City has a rich network of public and personal transportation which allows moving easily and comfortably. Public transportation includes electric buses, electric cars, light rail and metro for wider metropolitan area. PRT (Personal Rapid Transport) and FRT (Freight Rapid Transport) system offer single cabins with

privacy, comfort and reliable taxi service. Another example for a zero emission project is the Wuhan Energy Centre. However, it is not as complex as Masdar City and limited to one complex of building. Many projects have been started or planned in the recent years with the intention to raise zero emission cities. But none of them have been realized. Some have been started, like Masdar. However, its projected completion has been delayed several times. Currently, it is expected to finish in 2025, if at all.

Another project was the project of a sustainable city in Dongtan, near Shanghai in China. The project was stopped, after some minor constructions had taken place. Recently Malaysia has announced a big project for a green city in the Iskandar region, to be a reference for bigger scale cities. According to news reports, fundraising of the project was successful. The idea behind this project is similar to other green-city projects: zero-emission buildings, no private automobiles or sustainable energy production. Also China has announced a new green city project in Tianjin. All these projects show the need and intention to strive toward sustainable cities. Many of the projects promise a higher quality of life in an intact and sane environment. However, none of these or similar projects have been realized or finished and some skepticism if they ever will seems to be appropriate. Statistics and estimates however indicate that in the high dense population regions in Asia, by far the greatest growth will be in slums. The question why many of the projects fail is a comparison between investment costs and return. Investment costs of these projects are very high, mainly because new technologies may be necessary that have never been tested and implemented before in big scale.

Any new design of a future city has to address the aspects drawn in Figure 1. The figure below shows some of the common aspects that you certainly will stumble upon, when thinking of future cities. Some of the aspects that have an influence of transportation are discussed in more detail in the following. However, it has to be noted that all aspects are strongly interrelated and influence each other.

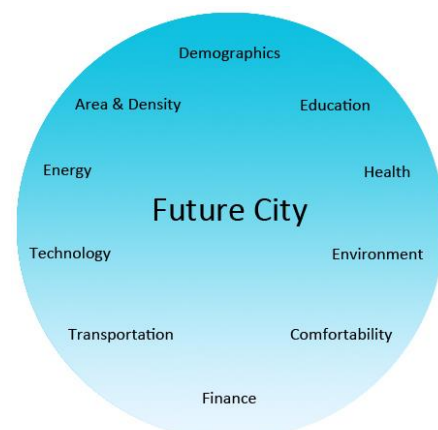


Figure.1 Aspects to be considered in city planning

### DEMOGRAPHICS

The demographic composition of a city area depends on the city structure, but since cities have structures that are to a certain extent similar all over the world (with different sizes of course), it is possible to predict the distribution of dwellers.

Occupiers of city center residential properties are mainly young singles and couples, who intend to stay there only for a short time. Households with children are more likely to settle in areas where educational facilities are easy to access. On the other hand, bad policy and city planning leads to the formation of run down areas, also known as slums. It is estimated that today, around one billion people live in slums. Future urbanism trends are not necessarily able to solve this problem. Quite the contrary, the number of slum dwellers will double within the next 20 years. Also the problem with aging society (particularly in developed countries) has to be faced. In Japan for example, projects that deal with this problem are already under way: The Yamaguchi Active Aging city is a specific area for aged people. The aim is to establish an advanced medical care center to detect and cure diseases at an early stadium. As one can see, different people have different needs and those have to be kept in mind for planning the future.

### AREA AND DENSITY

There are different urban forms and all of them have their benefits and flaws. The final report on Sustainability of Land Use and Transport in Outer Neighborhoods (Mitchell, 2005) shows and compares some of possible urban forms that might be implemented in the future. Three forms were analyzed in the report in respect to different topics:

#### 1. Compaction

A compact city can reduce the travel costs by reducing travel needs. Also CO<sub>2</sub>-emissions can be reduced through efficient energy use, while protecting natural landscape due to reduced land use.

#### 2. Dispersal

Due to limited availability of land, land prices rise and lead to higher housing and commercial property costs. Higher prices make the area less competitive, also for industrial activities. From the economic point of view, living costs are decreasing in dispersed cities. Crowding will also be reduced, which is an important factor from the social perspective. As a result of having more space, renewable energy sources can be used more efficiently.

#### 3. Planned Expansion

Another option is the so called planned expansion, an idea based on the concept of garden cities, which has been presented over one century ago by Ebenezer Howard. Howard thought of cities which consisted of a central city which is surrounded by several smaller city areas arranged in a circle around the central city. The first garden city Letchworth was founded by Howard in 1903 north of London and the concept was adapted for some other cities, e.g. Hellerau in Germany. Benefits from planned expansion are reduced travel costs through balanced communities and reduced crowding. Like in dispersed cities, renewable energy can be used.

A phenomenon which can be observed today is rural flight. The abandonment of rural areas effects city development massively and is one reason for the development of so-called mega-cities, which are cities with a total population of more than 10 million people. Unfortunately the high demand for living spaces in cities leads to various problems especially in poor countries. Slums with lack of health care and disastrous sanitary conditions along with all the problems that

overcrowding brings with it, will continue to grow, unless proper measures will be taken.

Transportation depends very much on the city structure and the key task is to find proper solutions. Most cities have the goal to reduce car travel and to increase the use of alternative transportation systems. A reduction of car-using can be achieved by making car travel expensive while at the same time alternative convenient modes of transport. Figure 2 shows a matrix where the optimal transportation modes are listed in dependency on the urban form.

Compact	Dispersal	Expansion
Pedestrian	Highspeed-train	Train
Bicycle	MAGLEV	Monorail
Bus		Bus
Light rail		Cable car
PRT		

Figure.2 Transportation modes for different urban forms

### ENERGY AND ENVIRONMENT

Energy and environment is one of the top-priority issues in today's world. While today fossil fuels are the most convenient energy source for transportation, it seems that in future electric energy will play a key role. However, there are a lot of challenges ahead and some severe unsolved problems are currently blocking the successful introduction of electric mobility. One issue is the limited capacity of batteries and another one is the lack of a compatible infrastructure. While the first problem may be solved with research work and innovation, the second one is more a financial challenge. It is not clear yet, which technology will survive on the market (e.g. battery changing systems or perhaps inductive energy transmission via the street itself). Some projects regarding future cities, as discussed previously, are trying to design a low-emission or zero-emission city. This goal can be achieved through various enhancements and innovation in architectural design and urban structure. But also the use of renewable energy sources like solar, wind, water and biomass can help to reach the goal. Many public transport systems already use electric energy successfully (e.g. tram, train, monorail, cable car, PRT), but to become environment-friendly, the electricity has to be generated with renewable power sources. Otherwise, the transport systems themselves are not emitting greenhouse gases, but the power generating plants are and the benefit of using "green technology" vanishes. In fact, the whole production chain also has to be considered. A lot of the used material for building the transportation systems is gained through various environment-damaging processes.

### EDUCATION, TECHNOLOGY AND INDUSTRY

In Japan, a lot of projects for establishing new technologies regarding urban living are now underway. It is interesting to see that there are a lot of collaborations with companies taking place. Of course, both sides, government and companies,

benefit from the cooperation. Innovation will become one of the most important issues for the next decades, even more for technology-driven countries. The awareness of the problems (e.g. climate change) that will emerge in the future continues to rise and that makes it easier to convince the people that measures have to be taken in order to prevent serious damages to the society. Solutions to the problems of the future are manifold, but almost all of them include developing technologies. The collaboration of the government with universities and the companies makes it possible to think of new approaches in all the fields that will become eminent in future's society. However, a strong educational basis is required. Without investing in education, it will become practically impossible to keep up and enhance the lifestyle of today's society. To grow the awareness of environmental issues, programs at schools all over the world have started. It is important to raise awareness about environmental issues today for the decision makers of tomorrow.

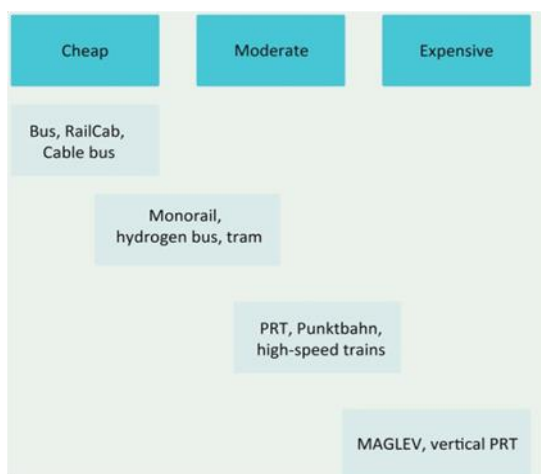
## FINANCE

Financial aspects regarding urban transportation can be distinguished between:

**Construction costs:** The costs for setting up the including all peripheral systems.

**Maintenance costs:** Costs for keeping the system running

**Customer costs:** The consumer price for a specific transport system has a big influence on the success of the system; high prices will most probably lead to rejection of the system (as long as there are alternatives). Pricing is a very powerful instrument to direct consumers and to bring new technologies to the market (e.g. high taxes for individual cars to subsidize cheaper PRT).



**Figure.3** Categorization of construction costs of different transportation systems, based on (Haberfellner & Ostad-Ahmad-Ghorabi)

## TRENDS IN PUBLIC TRANSPORTATION

There has always been a strong correlation between mobility and the development of humankind. The reason behind is that mobility enables people to distribute resources of all kind, which is necessary for the human progress. But a higher rate

of mobility also brings a high rate of negative side-effects with it: air and noise pollution, the usage of limited resources and the occupation of land-effects that are in contradiction with the trends for future cities. Negative side-effects have always been reasons to improve existing systems, but they are not the only driving forces in mobility. Economy, technology, settlement structures, demography, politics and also cultural aspects influence the development of new ways of transportation. In their book from 1972, Martin Ziegler and Wolfgang Klemm have summarized transportation trends which were regarded as future visions by then (Ziegler & Klemm, 1972). Some of them have become reality, and some of them are still a future vision today. The idea of using alternative energies was emerging already some 50 years ago. Same appeals to electric powered solutions and even computer steered systems like the Personal Rapid Transit systems.

The reason why some of the past visions have become reality is for sure the technological progress, in particular in electronics technology or light weight design. An important reason why some of the visions are still visions is their need for completely new infrastructure. The main barriers for new infrastructure are the high costs. In other words, visions from the past that have become reality were those building upon existing infrastructure and using new technologies.

A look at some statistics considering transportation in different countries gives a good overview on the existing state of the art of transportation: (Schafer, 1998) shows that the average kilometers per person per year differ from under thousand kilometers in parts of Asia and Africa to about 15000 in Central Europe, Japan and Australia up to 22440km in Northern America. To cover this distance, about 60% of the people use cars, 25% buses, 7% trains and 8% aircrafts (Schafer, 1998).

Water transportation was not considered in the statistics. In this paper, the focus is on European countries. There have been many incentives in Europe to make public transportation more attractive. Public transportation is in most cases more energy efficient than individual car traffic. In the past transportation was often focused on the idea of carrying as much goods as possible, as fast as possible from one point to another. Today other factors are much more important. In urban areas people prefer reliable transportation systems and accept a longer travel. Comfort is another important factor and so is flexibility. Transportation systems that meet these requirements are more likely to become reality in future. An intermediate solution of future transportation system is the concept of public transport projected in Masdar City. The public transport consists of three parts: a metro and a light rail line as well as a personal rapid transit (PRT) system. The wagons are electric, driverless standalone-vehicles, which can be linked together for better energy efficiency. Each of the cars has the size of a minivan. Some aspects of this transportation system can be found many other future visions of transportation systems: A centrally controlled transportation system that can be used on individual level and can be connected to form convoys. This is also found in vision for basically all cable- and rail-guided types. Another point is the reliability of a transport system. Researchers have shown that most people prefer a slower but predictably and fluently working transportation system rather than options that allow high peak velocities, but might entail waiting times or delays (WBCSD, 2004). Safety is another important aspect:

accidents do not only scare the passengers, but also impair the convenience of use and reliability; they are responsible for about 25% of external traffic expenditures of the EU (Hoppe, 2004). Aging society and the needs of aged people is an additional aspect to be considered in any future vision of a transportation system (Haberfellner & Ostad-Ahmad-Ghorabi).

Modular vehicles with automatic collision and congestion avoidance that are able to reach every house and every street and are driven by renewable energy seem to be the perfect solution for these needs. But it also has its limits and its price. The financial aspect is often a hard barrier for the entry of new transport systems. It is observable that more and more concepts try to make use of existing infrastructure, to lower the installation costs. One of the most advanced concepts of that kind is the RailCab, a system that makes use of already established rails. The common trains are replaced by smaller vehicles, similar to a van or a bus. Instead of travelling on fix routes, the passenger can freely select the destination from the whole rail-network. Another approach to reduce installation costs is used in the idea of the Punktbahn.

It uses pillars with magnets that are placed at a distance of the half vehicle length and it is driven by induction. No rails are needed. In cities, it is very difficult to implement any new transport system that needs additional occupation of land. Therefore underground or elevated systems are used often, although these constructions induce very high costs and also high cost for maintenance and operating these systems. Cable-guided solutions are becoming more popular for dense urban areas. Their installation costs can only amortize with a very high passenger throughput, but the system itself needs very little space and is very cheap in use and maintenance. The trend in drive technologies on roads and rails are closely interlinked with implementing electrical power supply. However, from the sustainability point of view, the clean production and provision of electricity is not sufficiently resolved.

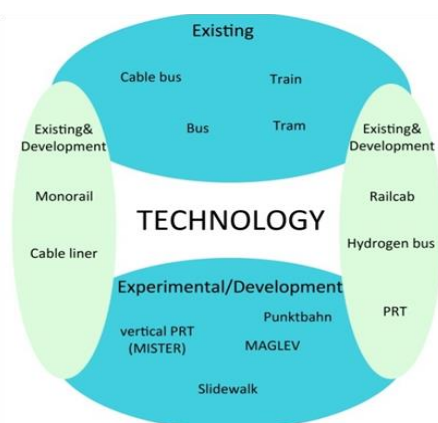


Figure.4 Overview of transportation systems

## CONCLUSION

Future vision in both areas, transportation and city areas, consider various ways of living and the settlement structures which are related to them. There are different future concepts for long and short distance travel, for line and network structures and concepts which depend on the density.

However, a point that is not covered by future transportation trends is the number of slum dwellers that will double over the next 20 years. The concepts seem to be based on more or less ideal future cities. The needs of people with social disadvantages will become more important over the next years. Keeping that in mind is important to work against those social side effects of urbanization.

Sustainable and environmentally friendly solutions are more often in discussion today than ever before. Air and noise pollution are strongly correlated to healthy living conditions. Finding alternatives to fossil fuel powered transportation systems has been an aim to many engineers. Although this way of sustainable thinking is not a new idea, it started to become more interesting to the public only some years ago.

Due to increasing prices of limited resources and catastrophes related to environmental impacts, green energy is getting more and more popular. Currently, green energy and electric power transportation are intensively followed by companies and politics. However, there are also voices talking about hype and underlining the unsolved issue of providing enough green energy for the electric power supplies of vehicles.

Installation costs will play an important role in the introduction of new transportation systems. Solutions that build upon existing infrastructure are more likely to become reality than those needing completely new infrastructure, e.g. the vacuum tunnels of the MagLev concept. The financial aspect brings a lot of limitations to the practicability of new ideas. This is also true for the development of cities: most concepts for new planned green cities either have failed or have been massively delayed. On the other hand, concepts of green buildings that are integrated in the existing city structure have been more successful.

It is important to keep in mind that there is no single solution that meets all requirements and needs. Even in the concepts of green cities like Masdar, a combination of already existing but technologically improved transportation solutions together with new innovations like the modular PRT are followed. However, new city concepts can reduce the need for urban mobility, if planned so ahead. Having facilities for daily life nearby, such as banks, post offices, supermarkets, administrative offices, schools etc can help to reduce individual mobility. This latter option can also be realized in existing city structures: from centralized to decentralized supply of daily needs.

## REFERENCES

- Bairoch, P. (1991). *Cities and economic development: from the dawn of history to the present*: University of Chicago Press.
- Bremner, J., Haub, C., Lee, M., Mather, M., & Zuehlke, E. (2009). *World Population Highlights: Key Findings from PRB's 2009 World Population Data Sheet*: Population Reference Bureau.
- Haberfellner, D., & Ostad-Ahmad-Ghorabi, H. An Evaluation of Mobility Trends until 2030 under the Aspect of Sustainability.
- Kelly, J. F. (2010). *The cities we need*: Grattan Institute.
- Mitchell, G. (2005). *Sustainability of Land Use and Transport in Outer Neighbourhoods (SOLUTIONS): A Proposed Appraisal Framework*. Paper presented at the EPSRC SOLUTIONS conference, December 2005, Cambridge.
- Schafer, A. (1998). The global demand for motorized mobility. *Transportation Research Part A: Policy and Practice*, 32(6), 455-477.
- WBCSD, M. (2004). 2030: meeting the challenges to sustainability, Full Report 2004, The Sustainable Mobility Project. *World Business Council for Sustainable Development*.
- Ziegler, M., & Klemm, W. (1972). *Neue Nahverkehrssysteme: Verkehrsmittel d. Zukunft*: Bauverlag.