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Preliminary draft version of the forthcoming Handbook on Sustainable Transport and Urban Planning

Note by the Secretariat

This document contains the preliminary draft version of the Handbook on Sustainable Transport and Urban Planning – A practical guide featuring good practices and case studies on integrating transport, environmental, health and quality of life objectives into urban and spatial planning policies. The Handbook is being prepared by the Working Party on Transport Trends and Economics (WP.5) in cooperation with THE PEP.

PRELIMINARY DRAFT

UNECE HANDBOOK ON SUSTAINABLE TRANSPORT AND URBAN PLANNING

A practical guide featuring good practices and case studies on integrating transport, environmental, health and quality of life objectives into urban and spatial planning policies

Table of Contents

Foreword by the UN Secretary General (tbc)
Executive Summary
Chapter 1: Sustainable urban mobility
1.1 Definitions
1.2 Global trends, challenges and forecasts for the future
1.2.1 Urban population growth and mobility
1.2.2 Accessibility, congestion and economic viability
1.2.3 Pollution and environmental degradation
1.2.4 Health and well-being
1.3 UN 2030 Agenda
1.3.1 Sustainable transport as enabler of the SDGs
1.3.2 SDG 11 - "Making cities and human settlements inclusive, safe, resilient and sustainable"
1.4 Transport Health Environment Pan-European Programme - THE PEP
1.5 United for Smart Sustainable Cities Initiative
1.6 World Health Organization (WHO) Healthy Cities Initiative
1.7 Global and regional initiatives

Chapter 1: Sustainable urban mobility

1.1. Definitions.

Transport - the set of technical systems designed to move people, cargo and information from one place to another.

Transport demand - the sustainable volume of transport movement which has developed as a result of social and economic processes endemic to a given area.

Transport supply - the set of means of transport available in a separate area.

Sustainable transport policy - a policy directed at ensuring the sustainability of urban transport systems and oriented at changes in the transport behaviour of the population and promising trends in the development of transport.

Sustainable transport system - the state of the transport system that helps to ensure a socially and economically justified volume of traffic without adversely impacting human health and the environment and without violating the rights of both living and future generations.

Mobility - the number and length of trips, i.e. the result of transport systems operations.

Population's quality of life - a comprehensive characteristic of the living conditions of the population expressed in objective indicators and subjective assessments of the extent to which material, cultural and social needs related to people's perception of their position in society are met depending on cultural background, social standards and values.

Public transport service - activities carried out to ensure transportation of passengers and baggage by road transport and by urban on-ground electric transport along the regular routes.

Quality of public transport service - an integral assessment of the level of public transport service as regards the transportation of passengers and baggage by road transport and is expressed in the combination of reliability, accessibility and comfort characteristics.

Road traffic quality cumulatively encompasses characteristics such as safety, environmental friendliness, cost-efficiency, reliability, productivity and comfort.

Transport infrastructure facilities - structures and technological facilities designed to service passengers, carriers, as well as to ensure the operation of vehicles.

Road safety - the state of road traffic that is representative of the degree to which its users are safeguarded from road crashes and the consequences thereof.

Transport system capacity - the maximum mass of cargo or number of passengers that can be carried along a section of a road, street or other transport link in one lane per unit of time by means of a certain transport system.

Territory transport dependence - the volume of passenger (cargo) traffic in a given territory (person/km) for a certain period of time with the existing transport demand perfectly met.

Transport correspondence - the stable carriage of a person (cargo unit) from one location to another by means of transport.

Transport accessibility - a measure of the capability of an area to be reached or to reach other areas by means of transport.

Transport costs - a monetary measure of how much a transport consumer must pay in order to meet the need for transportation.

Efficiency - the effectiveness of a process, operation or a project defined as the ratio of the effect/result to the costs borne to attain it.

Transport system efficiency - the ratio of useful end results yielded by its operation to the resources expended.

Road pricing - it covers various options to introduce fees charged for use of the road network including fees for entry to the “public area”, duration of stay in this area and/or parking in designated areas within it.

LRT (Light Rail Transit) - it covers all types of rail transport which are separated from the total flow of vehicles along most of their lines by engineering means. They stretch on the ground, along flyovers or through shallow tunnels. LRT is positioned at the intersection of the traditional tram and the metro in terms of operational speed and transportation capacity. This category includes, among others, the high-speed tram and the light metro.

Carsharing - a kind of car-using when one of the parties is not the owner of the car. This is an option to rent a car from specialized companies (most often for intra-city and/or short trips) or from individuals (the period and distance of the trip notwithstanding,) realized by agreement. This kind of car rental is convenient for those who seek to use a vehicle on an off-and-on basis or for those who require a car different in the brand, body type and carrying capacity from the one normally used.

Carpooling - the sharing of a private car with fellow traveller through online search services. Furthermore, fuel costs are distributed proportionally and the best route for all parties taking the trip is selected without significant deviations from the main route of the driver (the car owner).

Park-in-ride - a location in a city or near that city where a person can park his or her car for a small fee and transfer to any type of public transport to get to the city centre.

Transit Oriented Development (TOD) - a land-use pattern that envisages multi-storey buildings densely located within walking distance (no more than 400 - 800 meters) from mass public transport (rail or bus) terminals with the density and number of floors in the buildings always diminishing as the distance from the centre increases.

Shared street or shared space - one of the types of streets with priority pedestrian traffic. Such a street either has no sidewalks or they are on the same level with the roadway so that pedestrians and motorists can use the space together on the terms of self-organization. With drivers having to be more attentive, the car traffic grows more uniform thereby improving the safety of pedestrians[1].

Intelligent Mobility - Using technology and data to create connections between people, places and goods across all modes of transport.

CAV (Connected and Autonomous Vehicles) - connected vehicles use communication technology to interact with the driver, other cars on the road, the infrastructure and the 'Cloud' and autonomous vehicles are self-driving.

ITS (Intelligent Transport Systems) - the interaction of Information Technology and Telecommunications to enable information to be used by the public and through private administration, that is applied to transport.

Multi-modal - a combination of the use of different modes of transport in one trip.

MaaS Provider - stakeholder that designs and offers the MaaS value proposition.

[1] https://city4people.ru/post/blog_540.html, https://city4people.ru/post/blog_634.html.

Data Provider Acts - Stakeholder that acts as a data broker.
Transport Operator - Stakeholder that provides transport assets and services[2].

1.2. Global trends, challenges and forecasts for the future.

1.2.1. Urban population growth and mobility

According to the UN World Urbanization Prospects, about 67% of the world's population (6.5 billion people) are projected to reside in cities by 2050. Moreover, the World Bank estimates that cities currently generate up to 80% of the GDP of states and are the heart of economic and social interaction[3].

The process of urbanization is taking place all over the world. In 2007, UN statistics put the ratio of urban population in the world at a figure surpassing 50% for the first time. The situation in the UNECE region developed states is marked by the urban population growing at a faster rate than the world average as well as by this rate exceeding the rate of decline in the rural population in many cases. This fact can be attributed to a considerable rate of external migration (Fig. 1.1).

Figure 1.1. Percentage of population at mid-year residing in urban areas of UNECE Region countries, 1950-2050[4]

Region, subregion, country or area	1950	1970	1990	2000	2010	2015	2020	2030	2050
Kazakhstan	36,4	50,2	56,3	56,1	56,8	57,2	57,7	60,0	69,1
Kyrgyzstan	26,5	37,5	37,8	35,3	35,3	35,8	36,9	40,9	53,6
Tajikistan	29,4	36,9	31,7	26,5	26,5	26,7	27,5	30,8	43,0
Turkmenistan	45,0	47,8	45,1	45,9	48,5	50,3	52,5	57,9	68,9
Uzbekistan	28,9	36,7	41,4	46,1	51,0	50,8	50,4	51,8	61,5
Armenia	40,3	59,9	67,4	64,7	63,4	63,1	63,3	65,5	74,3
Azerbaijan	45,7	50,0	53,7	51,4	53,4	54,7	56,4	60,8	71,0
Cyprus	28,4	40,8	66,8	68,6	67,6	66,9	66,8	68,1	74,5
Georgia	36,9	48,0	55,0	52,6	55,5	57,4	59,5	63,9	73,2
Belarus	26,2	44,0	66,0	70,0	74,7	77,2	79,5	83,3	88,3
Bulgaria	27,6	52,3	66,4	68,9	72,3	74,0	75,7	79,0	84,9

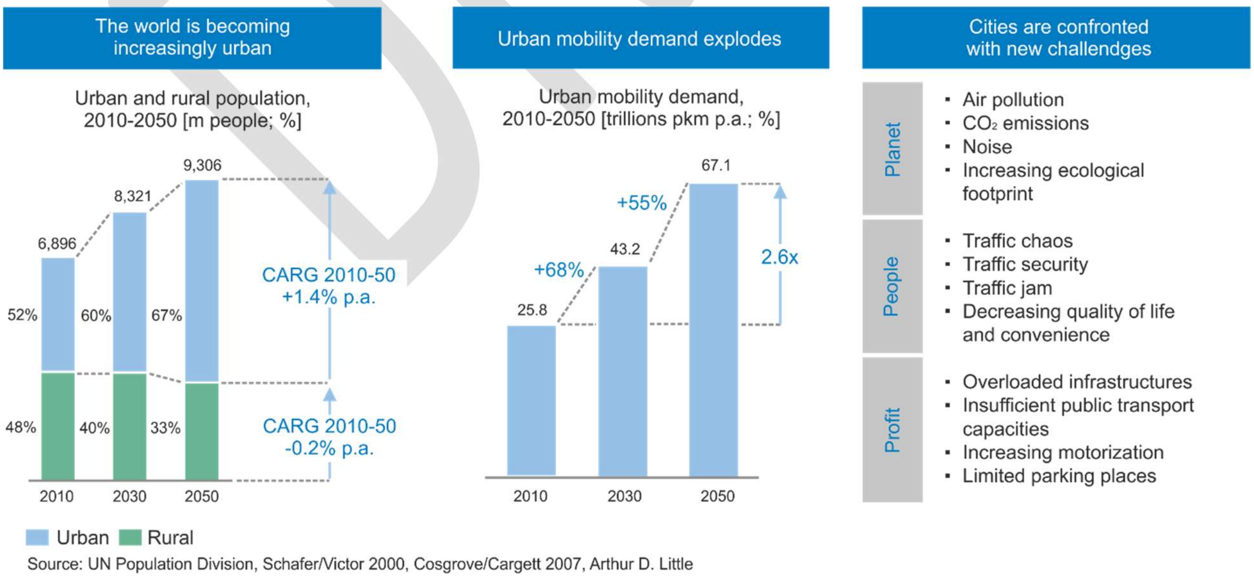
[2] https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf, Transport Systems Catapult 2016, Exploring the Opportunity for Mobility as a Service in the UK.
[3] Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.
[4] https://population.un.org/wup/Download/, the Population Division of the United Nations Department of Economic and Social Affairs (UN DESA), 2018 Revision of the World Urbanization Prospects.

Czechia	54,2	64,4	75,2	74,0	73,3	73,5	74,1	76,1	82,2
Hungary	53,0	60,1	65,8	64,6	68,9	70,5	71,9	75,1	81,8
Poland	38,3	52,1	61,3	61,7	60,9	60,3	60,0	61,5	70,4
Republic of Moldova	18,5	32,1	46,8	44,6	42,6	42,5	42,8	45,5	56,9
Romania	25,6	40,3	53,2	53,0	53,8	53,9	54,2	56,6	66,7
Russian Federation	44,1	62,5	73,4	73,4	73,7	74,1	74,8	77,1	83,3
Slovakia	30,0	41,1	56,5	56,2	54,7	53,9	53,8	55,6	65,7
Ukraine	35,5	54,8	66,8	67,1	68,6	69,1	69,6	71,7	78,6
Denmark	68,0	79,7	84,8	85,1	86,8	87,5	88,1	89,4	92,3
Estonia	49,7	64,9	71,2	69,4	68,1	68,4	69,2	71,4	77,3
Finland	43,0	63,7	79,4	82,2	83,8	85,2	85,5	86,6	90,0
Ireland	40,1	51,3	56,9	59,2	61,5	62,5	63,7	66,8	75,1
Latvia	46,4	60,7	69,3	68,1	67,8	68,0	68,3	69,9	75,9
Lithuania	28,8	49,6	67,6	67,0	66,8	67,2	68,0	70,6	78,1
Norway	50,5	65,4	72,0	76,0	79,1	81,1	83,0	86,1	90,2
Sweden	65,7	81,0	83,1	84,0	85,1	86,6	88,0	90,3	93,2
United Kingdom	79,0	77,1	78,1	78,7	81,3	82,6	83,9	86,3	90,2
Albania	20,5	31,7	36,4	41,7	52,2	57,4	62,1	69,5	78,2
Croatia	22,3	40,2	51,0	53,4	55,2	56,2	57,6	61,5	71,3
Greece	52,2	64,2	71,5	72,7	76,3	78,0	79,7	82,8	87,7
Italy	54,1	64,3	66,7	67,2	68,3	69,6	71,0	74,3	81,1
Malta	88,9	89,7	90,4	92,4	94,1	94,4	94,7	95,4	96,6
Portugal	31,2	38,8	47,9	54,4	60,6	63,5	66,3	71,4	79,3
Serbia	20,3	39,7	50,4	52,8	55,0	55,7	56,4	59,3	68,8
Slovenia	19,9	37,0	50,4	50,8	52,7	53,8	55,1	58,8	68,8
Spain	51,9	66,0	75,4	76,3	78,4	79,6	80,8	83,3	88,0
Austria	63,6	65,3	63,0	60,2	57,4	57,7	58,7	61,8	70,9
Belgium	91,5	93,8	96,4	97,1	97,7	97,9	98,1	98,4	98,9
France	55,2	71,1	74,1	75,9	78,4	79,7	81,0	83,6	88,3
Germany	67,9	72,3	73,1	75,0	77,0	77,2	77,5	78,9	84,3
Netherlands	56,1	61,7	68,7	76,8	87,1	90,2	92,2	94,8	96,6
Switzerland	67,4	73,8	73,9	73,4	73,6	73,7	73,9	75,4	81,4

Modern cities concentrate resources and the most efficient productive forces within their confines thus representing hubs of economic, social, industrial and cultural life of people and uniting surrounding settlements. The growing economic and cultural potential of the world's large and largest cities is often what draws increasing numbers of inhabitants from small and medium-sized cities, rural areas and other states. The process of suburbanization is characterised by growing and developing peripheral and suburban areas in many of the world's large and largest cities along with growing population density in these areas. In some cases, however, growing well-being enables the wealthiest strata of the population to build country houses in the suburbs which does not result in changes in their urban lifestyle but helps them avoid the various negative effects of urban environment development, such as noise, air pollution, lack of greenery, etc. The urban agglomerations created by the combination of these processes are known as urban sprawl.

In many instances, the growth of urban areas (primarily peripheral ones) and the population density thereof, lack of uniformity in development and deployment of social infrastructure and workplaces translate into excessive transport demand and population mobility. Nowadays, cities account for 64% of all man-kilometres travelled with this number projected to triple by 2050. This booming growth of urban mobility exacerbates existing urban issues and requires new approaches and solutions in different areas (Fig. 1.2)[5].

Figure 1.2. The future of earth will be urban[6]



[5]https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

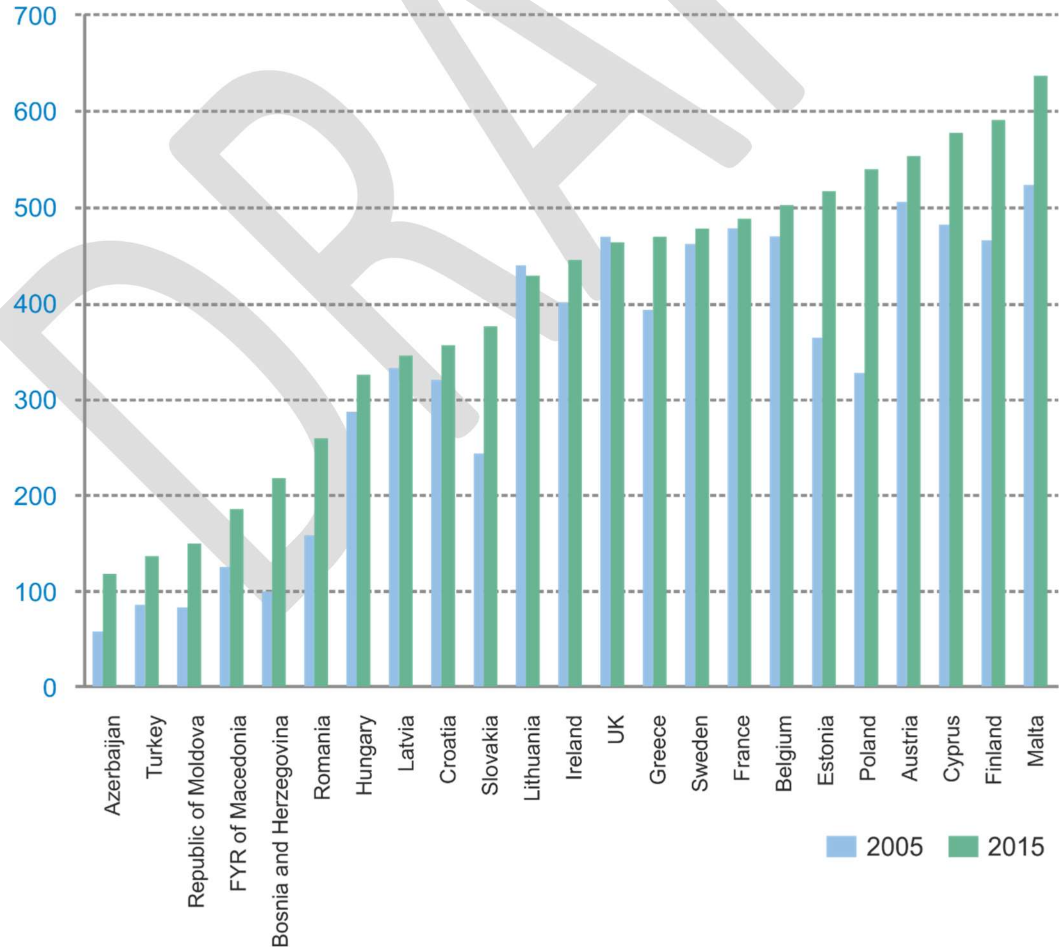
[6]https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

The importance of ensuring mobility coupled with the need for appropriate investments in infrastructure have been highlighted in population surveys conducted in major cities. Aside from that, steadily increasing investments in ensuring the mobility of the urban population have been observed taking place since the 1990s and are projected to last up until 2050.

Urbanization and, suburbanization in particular, are impossible to be achieved without systems in place to meet the transport demand of the population and the economy and without efficient urban transport systems. In recent decades, transport demand in the world's large and largest cities has often increased in the context of significant underdevelopment of public passenger transport systems which, along with the rising well-being of the population, has spurred mass motorization.

With the majority of the population in the UNECE region residing in urban areas, the region boasts the largest concentration of registered privately-owned vehicles (Fig. 1.3)[7].

Figure 1.3. Motorization trend in certain UNECE countries between 2005 and 2015



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[7]file:///C:/Users/User/Desktop/%D0%95%D0%AD%D0%9A%20%D0%9E%D0%9E%D0%9D%20%D0%9E%D0%9F%D0%A2%D0%9E%D0%A1%D0%9E%D0%97/2017_INLAND_TRANSPORT_STATISTICS.pdf, Inland Transport Statistics for Europe and North America, UN, New York and Geneva, 2017, ECE/TRANS/260.

As can be seen from Fig. 1.3., the highest private vehicle ownership rates in Europe in 2015 were observed in countries such as Malta, Finland and Cyprus. In Western Europe, the United States and a number of other developed countries, car ownership generally rose steadily until the late 2000s and early 2010s, reaching a number of 400-600 (in the United States - 800) cars per 1.000 inhabitants. Out of the UNECE region states that furnished relevant data for the period under examination, it was only Lithuania and the United Kingdom that demonstrated a slight decline in car ownership[8].

In the CIS countries, the "car ownership" trend has been quite high over the past 25 years. However, as initial reference values were low, the current motorization level of these countries is markedly lower than that of developed countries. That notwithstanding, many of the largest cities in these countries see the level of car ownership nearing the mark of 300-400 cars per 1.000 inhabitants with a steady tendency to rise further. In parallel with the growing number of privately owned cars, most countries have until recently seen (and the trend still persists in many countries) an increase in car usage measured in kilometres travelled per capita[9].

As shown by previous studies [Implementing sustainable urban travel policies. Final Report. ECMT, 2002], the total number of daily trips per person remains relatively constant, ranging from 3.52 to 3.55. At the same time, the number of trips by private motor vehicles in almost all EU countries steadily increased in the 1990s — 2010s (from 0.4-1.51 trips per year per person to 1.7-1.9) which was then followed by a decline in this figure in many European cities due to people switching to public transport and non-motorized transport. Still, most countries have experienced an increase in the annual mileage of personal vehicles at the same time. For instance, in Russia the average annual mileage of privately owned cars has risen by 1.6 times over the past 25 years. It is the mileage of cars that ultimately determines the extent to which the road network is used and loaded along with pollutant emissions, the risk of road accidents, etc.

Motor vehicle kilometres are accrued in road traffic. In cities, private motor transport makes up 85 to 95 percent of traffic.

Road traffic in cities and its quality are affected by a number of factors:

• increase in the number of privately owned cars;
• higher usage of privately owned vehicles;
• decrease in the share of public transport in passenger traffic;
• growing demand for movement among urban dwellers;

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[8] file:///C:/Users/User/Desktop/%D0%95%D0%AD%D0%9A%20%D0%9E%D0%9E%D0%9D%20%D0%9E%D0%9F%D0%A2%D0%9E%D0%A1%D0%9E%D0%97/2017_INLAND_TRANSPORT_STATISTICS.pdf, Inland Transport Statistics for Europe and North America, UN, New York and Geneva, 2017, ECE/TRANS/260.

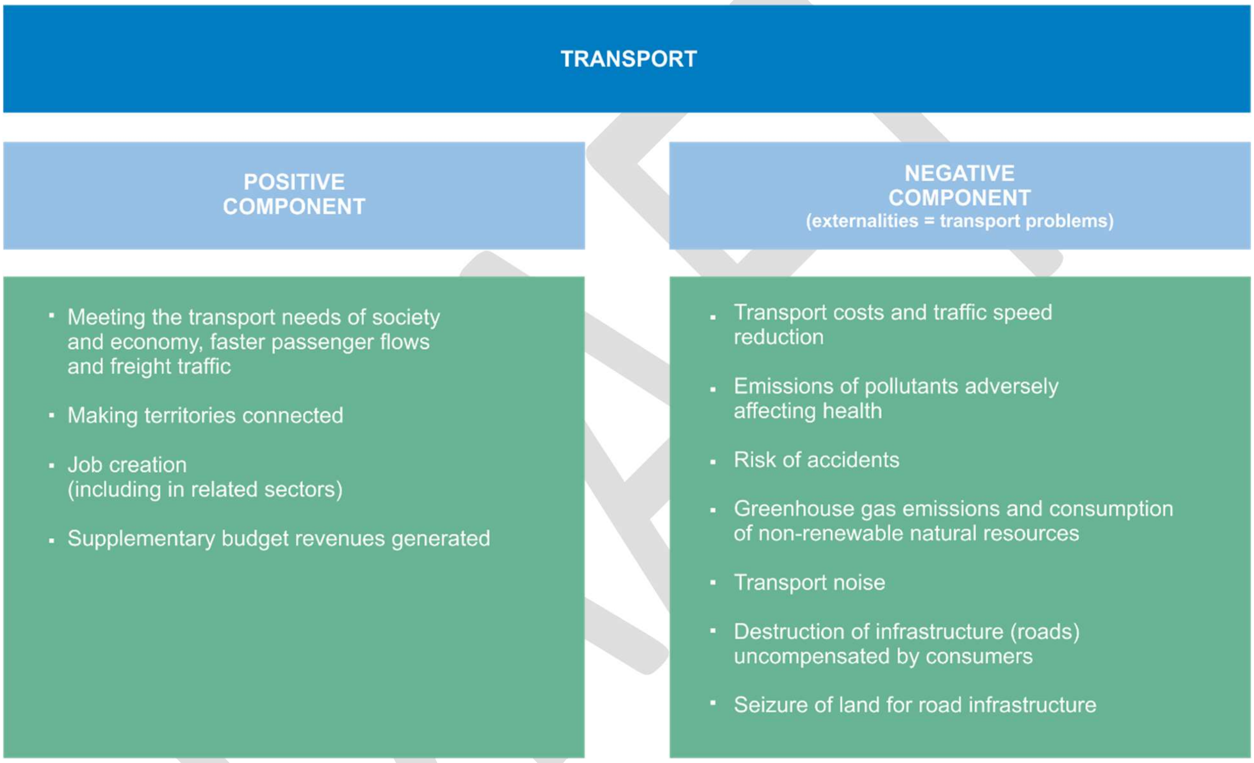
[9] Automobility in Brazil, Russia, India, and China. Quo Vadis? Tobias Kuhnimhof, Charlene Rohr, Liisa Ecola, and Johanna Zmud, Published in: Transportation Research Record: Journal of the Transportation Research Board, no. 2451, 2014, Washington, D.C., p. 10-19.

• disproportion between the rate of motorization on the one hand and the state and level of development of the road network on the other hand;

• a number of objective urban planning problems related to urban spatial development inherited from the past[10].

As indicated above, the development of urban transport goes hand in hand with a number of major negative implications which reveal the flip side of its rapid development and its predominant focus on the use of motor vehicles (Fig. 1.4).

Figure 1.4. Positive and negative impacts of urban transport systems development



Persons who choose a private car as their transport mode in cities may do so driven by personal factors and public transport behavior patterns.

The primary personal factor is to ensure accessibility (to other people or destinations) with no real qualitative alternatives to a private car at hand. Beyond that, however, there are other properties to a private car that make it attractive to users.

A private car can be considered by individual users as:

- a way to ensure the desired speed and time of travel;
- a symbol of well-being which highlights one's “status” in society (a mind-set that has developed in societies);
- door - to - door means of transportation;

[10]Transport planning: establishment of efficient transport systems in major cities: monograph / Y.V. Trofimenko, M.R. Yakimov. — M.: Logos, 2013. 26 p.

- a way to ensure a comfortable trip (“home on wheels”);
- a way to be autonomous and isolated from traffic and other traffic users;
- a way to transport one's family, luggage;
- a way to experience the pleasure of driving, a sense of “freedom”.

The transport mode is selected in large part depending on the travel conditions. Mounting congestion of road networks, measures taken by city administrations to discourage the use of personal vehicles, changing the mindset of society - all this affects how people view the car from the perspective of being a means of transport in a city (Fig. 1.5).

Figure 1.5. Trends in the changing attitude of people towards car ownership in cities in a time of increasing motorization

Pros of using a private car	Congested urban traffic	Urban transport policy measures (parking restrictions, other various restrictions)	Changing public opinion
Symbol of one's “status” in society	-	-	↘
Speed and time of travel	↓	↗	-
Door - to - door means of transport;	-	↓	-
Comfortable trip	↓	↓	-
Autonomous	-	-	-
A means of transport for one's family and luggage	-	-	-
Pleasure	↓	↓	-

1.2.2 Accessibility, congestion and economic viability

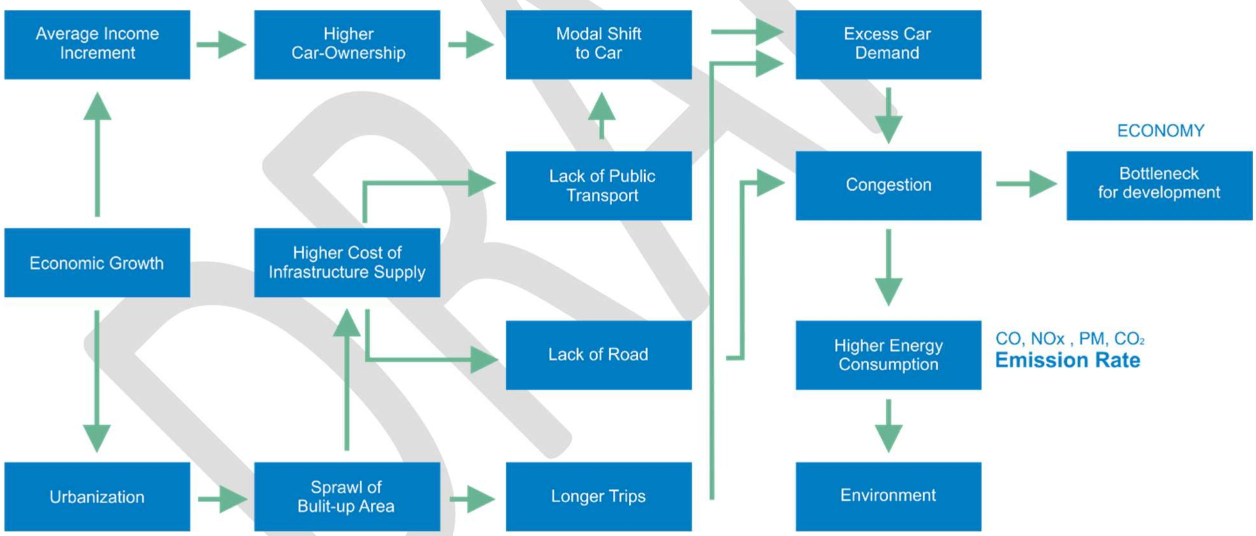
Researchers of urban transport systems in different countries and cities concur that with the unbridled rise in the use of privately owned cars, traditional and mature cities are no longer comfortable for living, that is, the collision of cities and cars is recognized as an objective reality.

B. Vuchic in his book "Transportation for Livable Cities" says that: "A city on the needle of total automotive dependence becomes infunctional, inefficient and inconvenient for life. The goal of the transport system is to move people, not vehicles."

Urban population growth and expanding urban areas engender both rising transport demand and population mobility and challenges related to the accessibility of certain urban areas, transport destinations and transport services. The growing congestion of transport networks (road networks) and increasingly congested public transport systems are seen taking a toll on transport accessibility.

The congestion of urban road networks in large cities is the consequence of transport demand being disproportionate to the capacity of available road infrastructure. This results in traffic congestion (Figure 1.6).

Figure 1.6. Distribution of street space between traffic users[11]



OECD estimates the annual economic damage associated with delays in passenger transport and cargo due to traffic congestion in Europe at $100bn, or more than 1.0% of the GDP of EU countries. Around 80% of all traffic congestion occurs in urban areas[12].

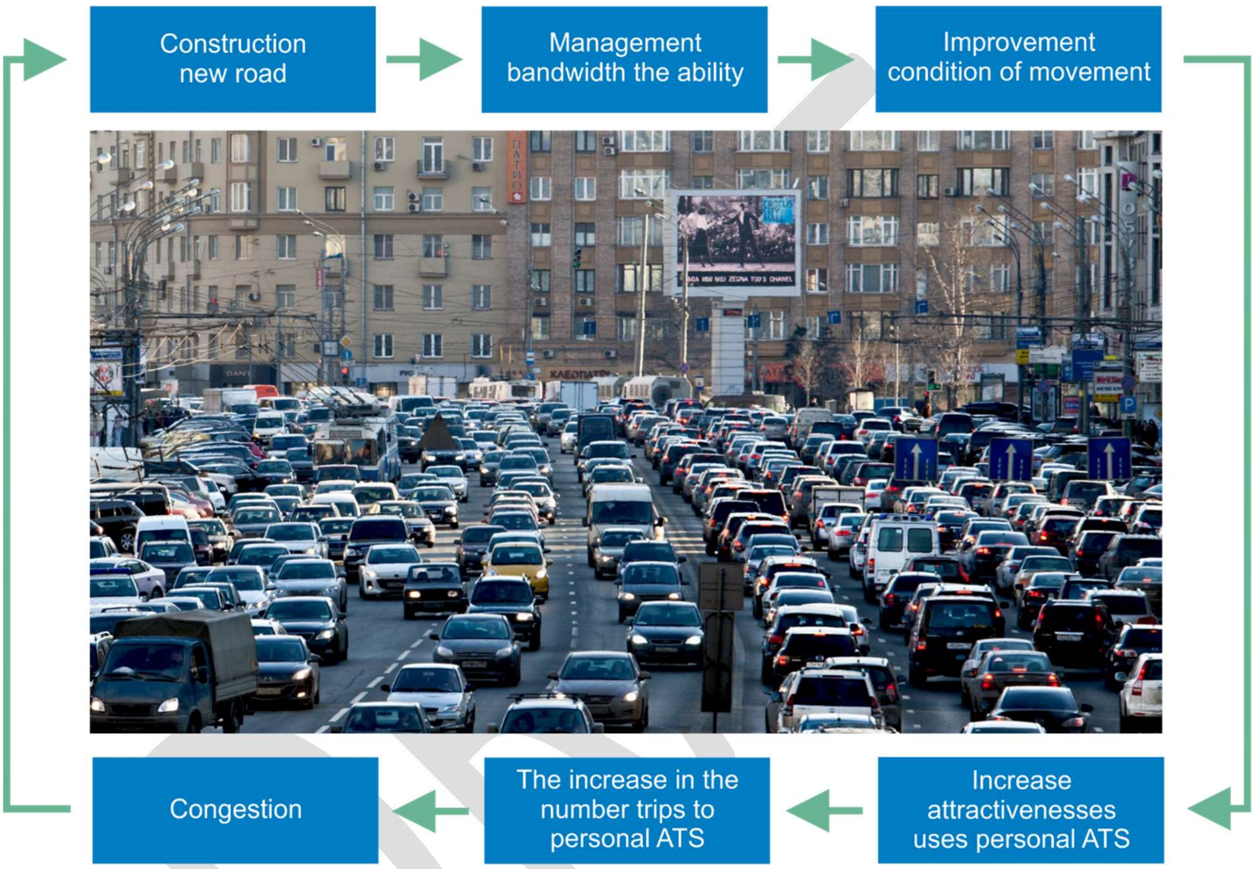
For many years, administrations in major cities have considered (and, in some cases, they still do) ramping up the capacity of urban roads through their reconstruction and construction of new ones as the principal measure against traffic congestion. The respective transport planning concepts of the twentieth century, a

[11] A slide from a presentation of Prof. Yoshitsugu HAYASHI, Professor Dr-Eng., Institute of Science and Technology Research, Chubu University, Japan. Full Member, Club of Rome. President, WCTRS (World Conference on Transport Research Society) (Japan).

[12] https://ec.europa.eu/transport/themes/urban/urban_mobility_en, Directorate General for Mobility and Transport, European Commission.

century known for "rapidly developing motorization", were premised upon the paradigm of "Planning for Cars in Cities". As has been evidenced by practice, such attempts to tackle the issues of increasing the accessibility of urban areas and reducing the number and duration of traffic jams never yielded long-term positive outcomes due to the emergence of so-called new "induced" mobility (Fig. 1.7).

Figure 1.7. The mechanism of "induced mobility"



At the end of the 1980s, the realities of the increasing car usage rate which dramatically outpaced the development of the urban road network combined with growing pollution and destruction of the urban environment due to the expansion of road infrastructure highlighted the need to transition to a new paradigm for urban transport development, the concept of "Sustainable Urban Transport" or "Sustainable Mobility" which sought to ensure the mobility of population by reorienting transport demand towards safer and more environmentally friendly modes of transport ("urban mobility planning").

The transition to the sustainable mobility pattern is characterised by the complexity of interaction between authorities, difficulties faced in decision-making and the diversity of objectives as cities are not "islands"; their policies being influenced by other public authorities, the population, neighboring cities, the policies pursued by the region, etc.

Urban mayors and public authorities in charge of the transport policy find themselves confronted with institutional barriers, legal and financial constraints as well as political and social backlash. This being the case, it is critical for cities at the very outset to define their goals properly, assess the issues at hand, find potential solutions and adopt an appropriate strategy so as to go ahead with implementing the plans, then evaluate the outcome and conduct monitoring.

However, with all the positive aspects of this approach that is to some extent implemented by the administrations of many major cities, it should be acknowledged that it stems from the given transport demand for which the public transport service system is designed. Planning of cities and their transport infrastructure “around motor-vehicle traffic (transport mobility)” continues to produce major externalities associated with transport activities, in particular, leading to 1.250.000 road accident deaths and 3.200.000 premature deaths from air pollution per annum.

Bearing this in mind, the need to “shift our dominant transport paradigm towards focusing investments on creating bright, energetic and lively urban areas adapted to accommodate the livelihood of people is becoming increasingly clear.” The significance of this approach to urban planning is now being acknowledged by a growing number of scientists and specialists[13]. This reorientation of transport planning priorities in no way cancels out, but is instead intended to complement the basic planning principles of sustainable urban transport systems, such as:

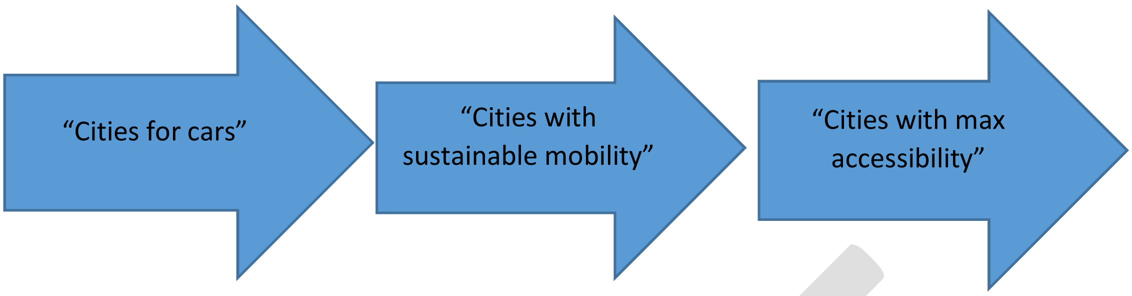
- creation of efficient alternatives to the use of privately owned vehicles;
- implementation of transport demand management mechanisms;
- development of means of active mobility;
- effective integration of transport and urban planning;
- engagement of stakeholders through a transparent and participatory approach, etc.

Within the new paradigm, the key concept associated with the sustainability of the transport system is not mobility (i.e. number and length of trips) but accessibility to individual locations and urban areas, accessibility to workplaces and recreational facilities, social and commercial infrastructure, accessibility of transport services i.e. the quality of life of the urban population (“Planning Cities For People, Not For Cars”). When put in perspective, accessibility can be regarded in different ways: physical accessibility, temporal accessibility, affordability, equal accessibility for certain categories of users (pedestrians, persons with reduced mobility, etc.), accessibility of urban areas and services (including transport-related ones), etc.

Accessibility can be defined as the primary objective of transport systems that establish an environment for movement through “open” design and planning.

[13] Beyond Mobility: Planning Cities for People and Places, 2017, Robert Cervero, Erick Guerra, and Stefan Al, p.296.

Figure 1.8. Stages of transition from “cities for cars” to “cities with max accessibility”



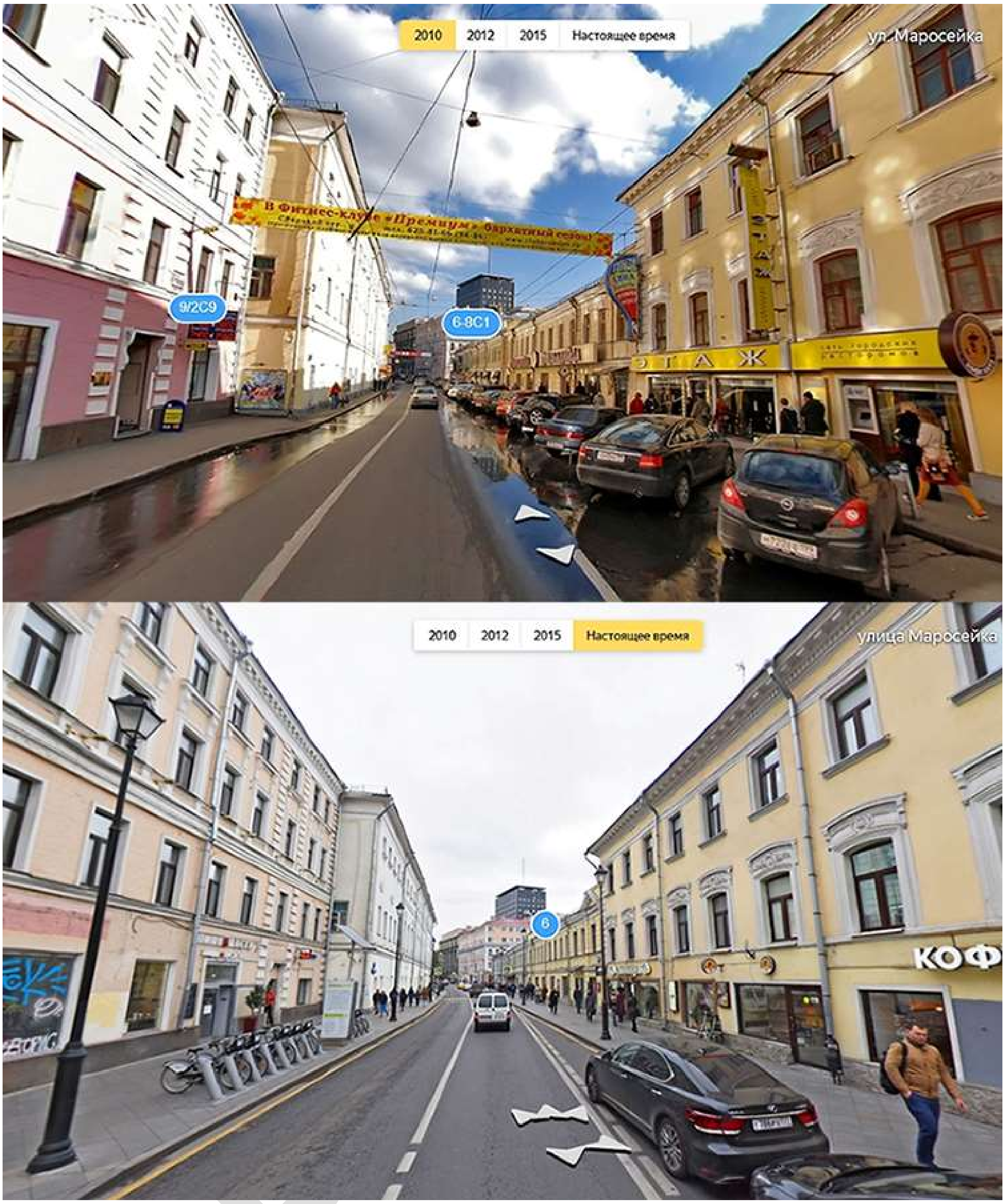
The effective alignment between transport and urban planning, results-orientation, formulating "Cities for People" strategies and (political, financial, legal, communication, marketing) tools to implement them has a pivotal part to play in ensuring accessibility.

Shifting urban and transport planning from mobility planning to planning accessibility and quality placemaking yields results in the form of the creation of the best urban communes, improving the environment and the state of the urban economy while enhancing the physical activity of citizens. These communes are safe, healthy, accessible to pedestrians and cyclists providing equal and free access to a variety of destinations by different transport modes and playing a part in reinforcing interpersonal relationships and interaction within local communities[14].

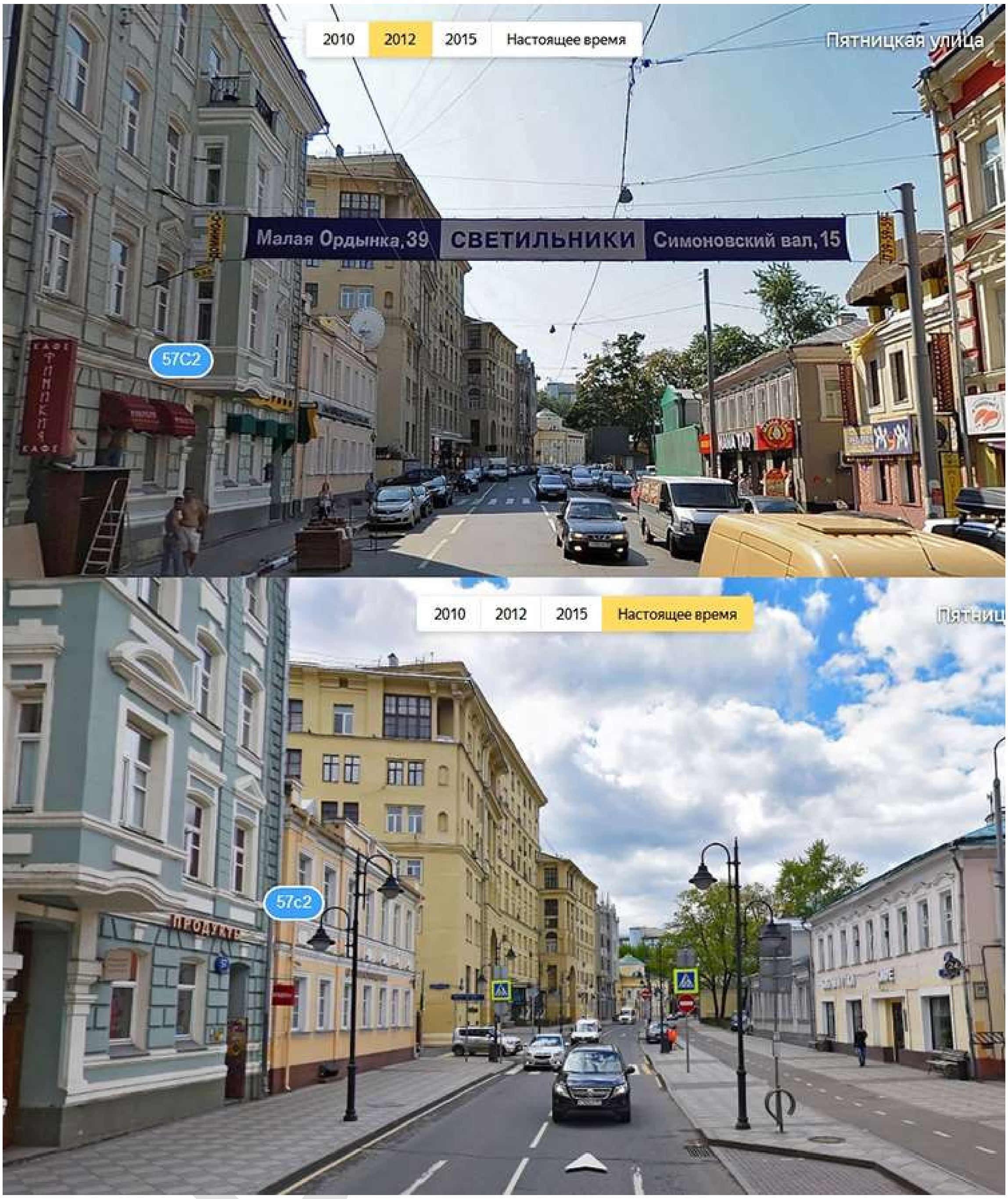
Figure 1.8. Examples of street space transformation in central Moscow; before and now:

Maroseika street

[14] Beyond Mobility: Planning Cities for People and Places, 2017, Robert Cervero, Erick Guerra, and Stefan Al, p.296.

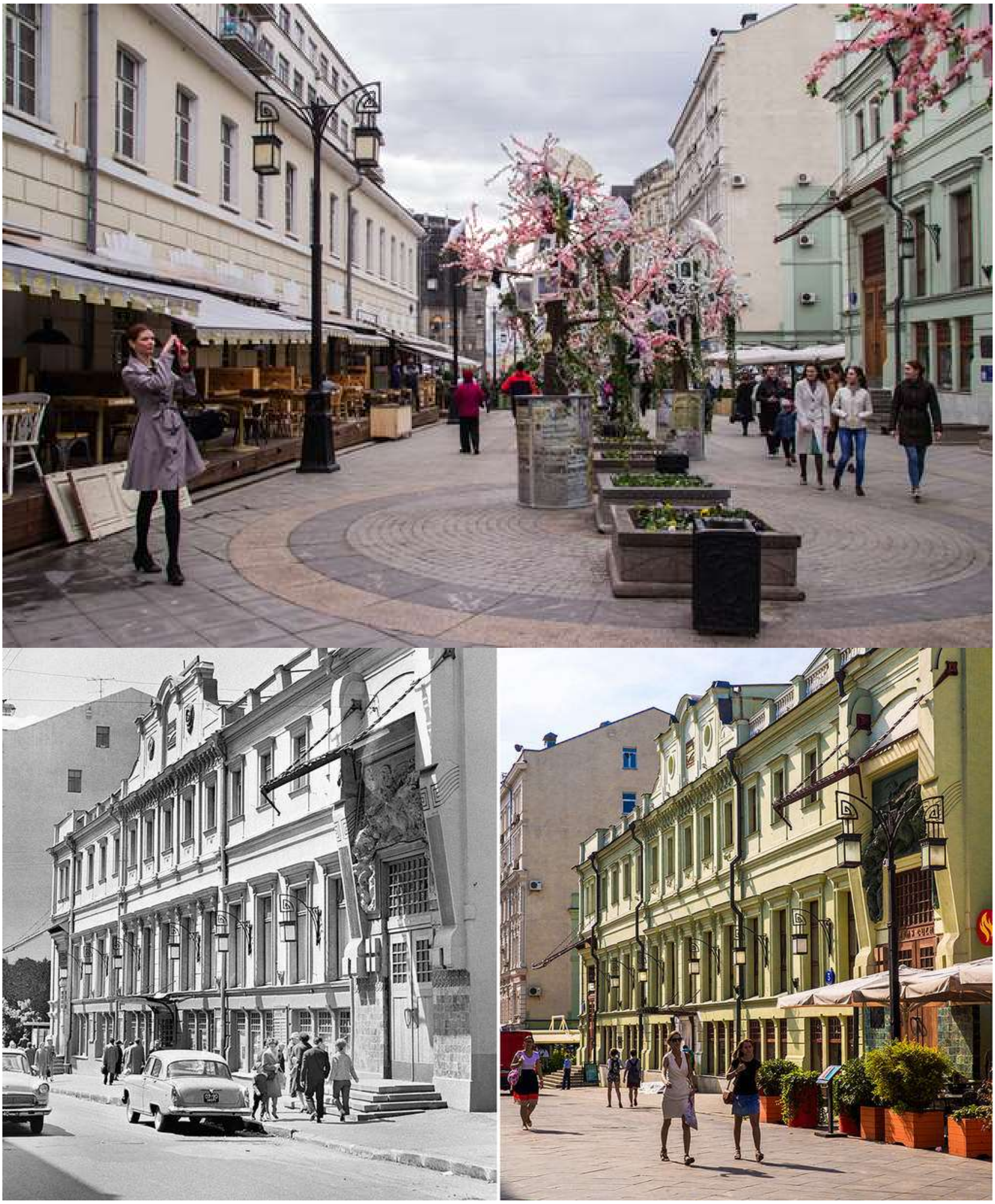


Pyatnitskaya street



Crimean embankment

Kamergerskiy Lane



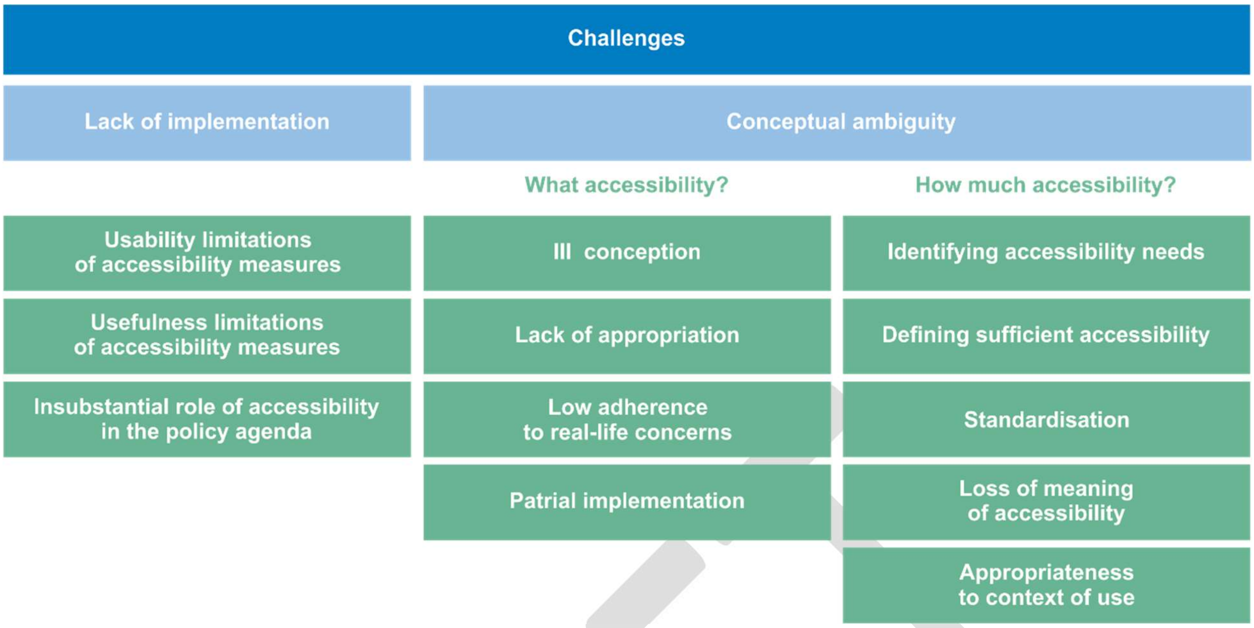
Kuznetsky Bridge


dpg.andynet.org


афиша

It merits mention, however, that measures to provide accessibility are often not given due regard in planning practices. In the few cases in which they are applied, there are often situations wherein a decline in sustainability is triggered, for instance, by providing incentives for further urban sprawl. Figure 1.9. shows a classification of accessibility issues in cities[18].

Figure 1.9. Accessibility issues



In view of the above, it is of vital importance to act and take measures in order to plan and manage accessibility in the context of ensuring sustainable urban development.

Basel (Switzerland):

In 2010, as a consequence of a referendum held in the canton Basel-Stadt (Switzerland), a quantitative reduction goal for cars was incorporated into the Environmental Protection Act (Umweltschutzgesetz USG). It was thereby established that a 10% reduction of the traffic flow of privately owned cars, from the level of 2010, has to be achieved by 2020.

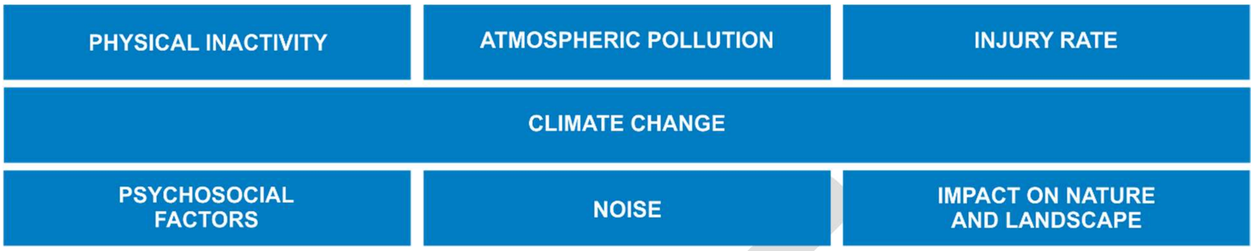
This target has been chosen because traffic in the canton Basel-Stadt is highly influenced by international commuters and visitors, which makes it difficult to determine a modal split for these categories. In addition, the modal split alone is not enough to fully determine the sustainability of an urban mobility system. The canton Basel-Stadt wants to focus more on the quantity of trips and the length of these trips, while also taking into account growth effects: the quantitative goal aforementioned states that the number of cars has to be reduced by 10% in spite and no matter how high the population growth will be. This target, however, is not a mere ideological one, the idea is to promote and to favour vehicles and transport modes with low emissions and low energy consumption that are space-efficient, also very important in city dense with narrow streets[15].

1.2.3 Pollution and environmental degradation. Vehicle emissions and climate change.

[15] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.

Transport operations entail a series of adverse effects whose structure is presented in Fig. 1.10.

Figure 1.10. Negative factors of transport impairing the environment and public health

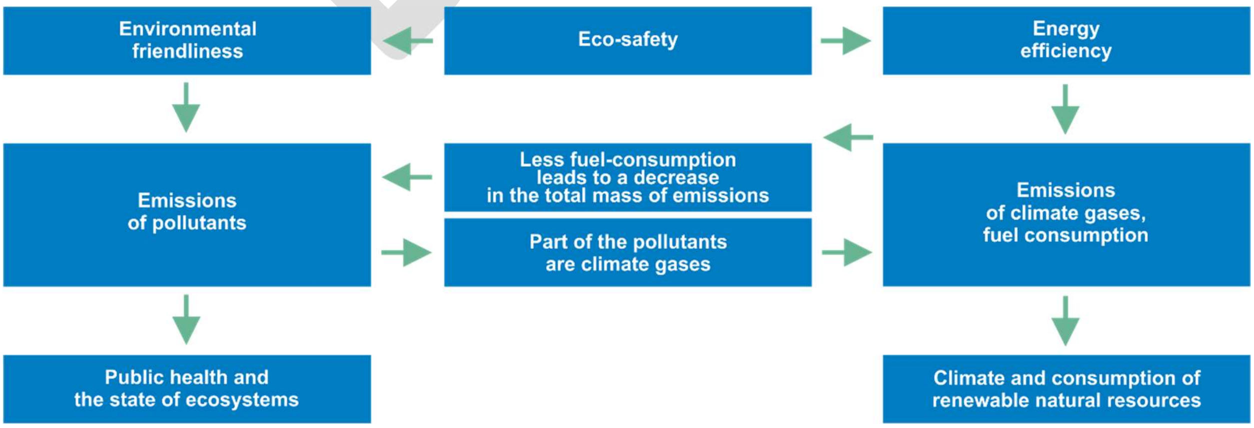


Transport and, above all, motor vehicles are the largest source of pollution for the environment. Over 200 different substances are released into the atmosphere as a result of fuel combustion in vehicle engines. The main hazardous components of vehicle emissions are traditionally recognized as nitrogen oxides (NOx), hydrocarbons (VOC and NMVOC), particulate matter (PM), carbon monoxide, sulphur oxides (SOx) (Fig. 1.11).

Figure 1.11. Pollutants and climate gases produced by motor vehicles

Pollutants and climate gases produced by motor vehicles		
Traditional gases	Climate gases	Unconventional gases
CO, VOC, NOx, PM, S02, Pb,NMVOC, NH3	C02 N20 CH4	Acrolein, 1,3-butadiene, toluene, xylenes, styrene, acetaldehyde, benzene, formaldehyde, benzo(a)pyrene

Figure 1.12. Aspects of motor vehicle environmental safety



As reported by the European Environment Agency, the air pollution damage inflicted by motor vehicles in EU countries stood at €100 billion per year as of 2013 [May]. The detrimental impact of vehicle emissions on public health is the main component of this damage. Air pollution is the cause of 350.000 premature deaths per year in EU countries, while emissions from heavy trucks alone inflict health damage to the extent of €43-46 billion per year. Moreover, vehicle emissions negatively affect the state of flora and fauna along with the condition of buildings and structures.

It is not only with the toxic components of exhaust gases that motor vehicle pollute the atmospheric air and the environment, but also with fuel vapors, tire wear and road wear products, brake lining wear, etc. Soot, fuel and oils, detergents and water used for car washing ultimately enter urban water bodies and soil. Chemical reagents used to treat roads and pavements to improve traffic safety in winter also leads to pollution of roadsides and urban environments.

Another daunting challenge is the impact of transport on global climate change. Ample scientific evidence suggests that a temperature rise of 2°C results in a substantial increase in the risk of extreme climatic events, such as sea level rise, forest fires, floods, ecosystem degradation and severe droughts (IPCC, 2014), which pose a major threat to the environment and human health. Transport, especially motorized transportt, is one of the largest sources of climate gas emissions (CO_2, N_2O, CH_4). The transport sector accounts for 23% of total CO_2 emissions from fuel combustion (IEA, 2016). In addition, transport-related emissions increase faster than emissions from any other sector of the economy (ITF, 2017).

Continued urban population growth and economic development around the world will further fuel transport demand in the coming years, which in turn can speed up the rate of growth in CO_2 emissions from urban passenger transport. Constraining the global average temperature growth to 2°C will pose a challenge as urban passenger transport is projected to grow by 60 to 70 percent by 2050 as compared to 2015 levels (ITF, 2017; IEA, 2016). Total motorized mobility in cities may increase by 94% between 2015 and 2050, translating into a 26% global increase in CO_2 emissions resultant from urban mobility growth alone (ITF, 2017).

It should be noted that measures directed at improving the energy efficiency of motor vehicles and thereby reducing their CO_2 emissions also serve to curtail vehicle pollutant emissions.

The excessive use of motor vehicles produces an adverse effect on almost all components of the biosphere: atmosphere, water, land, lithosphere and humans:

- Accommodating transport linkages demands resources such as water, land, air, sometimes, in huge quantities and areas;

- Motor vehicles cause soil destruction and degradation of natural ecosystems. Natural sites located near the embankments of highways are transformed and degraded over time with wetlands oftentimes emerging along roads;

- Motor vehicles contribute to the deterioration of the agrochemical quality of the soil and that of the surface air. The surface air layer near roads is contaminated with dust consisting of particles of asphalt, rubber, metal, lead and other substances, some of which have carcinogenic and mutagenic effects;

- Motor vehicles cause physical radiation and electromagnetic fields that have a negative impact on human health;

- noise exposure that occurs due to motorways and urban roads adversely affects human health as well as the quality of habitats;

- vehicles inflict significant environmental damage on surface water bodies as gasoline, technical oils and other substances are released into the water.

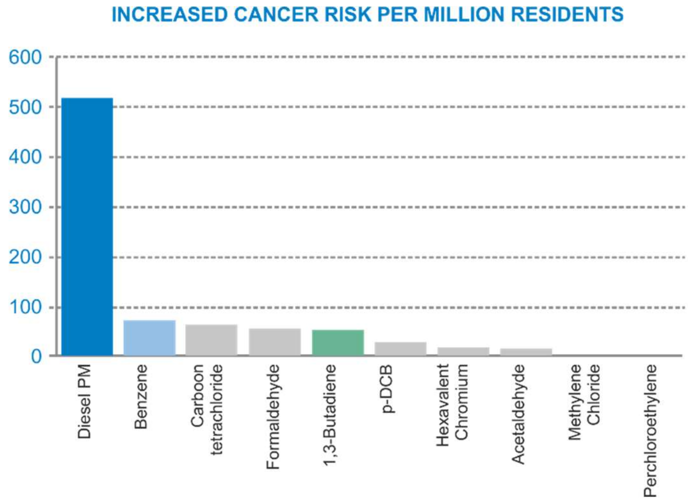
1.2.4 Health and well-being. Impact of motor vehicles on public health and the economy of cities.

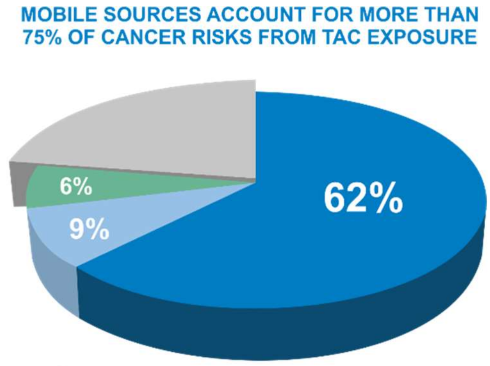
The negative effects of transport activities are chiefly related to the impact which transport (especially motor vehicles in cities) has on the lives and health of the population and the resultant decline in the quality of life. The life and health of the population are affected by road safety, the impact produced by transport on the environment (primarily affecting air quality) and reduced physical activity as a consequence of excessive use of private cars.

Air pollution is ranked 4th in the list of global health risk factors. Air pollution is the cause of 350.000 premature deaths per year in EU countries, while emissions from heavy trucks alone cause health damage to the extent of €43-46 billion per year. As reported by the European Environment Agency, the air pollution damage inflicted by motor vehicles in EU countries stood at €100 billion per year as of 2013. In the OECD countries, road pollution damage was estimated at around US $800-850 billion in 2013 [OECD Secretary General Gurria, May 21, 2014].

The carcinogenic risks arising from particulate emissions released by diesel engines are much higher than the same risks associated with other pollutants (Fig. 1.13).!

Figure 1.13. Cancer risks associated with toxic air pollutants

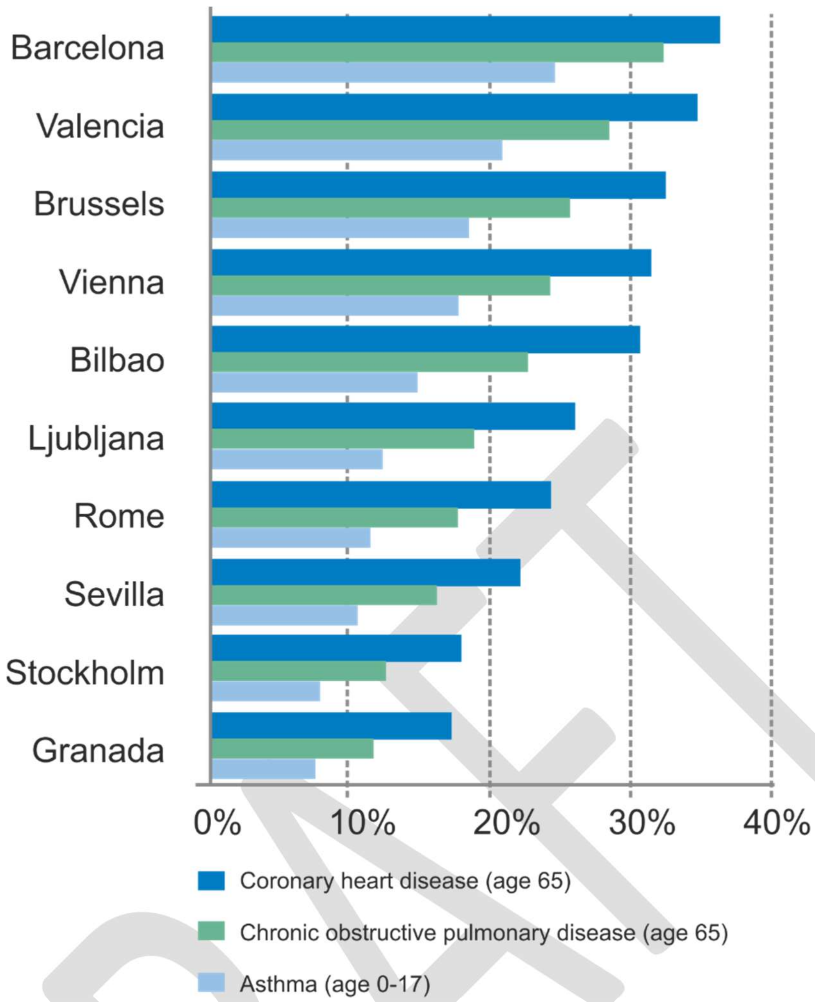




Motor vehicles stand out among other sources of pollutant emissions into the atmosphere due to the exhaust gases that they produce being released into the atmosphere at the ground level making it difficult for them to disperse. Beyond that, motor vehicle emissions are unique in the sense that pollutants are discharged into the atmosphere almost at the human-respiratory level. Fig. 1.14 shows the proportion of the population with chronic non-communicative diseases living along urban motorways in 10 European cities.

Figure 1.14. The proportion of the population suffering from chronic diseases whose incidence may be associated with living near the busiest streets and roads in 10 European cities[16]

[16] Perez, L. et al., 2013. Chronic burden of near-roadway traffic pollution in 10 European cities (APHEKOM network). The European respiratory journal, 42 (3), pp.594 — 605.



Public health is also affected by climate change. According to the World Health Organization, about 250.000 additional deaths per year will be caused by climate change between 2030 — 2050. It should also be taken into account that the share of motor vehicles surpasses 35% of the emissions covered by the Climate Action Regulation, which sets goals for the Member States to reduce GHG emissions in the sectors not incorporated in the Emission Trading Scheme until 2030 [“Impact of vehicle CO2 standards on national transport emissions” T&E, Published on September 27,2018].

The impact of transport and, in the first instance, that of motor vehicles on the environment and public health constitutes a major factor in determining the well-being of the population.

Gallap defines well-being as an inner feeling of a person, a combination of love for what we do every day, good relations with others, sustainable material status, strong health and pride in our contribution to society, as well as the interrelationship of these five elements.

Well-being has been assigned other definitions which sometimes view it as a synonym or essential element of the quality of life, an essential component of the broad and so much indefinable concept of “happiness”. There are different patterns and components to "well-being". Thus, the UK Office for National Statistics characterises well-being "as a concept made up of 10 broad areas that, as demonstrated in the national debate, are most essential to the people in that country." These embrace:

- Natural environment,
- Personal well-being,
- Our relationship with other people,
- Health,
- What we do
- Where we live
- Personal finances,
- Economy,
- Education and skills, and
- Leadership.

Figure 1.15. Distribution of average external costs by impact factor (countries with economies in transition)

Type of motor vehicle	Average external costs, in Euro per 1.000 tonne-kilometres/passenger km				
	Road accidents	Air pollution	Noise	Impact on the climate	Impact on nature and landscapes
Passenger vehicles	21 (78%)	3,2 (11,9%)	0,8 (3%)	1,2 (4,5%)	0,7 (2,6%)
Trucks	4 (9%)	34,5 (78%)	2,1 (4,8%)	1,7 (3,8%)	1,9 (4,4%)

Personal well-being is a particularly significant factor determined by how we are satisfied with our lives, our feeling that what we do in life makes sense, our everyday emotional experiences (joy, anxiety) and, in general, mental well-being[17]. In many cases, "well-being" is determined by the fostering of a positive attitude towards health, a view supported by WHO research. In this context, well-being is a form of life aimed at achieving an optimal physical, mental and spiritual state. One of the most underlying principles of well-being lies in the fact that prevention is much more important than cure as treatment calls for significantly more energy and effort.

The increase in morbidity and mortality associated with the operation of motor vehicles leads to significant additional expenditures on public medicine as well as incurring costs for budgets at all levels. That is why different governments pay special attention to the issues of prevention of morbidity and mortality, including those stemming from the impact of transport, and, therefore, quality planning for urban

[17] https://whatworkswellbeing.org/about/what-is-wellbeing

areas where transport systems are a critical factor in urban sustainability. Against this background, the development of various kinds of active mobility is the most important area of sustainable urban transport planning.

The benefits yielded by active urban mobility are enjoyed both by individuals in terms of their own health care costs going down, by city authorities in terms of reducing health care expenses, as well as businesses by virtue of strengthening the appeal of business entities (cafes, restaurants, shops).

Research results indicate that with the costs associated with the treatment of diseases caused by pollution, accident risk assessment, etc. taken into account, it turns out that every kilometre travelled by car in the EU countries costs society on average 15 Eurocents whereas every kilometre travelled cycling benefits society in the form of 16 Eurocents thanks to the improvement of public health and the absence of negative effects associated with car use[18].

Furthering active mobility (walking and cycling) helps different sectors of the urban economy to attain their own aims:

- reducing noise and pollutant emissions into the atmosphere;
- achieving less congested roads;
- lowering the number of road injuries;
- reducing investments in road infrastructure;
- improving accessibility and quality of urban life;
- enhancing the physical activity and health of the population;
- promoting tourism and job creation.

Studies point to the development of active mobility having a beneficial effect on urban economy development. Pedestrians and cyclists spend 40% more time in stores than motorists. This conclusion, in particular, was drawn by researchers from the Bartlett School of Planning, University College London and the Department of Transport of London. The study also observes that employees who cycle their way to work take sick leave 1.3 times less often than their colleagues. This saves the country's economy £128 million annually[19].

Figure 1.16. The contribution of cycling and walking to the economy of London

[18] https://www.sciencedirect.com/science/article/pii/S0921800915000907?fbclid=IwAR39ErgnQGfMFWcme9KHmR7TuoqiMsT4bQXruuh-hRlrZEUwYFWqCTJXmTw, Transport transitions in Copenhagen: Comparing the cost of cars and bicycles

[19] http://content.tfl.gov.uk/walking-cycling-economic-benefits-summary-pack.pdf?fbclid=IwAR2OxnxBhqfofsW5CRSWvQ_gWmTL1euoLdIxtmk9-h5E6UHWo08H3N1ViYk

The provision of compact and dense urban development and the diversity of land-use patterns in urban areas is conducive to the emergence of active transport modes among the population which boosts their motor activity. The promotion of walking and cycling and public transport, for instance, by improving the infrastructure operated by these transport modes, also encourages the development of active transport modes and motor activity. Fig. 1.17 illustrates possible strategies and key practices for sustainable urban land use and transport.

Figure 1.17. Possible strategies and key practices for sustainable urban land use and transport[20]

[20] Module 5g. Environmentally sustainable transport: A Sourcebook for Policy-makers in Developing Cities, Internationale Zusammenarbeit (GIZ) GmbH, WHO, 2011.

STRATEGY	KEY METHODS
Land-use systems increasing population density and diversity of use types;	Improving the proximity of destinations, thus reducing the need for using passenger cars and reducing VKT; Improves walking and cycling accessibility and accessibility by using high-speed/public transport;
Investments in spaces for pedestrian and cycling infrastructure;	Improves walking and cycling accessibility; Promotes the transition from using cars to walking and cycling, reducing VKT;
Investment in spaces networks with infrastructure of high-speed/public transport;	Improves accessibility by speed/public transport; Promotes the transition from using passenger cars to high-speed/public transport, reducing VKT.
Engineering infrastructure and speed reduction measures to mitigate risks posed by motor vehicles;	Reducing speed enhances the safety of walking and cycling; The further removal of vehicles from pedestrians and cyclists improves the safety of walking and cycling; Promotes walking and cycling by removing safety fences; Technological improvements reduce the frequency of hazards per vehicle (greenhouse gases, pollutants, noise).

VKT: Vehicle-kilometres travelled

"Wellness is money spent to make you feel healthier, even when you're not "sick" by any standard medical terms. The overall primary need today is not wealth–it's health". Paul Zane Pilzer, economist and analyst, presidential economic adviser.

The burden of road traffic injuries augments as motorization progresses. Road traffic is projected to be account for 5% of diseases by 2030, and to become the third leading cause of mortality (WHO, 2008c). About 90 percent of the burden of road traffic injuries is attributed to low- and middle-income countries where transport conditions are more dangerous. Road traffic injuries particularly affect young people, being the second most likely cause of death in the 5-29 age group[21].

Low road safety is a factor in the "vicious circle" that puts a constraint on the number of pedestrians and cyclists, while improved road safety can create a "virtuous circle", one which promotes walking and cycling. For example, traffic calming measures that slow down the speed of vehicles are often associated with increasing rates of walking and cycling (Servero et al., 2009, Centres for Disease Control and Prevention, 2000). Thus, improving road safety by reducing traffic intensity and speed is a fundamental activity, both in order to prevent injuries and to stimulate healthy motor activity.

1.3 UN 2030 Agenda. UN 2030 Sustainable Development Goals

1.3.1 Sustainable transport as enabler of the SDGs

[21] Module 5g. Environmentally sustainable transport: A Sourcebook for Policy-makers in Developing Cities, Internationale Zusammenarbeit (GIZ) GmbH, WHO, 2011.

On 25 September 2015, at the United Nations Summit, the UN Member States adopted the 2030 Agenda for Sustainable Development which enshrined 17 Sustainable Development Goals [22]. In the coming years throughout which these goals are to be achieved, all countries of the world must step up their efforts to tackle the issues of social protection, economic growth, environmental protection, ensure well-being for all, fight against inequality, etc. Almost all of the global Sustainable Development Goals (SDGs) are linked in one way or another to urban and transport planning and urban activities to improve the sustainability of transport systems. In that respect, many countries are now answering the call of the UN by working to improve the sustainability of transport activities in order to make transport more accessible, efficient and convenient, as well as to reduce emissions of noxious substances and greenhouse gases into the atmosphere, to enhance the quality of urban air and public health, and to improve the quality of life in general.

Of the 17 global Sustainable Development Goals (SDGs), the following are related to sustainable development and urban transport systems (Figure 1.18).

Figure 1.18. The SDG targets most relevant to THE PEP priority goals[23]

[22] https://www.un.org/sustainabledevelopment/ru/about/development-agenda/

[23] http://www.euro.who.int/en/publications/abstracts/making-the-transport,-health-and-environment-link-2018, Transport, Health and Environment Pan-European Programme and the Sustainable Development Goals, MAKING THE (TRANSPORT, HEALTH AND ENVIRONMENT) LINK, World Health Organization, Oana Arseni, Francesca Racioppi 2018.

PRIORIRY GOAL 1
Contribute to sustainable economic development and stimulate job creation

Direct link to target	Indirect link to target
1.2, 1.b	1.4, 8.5
3.4, 3.6, 3.9	
7.2, 7.2, 7.b, 8.2, 8.3, 8.9	
11.1, 11.6, 12.2, 12.7, 12.8, 12.b	

PRIORIRY GOAL 2
Manage sustainable mobility and promote a more efficient transport system

Direct link to target	Indirect link to target
3.4, 3.6, 3.9	5.b
8.4, 8.9	13.a
11.2, 11.6 12.2, 12.7, 12.8, 12.b	
13.2, 13.3	
15.5, 15.9	

PRIORIRY GOAL 3
Reduce emissions of transport-related rgeenhouse gases, air pollutants and noise

Direct link to target	Indirect link to target
3.4, 3.6, 3.9	9.5
7.2, 7.3, 7.b	13.a
11.1, 11.6 12.2, 12.7, 12.8, 12.b	
13.2, 13.3	

PRIORIRY GOAL 4
Promote policies and actions conducive to healthy and safe modes of transport

Direct link to target	Indirect link to target
1.2, 1.4, 1.b	5.1
3.4, 3.6, 3.9	
10.2	
11.2, 11.6, 12.2, 12.7, 12.8, 12.b	

PRIORIRY GOAL 5
integrate transport, health and environmental objectives into urban and spatial planning policies

Direct link to target	Indirect link to target
1.2, 1.4, 1.b	13.a
3.4, 3.6, 3.9	
7.2, 7.3, 7.b, 8.4, 8.9	
9.4, 10.2	
11.2, 11.3, 11.6, 12.2, 12.7, 12.8	
13.2, 13.3	
15.5, 15.9	

SDG 1: End poverty in all its forms everywhere

1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.

1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.

1.b Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions.

SDG 3: Ensure healthy lives and promote well-being for all at all ages

3.4 By 2030, reduce by one third premature mortality from noncommunicable diseases through prevention and treatment and promote mental health and well-being.

3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents.

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

Sustainable mobility will contribute significantly to the achievement of SDG 3 for four main reasons:

Firstly, the principles of sustainable transport development imply the establishment of an enabling environment for greater physical activity. Putting in place bicycle lanes, comfortable pedestrian infrastructure and public transport motivates people to move more as well as promoting a healthy lifestyle.

Secondly, sustainable mobility will reduce the adverse effects of motorization by: reducing emissions released into the atmosphere and their negative impact on human health and the environment, and decreasing road accident mortality and injuries.

Thirdly, mobility is indispensable for social participation, which seems to be a substantial factor in social well-being.

Fourthly, good transport accessibility means "better access to health services".

SDG 5: Achieve gender equality and empower all women and girls

5.1 End all forms of discrimination against all women and girls everywhere.

5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.

7.3 By 2030, double the global rate of improvement in energy efficiency.

7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support.

Sustainable mobility promotes the development of alternative energy sources. Increasing transport energy efficiency will unlock more energy for other purposes.

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors.

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.

8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead.

8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.

8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.

Sustainable transport can contribute to economic growth by improving access to jobs, including opportunities to migrate to regions with "decent" jobs, which will enable to harness the potential of people more effectively along with bumping up productivity.

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.

SDG 10: Reduce inequality within and among countries

10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

Transport determines comfort, quality of life and opportunities for economic development for a number of reasons:

Firstly, the principles of sustainable mobility mitigate the impact of road accidents and reduce atmospheric and noise pollution that have a negative impact on human health.

Secondly, favorable transport conditions facilitate social integration and participation of people in public life. In addition, public transport improves the affordability of trips and ensures better access to jobs, leading to employment growth and better financial stability.

Thirdly, transport infrastructure determines how cities are arranged. Every person interacts regularly with this part of the urban environment. Sustainable transport renders the environment more comfortable in every sense.

SDG 12: Ensure sustainable consumption and production patterns

12.1 Implement the 10-year framework of programmes on sustainable consumption and production patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.

12.2 By 2030, achieve the sustainable management and efficient use of natural resources.

12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities.

12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.

12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products.

With regard to transitioning to sustainable consumption and production patterns, sustainable transport plays the following role:

Firstly, since the transportation of raw materials and finished products makes up a vital part of production processes, overall economic sustainability will depend on the sustainability of transport systems. A sustainable transport system will enable streamlining supply chains.

Secondly, transport systems dependent on fossil energy sources in themselves serve as an example of waste of resources therefore improving the energy efficiency and sustainability of the transport sector will facilitate responsible consumption in general.

Thirdly, some transport services, such as carsharing and bikesharing, promote the development of a sharing economy which is a form of responsible consumption.

SDG 13: Take urgent action to combat climate change and its impacts

13.2 Integrate climate change measures into national policies, strategies and planning.

13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.

13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.

Sustainable transport is an important prerequisite for successfully combating climate change and its impacts for two main reasons:

Firstly, transport consumes a tremendous amount of energy with the bulk of that energy coming from fossil sources whilst remaining the only sector in many countries where energy consumption keeps growing so regulation of the transport sector is therefore essential for the implementation of the Paris Agreement.

Secondly, transport is responsible for the growing share of greenhouse gas emissions. Consequently, the establishment of sustainable, energy-efficient transportation systems independent of petroleum fuels will help to combat climate change.

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

The negative impact of transport on terrestrial ecosystems comes down to unsustainable use of space. Sustainable mobility, however, requires less space thanks to (1) coordination of urban planning and transport planning, leaving room for greater density and, therefore, reducing the need for road infrastructure as well as owing to (2) prioritized public transport development and (3) a shift to a sharing economy. All this put together will reduce the need for car trips. In addition, the number and length of road trips in cities with a multifunctional high-density built environment are lower than in cities occupying large spaces. This helps to decrease atmospheric pollution and CO_2 emissions, as well as mitigating the damage caused by road accidents.

SDG 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Finance

17.3 Mobilize additional financial resources for developing countries from multiple sources.

Technology

17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed.

17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.

Capacity-building

17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation.

Multi-stakeholder partnerships

17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries.

17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.

1.3.2 SDG 11- "Making cities and human settlements inclusive, safe, resilient and sustainable"

Faced with the adverse ramifications of high motorization, government agencies and scientific institutions are aggressively pursuing studies into how opting for a private vehicle as a mode of transport correlates with the public interest. It is obvious that the population must be offered qualitative alternatives to the use of private cars in order to ensure the sustainability of our cities.

Fig. 1.19 presents a scheme showing the operation of a sustainable urban transport system which is planned in such a way as not only to meet the public transport demand for commuting to and from workplace and cultural and social destinations but also to save urban area, to cause minimal harm to public health and the environment. Still, in planning the transport system, one should take into account the requirements of that system from the perspective of urban dwellers, transport operators as well as the state and municipal authorities.

These requirements are quite contradictory. As an example, it is rather convenient for a passenger using public transport to have the vehicle arrive at the station as soon as he or she turns up at it while the carrier seeks to establish a traffic interval in such a way as to keep the vehicles always filled as much as possible with a view to maximize incomes. What the passenger expects are accessibility of transport and high-level service, including quality, comfort, cleanliness and safety whereas the carrier strives to reduce its internal and external costs. This is the contradiction between the interests of the carrier and those of the passenger. This being the case, the role of the state lies in building a management system in the industry to ensure the maximum possible compromise between the interests of the serviced population, transport companies and state governmental bodies.

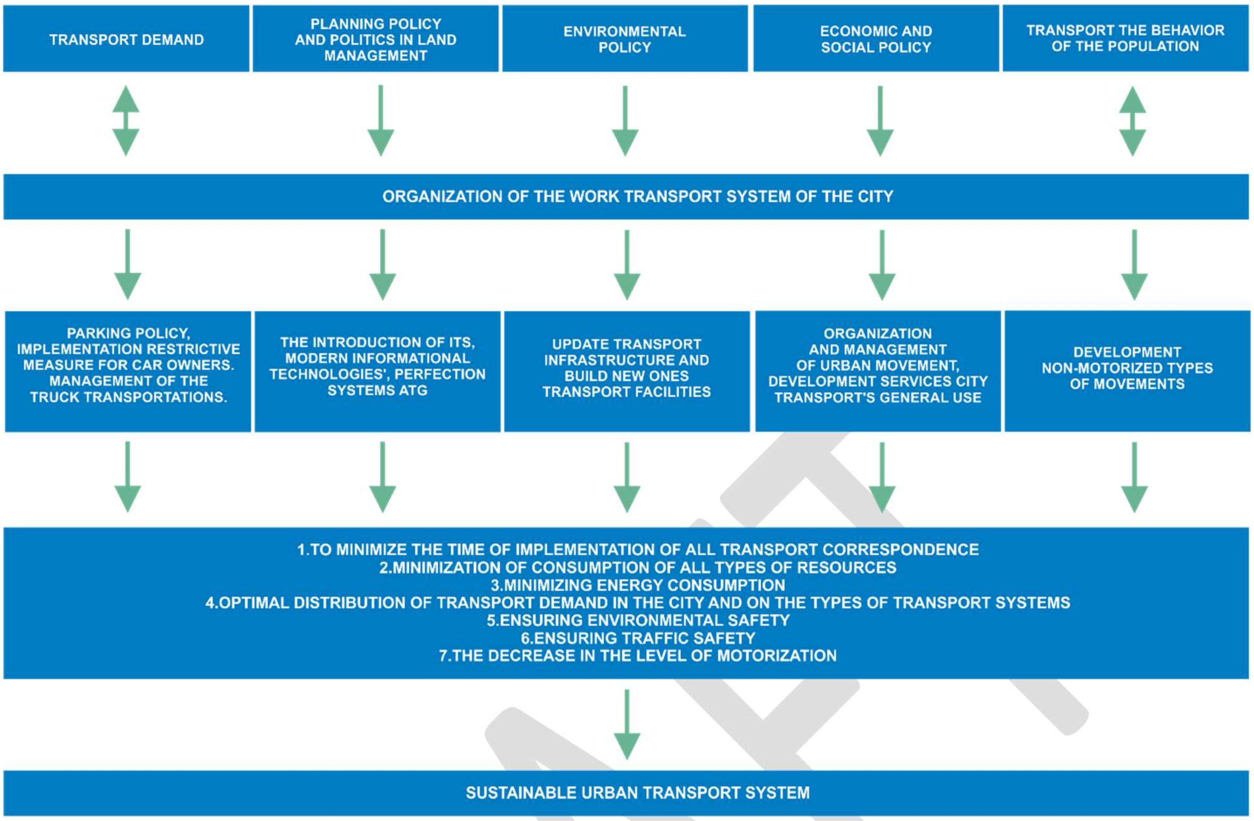
Transport system efficiency is defined as the ratio of useful end results of its operation to the resources expended.

Building a sustainable urban transport system involves planning its activities in conjunction with the economy, land use, urban planning, geography, ecology, sociology and psychology. The basic principles of such a system are (Fig. 1.19).

:

- Primary focus on people and their needs;
- Improving the quality of life and meeting the needs of all people by ensuring equal, safe and equitable access to places, facilities, goods, services and other people;
- Ensuring a balanced development and alignment of all modes of urban transport and prioritizing the use of the most environmentally friendly modes of transport and travel (pedestrians, cyclists, public transport, urban rail transport);
- ensuring packages of quality measures and solutions are designed to deliver cost - effective results and promote sustained socio - economic growth;
- use of intersectoral planning tools (effective integration of transport and urban planning, health, environment, energy efficiency, striking a balance between meeting the transport demand of society and economy and potential adverse impacts of transport activities, etc.);
- meeting the needs of the economy in ensuring the timely and safe transportation of goods;
- securing a reduction in the adverse impact of transport activities on the environment and human health;
- engaging key stakeholders, the general public and local residents in the transport planning process;
- ensuring the protection of the rights of both living and future generations.

Figure 1.19. Operational scheme of a sustainable urban transport system



A sustainable urban transport system should adequately deal with negative external and internal factors while serving its primary function i.e. providing mobility, including for disadvantaged and vulnerable groups which constitutes an integral component of the Millennium Development Goals[24].

The kinship between urbanization, rising motorization and the state of the environment derives from a number of factors in the complex system of socio-economic development and interaction between society and nature. Gaining an understanding of the particular characteristics of that system in cities is crucial for elaborating long - term strategies as well as for international cooperation on issues related to the global population and environment.

The new key message of modern urban environment development is bound up with the humanization of cities wherein they not only gain in convenience to accommodate people's life, but also contributes to their professional fulfillment and expands their social and cultural scope.

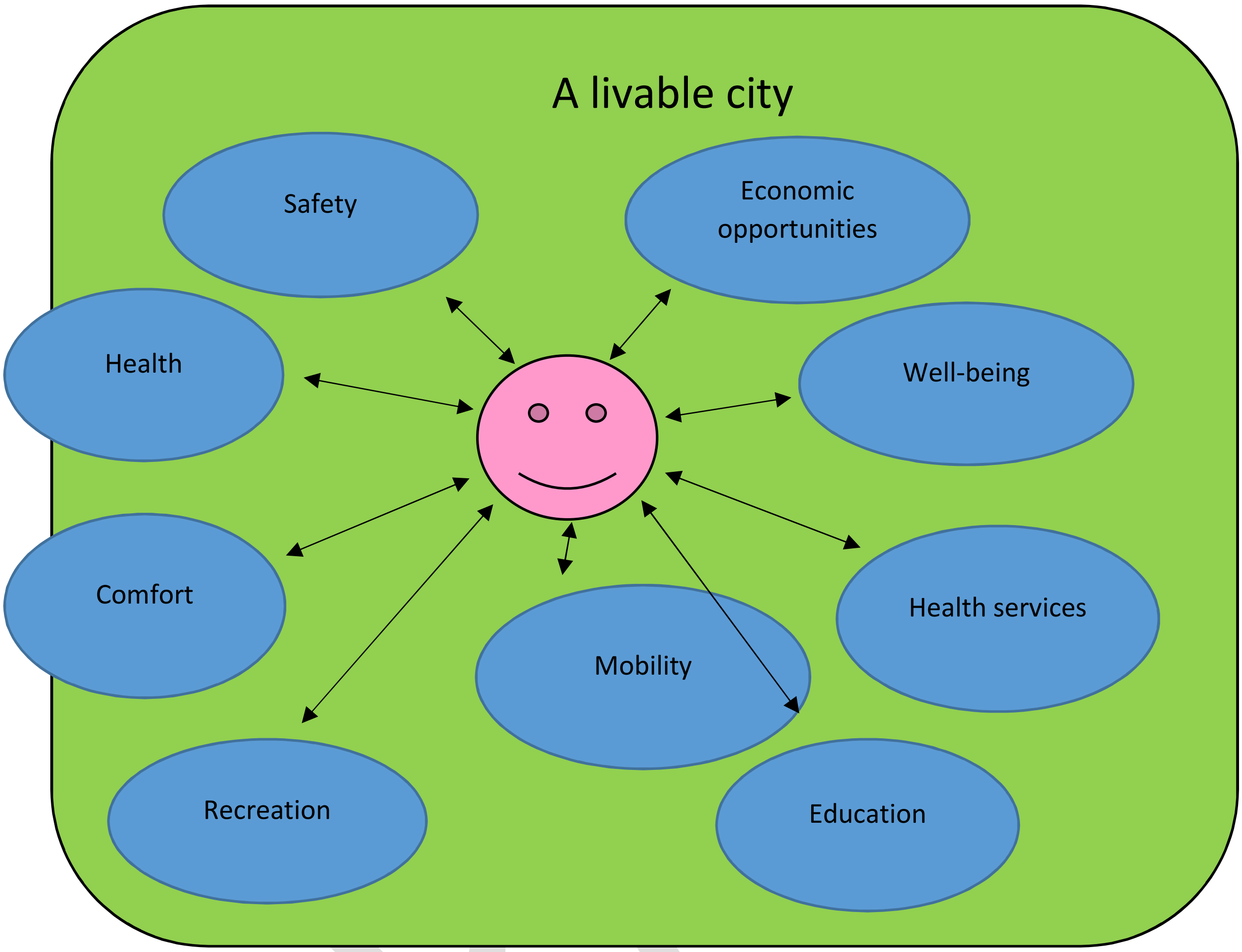
In solving their respective problems, urban mayors and public authorities in charge of urban transport and urban development policies are faced with institutional problems, legal and financial constraints as well as political and social opposition. This being the case, it is critical for cities at the very outset to define their goals properly, assess the issues at hand, find potential solutions and adopt an appropriate strategy

[24] http://www.unece.org/fileadmin/DAM/trans/doc/2015/itc/Sustainable_Urban_Mobility_and_Public_Transport_FINAL.pdf, UNECE, Sustainable urban mobility and public transport in ECE capitals, New York, Geneva, 2015

so as to go ahead with implementing the plans, then evaluate the outcome and conduct monitoring.

In the past 15 years, the concept of quality and comfort of life in cities or in urban areas has come to be recognized as an essential criterion and, at the same time, as a problem of modern communities. The notion of a liveable city brings into focus such things as a home, a district and a city as a whole from the perspective of the conditions they provide to a person in terms of safety, economic opportunities, well-being, health, comfort, mobility, health services, education and recreation (Fig. 1.20).

Figure 1.20. People and a livable city



Significant technological, economic and environmental changes, including climate change, economic restructuring, transition to online retail and entertainment, aging population, urban population growth and pressure on public funds have stimulated interest in "smart cities". The European Union (EU) is making continuous efforts in order to devise a strategy for ensuring "smart" urban growth in major urban regions.

Transport is essential to the "smart city" concept, a concept that implies the integration of information and communication technologies (ICT) and the Internet of Things (IoT solutions) as a way of bettering urban management and providing a high quality of life for people. The goal pursued by creating a "smart city" is to enhance quality of life with the aid of urban informatics technology in order to step up service efficiency and meet the needs of citizens. ICT enables city authorities to engage directly with communities and urban infrastructure, and to monitor what happens in the city, track the way the city is developing, and see what ways lead to the improvements in the quality of life. Urban infrastructure, including transport, energy, environmental protection and safety, is a major area of city intellectual activation.

The advantages of urbanized “smart cities” areas are that they can offer users high-quality public transport and various infrastructure facilities within walking distance. Among other things, this precludes the emergence of “second class” citizens in cities i.e. people who do not own a car, or those who cannot or are unwilling to drive it which leads to them not being able to meet fully their needs for transportation.

Nowadays, the basic idea of urban development is beginning to transform into making all the necessary benefits available to people. It is accessibility that is becoming the main goal of transport systems that establish a necessary environment for fast and comfortable travel and effective mobility through “open” design and urban planning.

1.4 Transport Health Environment Pan-European Programme - THE PEP. Transport Health Environment Pan-European Programme - THE PEP.

With the growing motorization of society and international carriage of passengers and goods, the negative effects of transport activities came into stark focus in the 1970s and early 1980s. It was at this time that the first environmental standards that set vehicle emission and noise requirements were developed. In June 1992, the United Nations Conference on Environment and Development (UNCED), known as the Global Summit, was held in Rio de Janeiro. The meeting in Rio combined the efforts of the leaders of 118 industrialized and developing countries, as well as hundreds of environmental non-governmental organizations and tens of thousands of committed environmental activists. They were confronted with the challenge to find ways to cope with the mounting threat of environmental catastrophe due to increased greenhouse gas emissions (especially CO2), causing global climate warming together with the irretrievable loss of flora and fauna diversity. In the light of the decisions taken at Rio, transport activities and, above all, motorized vehicles have been viewed as one of the growing negative impacts on the environment. The development of international transport and increasing volumes of cargo transported between the UNECE region countries have put on the agenda urgent measures to improve the environmental sustainability of transport.

Preparations for the UNECE Regional Ministerial Conference on Transport and the Environment commenced in 1994. The Conference took place in Vienna in 1997, bringing together a large number of ministers and senior managers from the transport and environmental sectors of the UNECE region. The Conference adopted the Vienna Declaration and Programme of Action in the field of transport and the environment, signed a number of legally binding instruments, including but not limited to amendments to the 1968 Vienna Convention on Road Traffic, the 1997 European Agreement on Uniform Conditions for Periodical Technical Inspections of Wheeled Vehicles and the reciprocal recognition of such inspections. The implementation and monitoring process for the resolutions of the Conference (including the establishment of Focal Points on Transport and the Environment in the countries) was defined.

In 1999, the Third WHO Ministerial Conference on Environment and Health took place in London, which adopted, among other things, the WHO Charter on Transport, Environment and Health, which introduced into the agenda the impact of transport activities on public health, including active mobility issues. The Conference founded the Charter Steering Committee and established Focal Points in the participating countries.

In 2001, the first High-level Meeting on Transport, Health and Environment (THE) in Geneva resolved to merge these two parallel processes into the Pan - European Programme on THE and to hold an inaugural meeting in 2002.

In 2002, the 2nd High-level Meeting on Transport, Health and Environment in Geneva adopted THE PEP and founded its governing bodies (the Steering Committee and its Bureau) and the Secretariat as well as establishing Focal Points in countries. The THE PEP High - level meetings held every 5-7 years continue to be the supreme governing body of the Programme. The 3rd and 4th PEP High-level Meetings in in 2009 (held in Amsterdam) and in 2014 (held in Paris) adopted THE PEP objectives and endorsed the relevant Action Plans and Ministerial Declarations (Amsterdam and Paris Declarations). The next PEP High-level Meeting will be held in Vienna in October 2019.

Figure 1.21. High-level Meetings on Transport, Health and Environment

The THE PEP website states that "Travel and transport are essential parts of modern life". We depend on transport to travel to work, for shopping and leisure, by car, by bus, by train, by walking and cycling. Human powered mobility can also contribute to our health and well-being through physical activity. But transport also has harmful effects on the environment and on our health – through congestion, accidents, pollution and greenhouse gas emissions. More than ever, we need to be aware of the crucial connection between transport, health and the environment. THE PEP – the Transport, Health and Environment Pan-European Programme – makes the link.

The key challenges addressed by the Programme are the following:

- growing transport demand and excessive reliance on the use of private vehicles;
- the impact of transport - related air pollutants on human health and ecosystems;

- traffic congestion and the reduction of green spaces because of the lack of necessary coordination of transport and spatial planning;
- a rise in non - communicable diseases due to lack of physical activity and sedentary lifestyles.

The goals of THE PEP in Amsterdam and Paris are declared to be the following:

- To contribute to sustainable economic development and stimulate job creation through investment in environment- and health-friendly transport;
- To manage sustainable mobility and promote a more efficient transport system;
- To reduce emissions of transport-related greenhouse gases, air pollutants and noise;
- To promote policies and actions conducive to healthy and safe modes of transport;
- To integrate transport, health and environmental objectives into urban and spatial planning policies.

Figure 1.22. THE PEP Five priority goals and the links to the SDGs[25]

[25] http://www.euro.who.int/__data/assets/pdf_file/0004/375511/9789289053334-eng.pdf?ua=1, MAKING THE (TRANSPORT, HEALTH AND ENVIRONMENT) LINK, Transport, Health and Environment Pan-European Programme and the Sustainable Development Goals, Oana Arseni, Francesca Racioppi, World Health Organization, 2018.

Figure 1.23. 5 THE PEP Priority Goals

5 THE PEP PRIORITY GOALS		
	GOAL 1	To contribute to sustainable economic development and health-friendly transport
	GOAL 2	To manage sustainable mobility and promote a more efficient transport system
	GOAL 3	To reduce emissins of transport-related greenhouse gases< air pollutants and noise
	GOAL 4	To promote policies and actions conducive to healthy and safe modes of transport
	GOAL 5	To integrate transport, health and environmental objectives into urban and spatial planning policies

The solutions proposed by the Programme are related to:

- integration of transport, health and environmental objectives into urban and spatial planning policies by improving collaboration, coordination and cooperation between all levels of relevant authorities;
- the development of public transport systems that are safe, clean, convenient, accessible, efficient and affordable;
- development of infrastructure, road signs and signals to ensure safe and healthy active mobility, in particular cycling and walking;
- mobility management schemes for work, school, leisure travel and other needs; development of eco - driving; introduction of new technologies.

The mechanisms for the implementation of THE PEP Programme are:

- THE PEP Relay-race Workshops (a series of seminars and conferences on issues related to Transport, Health and Environment in cities of the UNECE Member Countries to disseminate best practices and knowledge);
- development of national Action Plans on Transport, Health and Environment;
- THE PEP partnerships on singled out issues in line with the objectives of the Programme;
- development of THE PEP tools (guidance materials and practical recommendations);
- “THE PEP Academy” (a system of courses and curricula on Transport, Health and Environment, “summer schools”, etc.).

Between 2008 and 2018, THE PEP Relay Race workshops covered 14 cities in 10 countries with conferences and workshops held on topics such as “encouraging cycling and walking”, “sustainable urban and public transport”, “sustainable transport planning”, “innovation in transport”, “decarbonization and reduction of transport emissions”.

Figure 1.24. THE PEP Relay-race Workshops

WHERE	**WHEN**	**WORKSHOP**
Rimini, Italy	2018	Active mobility - Making the change towards a green and healthy urban transport environment
Saint Petersburg, Russia	2018	Introduction of innovative green and healthy technical and technological solutions in road and urban passenger transport: global trends and opportunities
Mannheim, Germany	2017	Cycling and Walking

Vladivostok, Russian Federation	2016	Sustainable transport planning in big cities
Vienna, Austria	2016	Decarbonization — Zero emission mobility starts now!
Petrozavodsk, Russian Federation	2016	Burdens and benefits of motorized and non-motorized transport
Irkutsk, Russian Federation	2015	Integrating Transport, Urban Planning and Traffic Management
Kaunas, Lithuania	2014	Sustainable Mobility for Better Health and Environment
Almaty, Kazakhstan	2013	Sustainable Mobility: Focus on Urban Central Asia
Moscow, Russian Federation	2012	Sustainable Development of Urban Transport
Kyiv, Ukraine	2011	Working together for sustainable and healthy urban transport
Batumi, Georgia	2010	Safe and healthy walking and cycling in urban areas
Pruhonice-Prague, Czech Republic	2009	Safe and healthy walking and cycling in urban areas
Skopje, FYROM	2009	Sustainable urban transport policies in south-east Europe
Chisinau, Moldova	2008	Sustainable and healthy urban transport

The Programme established 6 Member States partnerships on the following topics:

- “eco - driving”;
- Green and healthy jobs in transport;
- Integrate transport, health and environmental objectives into urban and spatial planning policies;
- Transdanube Partnership;
- Health economic assessment tool for walking and cycling;
- Cycling.

One of the important outputs of the Programme is support for the development of national action plans (programmes, strategies) on Transport, Health and Environment.

National plans are required to:

- define policy goals, objectives and priorities;

- develop integrated strategies and packages;
- achieve well-coordinated action and cooperation between stakeholders in addressing issues;
- achieve successful outcomes nationwide.

The activities of THE PEP are supported by the Clearing House in the official UNECE languages.

Ongoing activities under the Programme and guidance documents made under the Programme are available at https:// thepep.unece.org.

1.5 United for Smart Sustainable Cities Initiative. Global initiative to join forces for smart and sustainable cities

The “United for Smart Sustainable Cities” (U4SSC) is a United Nations initiative coordinated by the International Telecommunication Union (ITU) and the United Nations Economic Commission for Europe (UNECE) and supported by supported by the Convention on Biological Diversity (CBD), the Economic Commission for Latin America and the Caribbean (ECLAC), the Food and Agriculture Organization (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Development Programme (UNDP), the United Nations Economic Commission for Africa (UNECA), the United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women), the United Nations Environment Programme (UN Environment), the United Nations Environment Programme Finance Initiative (UNEP-FI), the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Human Settlements Programme (UN-Habitat), the United Nations Industrial Development Organization (UNIDO)United Nations UniversityOperating Unit on Policy-Driven Electronic Governance (UNU-EGOV) and the World Meteorological Organization (WMO) to achieve Sustainable Development Goal 11: “Make cities and human settlements inclusive, safe, resilient and sustainable”. U4SSC serves as the global platform to advocate for public policy and to encourage the use of ICTs to facilitate and ease the transition to smart sustainable cities[26].

U4SSC serves as the global platform to advocate for public policy and to encourage the use of ICTs to facilitate and ease the transition to smart sustainable cities.

https://www.itu.int/en/ITU-T/ssc/united/Pages/default.aspx

1.6 World Health Organization (WHO) Healthy Cities Initiative

The term “Healthy City” is used in health care and urban design to denote the impact of urban policies on human health. The WHO European Office Healthy Cities project got underway in 1986 in 11 European cities quickly expanding to other cities in

[26] https://www.itu.int/en/ITU-T/ssc/united/Documents/Report-for-U4SSC-26-04-2018.pdf

the region. It was not long before the project went international as a way of implementing public health policy at the local level. This project reflects the multifaceted nature of health care problems, as stipulated in the WHO Charter and, most recently, the Ottawa Charter for Health Promotion. The objectives of the project are being met through undertaking commitments at the political level which reflect devotion to the principles of "Health for All" and "Sustainable Development"; institutional changes and the establishment of infrastructure to support and ensure intersectoral cooperation and community involvement; work at the strategic, policy and community levels with special end products, including urban health system development plans and mechanisms that strengthen responsibility for public health; establishing formal and informal links at local, national and international levels.

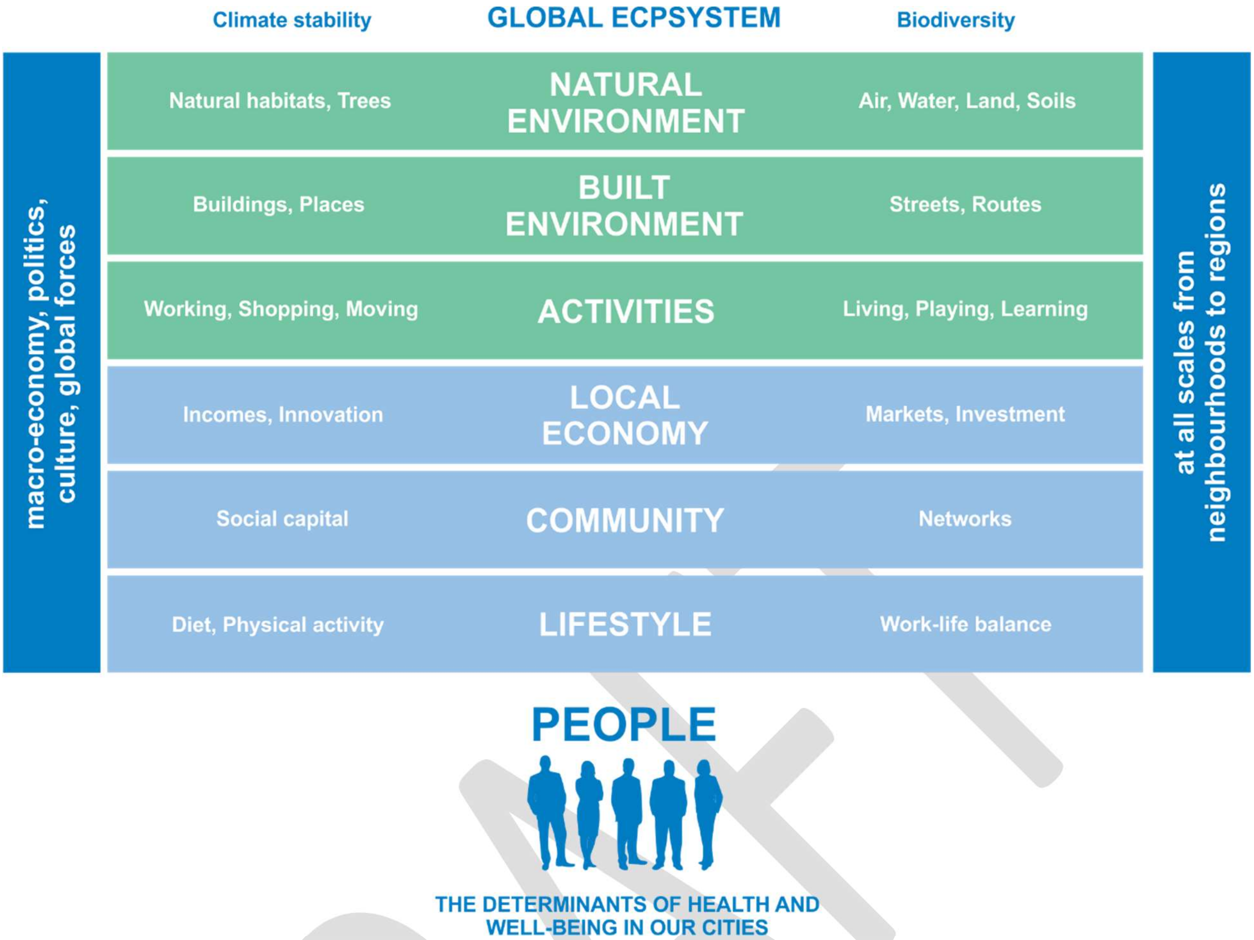
A healthy city is one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential. It is difficult to establish specific indicators and standards in this area and to determine the impact of each component on public health. In some regions, such as Europe, health impact assessment is a mandatory part of public policy-making.

The Healthy Cities project is a long-term international development initiative that aims to put health high on the agenda of public authorities at different levels and to promote a comprehensive strategy for health and sustainable development. Healthy cities strive to create a healthy environment and ensure a high quality of life, sanitation and hygiene, and access to health care. Still, being included among the "healthy cities" does not depend on the existing health infrastructure in a city, but on the desire to improve urban infrastructure (including transport) and the willingness to establish the necessary ties and engage in interaction politically, economically and socially.

Health care is not the determining factor when it comes to health as education, the working environment and other general conditions are equally as important such as socio - economic, cultural ones, including those defined by the environment.

Figure 1.25 Factors affecting health[27]

[27] https://link.springer.com/article/10.1007/s11524-011-9649-3#CR11, Urban Planning for Healthy Cities, Hugh Barton author, Marcus Grant, Journal of Urban Health, 2013, Volume 90, Supplement 1, pp 129–141.



An evaluation of the Healthy Cities project suggests its success in enhancing the understanding of the links between health and the environment, in establishing cross-sectoral partnerships with a goal to ensure a sustainable and large-scale programme of action.

A healthy city is defined not by the outcome but by the process.

- A healthy city is not necessarily one where certain health indicators have been achieved.
- It is a city that is aware of the significance of health and seeks to improve it. Therefore, any city can be healthy, irrespective of the current health indicators of its residents.
- The primary condition is: commitment to improving health as well as a process and a structure in place to achieve that goal.
- A healthy city is continuously engaged in creating and improving the physical and social environment as well as mobilizing local resources, enabling people to support each other in the exercise of all vital functions while conducing to their harmonious development so that the maximum potential can be achieved.
- It is recommended that the ERB WHO healthy city basic model be used.

In conformity with the Healthy Cities approach, health issues should be prioritized on the political and social agenda of cities; a robust movement should be encouraged locally to support public health.

Successful implementation of this approach requires innovative action on all aspects of health and living conditions of citizens, as well as extensive networking between cities in Europe and beyond. This includes:

- explicit political commitment;
- leadership;
- institutional change;
- intersectoral partnerships.

The Healthy Cities approach recognizes the determinants of health and the need to work in collaboration across public, private, voluntary and community sector organizations. This way of working and thinking includes involving local people in decision-making, requires political commitment and organizational and community development, and recognizes the process to be as important as the outcomes. The concept of Healthy Cities was inspired and supported by the WHO European Health for All strategy and the Health21 targets. It is fully aligned with the European policy framework Health2020 and the 2030 Agenda for Sustainable Development[28].

In September 2015, world leaders set a target within the Sustainable Development Goals of substantially reducing the number of deaths and illnesses from air pollution by 2030.

In May 2016, WHO approved a new "road map" for accelerated action on air pollution and its causes. The roadmap calls upon the health sector to increase monitoring of air pollution locally, assess the health impacts, and to assume a greater leadership role in national policies that affect air pollution.

The air quality model developed by WHO confirms that 92% of the world's population lives in places where air quality levels go beyond "WHO Air quality guidelines" levels for annual mean particulate matter figures with a diameter of less than 2.5 micrometres (PM2.5)[29].

There is a wide set of tools to be used to assess the public health impact of motor vehicles in urban projects (including within Healthy Cities):

1) Planning tools/methodological tools. The main tool is Health Impact Assessment (HIA). These tools are successfully combined with the Environmental Impact Assessment or Strategic environmental assessment (SEA);

2) Qualitative evaluation methods (interviews, focus groups, discussions with stakeholders);

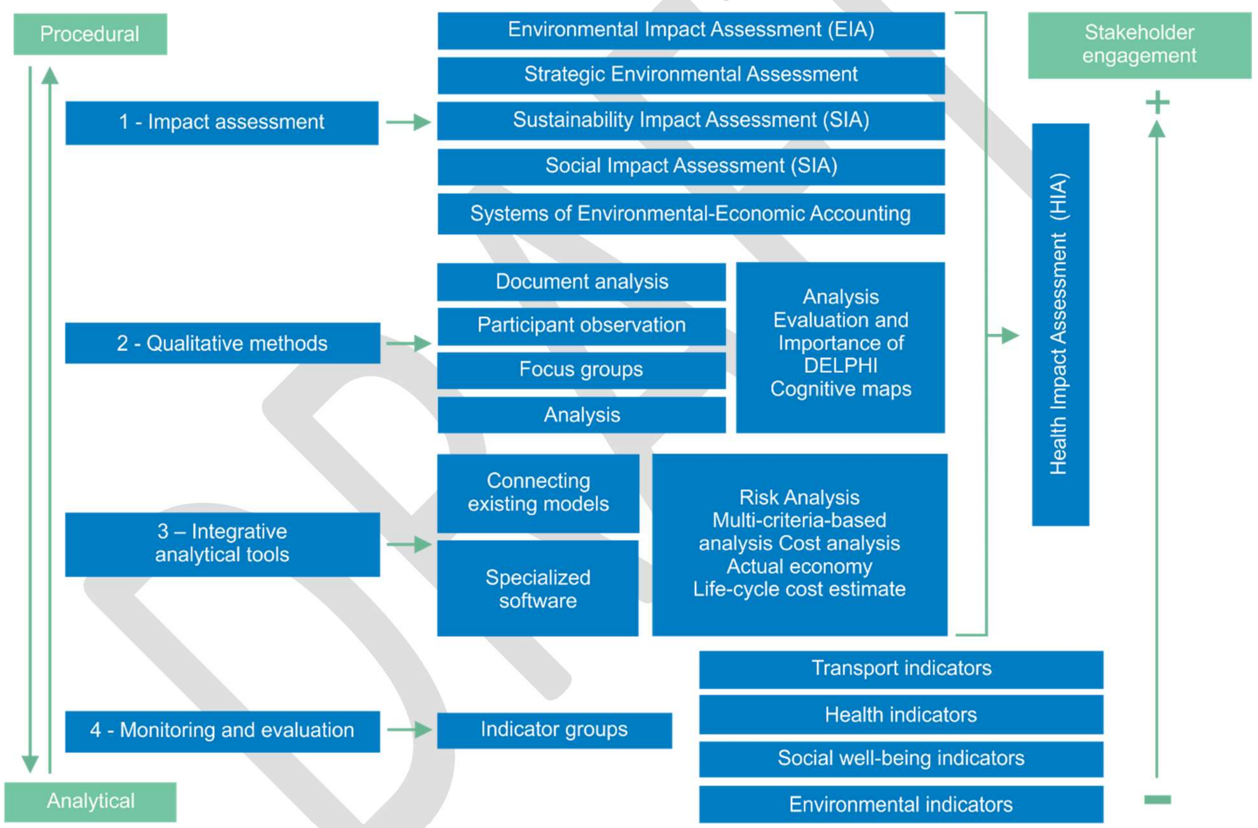
[28] http://www.euro.who.int/ru/health-topics/environment-and-health/urban-health/who-european-healthy-cities-network/what-is-a-healthy-city

[29] http://www.who.int/ru/news-room/detail/27-09-2016-who-releases-country-estimates-on-air-pollution-exposure-and-health-impact, WHO, 2016, news.

3) Integrative analytical assessment methods that can be quantified and model actual or expected health effects. These include methods such as analysis of burden of disease, risk quantification and modelling. They are often used as combinations. Economic modelling (cost - benefit analysis and cost - effectiveness analysis) can be used to translate external costs, including those related to the mortality rate, disease and reduced productivity, into economic indicators.

(4) Monitoring and evaluation tools often involve the use of indicators to track the achievement of the desired objectives.

Fig. 1.26 Tools to assess the potential health impacts of transport policies[30]



WHO's most famous integrative analytical and quantitative tool is the Health Impact and Risks from Transport Systems (HEARTS) project. This project comprises three case studies designed to test models of quantitative analysis of the impacts of different urban land-use and transport policies on human health.

More detailed information on the HEARTS project is available at: http://www.who.int/cardiovascular_diseases/hearts/en/.

[30]https://www.sutp.org/files/contents/documents/resources/A_Sourcebook/SB5_Environment%20and%20Health/GIZ_SUTP_SB5g_Urban-Transport-and-Health_RU.pdf, Transport-and-Health. Environmentally sustainable transport: A Sourcebook for Policy-makers in Developing Cities, GIZ/WHO, Carlos Dora, Jamie Hoskings, Pierpaolo Mudu, Elaine Fletcher, 2011.

Another WHO toolkit, HEAT, developed under THE PEP, serves to assess the health benefits of cycling and walking. The tool can be used to perform several types of assessment:

- Assessment of the prevalence of cycling or walking, for example, to demonstrate the benefits of cycling or walking for a particular city or country;
- Assessment of changes in the dynamics, for example, a comparison of the situation before and after, or comparison of scenarios A and B (for example, with the required measured implemented or without them);
- project evaluation, including cost–benefit calculations.

HEAT tools can be used autonomously or in combination with other methods to conduct integrated economic assessments or to assess expected health effects.

More detailed information on HEAT can be found at:

http://www.euro.who.int/HEAT.

In addition, WHO has established a Global Urban Ambient Air Pollution Database. The database provides an extensive information set on particulate matter air pollution (PM_{10} and $PM_{2.5}$) and contains indicators of more than 3.000 settlements whose population is ranges from 100 to more than 9.000.000 inhabitants. In a majority of cases, these data are available for cities with a population of 50.000 or more; smaller urban areas with a population of up to 20,000 residents accounting for approximately 25 percent of the data[31]. The database provides measurements taken at monitoring stations which are located in urban areas, urban traffic sections, in residential, business and mixed use areas. The data collected are used as the basis for estimates of the likelihood of various diseases triggered by urban air pollution to build on.

More information on the WHO database can be found at:

http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/.

1.7 Global and regional initiatives

Chapter 2: Spatial planning and urban transport.

2.1 Definitions

2.2 Models of spatial planning and typologies of urban development

2.3 Inclusive urban planning, decision-making and strategy formulation

2.4 How spatial planning transforms transport demand & How transport demand shapes spatial planning

2.4.1 Case studies and good practices

~~2.5 How transport demand shapes spatial planning~~ (2.4)

~~2.5.1 Case studies and good practices~~

2.5 Urban traffic management — How to prevent congestion?

~~2.5.1 General principles~~

[31] http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/

2.5.1 Passenger traffic
2.5.2 Urban freight traffic and city logistics
2.5.3 Case studies and good practices
2.6 Organisation of urban parking space and parking policy
2.6.1 Case studies and good practices
~~2.7 Intelligent Transport Systems (ITS)~~
~~2.7.1 Case studies and good practices~~

2.1 Definitions

Agglomeration - comprised of compact locations, mainly urban, united by close economic, cultural and household, and demographic ties (specifically manifested in circular migration), mutual use of labour resources and a single production and social infrastructure[32].

Urban environment - a set of tangible (buildings, structures and space between them) and intangible (human activity) elements with which a person interacts in his or her everyday life in the city.

The concept of "Mixed-use" territorial development is a combination of several functional uses within a block, a group of blocks, a land plot or a building. For instance, the inclusion of commercial infrastructure in housing construction[33].

Type of construction - a method of arrangement of individual buildings within the confines of a block that involves a certain functional zoning as well as distribution of public, collective and private open spaces.

Vertical functional zoning - the arrangement of rooms, each serving different functional purposes, on different floors of a building. As an example, the lower floors of a residential building may accommodate sales outlets and service office.

Horizontal functional zoning - the arrangement of several buildings of different functional purpose within a single block. As an example, an office center neighbouring on a residential building.

Open public space - territories and buildings in a city which are designed for free use by all citizens. Open public spaces include streets, squares, embankments, parks, garden squares, pedestrian areas, etc.

Multimodal network of movements - a comprehensive network of movements which ensures coordinated use of two or more modes of transport for fast, safe and comfortable movement of its users in urban areas.

Single parking space - a combination of urban parking spaces, including parking on the municipal street and road network and outdoor parking of all kinds and types, parking space used on a paid basis.

[32] K. Pavlov Suburban economy // Municipal economy. 2004. No. 4. P. 32-38.

[33] (Printsipov kompleksnogo razvitiya territoriy "Principles of complex territorial development"), OOO "KB Strelka", ordered by Dom.rf, 2017.

Parking lot - a specially designated and, if necessary, specially fitted-up building, structure or object that is, part of a road and/or adjacent to the roadway and (or) a sidewalk, roadside, flyover or bridge, or which is part of under-flyover or under-bridge spaces, areas and other units of the street and road network, building, structure or object and is intended for organised parking of vehicles on a paid basis or on a free-of-charge basis as decided by the owner or another person in possession of the road, the owner of the land plot or the owner of the whole building, structure or object, or part thereof.

Parking spot - a section of a parking area (an area) identified as such by special markings and intended to accommodate one vehicle.

Urban street and road network - a compound of facilities, including various categories of main streets of citywide importance, main streets of regional importance, streets, roads and passages in residential, industrial and other areas, roads and passages within natural complexes, squares, bridges, fly-overs, embankments, pedestrian subways, pedestrian and cycling paths, turn-around area for urban route vehicles and other facilities.

Paid parking area - an urban area the street and road network of which houses paid parking places in line with the paid parking layout.

Parking lot user - a person who drives a vehicle that enters a parking lot and leaves the vehicle in the parking lot.

Accountability - the ability to provide explanation and justification for choices and activities as well as a description of what has happened. The accountability of local authorities to their citizens is a fundamental tenet of good urban governance.

Action Plan - an output-oriented, actor-specific document outlining the mechanisms required to achieve the objectives of a specific strategy. The plan specifies details of inputs and actions by various stakeholders with practical work programmes, time schedules, types and timing of financial and other resource commitments.

Action Planning - the process through which strategies are converted into practical programmes or activities for implementation. The key feature throughout the process is an emphasis on full discussion and negotiation among the stakeholders involved.

Citizenship - a characteristic of citizens, i.e., the fact that they are members of a city or state by virtue of being legally resident there. As a norm of good urban governance, citizenship implies that all citizens, especially women, must be empowered to participate effectively in decision making processes (UN-Habitat, 2002).

City Profiling Team (CPT) - a group consisting of selected representatives of municipal departments and stakeholder representatives who can contribute significantly to data collection and the drafting of the Urban Situation Profile, Urban Situation Appraisal and Consolidated Urban Diagnosis.

Civic Engagement - one of the principles of good urban governance norms advocated by UN-HABITAT. Civic engagement implies that living together is not a passive exercise – in cities, people must actively contribute to the common good (UN-Habitat, 2002).

Consensus - an agreement reached by virtue of gathering information and viewpoints through discussion. A negotiated position is arrived at that is acceptable to all stakeholders once they have interacted through consultations, working groups and other mechanisms. The goal of the consensus-building process is to reach a decision with which everyone can agree.

Efficiency - in economics, the degree of efficiency is the ratio of project output (or business income) to project input (or business expenditures). Efficiency as advocated by UN-HABITAT good urban governance norms relates to efficiency in the delivery of public services and in promoting local economic development. Cities must be financially sound and cost-effective in their management of revenue sources and expenditures as well as in the administration and delivery of services; based on comparative advantage, cities must enable government, the private sector and communities to contribute formally or informally to the urban economy.

Equity - refers to impartiality, fairness or justice. Norms of good urban governance refer to equity of access to decision-making processes and the basic necessities of urban life. Sharing of power leads to equitable access to and use of resources. Women and men must participate as equals in all urban decision-making, priority-setting and resource allocation processes.

2.2 Models of spatial planning and typologies of urban development

The spatial organisation of the territory of any country and its regions and cities in large part ensures the functioning and development of all sectors of the economy, particularly those associated with land use, real estate market, infrastructure development, development of settlements and housing and utility services. Planning of spatial organization of territories or spatial planning is a key instrument for establishing long-term, sustainable frameworks for social, territorial and economic development both within and between countries. Its primary task is to enhance the integration between such sectors as housing, transport, energy and industry, and to improve national and local systems of urban and rural development, also taking into account environmental considerations. The nature of spatial planning substantially sets out the conditions in which the transport demand of the population and that of the economy is shaped and along with the characteristics of the transport system relevant to its operations.

The concept of spatial planning is often associated with its private ownership variations such as land-use planning, urban and regional planning, transport planning and environmental planning. Spatial planning can be implemented at various levels: to name, at local, regional, national and international levels.

As noted by Koresawa and Konvitz (2001) “the scope of spatial planning differs greatly from one country to another, but most share a number of similarities. In almost all countries, spatial planning is concerned with identifying long- or medium-term objectives and strategies for territories, dealing with land use and physical development as a distinct sector of government activity, and coordinating sectoral policies such as transport, agriculture and environment”.

As noted in [GIZ, Land use planning and urban transport], spatial planning for urban areas (urban planning) “must functionally meet the diverse needs of the urban population, to wit, accommodation, work, social interaction, leisure, movement of people and goods. People also need a natural environment in the places where they live: green areas for recreation, health purposes, restoring mental and physical strength as well as urban conservation areas and parks”.

Urban environment planning and shaping concepts are very diverse having changed much over time. Historically, cities were initially oriented towards pedestrian accessibility; the use of their territories shared to serve different functions. Yet, the territories were not divided by function. Monofunctional urban zoning emerged as the industry developed and urban population and territories grew. By function, cities came to be divided into a number of specific functional zones: residential, industrial, communal and warehouse, external transport zones, sanitary protection and recreational. The monofunctional approach to urban planning results in growing urban territories, transport correspondence, street and road infrastructure as well as the establishment of an environment conducive to the development of motorisation.

The inflow of population into megacities, stricter requirements to quality of life and environment, better focus on environment and sustainable development all call for changes to be introduced into the spatial planning concept.

UN-Habitat proposes that “cities of the future should build a different type of urban structure and space, where city life thrives and the most common problems of current urbanization are addressed”. To realize this UN-Habitat proposes an approach that summarizes and refines existing sustainable urban planning theories to help build a new and sustainable relationship between urban dwellers and urban space, and to increase the value of urban land. This approach is based on 5 principles that support the 3 key features of sustainable neighbourhoods and cities: compact, integrated, connected.

Spatial planning aims to[34]:

- Promote territorial cohesion through a more balanced social and economic development of regions, and improved competitiveness;

[34] SPATIAL PLANNING - Key Instrument for Development and Effective Governance with Special Reference to Countries in Transition, ECONOMIC COMMISSION FOR EUROPE, UNITED NATIONS, New York and Geneva, 2008.

- Encourage development generated by urban functions and improve the relationship between the town and countryside;
- Promote more balanced accessibility;
- Develop access to information and knowledge;
- Reduce environmental damage;
- Enhance and protect natural resources and natural heritage;
- Enhance cultural heritage as a factor for development;
- Develop energy resources while maintaining safety;
- Encourage high-quality, sustainable tourism;
- Limit the impact of natural disasters.

Spatial planning is extremely critical to achieving economic, social and environmental benefits by creating a more stable and predictable environment for investments and development, guaranteeing development benefits to local communities and encouraging the rational use of land and natural resources for development. In consequence, spatial planning is a major tool in achieving sustainable development and improving the quality of life.

Figure 2.1. The benefits of spatial planning

The benefits of spatial planning[35]

Economic benefits:

✓ Providing more stability and confidence for investment;
✓ Identifying land in appropriate locations to meet the need for economic development;
✓ Ensuring that land for development is well placed in relation to the transport network and the labour force;
✓ Promoting environmental quality in both urban and rural areas, which can then create more favourable conditions for investment and development;
✓ Identifying development that meets the needs of local communities;
✓ Promoting regeneration and renewal;
✓ Making decisions in a more efficient and consistent way.

Social benefits:

✓ Considering the needs of the local communities in policy development;
✓ Improving accessibility when considering the location of new development;
✓ Supporting the provision of local facilities where they are lacking;

[35] SPATIAL PLANNING - Key Instrument for Development and Effective Governance with Special Reference to Countries in Transition, ECONOMIC COMMISSION FOR EUROPE, UNITED NATIONS, New York and Geneva, 2008.

- ✓ Promoting the re-use of vacant and derelict land, particularly where it has a negative impact on quality of life and economic development potential;
- ✓ Aiding the creation and maintenance of pleasant, healthy and safe environments.

Environmental benefits:

- ✓ Promoting regeneration and the appropriate use of land, buildings and infrastructure;
- ✓ Promoting the use of previously developed (“brownfield”) land and minimizing development on “greenfield” land;
- ✓ Conserving important environmental, historic and cultural assets;
- ✓ Addressing potential environmental risks (e.g. flooding, air quality);
- ✓ Protecting and enhancing areas for recreation and natural heritage;
- ✓ Promoting access to developments by all modes of transport (e.g. walking, cycling and public transport), not just by car;
- ✓ Encouraging energy efficiency in the layout and design of development.

The benefits of spatial planning

Economic benefits:

- ✓ greater stability and confidence for investments;
- ✓ identifying territories and lands suited to the needs of economic development;
- ✓ interlinking the location of land to be developed, transport and labour;
- ✓ promoting the preservation of environmental quality in urban and rural areas, which can in turn then translate into a more propitious environment for investment and development;
- ✓ identifying the type of development that fits the needs of local communities;
- ✓ promoting revival and renovation;
- ✓ decision - making in a more efficient and consistent manner.

Social benefits:

- ✓ taking into account the needs of local communities in policy-making;
- ✓ increased accessibility when addressing the issues of development in new areas;
- ✓ support for the development of local infrastructure in areas where it is found to be lacking;
- ✓ promoting the reuse of free or abandoned land, especially in places where
- ✓ it adversely impacts the quality of life and the potential for economic development;
- ✓ helping to create and maintain a favorable, healthy and safe environment.

Environmental benefits:

- ✓ promoting the reclamation and proper use of land, buildings and infrastructure;
- ✓ promoting the use of previously built-up land (abandoned areas) and minimizing development of greenfield land;
- ✓ preserving major environmental, historical and cultural values;

✓ taking into consideration potential environmental hazards (e.g. floods, deterioration of air quality);
✓ protection and improvement of recreation areas and natural heritage;
✓ ensuring access to development areas through all modes of transport (including hiking trails, cycling paths and public transport) avoiding being limited by just motor vehicles;
✓ Promoting energy efficiency in development planning and structuring.!!!!!!!!!!!!!!!!!!

Skilled spatial planners should have the ability to engage actors at all levels of development:

- Participation: engaging actors in reciprocal relationships of communications;
- Consultation: delivering expert advice for the purpose of drawing conclusions;
- Representation: acting on behalf of one or more groups of actors in an effort to represent both ideas and individuals;
- Appeal: acting as advocates for collective decision-making and for the improvement of the affected community.

Effective management is an essential factor defining the success or failure of spatial planning. Management is understood as organisation and coordination, policy and planning, and monitoring of relevant projects. The goals thereof extend to giving a hearing to opinions, analysis, decision-making and clarifying ideas that may have been misinterpreted.

Overarching goals of spatial planning

- To promote a system of meaningful and democratic governance that responds to the needs of local communities;
- To improve urban environmental performance;
- To facilitate social cohesion and security;
- To promote market reform in the housing and urban sector;
- To improve land and real estate markets and securing private rights in land.

Cities of the future should build a different type of urban structure and space, where city life thrives and the most common problems of current urbanization are addressed. UN-Habitat proposes an approach that summarizes and refines existing sustainable urban planning theories to help build a new and sustainable relationship between urban dwellers and urban space, and to increase the value of urban land. This approach is based on 5 principles that support the 3 key features of sustainable neighbourhoods and cities: compact, integrated, connected. UN-Habitat supports countries to develop urban planning methods and systems to address current urbanization challenges such as population growth, urban sprawl, poverty, inequality, pollution, congestion, as well as urban biodiversity, urban mobility and energy.

The Five Principles are[36]:

1. Adequate space for streets and an efficient street network. The street network should occupy at least 30 per cent of the land and at least 18 km of street length per kmI.

2. High density. At least 15,000 people per kmI, that is 150 people/ha or 61 people/acre.

3. Mixed land-use. At least 40 per cent of floor space should be allocated for economic use in any neighbourhood.

4. Social mix. The availability of houses in different price ranges and tenures in any given neighbourhood to accommodate different earnings; 20 to 50 per cent of the residential floor area should be for low cost housing; and each tenure type should be not more than 50 per cent of the total.

5. Limited land-use specialization. This is to limit single function blocks or neighbourhoods; single function blocks should cover less than 10 per cent of any neighbourhood. In recent decades, the landscape of cities has changed significantly because of rapid urban population growth. A major feature of fast growing cities is urban sprawl, which drives the occupation of large areas of land and is usually accompanied by many serious problems including inefficient land use, high car dependency, low density and high segregation of uses. Coupled with land use speculation, current models of city growth result in fragmented and inefficient urban space where urban advantage and city concept are lost.

The implementation of these principles has engendered the **compact city concept.** Key characteristics of a compact urban environment are shown in Figure 2.2. Compact urban environment is characterised by a combination of high-density development and a high-density street and road network while maintaining mid-rise buildings with buildings and territories sharing mixed use.

Figure 2.2. Key characteristics of a compact urban environment[37]

The urban environment compactness is described by the ratio of several interrelated parameters:

[36] https://unhabitat.org/wp-content/uploads/2014/05/5-Principles_web.pdf.

[37] Dileman F., Wegener M. Compact City and Urban Sprawl // Built Environment. 2004. Vol. 30, No. 4. P. 308 — 323.

- block size;
- width-to-length ratio of a block;
- the area of the construction footprint;
- the width of streets;
- the total area of the buildings.

The main strengths of compact cities are shown in Figure 2.3.

Рис. 2.3. The benefits of compact cities from the perspective of social life, economy, governance and ecology

High population density implies the generation of significant transport demand and a major load on transport infrastructure. In this context, the most effective solution is the use of public passenger transport. But the more users there are and the more diverse their requirements are to the quality of transport service, the more diverse the transport supply and the types of mobility used should be. In a compact urban environment with a highly dense street and road network, every mode of transport is given all the necessary conditions including walking and cycling.

As urban residents prefer to live, work, rest and do the shopping in a single particular area without wasting their time, money and effort on hours-long trips from one part of the city to another, a new trend for urban development has sprung up within the compact city concept (as one of its underpinning components) that is supposed to meet the diverse needs of citizens - “mixed-use development”, a trend interwoven with mixed-use development.

Mixed or multifunctional use is a concept of territorial development implying a variety of functions, social strata and ages within its confines. This combination of functions cannot be well implemented in areas made up of individual residential buildings but proves effective in residential apartment blocks[38].

The term “mixed-use” implies a combination of at least three formats and three functions for a building: housing, commerce space and a business sector. This being the case, the commercial part of the building should be limited to just a few grocery stores, but should make up a large retail space that would accommodate dress

[38] http://strelka.com/ru/magazine/2017/09/20/mixed-use, “Smeshannoye ispol'zovaniye - retsept sbalansirovannogo goroda” (“Mixed use - a recipe for a balanced city”.) Ksenia Bobrova, Architect-analyst, KB Strelka, 2018.

departments, sports goods, pharmacies, cafes and restaurants. The key objective pursued by developers is to reduce the need for residents in the building to move around town as everything they need is located right outside the building.

Nowadays, the mixed-use concept is a popular trend among urbanists, as illustrated by the 5 Five UN-Habitat Sustainable Development Principles.

The mixed-use concept is realised through land-use and development regulations known as zoning in New York and Cornwall, Flächenwidmungs — und Bebauungsplan in Vienna. The land-use and development regulations establish territorial zones; all with a designated use, even if the land plot is owned. This is needed to take into account the interests of all citizens, namely the right of everyone to a favorable environment.

The objective of the land-use and development regulations is to minimise the harmful effects of the urban environment on human health. In line with this, zones with potential noise, vibrations, odours, excessive traffic and pedestrian flows should not be located near residential areas. Each zone is given a list of permitted types of use.

The fact that the land-use and development regulations limit the types of use for each territory helps the city authorities regulate the real estate market establishing favorable conditions for citizens.

Mixed use is characterised by a synergy effect: the proximity of sales outlets and services expands the clientelle with shops exchanging their customers.

Different lifestyles can be also combined in territories of mixed use. Thanks to this, citizens do not need to leave the district that they have come to be so attached to as they get older nor to cut established social ties. Multifunctionality promotes the improvement of urban environment quality, thus driving up the value of real estate as well as boosting the incomes of the city and owners.

As home, work and shops are located close to each other in multifunctional areas, walking and cycling traffic goes up by 10% — 20%. Spending money on cars and public transport there is no longer a necessity for people which improves conditions for low-income citizens also effacing the boundaries of spatial segregation.

Compact blocks save time on trips which grants people more free time at the same time mitigating the environmental footprint. This way, the city capitalises on savings on environmental protection measures while the residents enjoy health benefits.

In addition, the high density of mixed-use areas brings down the costs of infrastructure maintenance. The city saves on operating expenses whereas the residents and entrepreneurs save on utility costs.

Finally, people feel safe in mixed-use areas. Acts of violence are less common there. The sense of security is also an attractive factor which promotes attendance, improves sales as well as revenues of the local shops and services.

Being a natural path to urbanisation, the number and scale of urban agglomerations have been growing in Europe in recent decades. Currently, there are approximately 100 agglomerations with about 60% of the population of Europe living in them. Agglomerations are economic development hubs as well as being centres of social challenges and environmental burden. The development of new communication and transport systems coupled with better management mechanisms lead to the further expansion of agglomerations and the emergence of mega-urbanised areas.

Creation of agglomerations addresses the following territorial challenges by:

- Enhancing the competitiveness of the economy and securing a stable inflow of development resources;
- Regulation of internal (circular, daily, weekly) migration from small and medium-sized cities to regional capitals and agglomeration-core cities;
- Bringing the agglomeration and the region to the world market as a major actor in the system of commodity, financial, technological and cultural exchanges and as an "operator" of global financial flows;
- Management of the development of the core city and ensuring prevention of oversaturation and overpressure on infrastructure;
- All municipalities in the agglomeration have the opportunity to get involved in a joint, larger "project" to gain benefits that one cannot count on gaining on one's own.

At the same time, agglomeration development is associated with such challenges as an extreme lack of transport linkages, high infrastructure deterioration, environmental issues, the need for legal regulation of relations with municipalities included in an agglomeration. Agglomeration areas are also characterised by functional zoning (to fit housing construction, production, organisation of recreation areas (areas with recreational potential), etc.

Several groups of spatial development structural models for cities and urban agglomerations are identified, to name:

- the traditional (dispersed) model is aimed at the preservation of existing practices of dispersed development, accompanied by the development of a number of unrelated objects within the city. It is accompanied by the development of a number of unrelated regional settlements in relation to urban agglomerations;

- compact city model — increasing population density in areas close to the city centre (inner suburbs);

- the "suburban, middle" city model comes down to growing population, building density and the number of jobs in separate parts of the urban area (located outside the city centre and its business district) and increasing investments in urban highways linking these parts of the city;

- the corridor city model/radial or linear model of urban agglomeration sees the development of cities along feeder roads that lead from the central business district, along radial highways and urban roads served by public passenger transport. This model is more suitable for rapidly developing megalopolises (as this model allows rapid development along robust transport corridors).

- “peripheral” city model is where a city grows mainly thanks to its outskirts;

- “supercity” model or polycentric model of urban agglomeration sees the development of regional centres up to 100 km from the central business centre of the main city with these satellite cities being connected to the city centre by high-speed trains. It is characterised by the development of a compact city where there is maximum redevelopment of urban land and the development of satellite cities closely interlinked with each other and with the Main City. It is a typical model of urban agglomeration development. The polycentric model shares many advantages with the monocentric model but it also addresses the significant role played by remote settlements in the diverse development and strengthening of the agglomeration economy.

- monocentric model of urban agglomeration - this model implies that the development of an agglomeration is concentrated in the existing centre (the Main City) with expanding and developing areas around it. The monocentric model has many advantages in maximising the efficiency of transport and infrastructure networks being created. It also enables the city to evolve compactly with densely populated multifunctional areas being created marked by affordable education, health care, trade, recreation and choice of opportunities in employment. This model, however, fails to take into account the commercial and social needs of other settlements in the agglomeration which are isolated and of less economical significance.

Spatial patterns of urban development are largely determined by historical development of topology (planning scheme) of their street and road network.

There are the following types of street and road network planning schemes: radial, radial-ring, rectangular, rectangular, diagonal, triangular, combined and free.

The radial pattern is most commonly found in old cities, which took shape at the intersection of external roadways and progressed towards other cities by rural roads so as to establish links. This pattern ensures a robust link between the districts and the centre, but the central part of the city is inevitably overwhelmed with the districts poorly interconnected transportation-wise. This pattern does not meet the requirements for a modern urban transport system.

The radial ring pattern is a radial one complemented by ring highways whose number depends on the size of a city with its location determined by transport correspondence and the local conditions. Ring highways take a substantial transport burden from the central part of the city establishing convenient connections between the districts, bypassing the central city core. The Moscow street and road network is a telling example of the radial-ring pattern. There may be several radial-ring areas around the centres of urban planning zones in major cities. This pattern is called multifocal.

The rectangular scheme represents a system of streets reciprocally parallel and perpendicular to it. Usually it is found in relatively young cities that were built according to pre-developed plans. The strengths of this pattern include simplicity, high capacity, the possibility to disperse transport to parallel streets, the absence of a single transport hub. The drawback of the rectangular pattern is a considerable extension of the roads linking diagonally the opposite blocks and districts of the city.

A rectangle diagonal pattern is a rectangular one with additional diagonal links. It does feature the advantages of the rectangular pattern while mitigating its shortcomings. Diagonal highways facilitate links between the peripheral areas and the centre. The weakness of this pattern is the presence of hubs with many incoming streets, including at an angle, which makes traffic management and placing buildings in them very difficult.

The triangular pattern is found rarely as it leads to a large number of hubs with many highways intersecting at a sharp angle. One can find street and road networks built in this manner in some old areas of London and Paris.

The combined pattern represents a variety of combinations of geometrical patterns described above. It is seen quite often in large cities, where the old districts feature a radial - ring pattern, and the new districts being rectangular.

The free pattern of the street and road network does shares no elements with the patterns described above. It is found in spontaneously developing Asian and medieval European cities. This pattern is applied in the context of complex relief in resort towns or recreation areas.

2.3 Inclusive urban planning, decision-making and strategy formulation

As a key sector of the urban economy, transport makes a significant contribution to ensuring equal and fair living conditions for all. Accessibility of transport services is a critical factor in ensuring an inclusive urban environment. It is important to view all aspects of transport accessibility in a comprehensive manner: physical accessibility and barrier-free transport infrastructure, including, in particular, public passenger transport and non-motorised transport infrastructure (including for persons with reduced mobility); physical accessibility of motor vehicles (primarily public passenger transport) to all categories of users; affordability of public passenger transport services and new forms of urban mobility (taxi services, carsharing services); temporal accessibility of urban areas when using public passenger services. Accessibility requirements are set out by a system of standards and rules (in particular, standards of public transport service, standards establishing requirements for infrastructure facilities, etc.).

The quality of urban management is largely characterised by the quality of spatial (urban planning) planning, which, among other things, should ensure inclusiveness by striking a balance between urban accessibility and population mobility, taking into account the interests and capabilities of all categories of users as well as the impact of the transport system on the environment and health.

An effective urban policy aligned with multimodal transport solutions helps avoid irregular spatial development, provide a social and economic integration of different urban areas and population groups, and avoid environmental degradation.

Accessibility is a key performance indicator of the quality of the urban transport system and public passenger transport services. In the latter case, the indicator of availability should be used both in shaping requirements for the route network and in defining requirements for the services of transport operators. Planning for inclusive urban transport systems involves building barrier-free multimodal transport chains for all categories of users of the correspondences in question.

The inclusiveness of decision-making in the field of urban transport calls for wide involvement of different categories of users in discussions on the topic of relevant projects and programmes, specific solutions on transport provision of services to the population, public transport operational management and road traffic management.

Inclusiveness in cities:

- Reduces inequality and social tensions;
- Enables the use of knowledge, productive capacity, social and physical capital of the poorer segments of the population for urban development;
- Enhances the role of local resources in the implementation of programmes and development processes;
- Inclusive decision-making is a strategy in which the norms of quality urban governance are implemented in practice.

In carrying out spatial planning, the national governments are to perform the following functions[39]:

• Provide a common strategic vision and prioritise spatial planning; underscore the positive role of spatial planning in attaining these goals through clear political statements;

• Develop a legislative framework to support the establishment of spatial planning and policy mechanisms at different levels through democratic procedures;

• Use incentives and sanctions to ensure effective intersectoral and administrative cooperation as well as collaboration at all levels of government;

• Manage spatial planning at the regional and local levels to enforce laws; monitor the compliance of policies and actions in different jurisdictions;

[39] SPATIAL PLANNING - Key Instrument for Development and Effective Governance with Special Reference to Countries in Transition, ECONOMIC COMMISSION FOR EUROPE, UNITED NATIONS, New York and Geneva, 2008.

• Collect data on spatial planning trends and the effect of spatial planning; use indicators and set goals;

• Manage the process of providing a database and information on the state of spatial development and the effect of spatial planning;

• Ensure coherent policies and activities of national ministries and agencies with relation to spatial development throughout the implementation of spatial planning objectives;

• Support and provide counselling to regional and local governments to improve efficiency at all levels, both in terms of professional expertise and political leadership;

• Ensure appeal procedures in instances in which residents or entrepreneurs oppose the decisions of regional authorities by arbitration, conciliation proceedings or, when the occasion requires it, by passing binding judgement on disputed issues related to local projects;

• Ensure management and direct resolution of issues of national and international importance in cooperation with regions and local governments, for example, in cases where locations of national importance to remain unaffected by development need being defined;

• Establish "national institutions" to serve as links in cooperation with regional and local government authorities on urgent issues and issues that call for special attention such as global reconstruction of zones.

Streets and road transport represents the main transport assets for cities with mobility solutions depending in large part on their development. For instance, the current London transport development programme focuses on "healthy streets" for people and bicycles. A similar programme is being delivered in Moscow known under the name of "My Street". Now calculations show that walking accounts for about 30% in the modality of movement of people which even coined the term "pedestrian economy".

The use of privately owned cars enhances the spatial separation of activities and residential areas. High - quality public transport usually contributes to combined land use by promoting the creation of large hubs of activity and spurring more diverse residential development in which many apartment buildings alternate with private houses. Unilateral car-orientation at the expense of other types of travel leads to the abandonment of integrated land-use practices [Weyrich, Lind, 1996].

In practice, the following situation can be seen in cities: some activities (industry, educational institutions (schools and kindergartens), health facilities and mass housing) are scattered in some places with others, in particular many governmental and municipal institutions, consulting, banking and educational institutions (universities) more often concentrated in central areas which are more densely built-up. Various social and cultural events (concerts, conferences, parades) also involve a high concentration of people and are more often located in central areas. In order for all these activities to be happen without hindrance, urban transport systems need to connect areas effectively and handle a passenger traffic of varying intensity. This demand can only be met by a system comprised of various types of public, non - motorised and private transport.

What areas should decision-makers be focused on? Above all, the focus should be on ensuring high-quality and cost-effective transport service.

In circumstances where the capacity of city streets and that of city parking puts a significant constraint on curbing the increasing number of trips by private vehicles, also known to have a negative impact on the environment, greater attention should be paid to the potential of environmentally clean public urban transport.

However, a broad range of actions should be undertaken in order to make it really convenient and in demand:

- an efficient route network should be formed
- proper traffic regularity and predictable travel time should be ensured
- the real priority of route vehicles along the routes should be observed
- Rolling stock for transportation of residents with reduced mobility should be provided, landing sites should be constructed
- Public transport lanes should be separated by markings, road signs and fitted up with traffic cameras in sections carrying the heaviest traffic
- Widespread dissemination of passenger waiting time information systems has been implemented; it should be noted that although there is no common standard for the development and dissemination of such systems, they are becoming increasingly used with the development of global navigation satellite systems.

Since it is physically impossible to create a public transport network to satisfy absolutely all passengers, the transfer from one route to another or between modes of transport must also be as easy as possible. Given the limited capacity of city streets, such transport has the potential to become a real alternative to trips by private car. Another essential element is the creation of a favorable environment for pedestrians to walk through city streets, including from stations to places of high passenger traffic: wide and safe sidewalks, and pedestrian areas, where possible, must be put in place.

It is critical to not forget cyclists and “small urban mobility” users who grow in number with every year. Given the vulnerability of these road users, attention must be paid to the development of appropriate infrastructure in order to promote these modes of travel. An important element is the impact on human behaviour and the promotion of public transport, cycling and walking, when and where appropriate.

The versatility behind the task of creating a liveable city highlights the need to prioritise developing strategic planning documents aimed at increasing mobility. The preparation of these documents — real working documents for sustainable development — helps to improve transport accessibility, ensure speed and improve road safety and reduce the negative environmental impact of transport in the balance of transport and urban planning solutions. A fresh challenge to be dealt with is the growing number of trips between the city and the suburbs. To address this, they should reflect the integration of different modes of transport, both urban and suburban.

Described below is the world's practice of successful combination of urban and transport planning together with a list of measures required to build and develop sustainable urban transport systems. The exact sequence in which to implement the measures recommended should be set out by each city on its own with due regard to existing constraints and available resources.

Figure 2.4. The practice of successful combination of urban and transport planning together with a list of measures required to build and develop sustainable urban transport systems.

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
Strategic planning and development of sustainable transport systems integrated with urban policy and urban planning	Availability of strategic planning and development of sustainable transport systems integrated with urban policy and urban planning. Tools to limit the generation of excess transport demand in urban areas.	Formulation of a strategy for the development of sustainable transport systems. Formulation of Sustainable Urban Mobility Plans. Integration of spatial and urban planning legislation with transport planning strategic documents.
Financing	Predictable financial resources, efficient budget allocation, long-term planning.	Improving long-term budget sustainability and predictable planning and allocation of financial resources. Targeted financial support for sustainable urban transport activities. Identification of priority areas for expenditures.
Development and management of urban public transport operations	Ensuring high quality urban public transport (safe, quality, accessible, reliable, comfortable, environmentally friendly). Qualitative satisfaction of existing demand to be more competitive against passenger cars. Pursuing the practice of competitive bidding and ensuring commercial liability of operators. Advancing digital technologies in transport and logistics, implementation of the concept of “Mobility as a Service” (Maas). Use of ITS, new information and organisational technologies. E-Mobility development. An affordable pricing policy for all categories of citizens, convenient	System integration of all types of public transport. Targeted programmes aimed at the development of high-speed passenger transport. Commercialisation of municipal transport companies and consolidation of private carriers in the context of growing competition. Convenient tariff structure; introduction of a universal fare system. Efficient route network planning. Improving the quality of urban public transport operations (safe, quality, accessible, reliable, comfortable, environmentally friendly). Implementation of Maas services. Use of new information and organisational technologies. Prioritising the movement of route vehicles, including by dedicated lanes. Advancing digital technologies in transport and logistics, implementation of the concept of “Mobility as a Service” (Maas). E-Mobility

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
	tariff menus, single ticket (universal fare system), informing passengers in real time, route landmarks, convenient routes and schedule.	development. Use of ITS, new information and organisational technologies. Convenient tariff menus to promote the use of public transport for the population that would be uniform for carriers regardless of the form of ownership. Raising public awareness of passenger transport; introduction of real-time passenger waiting time information systems to keep passengers up-to-date about the movement of vehicles en route. Ensuring long-term and stable operating conditions for providers, introducing improvements into the fare system. Implementing targeted mechanisms to ensure affordable fares for low-income groups of population (targeted benefits for low-income persons; targeted transport subsidies). Conducting assessments of the economic and budgetary efficiency of the way public transport is organised; striking a balance between the level of quality provided and budget expenditures.
Road and street network	The road and street network should develop aligned with the needs and at the necessary scale. Clear priorities for investments into the development of road and street networks. Application of advanced techniques in equipping and maintaining roadways. Building street and road networks in adherence to the "Livable City" goal.	Regular roadway surveys. Vigorous implementation of automated traffic control systems in cities. Implementation of innovative "environmentally friendly and sound" technical and technological solutions.
Road traffic management	Ensuring a balance between the transport demand of the population and the functionality of sustainable urban transport systems.	Integration and reinforcement of engagement between authorities and providers. Introduction of advanced technologies in road traffic management. Use of new information and organisational technologies. Application of ITS. Enhancing design quality in road traffic management.
Reducing regular congestion affecting urban road and street networks	Taking measures to achieve a reasonable restriction of movement of privately owned vehicles, imposing restrictive measures to limit the traffic of freight vehicles.	Imposition of restrictive measures on privately owned vehicles as well as on the traffic of freight vehicles. Ensuring the required laws and regulations; introduction of amendments to the legislation currently in force.
Organisation of urban parking space	Pursuing comprehensive approaches to the organization of single urban parking space. Enforce measures to restrict the traffic of privately owned vehicles within reasonable limits.	Formulate a comprehensive strategy to organise single urban parking space. Approval of relevant legislation. Clarify and expand the powers of cities in regard to the parking policy and its enforcement.

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
Safety management	Integrate safety into the overall strategy of road traffic management. Implement "traffic calming" and speed reduction techniques and in certain parts of the street and road network, traffic cameras, fiscal measures, fines, etc.	Step up the availability of high-tech equipment in street and road networks. Streamline the development procedures of pre-design and design documentation. Improve the quality of design in road traffic management, apply best practices (traffic calming, speed reduction, traffic cameras, strict fiscal measures, etc.).
Environmental protection and mitigating the impact of motorised transport on climate change and public health	Concerted efforts with powers and responsibilities divided between federal, regional and municipal authorities in the field of regulation, monitoring and enforcement of environmental standards and mitigation of adverse environmental impacts.	Ensure a rational balance of regulations and incentives. Strengthen the accountability for failure to comply with environmental regulations. Develop methods for assessment of environmental and public health damage. Assess the volume of pollutants discharged into the atmosphere due to motorised transport; support and encourage the introduction and development of "environmentally friendly" vehicles and technologies. Introduce scrapping schemes for old cars: speed up vehicle fleet renewals by providing fiscal incentives for scrapping old cars, encouraging changes in public behaviour stereotypes towards public transport service and non - motorised modes of transport. Remunerate drivers who opt for more efficient vehicles. Introduce a fuel efficiency labelling for new vehicles. Make fuel efficiency and emission standards more stringent.
Comfortable urban environment and "living green" streets	Implementation of "Cities for People" strategies that intertwine efficiently urban and transport planning from the perspective of street and road networks, public spaces, green spaces, pedestrian spaces, cycling, etc. Accessibility, reliability, safety and quality must be prioritised.	Elaborate "Cities for People" strategies with urban and transport planning expressly interlinked. Impose restrictions on the traffic of motorised transport while putting in place and ensuring a comfortable and convenient street environment. Wise distribution of all road users in urban space with appropriate traffic safety provided. Accessibility, reliability, safety and quality must be prioritised.
Support and develop non-motorised modes of transport	Provide appropriate infrastructure and ensure that it is properly maintained (cycle lane, bicycle rental, bicycle parking, Internet services, etc.). Ensure the safety of cyclists under the "Safe System Approach" and the "Vision Zero" approach. Apply incentives to promote the use of non-motorised modes of transport and travel. Promote mobility through the mutual integration of public transport, cycling and car sharing.	View non-motorised modes of travel as a viable alternative to the use of privately owned vehicles for short (up to 1 km) and medium distances (up to 3-5 km). Implement advanced techniques and means in organising the traffic of cyclists and ensure their safety in real traffic taking into account different climatic conditions. Use incentives. Put in place necessary infrastructure and means to maintain this infrastructure. Develop and implement a consolidated public policy aimed at developing cycling. Integrate all modes of transport, including non-motorised modes of transport with the transport policy geared towards changing the transport behaviour of the population. Implement methods to assess the socio-economic efficiency of the measures and decisions being taken to promote cycling.

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
Enhance energy efficiency and energy saving in the road transport sector	Implement energy efficiency measures in the transport sector to save significant amounts of energy; support and promote the introduction and advancement of "clean" technologies and motorised vehicles (such as LRT, trams, trolleybuses, electric buses, electric vehicles, hybrid electric vehicles).	Implement measures to give a boost to energy efficiency in the transport sector to save substantial amounts of energy; support and promote the introduction and advancement of "environmentally friendly" motorised vehicles and technologies; draft and enact relevant laws and regulations. Pursue measures to cut down the share of privately owned cars to reduce the overall energy burden and to enhance the energy efficiency of passenger carriage through public transport. Reduce the fuel consumption of motorised transport. Reduce the energy intensity of new privately owned cars. Introduce a fuel efficiency labelling for new vehicles. Introduce a system of efficiency improvement in the transport sector. Make fuel efficiency and emission standards more stringent.
Implement green logistics and ensure the reliability of road transport	High accessibility. Ensure "door-to-door" cargo delivery. High maneuverability. Quick delivery. Make available different routes and delivery schemes. "Environmentally friendly" cargo vehicles.	Accessibility, reliability, safety and quality are the priority. Seek reductions in fuel consumption by road transport, ensure the use of "environmentally friendly" trucks, apply incentive measures. Ensure "door-to-door" cargo delivery. High maneuverability. Quick delivery. Ensure the use of different routes and delivery schemes.

In reality, the replication and implementation of the aforementioned practices of the successful combination of urban and transport planning and measures for the creation and development of sustainable urban transport is hindered as decision-makers often have no clear idea of the desired agglomeration as a whole nor of its urban core, or their ideas are just too abstract to make it possible to premise specific transport policy objectives and develop a "Cities for People" strategy and concrete action plans on them.

In this respect, the question of whether cities will be able to adopt successful practices and experiences, including approaches to the design of modern streets, traffic management technologies and transport system management is of great consequence. It is equally as important to learn from the many errors (Fig. 2.5) made at different times in different countries and avoid making them again. The worst error among all others was the failure to adopt the principles of sustainable transport and urban planning and the lack of a systematic approach to intermodal transport planning.

Figure 2.5. "Tram Cemetery"[40]

[40] https://urban3p.com/object22069/gallery/

Cities that adhered to the principles of sustainable urban and transport planning succeeded in becoming liveable and embark upon a path of sustainable development.

Prospects for the development of urban transport systems:

- Development and implementation of information and telecommunication technologies (“information revolution”, “digitalisation” of society and the transport sector);
- Development of “electromobility”, “smart mobility”, motorised transport shared use systems;
- Ensuring the emergence of automated driving vehicle systems;
- The growth of public environmental awareness;
- Sharpening the focus on healthy lifestyles;
- Promoting changes in the transport behaviour of the population;
- Step-by-step implementation of the concepts “Cities Are For People, Not For Cars”, “Smart city”, “Healthy Streets”, “Smart Mobility” by city administrations.

The headline goal of any effective urban mobility strategy is to satisfy the travel needs of both people and businesses in such a way that it improves quality of life for the citizen and increases the competitiveness of a country or region.

Ensuring this goal is achieved, however, involves a rigorous multi-stakeholder approach that takes in consultations between government and local authorities, public transport operators and other mobility providers, businesses, as well as community organizations like trade unions and NGOs, cycling associations and the media.

A successful urban mobility strategy needs to consider the interests of both public and private transport, passenger mobility and goods mobility, motorized and non-motorized transport and vehicles that are parked as well as those on the move. The establishment of a visionary and well-grounded urban mobility strategy requires careful consideration of a number of dimensions (figure 2.6).

Figure 2.6. Dimensions to be considered when defining a sustainable urban mobility strategy[41]

1	Senseof urgency	■ Understand patterns to reach shared understanding of mobility issues ■ Objectivize current mobility performance & gaps with best practices	Sening the Scene
2	Accountabilities	■ Identifv kev stakeholders and clarify "grey zones" of accountabilities ■ Understand current (public and private) mobility initiatives	
3	Stakeholders views	■ Understand needs and agendas of each stakeholder group ■ Understand needs of different customer groups (individual, businesses)	
4	Scope	■ Define geographical scope: city, region, nation ■ Define functional (mobility, sustainability) & modal scope (persons, goods	Vision & Objectives
5	Vision & Objectives	■ Develop a political vision and set priorities and targets ■ Ensure alignment between stakeholders on priorities (non normative)	
6	Good practices	■ Synthesis of experience from other mobility strategies and initiatives ■ Identify Good/Bad Practices and lessons learned	Strategy Formalization
7	Measures	■ Identify relevant mobility measures for set priorities and assess synergies ■ Select strategic options in form of integrated package of measures	
8	Roadmap	■ Develop master plan with responsibilities and resources allocation ■ Develop budget plan and synchronize with funding streams	Strategy Execution & Monitoring
9	Governance & Marketing	■ Set up clear governance mechanisms for monitoring and update ■ Marketing of mobilitv strategy, PR work with other stakeholder groups	

Arthur D. Little and the UITP have identified four key dimensions to be considered by mobility actors in cities seeking to put in place sustainable urban mobility systems:

- Visionary Strategy and Ecosystem;
- Mobility Supply (solutions and lifestyles);
- Mobility Demand Management;
- Public Transport Financing.

If an urban mobility policy based on implementing the above four dimensions is to succeed in achieving its aims, it is vital that all four dimensions are improved simultaneously as the overall results will be influenced by the performance of the weakest link. In this context, 25 imperatives should be carefully assessed by cities as a basis for setting up sustainable urban mobility policies and converted into a concrete set of actions. The relevance of the imperatives to each city will vary depending on the urban mobility city cluster to which they belong (figure 2.7).

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[41] https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

Figure 2.7. System-level framework for sustainable urban mobility system[42]

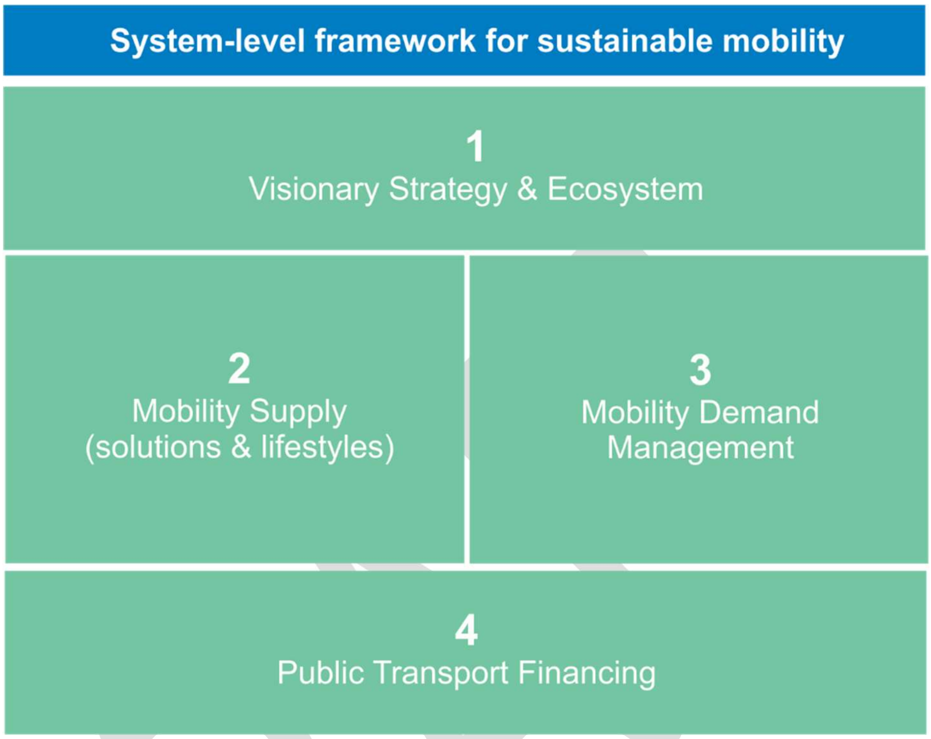
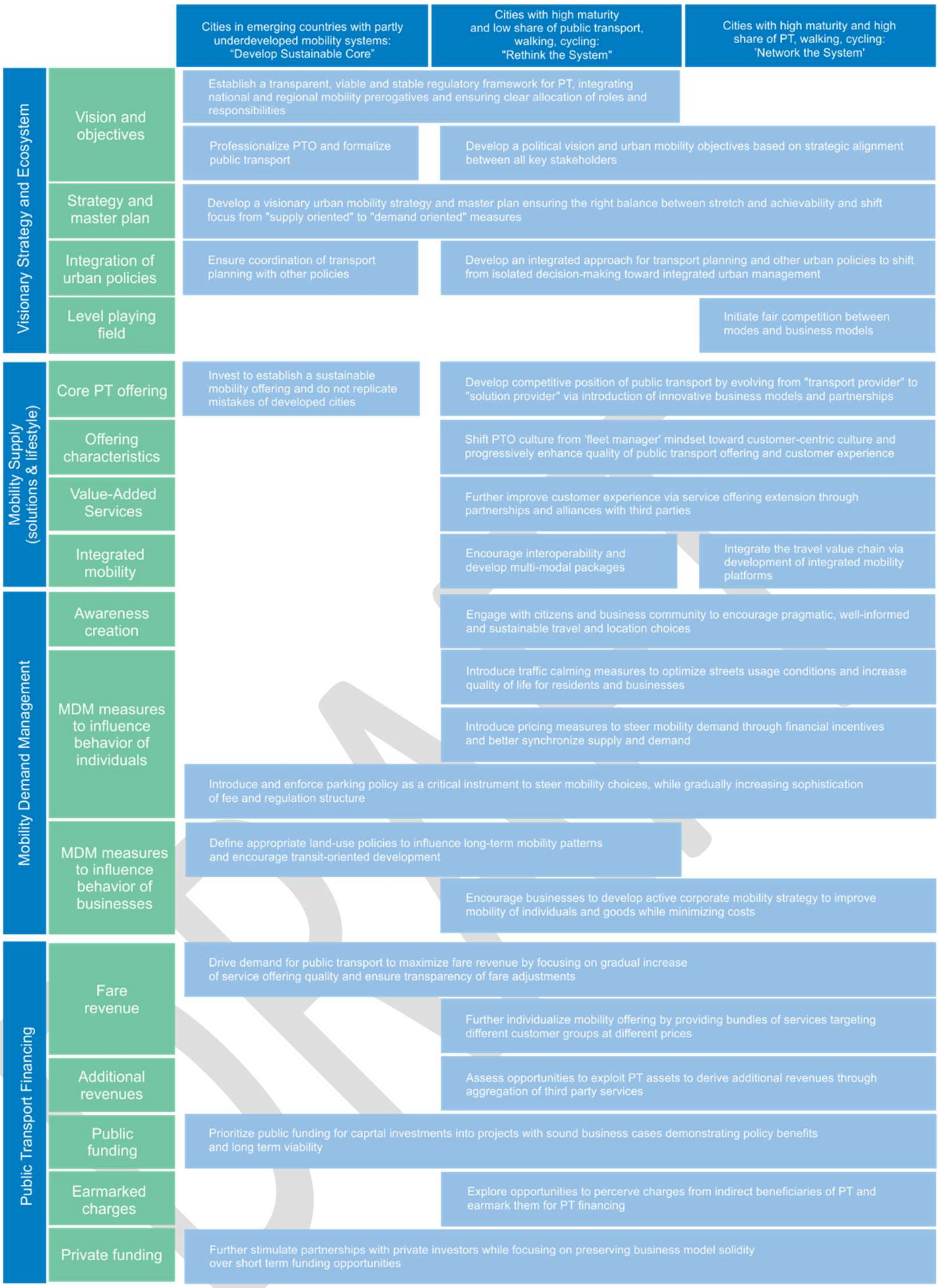


Figure 2.8. 25 imperatives to be considered by cities as a basis for defining sustainable urban mobility policies[43]

[42]https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

[43]https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.



The purpose of a spatial strategy is to provide an overview of the proposed pattern of spatial development of the territory and to add value by coordinating the territorial impacts of industry policies. The critical issue for spatial strategies is how to maximize sustainable development through encouraging and guiding the spatial distribution of development, redevelopment and investment; the coordination of infrastructure, e.g. the transport, water, housing, health and social services that support such development; and also the maintenance of environmental assets. The process of phrasinga strategy should take into account the alternative spatial development options which are open to consultation and subject to strategic environmental assessment.

Spatial strategies facilitate vertical policy integration by interpreting national spatial priorities for a given territory while enabling lower-level governments to cooperate on policy formulation. Spatial strategies provide guidance for the preparation of local policy frameworks and for public and private investment, government bodies, NGOs and the public. They will give a sense of direction and priorities but will leave discretion for decisions to be made at the local level when appropriate.

General guidance on planning proposals and the policy criteria upon which regulation decisions will be made should be set out in a spatial framework plan. Such plans are made for the area of local authorities or clusters of authorities, and should address the functional areas of cities, towns or rural areas.

Development and implementation of Sustainable Urban Mobility Plans is fundamentally different from traditional transport planning[44].

Figure 2.9. Differences between traditional transport planning and sustainable urban mobility planning

[44] http://www.eltis.org/sites/default/files/guidelines-developing-and-implementing-a-sump_final_web_jan2014b.pdf Guidelines. Developing and Implementing a Sustainable Urban Mobility Plan, The European Commission, ELTISplus, EACI/IEE/2009/05/S12 .558822, 2014

Traditional transport planning		*Development and implementation of a Sustainable Urban Mobility Plan* .
Focus on traffic flows	-	*Focus on people*
Main objectives: capacity of the road network to handle traffic flows and their speed	-	*Main objectives: accessibility and quality of life, economic development, social equality, human health and environmental safety*
Focus on the form, not the content	-	*Balanced development of all modes of transport with a shift towards more environmentally friendly and sustainable modes of travel*
Main focus on transport infrastructure	-	*Integrated range of actions required to achieve effective solutions. Special emphasis on urban planning and urban planning solutions*
Planning for each area separately pursuant to legal instruments in force	-	*Plans are integrated and interlinked with each other and with legal instruments in force (transport and urban planning, improvement of public spaces, safety, etc.)*
Short-term and medium-term plans	-	*Short-term and medium-term plans are part of a long-term vision or strategy*
Planning with experts involved in the process	-	*Planning with the engagement of stakeholders in the process through a transparent and participatory approach, etc.*

Figure 2.10. Designing Sustainable Urban Mobility Plans (SUMP)[45]

[45]http://www.eltis.org/sites/default/files/guidelines-developing-and-implementing-a-sump_final_web_jan2014b.pdf "Guidelines. Developing and Implementing a Sustainable Urban Mobility Plan, The Poly-SUMP Methodology", The European Commission, ELTISplus, European Platform on Sustainable Urban Mobility Plans, EACI/IEE/2009/05/S12.558822, 2014.

The full planning cycle of the SUMP encompasses four primary phases:

- Meticulous preparation of the planning process;
- Transparent and rational goal-setting;
- Development of the plan;
- Fulfilment of the plan.

The SUMP principles developed by ELTISplus incorporate 11 steps and 31 actions (clarification of specific objectives). The steps and actions form a logical rather than a step-by-step sequence. The process is a cycle of actions that take place partly in parallel. The cycle serves as the basic structure for the development and harmonisation of the SUMPs. The final actions involve an evaluation of the process and the result in order to find the best solutions in the next SUMP.

Barriers faced in the development and implementation of the SUMPs:

- Difficulties in collaboration between different authorities and lack of political consciousness;
- Weak collaboration between the areas of activity, i.e. transport, urban development and land-use;
- Insufficient funding and limited budgets of cities;
- Lack of experience in developing options;
- Inadequate public support;
- Lack of experience in attracting investors;
- Lack of information and data on how new programmes, technologies, etc. are applied

Recommendations to cities as regards the development of the SUMPs:

- Identify your prospects and tasks;
- Choose your strategy;
- Get access to the full range of required activities;
- Work out your set of activities to be undertaken;
- Work out your budgets, periods and constraints;
- Engage the public and investors into the process.

The goals can be based on prospects or problems, i.e.: efficiency, improving street-space, environment, balance, safety and security, economic growth.

Basel (Switzerland):

Basel (Switzerland) drafted and approved a Sustainable Urban Mobility Plan (SUMP) in 2015. The SUMP (Verkehrspolitisches Leitbild) includes fundamental measures for the next 10 to 15 years. The SUMP has its basis in the cantonal constitution and has four overriding goals:

1. Increase quality of life and liveability;
2. Further improve accessibility;
3. Increase safety and minimize risk of accidents;
4. Ensure cost-effectiveness.

Starting from these four overriding goals, seven strategic areas have been defined:

- Improve infrastructure for active travel modes
- Enlarge public transport offers, especially cross-border
- Reduce road traffic and channel it onto the highways
- Improve parking management
- Impact travel needs and patterns through mobility management
- Improve public street space and allow short paths
- Improve the sustainability of urban freight traffic

For each of these strategic areas, specific goals, strategies and measures have then been developed and documented in the SUMP. In 2018 the implemented measures have been checked for efficiency, progress has been monitored and the initial measures have been adapted and extended where necessary. At the same time, new measures and projects have been defined for the next three years.

The SUMP is therefore in different phases at the same time: measures are being implemented and monitored and new ones are being planned and elaborated while the targets are, in some cases, being adapted based on new developments and technologies.

Many positive results have already been obtained by implementing measures from the SUMP in the first three years. Some examples include the slight reduction of car traffic on urban streets in spite of the current population and economic growth in the canton Basel-Stadt, very good results in surveys concerning perceived quality of life of the inhabitants of the canton and the very high accessibility that characterizes the region, especially with public transport. A significant increase in the number of cyclists, the noticeable improvement of road safety and air quality, moreover, are further proof that the plan has been effective from the start. Furthermore, the possibility to adapt and define the specific goals every three years allows to also consider new technological developments and trends and to incorporate these in the plan of action, in order to keep up with the time. It is expected that, by continuing to follow the SUMP and implementing the measures defined in it, the targets will be met accordingly and the results will benefit not only the inhabitants of the canton Basel-Stadt but also the surrounding region and, on a bigger scale, the global climate[46].

2.4 How spatial planning transforms transport demand & How transport demand shapes spatial planning

In his book "Transportation for Livable Cities", Vukan R. Vuchic, one of the world's leading experts in urban and transport planning, cites an example of how urban transport systems were developed and adapted to a growing fleet of cars and heavy road traffic in many cities in the USA, Great Britain, France, Spain and other developed countries in the 1950s — 1970s.

"As more and more citizens refused public transport services and opted for cars, city authorities and transport administrations started having discussion on whether trams and trolleybuses had become "obsolete" and that they (as opposed to more "flexible" buses) were not capable of operating in heavy street traffic. Demands were made to "turn into asphalt" tramways segregated from roadways in order to boost the overall capacity of the total flow of vehicles.

All these measures were implemented in practice to the fullest extent: streets were enlarged, highways built, tram lines removed and parking lots were built in high numbers, especially in central city areas. This led to cars being more convenient for

[46] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.

travel and public transport - less so. Consequently, an increasing number of citizens felt incentivised to buy private cars with the frequency and range of car trips climbing as well. Growing congestion was a natural consequence of these events. Buses stuck in traffic jams together with all other cars could not present themselves as an attractive alternative to car trips.

Not only did the approach described above not solve the problem of congestion, but it also aggravated. Nowadays, it is absolutely clear that the policy of adapting cities to cars is no effective remedy for congestion, because sooner or later there will be no room for all. With mass motorisation, the failings of inadequate urban transport planning cannot be swept under the rug"[47].

Why is that the case? The analysis of the situation dominant in most cities in developed and developing countries indicates a number of causes:

1. First, in most cities, urban transport is seen as a whole neither functionally nor spatially.
2. Secondly, spatial planning often has no connection to transport planning: the impact of new developments and land - use changes on road traffic is rarely assessed.
3. Thirdly, financial resources allocated in cities for urban transport are often inadequate, erratic in nature and do not undergo strategic planning.
4. Fourthly, lack of statutory requirements or recommendations. Cities have no obligation to design strategic plans for sustainable urban transport systems or sustainable urban mobility plans and secure room for them in the urban budget.
5. Fifthly, weak institutional and technical potential in various functional areas, such as:

5.1 Traffic management in many cities is narrowly defined and poorly technically implemented: (a) There are no strategic plans with a special focus on these issues. Consequently, cities rarely take road engineering measures to improve pedestrian safety and prioritise public transport (b); Intelligent Transport Systems (ITS) lack wide implementation in traffic organisation and monitoring as well as in passenger information; (c) traffic light systems are obsolete in many cities.

5.2 Efforts aimed at investments in high-speed passenger transport systems (metro, LRT, BRT, city trains) and integration of different modes of transport (in terms of route planning, real-time passenger information, single ticket introduction, fare collection systems and timetables) need to be stepped up considerably. In some cities, the metros are very short and often poorly integrated with other modes of public transport; operating costs account for the lion's share of cities' budgets.

5.3 Management of the demand for privately owned vehicles by pursuing alternative measures (development of public transport, park and rides, carsharing,

[47] http://www.litres.ru/pages/biblio_book/?art=2874155 Vukan R. Vuchik, Transportation for Livable Cities / translated from English by A. Kalinin under scientific editorship of M. Blinkin.: Territory of the future; Moscow; 2011, ISBN 978-5-91129-058-0.

carpooling, non - motorised types of travel) along with implementing various transport policies to restrict trips by privately owned vehicles in congested parts of cities.

5.4 Tram tracks and lines being dismantled, transferred and closed, urban electric transport providers folding and going bankrupt.

6. Sixthly, the different types of urban passenger transport are poorly interconnected both with each other and with cycling and walking traffic; their potential still untapped or not capitalised upon.

7. Limited investments in innovative technologies that could improve traffic management and make travel more comfortable and safer for passengers.

Urban spatial planning is a long-term action tool with its effect likely to be felt in decades. However, "the accumulated effect of decisions made in land use now may significantly affect the transport behaviour of people for many years ahead.

Areas of mixed land use and with a well-developed network of internal streets and driveways are characterised by shorter distances and a shift in the proportion of travel to non-motorised (walking and cycling) types of travel. By contrast, separate land use and the prevalence of high-speed motorways translate into an increase in the number and length of road trips. In general, the characteristics of land use (settlement size, population density, public transport accessibility, balance between the number of places of residence and workplaces, etc.) change the average annual distance of travel of citizens by about 11% - 27%. Socio-economic and behavioural characteristics change the average annual distance of travel of citizens by about 20% - 55%[48]. In addition, public mobility correlates with the natural and climatic features of the region. On average, it is 25 - 35% higher in temperate cities[49]. It should be acknowledged that urban planning measures themselves are not very effective due to the conservativeness of human behaviour, so they must be complemented by carrot and stick measures aimed at overcoming conservativeness. However, a well-organised land-use structure is an essential element in the effective implementation of other measures targeted at discouraging excessive mobility. In view of the the close link between urban planning and mobility, much more attention should be paid, especially at the early stages, to analyses of planned activities/projects from the perspective of their potential impact on the generation of transport demand. If increasing transport demand cannot be averted, possible alternatives involving public and non - motorised transport should be examined.

The establishment of an enabling environment for a particular type of travel improves its attractiveness for potential users, thereby paving the way for the "induced transport demand" effect[50]. In other words, "demand begets supply, and

[48] Hickman, R. Planning for Sustainable Travel. Summary Guide. / R. Hickman, C. Seaborn, P. Headicar, D. Banister. – Commission for Integrated Transport. – Halcrow Group, Oxford Brookes University, University of Oxford, 2009. – URL: www.plan4 sustainabletravel.org.

[49] G.A. Mendelev Transport in urban planning: textbook / G.A. Mendelev. – M.: MADI (GTU), 2005.

[50] S.V. Shelmakov, Ekotransport (Eco-transport): textbook / S.V. Shelmakov — M.: MADI, 2018. 199 p.

supply begets demand." This effect reflects the economic law of "supply and demand balance": where the price of a commodity decreases, the demand for it increases. With extra roads constructed to prevent congestion, or with traffic management improved, people experience a change in their attitude towards using their privately-owned cars for travel which may alter their transport behaviour: they get the chance to cover longer distances or do so more often.

Induced transport demand is an extra peak transport demand derived from the expansion and improvement of road infrastructure. It is divided into "diverted trips" (shift of vehicle traffic by time and/or route) and "induced trips" (increase in average annual vehicle mileage).

Research into the transport behaviour of motorists suggests that when there is an increase in the traffic speed, it leads to extra trips rather than to saving time. Statistics indicate that as the network of high-speed roads expands, so do both the speed and length of trips therefore the time spent on daily trips remains effectively constant. As a result, traffic congestion turns into a "balancing" factor: growing traffic congestion results in restrictions on peak - hour trips. While expanding the road network initially reduces congestion, it ultimately results in induced traffic, which keeps growing until congestion increases again decelerating it. In consequence, the assumption that the combat against congestion leads to time saved for motorists is not justified. Also unjustified is the assertion that increased mobility of motorists brings them additional benefits as in the instance of induced demand, motorists chiefly take trips "out of necessity" which they would not mind avoiding. Due to the "induced transport demand" phenomenon, investments in transport infrastructure may lead to higher overall demand for travel. Enhancing the capacity of available roads or building new ones are popular ways to overpass congestion. However, experience has shown that such measures do not reduce the level of congestion in the long - term. According to European observations, "the capacity of roads enhanced by 30 - 80% is cancelled out by increasing demand within five years." Data from the United States indicate that "a 10% increase in the length of one motorway lane immediately increases the average annual mileage of cars by 4% with this value climbing to 10 percent within the next few years.[51]" Thus, within in a few years, induced transport demand virtually offsets the effect of expanding transport infrastructure. In the majority of cases, expanding the road network diminishes its overall efficiency while driving up the "external" transport costs and contributing to the car dependency of the population. On the contrary, the deployment of a public passenger transport system (PPT) is gradually gaining in efficiency by attracting more users[52].

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[51] Salzman, R. Build More Highways, Get More Traffic // The Daily Progress, December 19, 2010.

[52] Litman T. Generated Traffic and Induced Travel. Implications for Transport Planning / T. Litman. – ITE Journal, Vol. 71, No. 4, Institute of Transportation Engineers, April 2001, pp. 38 - 47. – URL: http://www.vtpi.org/gentraf.pdf.

In this regard, measures to contain "hypermobility" should therefore be taken; these covering a wide range of administrative, economic and information measures directed, in the first instance, at minimising the negative effects of "hypermotorisation". When implemented together with spatial planning measures, they help to maximise the potential of both, i.e. thus producing a synergistic effect. For example, some experts estimate the "climate" potential of measures to contain hypermobility at 20 - 30%[53]. All measures to contain "hypermobility" can be classified in the following way:

(a) Organisational: • restriction of vehicle ownership; • restriction of access for vehicles to a certain area; • design of transport plans (for enterprises, schools, residential areas and regions), as well as personal transport planning; • home-based work; •online commerce with home delivery; •information and marketing campaigns.

b) economic: •rising the cost of vehicle ownership;• rising the cost of vehicle use; •parking fees. c) infrastructure-related •optimization of the transport information network; •redistribution of street space for the benefit of pedestrians, cyclists and public transport, •"calming" traffic; restriction of parking spaces;• landscape street design.

The list of transport policies aimed at improving traffic conditions and preventing chronic congestion on the road network always goes hand in hand with demand constraints and, therefore, should incorporate:

• use of modern traffic management techniques to make the most effective use of the available resources of the street and road network;

• reconstruction of intersections in one level, which are bottlenecks in terms of the capacity of the street and road network as a whole;

• organisation of one-way traffic on all sections of the network which will enhance the capacity;

• introduction of strict parking rules, especially in the streets, where parked cars result in a deterioration of their capacity;

• placing public transport at an advantage in traffic, including by virtue of allocating designated lanes and ensuring a priority green phase at crossings in one level;

• introduction of hourly parking fees with fees significantly higher for long parking hours, especially in the city centre;

• implementation of regulations to encourage car owners to acquire a parking spot at their place of residence;

• introduction of speed and through-traffic restrictions in the streets in residential areas;

• introduction of shared use and speed-limited traffic;

[53] International Transport Forum Leipzig 2008. Transport and Energy: The Challenge of Climate Change. Research Findings.

• introduction of fees for using certain sections of the street and road network. For instance, a fee to drive into the city centre.

In Basel (Switzerland) forecast for urban public transport demand is made with a high resolution multi modal transportation model, which considers public transport, motorized individual transport, bicycle and pedestrians as well. Park & Ride and Bike & Ride are also displayed in the model. The model perimeter includes the swiss, german and french part of the basle metropolitan area[54].

In the Republic of Belarus, measures taken to regulate transport demand include the development of a park-and-ride network where a car is left in a parking lot with the owner transferring to public transport. In Minsk, there are currently two such parking lots with a capacity to accommodate 100 vehicles and 60 vehicles respectively. There are four ways to pay the parking fee: via the parking card, by sending a text message message or ussd i.e. a request to a common short number, through a parking metre or a payment terminal, as well as via mobile or Internet banking (United Payment and Information Space)[55].

Figure 2.11. A park-and-ride on Radialnaya Street in Minsk (Republic of Belarus)

[54] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.
[55] Based on the answers given by the Republic of Belarus to the UNECE questionnaire.

2.4.1 Case studies and good practices

Kazan (Russia):

By way of curbing congestion in the city, Kazan pursues measures to optimise traffic (traffic signalisation, re-marking roadways), demand-side management of trips by private motorised transport (paid parking, calm traffic zones), the redistribution of the traffic flows (one-way traffic) and the creation of new transport links (construction of new roads, overpasses, junctions).

The shaping of a sustainable urban transport system in Kazan rests on the following key principles:

1. Safety of passengers on the general-use public urban passenger transport routes;
2. Ensuring equal access to transport services for all areas and social groups of people;
3. Ensuring comfort for passengers using public urban passenger transport;
4. Ensuring the accessibility of public urban passenger transport for persons with reduced mobility;
5. Prioritising urban passenger transport over private vehicles;
6. Optimal combination of different types of public passenger transport;
7. Reducing time spent on passenger traffic;

8. Reducing economic costs associated with the maintenance of public urban passenger transport;

9. Curbing emissions of greenhouse gases and pollutants that come from the use of vehicles;

10. Streamlining the route network with its coverage area extended[56].

Fig. 2.12. Kazan (Russia)

Tyumen (Russia):

The city administration of the city of Tyumen approved a transport infrastructure integrated development programme for Tyumen for the period 2018 - 2040. Pursuant to the programme, the planned spatial development of the city is aimed at the intensive transformation of the urban environment, the consolidation of available buildings, the establishment of sustainable linkages between the existing network of streets and the emerging ring system of high-speed traffic arteries.

The planning structure of Tyumen builds upon natural and anthropogenic frameworks. The natural framework of the city rests upon the bed of the Tura River

[56] Based on the answers given by Kazan (Russia) to the UNECE questionnaire.

and a range of green areas made up by parks, squares, boulevards. The master plan of the city district of Tyumen involves the preservation of these areas with a focus on developing their recreational function.

The anthropogenic framework of the city of Tyumen covers the main lines of engineering infrastructure networks and roads that ensure internal and external transport links.

The resolutions set forth in the Master Plan of the city district of Tyumen provide for a functional saturation of the public city centre; strengthening its representational and socio-cultural functions. It is this part of the city of Tyumen that is undergoing the most intense reconstruction and re-development achieved through residential districts becoming denser, greening and improvements taking place, multi-level outdoor parking space and pedestrian streets being put in place and multifunctional complexes being constructed.

A planned increase in the density of buildings invariably gives rise to the need to change the properties and the capacity of motorways. Given the current structure of urban streets, it is only possible to ensure a projected increase in transport correspondence provided that the private vehicle usage rate is reduced in favour of public municipal passenger transport, walking and cycling[57].

Fig. 2.13. Tyumen (Russia)

[57] Based on the answers given by Tyumen (Russia) to the UNECE questionnaire.

Fig. 2.14. Tyumen (Russia)

Moscow (Russia):

In 2011, Moscow City Hall drafted and implemented a strategy for the development of Moscow transport until 2020 in cooperation with the academic and expert community and by relying on the best world practices in the field of transport and road transport infrastructure and by assessing in advance the extent of their applicability to Moscow.

Moscow transport system: areas of development

Improved convenience:

- Modern rolling stock;
- Passenger information system;
- Intermodal ticket and tariff solutions;
- Increased capacity of urban transport;
- Infrastructure for citizens with reduced mobility;
- "My street", a programme for reconstruction and improvement of the street and road network, etc.

Increased availability:

- Extension and integration of the metro, Moscow Central Circle and suburban railway lines;
- Development of city taxi and short-term car rental;
- Construction of new and rehabilitation of previously dismantled tram lines;
- Construction of Park-and-Rides to serve as transport hubs;
- Organisation of a single parking system;
- Construction of new roads and road junctions;
- Development of the urban transport network of routes;
- Development of alternative modes of transport, etc.

Increased speed:

- Construction of new metro lines coupled with the Moscow Central Circle and suburban railway lines;
- Introduction of dedicated lines for urban transport;
- Separate tram lines;
- Optimised timetables and reduced waiting time achieved through shorter intervals introduced for urban public transport;
- Integration of the Intelligent Transport System (ITS) and the Integrated Road Traffic Management Scheme (KSODD), etc.

The route network of Moscow responds flexibly to shifts in transport demand. State Institution (GBU) "MosTransProject" is the organisation in charge of determining whether routes should be altered and the financial and operational indicators of operating routes re-calculated. Whenever required, changes into the route network are introduced in the shortest time possible with the necessary time taken to properly inform the public.

Demand forecasting is carried out by macromodelling. In the process, the transport model used includes information on the entire road infrastructure: roads, marking, public transport routes, which helps determine the capacity and congestion of roads, the route network efficiency, as well as predict the behaviour of the transport system in a given scenario.

In essence, this model is a platform for experiments to be conducted upon, which helps foresee the effects of any innovation. As for Moscow, this transport model was created in 2012 and went on to become the key tool used for decision-making, for instance, when planning routes, overlaps, setting up traffic lights and other acivities[58].

Figure 2.15. Dedicated lanes for public transport in Moscow (Russia)

Kazan (Russia):

The current Code of Rules SP 42.13330.2016 “Urban development. Urban and rural planning and development” serves as the mechanism that links transport planning and urban planning. It is aimed at providing urban planning means to ensure security and sustainability in the development of municipalities, local design

[58] According to the response of Moscow (Russia) to the UNECE questionnaire.

requirements for urban development and cohesion for strategic planning documents. The Master Plan of Kazan acts as a document of strategic planning which determines the direction to be taken in urban development. It is comprised of units of urban prospective development, transport system prospective development and indicators of promising socio-economic development. Besides, the development of urban transport systems is incorporated into transport planning documents; the programme for integrated development of transport systems and the road traffic management integrated scheme serving as these planning documents. Urban planning and transport policies are interlinked while transport planning documents are in the pipeline. That helps track the transport accessibility of new districts while also preventing any shortage in transport services.

The use of public transport in Kazan is incentivised in two key areas: direct incentives to promote the use of public transport (establishing enabling conditions for fast, comfortable and safe traffic by dedicated lanes, ensured priority of travel, easy transfers, single tickets sold for all types of transport) and discouragement of private vehicle trips (introduction of speed limits as well tolled parking space).

Demand for urban passenger transport services in Kazan is forecast through a software system that is based on PTV mathematical transport modelling by using data obtained through sociological surveys and surveys of traffic conditions. Now, an up-to-date and relevant transport model has been developed for the Kazan agglomeration.

In order to manage transport demand within the city, Kazan utilises advanced domestic and foreign practices, including a single parking space (including tolled parking space), efforts to develop the network and improve the quality of public transport service. In the short term, calmed traffic areas will be introduced. Examples of these measures are given in the Integrated Road Traffic Management Scheme and the Integrated Transport Scheme until 2033[59].

Fig. 2.16. Kazan (Russia)

[59] Based on the answers given by Kazan (Russia) to the UNECE questionnaire.

Basel (Switzerland):

The inner city in Basel (Switzerland) does not offer good conditions for public transport, due to its spatial structure and topography. Public transport uses primarily the axes at the border of the inner city or corridors that were broadened during the 50s and the 60s, as part of an intervention program to meet the growing mobility demand. Some of these interventions did not take into account the historical context. Public transport must make compromises and concessions about the historical context. That means it is not always possible to comply with the normal standards like in other city parts (curve radii, space availability at stops and network density). This can be seen in the following examples of tram tracks (next to the Main Post Office, Spalentor)[60].

https://www.espazium.ch/glueckliche-synergie

[60] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.

https://www.tripadvisor.de/LocationPhotoDirectLink-g188049-d483141-i102160376-Hotel_Spalentor_Basel-Basel.html

Strasbourg (France):

Adapting the Urban Transport Plan in Strasbourg (France): a review of the 5 year Strasbourg's Urban Transport Plan was conducted in a participatory manner which brought together key players. Twelve workshops were set up, three of which were integrated into the "travel and public health" themed group, which was chaired by the city councillor in charge of health. These workshops focused on the promotion of active modes of travel, transport and pollution, and travel for people with reduced mobility.

The Strasbourg Urban Transport Plan aims to increase physical activity by encouraging promoting active mobility through:

- improving the communication of travel times on foot and by bike;
- implementing multimodal exchange centres favouring the use of modes of transport other than private cars;
- implementing a pedestrian plan in Strasbourg;
- building new, and improving existing, cycle paths;
- increasing awareness of the health benefits of active mobility[61].

Figure 2.17. Strasbourg (France)

[61] Based on the answers given by Strasbourg (France) to the UNECE questionnaire.

Figure 2.18. Strasbourg (France)

Since 2018 the transport department of Tbilisi City Hall has been participating in the urban planning process at the municipal level, guided by the relevant resolutions regarding the city planning and construction regulation. In the case of constructions or the change in the functional zone and etc., the transport impact assessment is prepared. Additionally, approving a Land use masterplan is soon to be expected. The masterplan deals with the issues of land use and the politics of city planning – factors that will facilitate the development of effective and sustainable mobility and, more generally, the compact city in order to reduce the dependency on the private cars and avoid urban sprawl[62].

The Green Mobility initiative, supported between 2013-2017 by the Nordic Council of Ministers (Copenhagen) which is being carried into effect by ICSER "Leontief Centre" (based in St. Petersburg) represents a unique strategic platform which pursues the goal of developing sustainable mobility in Russian cities and regions by relying on the best international and Russian practices in delivering effective transport policies and sustainable development of transport systems. The partnership network encompassed by the Initiative involves more than 150 Russian and international experts on sustainable territorial development. The Green Mobility Award Ceremony is held annually to highlight the best examples of sustainable mobility development in Russia and abroad. The award goes annually to cities where innovative projects and strategies aimed at the development of transport sustainable modes are put into action, the mobility of all citizens is being enhanced, greenhouse gases and pollutants in the atmosphere are dwindling with safety improving and an accessible environment for pedestrians and cyclists is being established.

Aarhus (Denmark):

With a population of 340,000 (2018), the city of Aarhus on the northeast coast is Denmark's second-largest city and the fastest growing in the country. It is estimated that, over the next 15 years, the city should grow by 50,000 inhabitants and 30,000 work and study places. At the same time, Aarhus should be CO2-neutral by 2030. All in all, this places heavy demands on the ambitious urban development in which the Department of Urban Development and Mobility plays a central role.

Like other large European cities, Aarhus is seeing a restructuring period. Run-down industrial estates are disappearing to be replaced by housing and knowledge-intensive businesses. A number of areas in Aarhus are currently undergoing major changes: large parts of the port area are being converted into residential, knowledge-based business, cultural and educational buildings. The disused rail freight terminal will in future house Aarhus School of Architecture and other educational institutions together with youth-/student housing. Today Godsbanen is the driver of the area, a

[62] Based on the answers given by Georgia to the UNECE questionnaire.

cultural production centre, including performing arts, visual arts and literature, focusing on youth culture.

Aarhus has the lowest average age of the country and does its best to keep youth from moving to Copenhagen. Aarhus believes culture can change the world and the status of the European Capital of Culture 2017 proves it. Aarhus has been preparing to it for at least 25 years. Investing in the university with its 60 thousand students makes Aarhus the youngest city in Denmark, and as a result of investments in social architecture (restructuring the port area and creating social centers like Godsbanen where all they can create, meet, design), in music and theater (the Musikhuset was built in the 80s and enlarged in 2007), more and more people choose Aarhus as a place to live for its cultural life.

Changing from a major town to the city causes mobility challenges. It gets cheaper to drive a car, and if there are no changes to the mobility patterns 20 000 cars will have been added by 2030. This is a challenge, since the road network at certain times of the day already suffers from congestion. Add weak public transport and parking problems in the inner city.

To prevent the consequences and solve the challenges, the City of Aarhus has developed a policy vision focused on growth, livability, health, sustainability, densification. Here are policy's goals and initiatives:

Goals:

- No growth in car traffic over the inner Ring;
- Traffic growth as biking, walking and public transport;
- Increase travel speed for bicycles;
- A greener and more livable city.

Main initiatives:

- A road network leading to central parking facilities;
- Improve conditions for active and public modes;
- Peaceful residential areas;
- Parking policy;
- Easier shift between modes – a mobility system;
- Flexible streets.

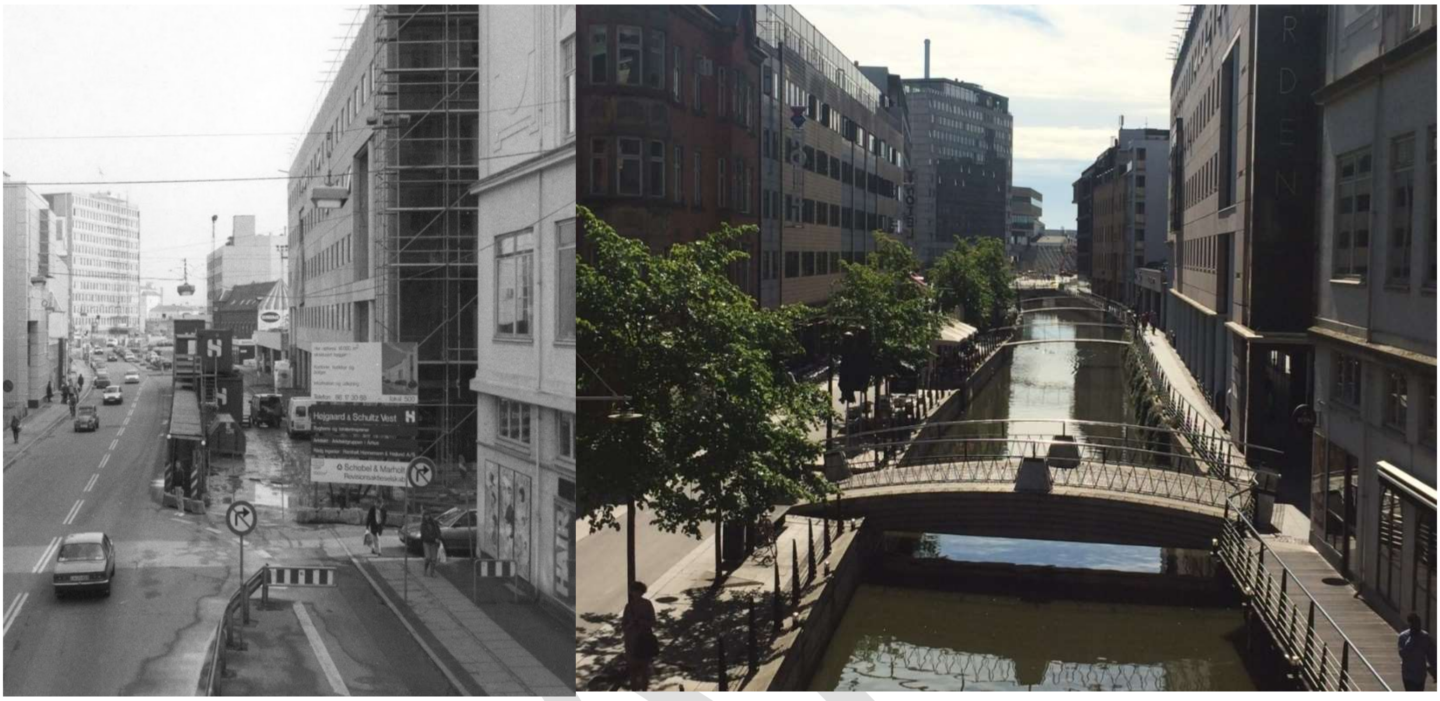
In the Municipal Development Strategy (2016), Smart Growth has high priority. Following the strategy, the city should grow denser in the future, moving travel destinations closer to each other and making the public transport system more efficient. The smart choice of mobility is an important part of the Municipal Development Strategy, supported by infrastructure projects, such as the almost completed light rail and super commuter bike paths. The transition to more public transport is one of the preconditions for reaching the ambitious climate goals.

The new Downtown Mobility Plan (2017) for the City of Aarhus replaced the existing Downtown Traffic Plan from 2005. The main objective of the existing traffic plan has been to rearrange the hierarchy of roadways. This was done to redirect much of the traffic going through the downtown area out on the surrounding ring roads in order to connect the city better with its redeveloping waterfront. The main objective of the Downtown Mobility Plan is to build on this hierarchy to accommodate a denser and more liveable downtown area. This means a more space-efficient mobility system, where rising mobility needs are primarily to be met though a focus on active and public travel modes as well as reduced commuting distances.

The Downtown Mobility Plan is intended to convert surface parking and road space to squares or green spaces where possible. To reach that goal the City of Aarhus employs a variety of soft and hard measures that can be crudely split into three categories. First, access to the strategic road network will be removed for selected residential streets while existing bidirectional streets are converted to one-way streets with a single lane. This will improve traffic flows on the strategic network and encourage local residents to consider alternatives to the car. Meanwhile, the leftover road space can be used for cycle lanes, bus priority lanes, wider sidewalks or green spaces. Second, local businesses, citizens and interest groups in busy downtown areas will get the option of using on-street parking for non-parking purposes at selected times such as during summer, on weekends or after office hours. This will favour active and public travel modes to these destinations due as well as allow more outdoor seating or green spaces through parklets or other temporary installations. Third, the existing parking restrictions for the city core will be expanded to cover the entire downtown area as well as the surrounding neighbourhoods. Since visitors will have to pay for parking, this will free up more on-street parking spaces for residents while making active and public travel options a more sensible option for long-distance commuters. Furthermore, the parking revenues can be used to construct underground parking facilities that will further free up surface area for a more liveable public realm[63].

[63] По данным Инициативы «Green Mobility», поддерживаемой с 2013-2017 Советом Министров Северных стран (Копенгаген) и реализуемой МЦСЭИ «Леонтьевский центр» (Санкт-Петербург), www.mobility.leontief-centre.ru.

Figure. 2.19. A long history of developing a liveable city of Aarhus (Denmark)



Sustainable mobility in Skolkovo (Moscow, Russia):

Skolkovo is much more than just a science city or a tech park as it represents a full-fledged city with colourful architecture and unique opportunities for engagement, a city which incarnates advanced solutions targeted at establishing an attractive urban environment, one comfortable for visitors and citizens to the fullest extent. Skolkovo has a population of 19,500 people (2017).

The concept of Skolkovo incorporates the dreams of an architect, an ecologist and a futurist engineer all at the same time featuring ingenious architectural solutions and electric transport which embody of the vision of a city of the future. Urban development innovations designed and fulfilled here are free to be adopted by any municipality in the world.

The principles of sustainable mobility lie at the heart of trasport management infrastructure in Skolkovo. Pursuant to the Transport Strategy of the Skolkovo Innovation Centre, only electric cars have clearance to drive into the city while ride-and-park parking lots, much like a membrane, limit entry to those visitors who arrive in private cars propelled by internal combustion engines. Special emphasis is placed on the development of unmanned vehicles; the city having a special track intended for testing out innovative vehicles.

Transport priority system in Skolkovo

1. Pedestrians

2. Cyclists

3. Public transport

4. Private vehicles (electric vehicles)

The Skolkovo transport system is oriented on pedestrians, cyclists and electric modes of transport. These are no empty statements as the city is vigorously expanding its infrastructure to accommodate sustainable modes of transport. The first electric buses were put into trial operation in the city back in 2016. The city is developing short electric bus routes useful for putting new models to the test. In June 2017, an ultra-fast charging station was launched.

Infrastructure for sustainable transport modes in Skolkovo:

• Separate cycling paths - 50 km
• Urban bike rental service - 8 stations
• Scooter rental service - 12 stations
• Electric vehicle charging stations - 29 stations

The city intends to have all "last mile" transport vehicles transition to electric traction by launching rental services of e-bikes, e-scooters and e-vehicle carsharing.

Skolkovo's experience is unique. There is no city in Russia that has thus far abandoned private motor vehicles in favour of eco-friendly transport modes in so resolute a manner nor has any Russian managed to plan out a transport system predicated so competently on the principles of sustainable mobility. Skolkovo is indeed a city of the future, whose transport solutions should be studied by other Russian cities.

Figure 2.20. Sustainable mobility in Skolkovo (Moscow, Russia)

2.5 Urban traffic management — How to prevent congestion?

2.5.1 Passenger traffic

Growing urban population leads to an obvious increase in the demand for urban routes while their extensive development no longer meets all the mobility needs of society and economy.

B. Vuchic in his book "Transportation for Livable Cities" proves that: "A city on the needle of total automotive dependence becomes dysfunctional, inefficient and inconvenient for life. The goal of the transport system is to move people, not vehicles."

There came a need for a clear distinction between "car ownership" and "car use" in terms of our understanding of and the functional content of these concepts.

Tackling these issues takes a close interconnection between decisions taken in the field of urban planning, road construction, public transport infrastructure development, road traffic management and information support for transport. However, it is important to be mindful of the need to take into account the environmental and social factors of decision-making.

Janette Sadik-Khan and Seth Solomonow in the book "Streetfight: Handbook for an Urban Revolution " say: "For many years, a great deal of big cities have demonstrated two counterproductive tendencies that hamper cities in their development. The first is the excessive love that mayors have for mega-projects — the construction of bridges, flyovers, junctions, and other large facilities. The second tendency comes down to ordinary citizens seeking, as is their wont, to stave off change in their usual habitats. Unfortunately, this conservatism often results in local citizens not only speaking out against projects that destroy their neighbourhoods, but also virtually any changes in the urban environment. Both trends have a negative impact on cities. There is insufficient knowledge among both sides as to how streets can support the lives of citizens, boost the potential of individual neighbourhoods and the urban economy as a whole. Cities' authorities and citizens speak different languages, so looking at transport and urban development issues from a fresh perspective is of vital importance[64].”

Studies of urban transport systems substantially differ in both approaches and conclusions. Still, all researchers concur that with the use of private vehicles growing in an unrestrained manner, traditional and well-established cities cease to be comfortable for life, i.e., they all recognise collision that occurs between cars and cities as an objective reality.

The objective reasons behind the deteriorating situation with road traffic in cities are:

• growing public motorisation;

• use of private vehicles climbing in intensity;

• decreased proportion of public transport in passenger traffic;

• growing demand for movement among urban dwellers;

• disproportion between the level of motorisation and the pace of road construction;

• a number of objective urban planning problems related to urban spatial development inherited from the past[65].

Why do citizens choose private cars?

- The private car grants accessibility in the absence of other alternatives, but besides that, there are other reasons such as:
- Speed and time of travel;
- A symbol of well-being which highlights one's “status” in society (a mind-set that has developed in societies);
- Door - to - door means of transport;
- Comfortable trip (“home on wheels”);
- A way to be autonomous and isolated from traffic and other traffic users;
- A way to transport one's family and luggage;

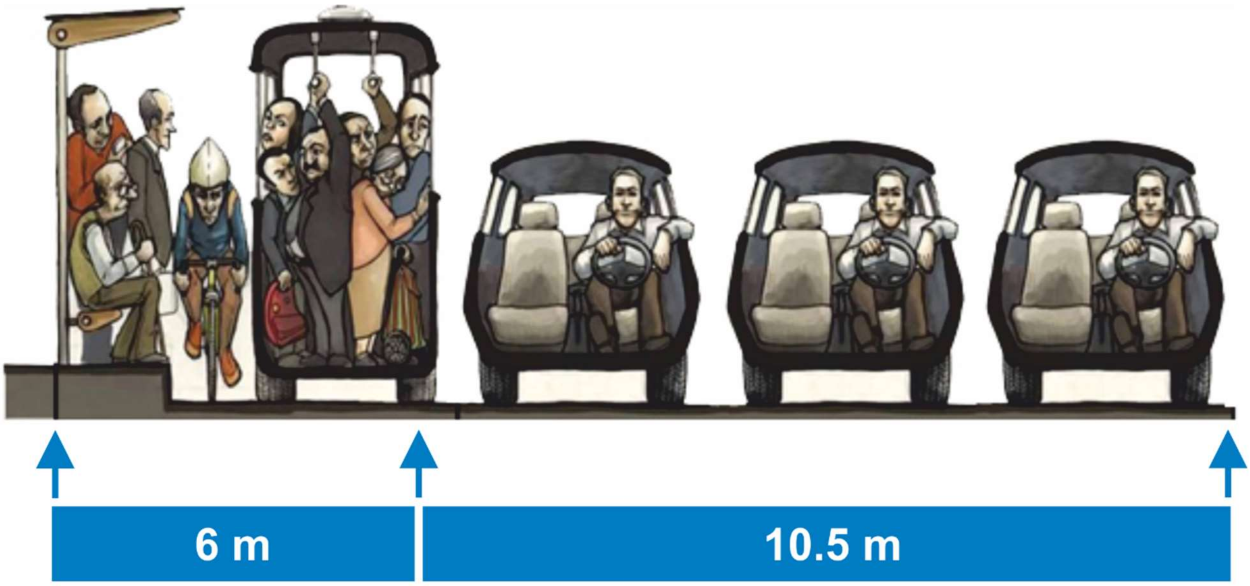
[64] Janette Sadik-Khan, Seth Solomonow, Streetfight: Handbook for an Urban Revolution " Olimp-Business, 2017.

[65] Transportnoye planirovaniye: formirovaniye effektivnykh transportnykh sistem krupnykh gorodov (Transport planning: establishment of efficient transport systems in major cities) monograph / Y.V. Trofimenko, M.R. Yakimov. — M.: Logos, 2013. 26 p.

- A way to experience the pleasure of driving, a sense of "freedom".

The desired transport mode is selected in large part depending on the travel conditions.

Figure 2.21. Distribution of street space between traffic users



The experience of many countries that has accumulated in recent decades suggests that transport-related challenges, especially in medium and large cities, can only be solved through a systematic approach, one that entails:

- profound knowledge of the characteristics and effects of different modes of transport on the urban environment;
- viewing transport as a functional system comprised of 66 different elements integrated for optimal use;
- concerted efforts to strike a balance between the behaviour of individuals and transport system efficiency as a whole and, to ultimately render the entire agglomeration efficient;
- the short-term and long-term roles of different modes of transport coupled with their impact on the natural and traditional urban environment must be factored in;
- all aspects of social justice must be taken into account: the transport system should provide a reasonable level of mobility for the entire population;
- use of modes of transport that can contribute to the creation of a humanitarian-oriented urban environment;

• a phased plan must be drafted to implement activities aimed at creating a liveable city[66].

Specific measures of sound transport policy can and should have an effect on the transport behaviour of citizens by shifting the “point of balance of individual preferences towards social optimum.”

Priority passage is at the top of the list of these measures which is implemented through dedicated lanes, priority traffic light cycle phases at signalled crossings, accessibility to areas in the city which are off limits for private vehicle traffic, etc. Terminology of V. Vuchic refers to it as high-level Right-of-Way; this category including a variety of engineering and organisational measures in place to ensure a predominant position of public transport in urban space thus helping to increase the speed, regularity and improve the comfort of public transport trips which makes public transport more attractive to all citizens, including motorists. The tools used to sway the “point of balance of individual preferences in favour of social optimum” also encompass fiscal and organisational measures that make daily car trips to the city centre more expensive and inconvenient. What also merits mention is "Internalization of externalities", another idea put forward by Vukan R. Vuchic. Translated from academic language, it means bringing user costs on urban road trips into line with the full amount of actual buildings, including social and environmental ones.[67]

Principle No. 1. A pedestrian is more important than a car. A cyclist is more important than a car. A shuttle bus or tram is more important than a car. All motorists are equal. A car on the move is more important than a parked car as the former is engaged in a useful transport activity and the latter is not.

Principle No. 2. The only part of urban space where a motorist is not a depressed road user and where he or she sees no pedestrians, cyclists or public transport stations is a network of urban highways. There is no advanced metropolis in the world where the road network is functionally stratified in a clear way. The first basic contour is the streets. The pedestrian takes precedence on the streets whereas the car traffic speed is strictly limited and traffic lights are installed. The second contour is highways; motorists being their exclusive users. Speeds are high; junctions are few and far between and well-equipped; no pedestrians and traffic lights.

Principle No. 3. Each section of urban space, that is streets, passages, sidewalks, yards, has its owner. Parking unauthorised by the owner of the space is deemed an offense. Paid parking is a tool used to limit excess transport demand where it is

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[66] Vukan R. Vuchik, Transportation for Livable Cities / translated from English by A. Kalinin under scientific editorship of M. Blinkin.: The Territory of the Future, 2011.

[67] http://www.litres.ru/pages/biblio_book/?art=2874155 Vukan R. Vuchik, Transportation for Livable Cities / translated from English by A. Kalinin under scientific editorship of M. Blinkin.: Territory of the future; Moscow; 2011, ISBN 978-5-91129-058-0.

impossible to put a constraint on it in another way. The capacity of parking spaces must be in line with the density of the built-up area[68].

The principles listed above lead to the following common practices:

Moving around on foot is always convenient in a liveable city: multiple and extensive pedestrian areas can be comfortably reached by metro, tram, bicycle or taxi but cars are banned from them.

In planning a new construction or the reconstruction of a building, a neighbourhood or a residential area, a developer is meticulous to provide parking space for new residents and provide easy access to and from their houses and neighbourhoods for them.

In city centres, cars are banned from parking on the motorway only allowed to stop to drop off passengers. Parking on sidewalks is limited by engineering means or administrative prohibitions. The idea is to impress on people that: It is difficult and expensive to park your car in the city centre; therefore you need to use public transport or taxi to get there.

The city authorities, when sanctioning new construction works, must ensure that this new (reconstructed) site will not hinder the traffic conditions in the vicinity. Also when the city authorities are in the process of approving a new traffic and parking space management policy, they must check whether these innovations are likely interfere with passenger correspondence as well as the cultural and historical identity and environment in the city.

Figure 2.22. Solutions to road network congestion

[68] http://www.litres.ru/pages/biblio_book/?art=2874155 Vukan R. Vuchik, Transportation for Livable Cities / translated from English by A. Kalinin under scientific editorship of M. Blinkin.: Territory of the future; Moscow; 2011, ISBN 978-5-91129-058-0.

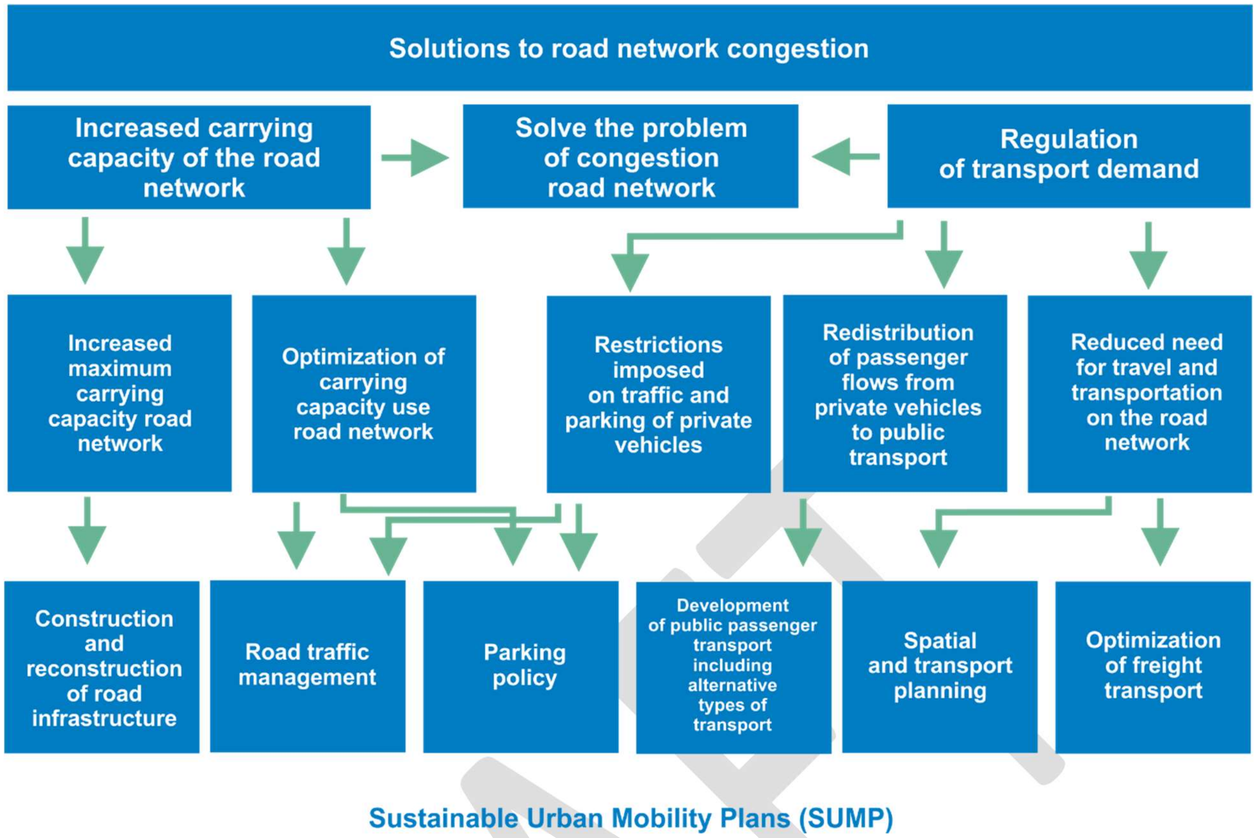
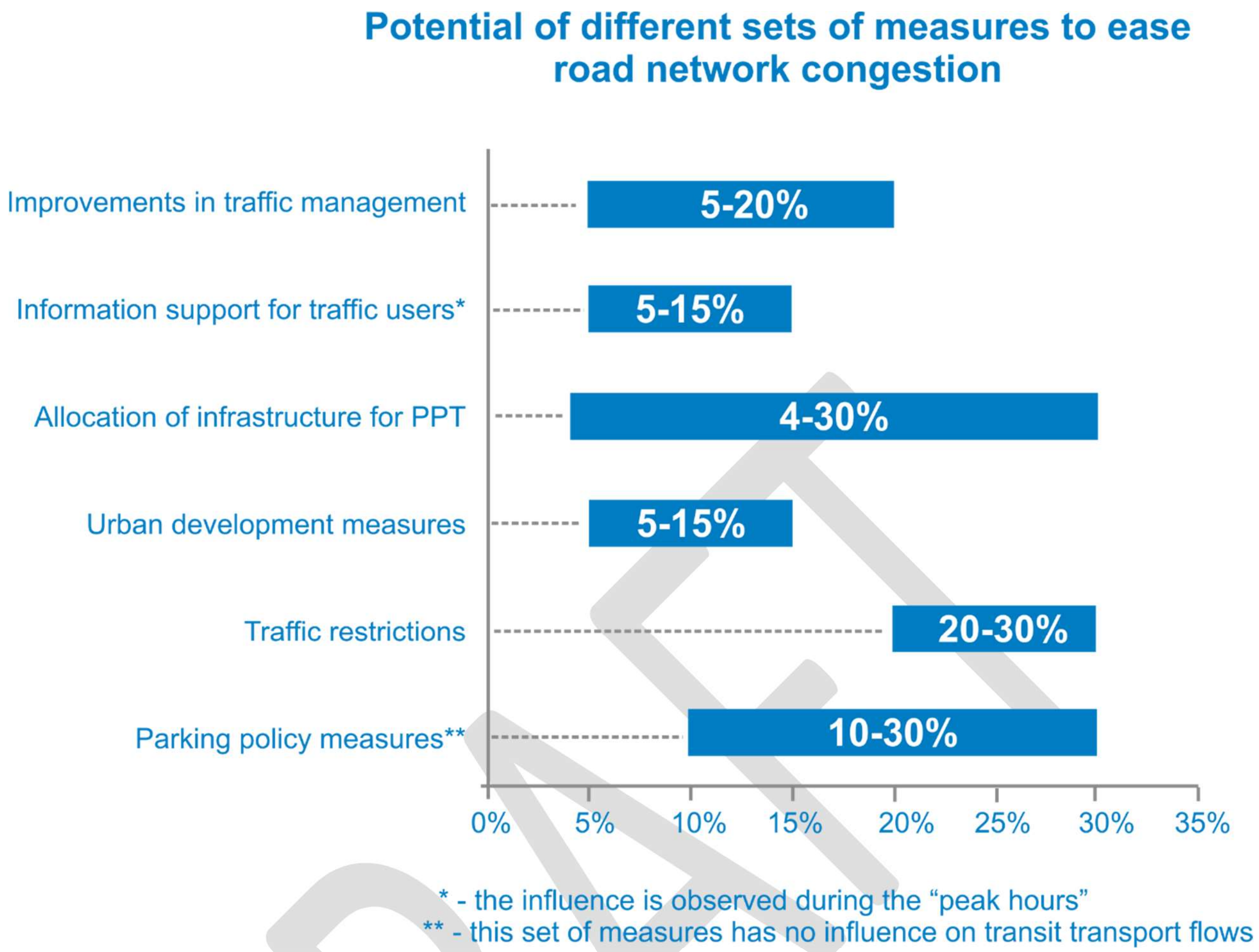


Figure 2.23. Potential of different sets of measures to ease road network congestion



2.5.2 Urban freight traffic and city logistics

Urban logistics should be seen as the practical organisation of the operation process of flows of materials, vehicles, people, energy, finances and information, as well as the management of (social, production, transport and logistics) infrastructure within the city agglomeration in the context of growing commodity exchange of economic entities. Infrastructure development is directly dependent on the efficiency of urban management through logistics principles, which implies meeting the needs of urban dwellers, rational management of material and social flows in time and space and ensuring maximum orientation of all production and economic activities of enterprises to meet the needs of the population[69].

In this regard, the integration of a city into a single tightly interconnected system of urban logistics facilities becomes possible by the following practical measures:

• the plans of various urban services must be harmonised in carrying out works which affect the capacity of highways and that capacity of parking lots;

• public transport locations (trade and office centres, companies and warehouses, educational and children's establishments) must be arranged in such a way as to take

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[69] Gubenko V.K., Lyamzin A.A. Gorodskaya logistika (City Logistics) // Herald of the Priazov State Technical University. — 2009. — No. 19 http://www.nbuv. gov.ua/portal/Natural/VPDTU/2009_19/%D0%A1/62.pdf.

into account the logistic load of a particular area, flows of people and transport being different when a facility is open from when it is under construction;

• reducing the traffic of large vehicles around the city;

• the transport infrastructure must be planned taking into account the length of the various sections of the highways and their interconnection;

• divergent traffic flows must be arranged at different levels;

• expenses related to production and sale of finished products and services to the population must be optimised; the burden on the urban environment must be relieved;

• ensuring that municipal and city administrations provide unified management of procurement and supply for urban facilities, municipal facilities and institutions[70].

The challenges associated with the management of the transport and logistics system are largely common in large cities and megacities, which is only natural given the large population and high concentration of vehicles.

When designing specific methods to organise these processes, two large-scale objects to be managed, freight and passenger transport, that form an integral part of urban logistics, must be taken into account. Both of them generate a flow of transport, ultimately functioning in a single system; each having characteristics of its own.

The fundamental differences between freight and passenger transport are that they are oriented at different user groups. Freight transport deals with is business and population as end users of goods and services while passenger transport targets with users of public transport and car owners. Unlike freight transportation, passenger transportation has a clear social orientation.

Despite freight transportation making up 10-15% of overall transportation activities, it handles all necessary deliveries within the city, such as: delivery of goods to retail outlets and retail chains; supply of short-lived commodities to restaurants, cafes, markets; home-delivery of goods; supply of building materials; garbage and waste collection (a kind of reverse logistics)[71].

Given the large scale of distribution of goods flows, cities are faced with the challenge of managing them properly. Developing measures to optimise goods delivery needs to factor in not only uninterrupted traffic and timely delivery of goods to destinations, but also the environmental impact as well as the image of the city.

Trucks have a major impact on global warming. While only accounting for 5% of the vehicles on the road in the European Union, they are responsible for 22% of road transport CO_2 emissions and this is only expected to grow. Road freight transport is projected to increase by 56% between 2010 and 2050. At the same time 4,000 EU citizens die in truck accidents year after year.

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[70] Filimonov V. Gorodskaya/munitsipal'naya logistika (City/municipal logistics) http://www.fill2001.narod.ru/GorodskayaLog.htm.

[71] Rodrigue J.-P., Dablanc L. City Logistics, http://people.hofstra.edu/geotrans/eng/ch6en/appl6en/ch6a2en.html.

Figure 2.24. Key statistics - trucks, buses and coaches[72]

EU total road transport emissions	Heavy duty vehicles (trucks, buses and coaches) are responsible for 27% of road transport emissions
EU total emissions	Ca. 6% of EU total greenhouse gas emissions
Increase of emissions since 1990	HDV emissions have increased by 25% from 1990
Projected increase	Without action, emissions are projected to increase by 9% between 2010 - 2030
Lorry fuel economy improvement since the 1990s	Over the last 15 years, fuel economy of average trucks has not improved
Potential to make trucks more fuel efficient	Compared to 2015, diesel trucks can become 43% more fuel efficient by 2030 by applying a wide range of vehicle technologies
EU policies to decarbonize trucks	In May 2018, the European Commission made a proposal for the first ever European fuel efficiency standards for trucks
Air pollution cost of trucks	45 billion euros in increased health costs according to the European Environment Agency
European oil imports for trucks	500 million barrels of oil, at a cost of around €60 billion
The real cost of trucks	Only 30% of the societal costs of HGVs (pollution, noise, infrastructure) are covered by revenues from taxes and charges
Natural gas trucks	Trucks powered by LNG do not have appreciable climate benefits.
Road freight can be decarbonised	T&E study shows how to decarbonise heavy duty vehicles by 2050, necessary for the EU's Paris Agreement commitments
Electric trucks are not science fiction	Battery electric trucks are better for the environment and are technically and economically viable

[72] https://www.transportenvironment.org/what-we-do/cleaner-safer-trucks, Transport & Environment, Brussels, Belgium, 2018.

How much do trucks transport?	75% of all goods carried over land in Europe, 1 831 billion tonne-km in 2016
Importance of EU truck makers	EU truck makers are responsible for ca. 40% of global truck production
How much congestion do trucks cause?	20% of road congestion costs in the EU are caused by trucks, despite representing just 3% of road vehicles
Road safety impact of trucks	With 3% of vehicles, trucks kill ca. 4200 people every year, around 15% of total EU fatalities

The need to rethink and rationalize urban logistics is being pushed on the front scene by the boom of the number of transportations (exacerbated by the online shopping growth) as well as the growing sensitivity by the general public of the negative environmental and societal impact of fuel driven deliveries in saturated urban centres.

However urban logistics is a difficult issue to apprehend as it encompasses several levels of complexity: next to the heterogeneity of the goods transported and of the leans of transportation, urban logistics encompasses a multiplicity of stakeholders (public transport authorities and other local authorities, transportation companies, shippers), each of which may have diverging interests and most of which will – in most cases – lack a shared understanding of the status quo, the priorities and the most appropriate action levers. While local authorities will be interested by opportunities to reduce congestion, pollution and noise, transportation companies – even if willing to contribute to urban mobility objectives, thereby improving their image – will be mainly triggered by keeping costs under control while maintaining or increasing service level. This complexity may very often lead to partial, sub-optimal or even counter-productive decisions/solutions being enforced. The establishment of a well-grounded urban logistic scheme strategy requires careful consideration of a number of dimensions. First of all, if a reform of urban logistics is to succeed, authorities need to set their priorities before selecting the most appropriate levers to achieve their objectives. After all, while they may be tempted to impose restrictions on trucks entering the city, they do not want to be blamed for harming the economy by raising the shippers' costs and reducing service levels. These measures need to be developed in a concerted way with the transportation companies, as well as the shippers/recipients around a shared series of objectives.

They should provide both positive incentives to the behaviours supporting these objectives, as well as negative ones to the stakeholders not accepting to play by these rules.

A urban logistic strategy can typically contribute to several goals, each of which can be influenced by different factors and some of which may be conflicting with each other, thereby requiring careful prioritization:

- Urban congestion reduction, influenced by distance travelled, vehicle capacity & length, and easiness to stop;

- Reduction of number of trucks in the city, influenced by vehicle capacity, vehicle filling ratio and congestion level;

- Pollution reduction (i.e. CO2/NOX and PM), influenced by vehicle type, distance travelled and congestion level;

- Noise reduction, influenced by vehicle type, distance travelled and congestion level;

- Development of local economy, influenced by solution costs, impact on service quality (speed, delivery time slots, flexibility/reactivity, etc.);

- Contribution to housing policy (increasing housing space within city limits), influenced by inner city logistics platform footprint.

To achieve these objectives, city authorities and transportation companies can typically apply a combination of levers. In order to select the most appropriate set of levers, there needs to be a shared understanding of their impact to the local contexts as well as their contribution to the defined objectives, taking into account each of the geographical area and goods category.

Figure 2.25. Levers to consider when defining appropriate urban logistic schemes[73]

[73]https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

Lever	Description
Urban Distribution Center (UDC) out of town	■ Massified delivery to Urban Distribution Center upstream of city ■ Delivery route preparation in UDC ■ Often coupled with Exclusivity zone and/or greener trucks
Direct injection	■ Preparation of delivery routes in containers ■ Transport of containers by massified transportation means (train, boat) and transfer to another mode for last mile transportation
Urban Distribution Center (UDC) in town	■ Massified delivery to urban distribution center within city core ■ Delivery route preparation in Urban Distribution Center ■ Often combined with Exclusivity zone and/or Greener trucks
Exclusivity area	■ Exclusivity (usually city core) to a single transportation company ■ Can be limited to some truck sizes and/or time slots
Traffic lane/drop off space reservation	■ Booking of dedicated stopping spaces/traffic lanes
Time slots	■ Opening/shutting of specific times slots for some types of trucks
Greener trucks	■ Usage of "greener" trucks (Euro NCAP 5, gas, electric) ■ Often combined with restrictions
Alternative transportation means	■ Delivery by alternative vehicles (bicycles, etc.) with a smaller capacity and range ■ Usually combined with Direct injection or UDC in town
Congestion charge	■ Implementation of congestion charges ■ Can foster development of UDC at congestion charge border
Lever efficiency strongly depends on transport authority's ability to enforce rules	

2.5.3 Case studies and good practices

Moscow (Russia):

Since 2011, the Government of Moscow has been systematically implementing a set of measures to regulate the traffic of freight vehicle throughout the city of Moscow in the daytime. Certain areas are open for passage and traffic only for trucks included in the Register of Valid Passes.

“Cargo frame” divides the streets of the district into 2 zones: “cargo frame” and “housing developments”.

Free traffic of trucks is permitted on the “cargo frame” streets. In residential areas, however, the traffic of trucks with a permissible maximum weight of more than 2.5 tons is allowed only to those that render service to companies or citizens within the area. Supporting documents are required to support that.

The “cargo frame” pursues the objective of cutting down the transit of trucks through residential areas and relieving the resultant environmental pressure.

These measures have led to the number of transit trucks in Moscow diminishing by 25% with the average daily traffic speed on the Moscow Automobile Ring Road climbing by 4%. The road network of some administrative districts of Moscow, those that are especially susceptible to high traffic intensity of freight vehicles, for instance, the Northern, North-Eastern and Eastern administrative districts of Moscow, have gone ahead with the “cargo frame” project under which the traffic of trucks with a maximum weight of more than 2.5 tons has been restricted on a round-the-clock basis (on the "cargo frame" streets). This has helped improve a number of environmental aspects, achieve reduced noise levels in residential areas and overall improvement of the road transport situation.

The map of the cargo frame of Moscow can be found on the Unified Transport Portal at: http://transport.mos.ru/.

In addition, commercial freight vehicles below environmental class 3 are barred from entering the central part of the city which is limited to the Third Transport Ring (TTK), as well as being prohibited from driving along the Third Transport Ring. These restrictions are in force 24 hours a day.

Restrictions on the traffic of freight vehicles are enforced both in automatic mode (by traffic cameras) and by employees of the State Road Traffic Safety Inspectorate, the Department of the Ministry of Internal Affairs of Russia in Moscow. Vehicles are identified by their state licence plate numbers.

These restrictions apply to all freight vehicles, regardless of their place of registration, ownership and purpose. Whenever found to have violated the Road Traffic Regulations on several occasions, a driver will have their issued permit revoked[74].

Minsk (Republic of Belarus):

Minsk (Republic of Belarus) has introduced restrictive measures on the passage of trucks with a total weight of more than 1.5 tonnes on a number of central highways and roads that lead to them. In order to meet the needs of industrial and commercial facilities that are within the area where the restrictions are enforced, truck deliveries are handled by logistics technologies where goods are supplied by light trucks through logistics centres[75].

2.6 Organisation of urban parking space and parking policy

2.6.1 Case studies and good practices

One of the cornerstones of the state policy in traffic management is "organisation of the urban parking space and parking policy". The introduction of single parking space systems in cities helps address the issue of parking vehicles on the network of streets and roads in cities in a comprehensive way, reduce the time that cars spend in congested transport areas, boost the turnover of vehicles on parking lots and mitigate the peak pressure on roads.

Since the 1960s, mainly the central parts of major European cities, have witnessed a shift from a poorly managed parking system to a parking space policy which balances the growing demand for urban space and its limited supply. After World War II, the number of private car users started to climb in European cities; the exception being

[74] According to the response of Moscow (Russia) to the UNECE questionnaire.
[75] Based on the answers given by the Republic of Belarus to the UNECE questionnaire.

Eastern Europe, where the number of car owners began to grow only in the early 1990s. The development of new settlements and towns outside the principal administrative centres often imitated trends that dominated countries such as the United States, Canada and Australia.

Thus, citizens in densely populated cities found it convenient to park their cars near their houses that oftentimes blocked pedestrian space and the motorway. Sidewalks almost vanished caving in to parking lots and wider roadways. So, public space gradually dwindled and became dominated by private car owners.

Municipal authorities in major European cities initially had no intention of introducing a fee for use of parking space, so motorists were allowed to park their vehicles free-of-charge on public pavements and in other places where it was possible to park the car[76]. However, this led to violations of parking rules and chaotically-shaped parking spaces in the most densely populated areas and the most visited public places in the historic centres, the central business areas and residential areas. As a result, the number of traffic jams began to grow sharply, air quality deteriorated, noise levels went up and street safety degraded. Motor vehicles began to occupy a great share of public space. The parking infrastructure was a blight on street panoramas, spilling over to pedestrian zones and increasing the time spent in travel. This prompted the municipal authorities to develop stricter parking regulations.

Initially, the interests of drivers in terms of them being allocated as much parking space as possible in the most convenient of place were on top of the urban planning list of tasks. However, other categories of road and street users, such as residents in houses, office employees, workers in the trade sector were not paid appropriate attention. Parking lots often took up areas of high social, ecological and even economic value. It is against this background that it was resolved to consider alternative kinds of use of these spaces.

As street parking space grew filled up in most European cities, local governments realised that there was no further potential for parking spaces to be expanded. In order to meet the increasing demand for extra parking spaces, it was decided to introduce concessional contractual relations with private investors to construct and manage parking space outside the streets[77].

Construction standards also underwent change. Plans to develop a parking space capable of meeting demand without constraining supply endangered the economic prosperity and viability of society. The growing demand for extra parking space was viewed as an indicator of a prosperous economy for a long time. Yet, the perception of this changed at a time when increasing traffic flows began to have a negative impact on labour productivity, air pollution and other aspects crucial for society. These

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[76] Jan Gehl and Lars Gemzoe (2006). New City Life. The Danish Architectural Press: Copenhagen.

[77] Kenneth J. Button (2006). "The political economy of parking charges in 'first' and 'second- best' worlds." Transportation Policy. 13 (6), 470-478.

adverse external effects highlighted the necessity to rethink investment priorities and pricing mechanisms in regulation of citizens' mobility as well as influencing people in the choice of the preferred mode of transportation[78].

The demand for parking varies depending on the location, time of day and day of the week. As an example, central railway stations are often areas where the demand for parking space is high. Often it is where passengers are quickly picked up and dropped off. The demand for parking space in business areas is at its highest during working hours while being significantly lower on weekends. In places where major sporting events are held, an inflow of cars is seen only during the competitions, while parking in residential areas is in high demand at night during working weeks and lower on weekends.

The basic policy instruments used to create a single parking system in cities include:

- financial (economic measures, such as tariffs and fines);
- administrative (e.g. no-parking zones or parking time limits);
- urban planning (enforcing regulation of standards for the design of parking lots and their capacity in new residential developments);
- others (this group includes physical barriers, methods to use parking space in alternative ways, tools for development and promotion of public transport, bicycles and motorcycles, etc.).

In creating a single parking space in a city, a set of interrelated regulatory and non-regulatory acts need to be adopted which would establish:

- responsible authorities to make decisions on the establishment of a single parking space and the environment required for it to function;
- the procedure for making decisions on creation of a single parking space which would also determine the scheme to create parking space facilities;
- empowering the organisation that is building and operating parking spaces that make up the single parking space;
- rules for the use of parking spaces that make up the single parking space;
- rules for setting fees for the use of parking spaces within the single parking space;
- introduction of administrative accountability for violation of the rules that govern the use of parking spaces facilities, including failure to pay fees.

The legal nature of parking fees can be defined as follows: non-tax revenues derived through service delivery or non-tax revenues from the use of property. The legal schemes behind the establishment of parking space facilities, which make up the single parking space may include: transfer of relevant functions and powers to a budgetary institution, which subsequently places a municipal order to create and

[78] COST Action 342 (2006). "Parking Policies and the Effects on Economy and Mobility." Technical Committee on Transport.

operate the facilities, or attract a private partner on a competitive basis under PPP projects.

The organisational modalities behind the establishment of a single parking space is directly dependent on what scheme is chosen by the local governments to create parking space.

In this case, the optimal combination of the operational mode of parking space facilities and benefits for residents in certain areas is fundamental to an effective parking policy.

From the perspective of pricing objectives, the following approaches to establishing parking fees can be distinguished:

a) maximising revenues;
b) improved traffic;
c) guaranteed free parking spaces.

Guaranteed parking spaces are the most appropriate approach to establishing parking fees inasmuch as it ensures balanced supply and demand with the fee set in strict compliance with the scope of demand and availability of parking spaces. This approach does not lead to excessively high fees, which renders parking services available to more users. Beyond that, vehicles in traffic "roaming around" in search of parking space being kept to a minimum help ensure solid social and economic effects (including reduced emissions of pollutants from motor vehicles).

The experience of European countries when examined demonstrates that the introduction of single parking space systems, including paid parking lots in the street and near the road, promoting the creation of off-street parking space and park-and-rides has resolved the problem of congestion in cities, especially in their central areas, reduced traffic flows by about 30 percent and improved transport accessibility to major places of attraction.

The target level of parking rates is decided on by relying on the global practice in such a way as to ensure optimal occupancy of parking spaces. Normally, this figure stands at 85 percent.

By regulating the capacity of the single parking space, city authorities are able to implement a parking policy, including managing the demand for parking space and, accordingly, the traffic generated by private cars.

Moscow (Russia):

Ever since it was established, the single parking space system in Moscow has helped to get a grip on the issue of "chaotic parking" in the streets of Moscow, achieve better safety and higher average speed of traffic and ensured the comfort of movement for all road users - pedestrians and cyclists, public transport and private cars.

The project “Moscow Parking Space” is designed to deal with the challenge of “chaotic parking” in the streets of Moscow (Russia) and to enable comfortable traffic of pedestrians, public transport vehicles and motor vehicles.

Objectives:

- less violations of parking rules in the streets and on the road;
- increased traffic speed in paid parking areas;
- higher turnover of vehicles in parking spaces;
- reduced flow of private vehicles entering the paid area and promoting the use of alternative modes of transport.

The parking spaces in the streets and on the road are premised on the following principles:

- existing geometric parameters of the streets and the roads;
- traffic intensity;
- the extent to which the streets and the roads are congested;
- separate lanes for separate traffic, etc.

Ever since it was launched in 2012 in Moscow, this project Moscow has shown positive outcomes such as:

increase in the traffic speed by 12%;

decrease in the number of parking violations by 64%;

the number of private vehicles entering the Garden Ring Road by 25%;

Turnover of car space increased by 4 times (previously a car on average occupied one parking space for 6-8 hours whereas now it is no more than 1.5 hours). Parking fees in Moscow vary from 40 to 200 rubles per hour in high-demand areas with a differentiated tariff introduced in the city centre wherein the parking fee is higher after the first 30 minutes or one hour of parking.

Since 2012, the total amount of proceeds collected by paid parking in the city of Moscow and transferred for urban improvement purposes has amounted to more than 19,851,249,090 Russian rubles.

To date, there are 8 options which one can use to pay for parking. It is noteworthy that that the most popular mode of payment among drivers is the “Parking of Moscow” mobile application (it is used by 84 percent of drivers). Parking payments via SMS and voice dialling or traditional parking metres are chosen by 15% and 1% of drivers respectively.

The established parking space has reduced the time spent in search of parking space by 65 percent with road congestion decreasing by 13 percent, and the turnover of parking spaces up by 3 times[79].

Figure 2.26. Intended expenditure of funds collected from paid parking lots in Moscow

[79] http://parking.mos.ru/, as well as based on the answers given by Moscow (Russia) to the UNECE questionnaire.

Figure 2.27. “Moscow Parking Space” Project

Figure 2.28. “Moscow Parking Space” Project

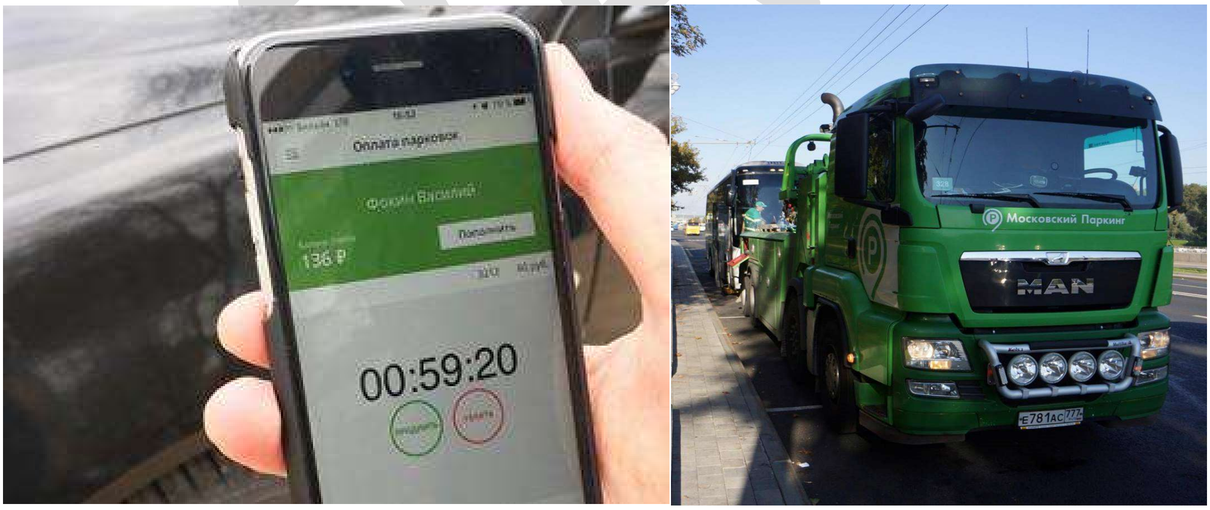


Figure 2.29. “Moscow Parking Space” Project

Figure 2.30. “Moscow Parking Space” Project

Figure 2.31. “Moscow Parking Space” Project

The following peculiarities unique to the development of parking policies in some advanced European cities should be underscored:

London, England

Innovations in the implementation of parking policy and differences in the cost of parking space based on the level of environmental friendliness of vehicles.

When registering a vehicle in the city, the emissions of harmful substances declared by the manufacturer are registered in a special database. This approach allowed administrative districts to charge parking fees based on the level of emissions of vehicles.

Figure 2.32. Parking inspector at work in Westminster County, London

Figure 2.33. Parking space for electric vehicles in Westminster County, London

Figure 2.34. Dedicated parking area for motorcycles in London

Munich, Germany

Enforcing a policy of widespread restrictions on urban parking to encourage citizens to completely abandon private vehicles in favour of public transport has proven to be a success.

Figure 2.35. Car parking space in one of the central streets of Munich combined with a bicycle parking lot

Figure 2.36. A park-and-ride near the centre of Munich

Paris, France

Discouraging the use of private vehicles among citizens. An increasing amount of street space is being transformed into pedestrian areas. Public bicycle rental services and the tram network are being developed.

Figure 2.37. Public bike rental station “Velib” in the street in Paris

Figure 2.38. A mixed parking zone in the city in Paris where one can find private cars sharing parking space with commercial vehicles

Barcelona, Spain

Barcelona is the first city to use 100% of the proceeds from parking to fund a public bike rental program.

Figure 2.39. Area Vérda is a regulated parking system divided into several areas in Barcelona

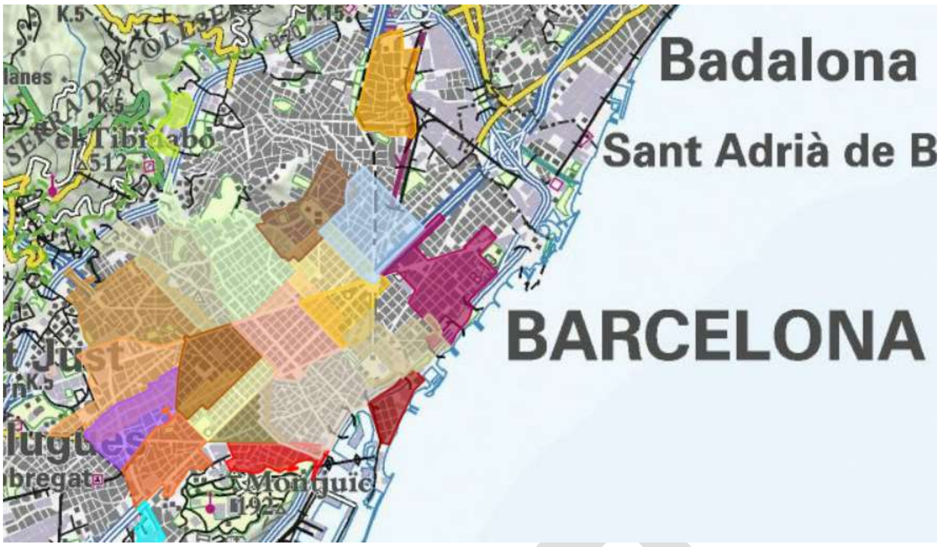


Figure 2.40. Dedicated spaces on the roadway for loading and unloading works in Barcelona

Figure 2.41. Dedicated parking spaces on the roadway for motorcycle vehicles in Barcelona

Copenhagen, Denmark

Policy of the authorities to discourage motorists from moving around by car in the central part of the city. Thousands of metres of street space have been transformed into a pedestrian zone while hundreds of parking spaces have been removed.

Figure 2.42. A bicycle path located parallel to a street parking area in Copenhagen

Figure 2.43. A parking inspector on duty in the street in Copenhagen

Figure 2.44. Electronic parking payment terminal in Copenhagen

Figure 2.45. Parking space equipped with chargers for electric vehicles in Copenhagen

Amsterdam, Netherlands

Installation of parking maximum limits to limit the amount of parking space available near large public transport junctions. Technical innovations of parking metering (electronic database of private vehicles, scanning cars).

Figure 2.46. Parking space in the central area of Amsterdam

Figure 2.47. Extensive bicycle parking in the central part of Amsterdam

Stockholm, Sweden

Enforcement of compliance with legal order is outsourced to several private companies.

Figure 2.48. Parking area in Stockholm

Figure 2.49. Checkpoint to the central part of Stockholm

Zurich, Switzerland

Widespread restriction of parking spaces in the city centre coupled with the introduction of fees for the use of available spaces and the establishment of parking maximum limits in relation to new constructions.

Despite the peculiarities of specific cities, all the measures under examination are aimed at reducing the total distance travelled by private cars within the city, as well as at developing and promoting public transport.

Figure 2.50. Introduction of parking restrictions in the streets of Zurich

Figure 2.51. Distribution of parking space for two-wheeled modes of transport in the streets of Zurich

Summing up the above experience***, we can highlight several successful parking space management strategies.***

The main parking management strategies are divided into four components: mechanisms of economic impact, mechanisms of regulatory (administrative) influence, design works and contractual relationships (the introduction of advanced technologies to activate all four components must be taken into account). They can be used in various combinations to achieve a wide range of goals, so best practices are more dependent on the goals of the city implementing such policies[80].

Figure 2.52. Grosvenor Square in London

[80] Robert Joumard et al. (1996). "Air quality and urban space management," The Science of the Total Environment, 189/190, 57-67.

Отсутствие счетчиков Счетчики Цены увеличились в четыре раза

Mechanisms of economic impact

Street parking tariffs

The first parking metre was installed in 1932 in Oklahoma City in the United States of America [81]. The first European version of this device was put into operation in the summer of 1958 at Grosvenor Square in London near the walls of the U.S. Embassy in Mayfair (Fig. 62) [82].

A fee for using street space is usually introduced in order to optimise the use of the roadway (motorway). It influences the extent to which space is used minimising the number of cars which slow down traffic in search of parking space. The fee is set based on the demand sensitivity (that is, depending on the target levels of parking space filling and availability of free spaces). Most often, drivers prefer to park as close as possible to their destinations, even if they block the traffic lane or pedestrian paths[83].

Market pricing mechanisms can change the behaviour of people who choose to use motor vehicles. An important factor in the optimal regulation and management of parking space is the harmonisation of fees charged for street and off-street parking. The fees should be aimed at encouraging drivers to opt for off-street parking.

Drivers who travel around the surrounding area in search of free or inexpensive street parking often slow down the overall traffic flow. At the same time, those drivers who have already parked in free or low-cost places are likely to prefer to leave their cars for a considerable period, thereby adversely affecting the use rate (turnover) of

[81] Rachel Weinberger et al (2010). “U.S. Parking Policies: An Overview of Management Strategies,” Institute for Transportation and Development Policy.

[82] “Parkeon Celebrates the Golden Anniversary of the Parking Meter.” http://www.parkeon.it/Press-Release/Parkeon-celebrates-the-golden-anniversary-of-the-parking-meter.html.

[83] Simon Anderson and André de Palma (2004). “The economics of pricing parking,” Journal of Urban Economics. University of Virginia. Volume 55, Issue 1.

parking spaces. These parking spaces could draw more customers to small and medium-sized businesses located in the area[84].

Reducing parking space available while driving up the fees of the remaining parking space may influence the behaviour of drivers in several ways which will in turn have an impact on public transport passengers, drivers who prefer to drive little and residents in the surrounding areas[85]. Behavioral reactions:

- choose an alternative parking spot;
- use some other time to move by car;
- switch over to another mode of transport;
- adjust car-trip destinations;
- avoid driving by car altogether.

In the UK, a study was conducted to assess the impact of parking restrictions and improvements in public transport services as compared to the use of private cars. As it turned out, a two-fold increase in parking fees led to a 20% reduction in the number of car use, while the improvement of public transport services was less efficient — a decrease in the use of private cars was only 1 to 2%. Also, halving the number of parking spaces resulted in a 30% reduction in the number of cars used[86].

Parking space prices depending on the number of free parking spaces affect the manner and way of travel in areas where the demand for parking remains significantly high. The demand for parking may vary depending on the concentration of commercial, residential and industrial buildings in the area.

A number of European cities have established "Controlled Parking Areas" that is designated areas within a city ranging from one block to a whole district. In London, for example, the Controlled Parking Areas enable the administration of each city district to set tariffs and rules of parking according to local conditions. An example is a special parking fee in a popular shopping area: the fee for long parking hours goes up in order to deter motorists who use the parking space during the working day. Thus, the preference is given to visitors who come around for a short time to do the shopping or owners of local businesses. A similar approach is pursued in Zurich and Munich, where prices vary from block to block, the popularity of a location and the time of day.

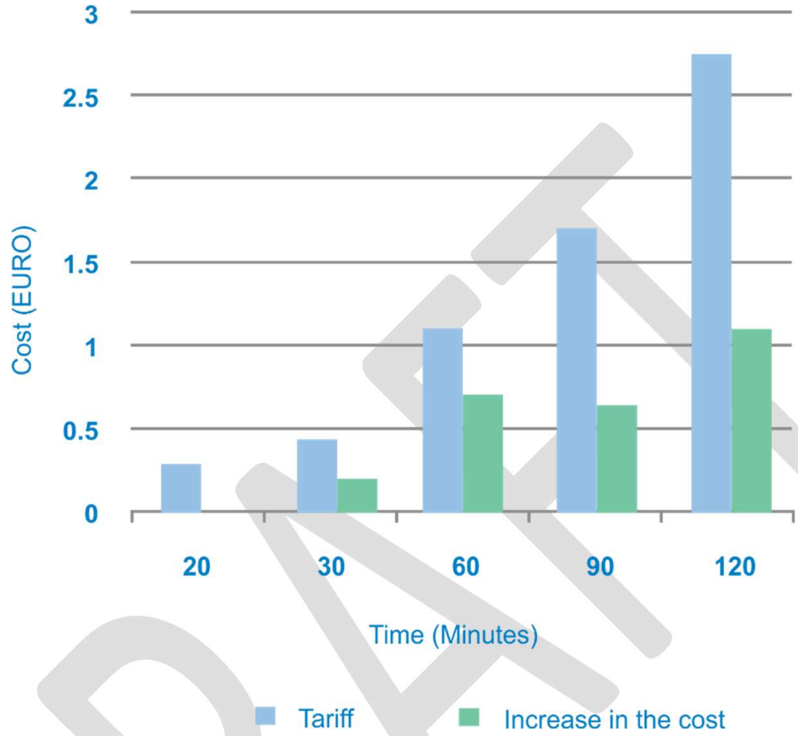
Progressive pricing methods

Zurich, Antwerp, Vienna and Madrid have street parking pricing schemes that increase the fees charged over time. This measure is aimed at setting an increasing marginal cost for the presence of a car in a parking lot — the longer a car is parked, the more expensive each subsequent hour is. Visitors who come to Madrid can park their

[84] http://www.theregister.co.uk/2014/06/16/how_practical_is_an_electric_car_in_london/.
[85] Bernard P. Feeney (1989). "A review of the impact of parking policy measures on travel demand," Transportation Planning and Technology, 13(4), pp. 229-244.
[86] M. Dasgupta et al. (1994). "The Impact of Transport Policies in Five Cities," Transport Research Laboratory.

cars in a parking lot for a maximum of two hours with the fee for each subsequent interval of time going up by a certain proportion.

Figure 2.53. The progressive scale for parking space fee in the Blue Zone, Madrid, Spain



Parking regulations at the place of residence

Trips between the city's central business district (CBD) and residential areas have prompted the municipal authorities of most European cities to introduce special parking permits in residential areas. Thus, managing the demand for parking among residents in a particular area has become more effective as the needs of local residents for parking near their places of residence are significantly different from the needs for visitors in transit. For instance, residents of London's administrative districts such as Camden and Islington pay for a home parking pass depending on the level of emissions discharged by their cars. Emissions are assessed in accordance with legally accepted standards when a vehicle is being registered.

The introduction of a parking permit in residential areas of Munich has helped reduce the number of car trips from 44% to 32% of the total number of public traffic. Almost 27% of the residents who once used their cars to travel to different parts of the city switched to other modes of transport [87]. This subsequently resulted in the number of users of public transport increasing from 40% to 47% [88].

Taxation for companies that reserve street parking spaces

[87] Harmut H. Topp (1994). “Zur Rolle des Parkens in der Verkehrsberuhigung,” Straßenverkehrstechnik, pp. 375-379
[88] Tom Rye et al. (2006). “Expansion of a Controlled Parking Zone (CPZ) and its Influence on Modal Split: The Case of Edinburgh,” Transportation Planning and Technology, 29 (1) pp 75 – 89

There is a practice of imposing additional taxes on companies and enterprises that provide parking space for their employees. For example, since in 2012, London has charged companies that provide parking for their employees a fixed annual fee for adjacent parking spaces if the number of parking spaces is over 11. This decision has already been supported in many cities of England and has affected more than 10 million drivers, because employers, in turn, shift these costs to their employees who seek to park their cars[89].

Defining the assignment and reservation of funds to achieve social goals (target expenditure of budgetary funds)

Barcelona, Strasbourg, Munich and some administrative districts of London follow the practice of allocating profits from parking funds to support environmentally friendly transport. Such a policy can receive public support provided that the surplus funds are used to improve public transport, pedestrian and cycling infrastructure. In Kensington and Chelsea, London's administrative districts, 12% of the revenue collected by parking is used to fund the Freedom Pass programme to provide free parking travel vouchers for older persons aged 60 or over, as well as for disabled persons. Barcelona uses 100% of the profits from parking to support the Bicing programme (Fig. 2.52), which aims to rent bicycles as part of a public-private partnership with ClearChannel[90].

Figure 2.54. A Bacing Station in the district of Gracia, Barcelona

Mechanisms of regulatory (administrative) impact

[89] Workplace parking levies may be imposed by councils http://www.independent.co.uk/news/uk/politics/workplace-parking-levies-may-be-imposed-by-councils-2059468.html.

[90] W. Young et al. (1991). “A review of urban car parking models,” Transport Reviews: 11 (1), 63–84.

Limiting the number of parking spaces

Hamburg, Zurich[91] and Budapest have introduced a maximum limit on the availability of parking spaces in the central areas by consolidating the reform of the new building standards. This reform limits the existing number of parking spaces with a further ban on the expansion and construction of new parking areas. Such restriction was established in Hamburg in 1976 covering approximately 30.000 parking spaces. Zurich undertook this reform in 1996.

Thus, each off-street parking space within a limited area should result in the same number of street parking spaces eliminated. Under this principle, supply remains stable without affecting the redevelopment and adaptation of the street structure for other purposes.

Motorists in most cases refrain from travelling to the central business areas of the city, except by certain modes of transport, such as vans owned by courier services.

A similar scheme of state regulation was used in Copenhagen. The project provided for the removal of 1,000 street parking spaces and the redevelopment of road space prioritising the needs of cyclists and pedestrians. In exchange for these measures, a roofed parking lot for 3,000 parking spaces was built at the expense of private investors.

Introduction of a parking maximum limit

The municipal authorities in a number of European cities have decided to introduce a parking maximum, setting a limit on the number of parking spaces to be determined in the areas under construction. Cities such as Zurich, Amsterdam and Strasbourg are the leading ones in the application of this measure, but in most cases the parking maximum limit is implemented relying on outdated construction codes, which have not been reviewed for decades. Countries such as Switzerland, Great Britain and Italy have adopted the regulations of parking maximum limits as state-level regulations. The municipal authorities of Milan and Italy, have adapted national standards to local conditions. The task of municipalities lies in determining the maximum number of parking spaces as an auxiliary tool for:

- support for environmentally sound modes of transport;
- reducing the use of land resources for development;
- introduction of territorial planning, most suitable for urban central areas;
- promoting the improvement of public transport routes for those who do not use cars.
- Solving congestion problems[92].

[91] Zurich Historic Compromise Parking Cap. Accessed online October 2010. URL: www.stadt-zuerich.ch/parkplatzkompromiss

[92] Annex D: Maximum Parking Standards (2001). “Planning Policy Guidance 13: Transport” Department for Communities and Local Government.

As for the regulation of non - residential construction, the policy tends to be even more stringent. In this case, the parking maximum limit should take into account the local context of reducing car use, promote the development of cycling and pedestrian infrastructure and other conditions[93]. Despite the strict rules described in the document, its requirements are not legally binding.

The idea of introducing a parking minimum limit is to shift the responsibility of providing parking space in new residential areas to private developers. However, it is difficult to predict the amount of parking demand in new residential areas at the moment, as there are still no accurate calculation algorithms. Thus, most experts on parking regulation cannot provide a logical justification for parking requirements for new buildings. Thus, the costs of lost opportunities end up with developers, who prefer to use the free area for other purposes. In historical areas, the regulation of the parking maximum limit has no significant impact, as buildings in them tend to remain in their original condition. But the effect of this policy is tangible in parts of the city with a great number of new residential areas.

For example, the authorities in Zurich tried to regulate the demand for parking while implementing the SilCity project. In this case, they made it obligatory for the developers to carry out the project, taking into account the preferences of local citizens in public transport, bicycles and walking. Also, a restriction was introduced on the permissible number of cars allowed to visit this area for a certain period of time.

Parking requirements in European countries will be more severely restricted in the future depending on the availability of public transport. This trend has already affected the urban life of Antwerp, Paris, Amsterdam and Zurich. The policy applied in the Netherlands under the name “A, B, C” has significantly changed urban parking standards, using the distance of certain parking spaces to public transport stations as the basis for parking space separation. The supply of parking space should be as limited as possible in the construction of residential areas closest to major public transport hubs (location A). In those new areas that are far from large hubs (location B), much more parking spaces are created.

For instance, in Paris it is forbidden to build a parking lot in a new building, located at a distance of not more than 500 metres from a public transport station. It should be noted that almost all buildings located in the central part of the city meet this requirement - metro stations are located quite close to each other.

Regulating the location of parking space

Cars passing through in pedestrian areas may be restricted or prohibited altogether. Exceptions are usually emergency and courier vehicles that operate at certain times of the day. Such bans and restrictions have already been introduced in most historical centres of European cities. Some categories of vehicles are not allowed to enter the city centre because of their pollution levels exceeding the established

[93] Department of Communities and Local Governments (2009). “Planning for Prosperous Economies, EC10.2”.

standards. This strategy is used in the following cities: Berlin, London, Milan and others. In addition, cars with high exhaust emissions are also prohibited from parking within the city.

Design works

Physical barriers

Paris and Milan have introduced bollards in all key locations. This prevents the accumulation of cars on walkways and in public places. In certain cases, alternative elements such as retractable bollards, vehicle barriers, bars to limit access to vehicles by their height and other elements are used to prevent access to conventional vehicles and provision of access and parking for emergency vehicles or other specialised vehicles.

Marking lines

In many European cities, such as Stockholm, white lines indicate areas of permitted parking. This is a kind of visual signal to let motorists know that the parking area is separated from other functional areas, to wit: pedestrian walkways, cycling paths, as well as the motorway. These symbols may also be accompanied by text characters that limit the potential categories of users, for example, to members of a car sharing club, disabled people and others. It should be noted that the successful introduction of this type of regulation will depend both on the consciousness of motorists and on the rigidity of control.

Promotion of public space alternatives

The positive effects of the decrease in the number of parking lots are:

- improved visibility at intersections;
- reduced duration of the “pedestrian crossing” mode of traffic lights due to the pavement zone being consolidated at intersections;
- Greening works on roadsides;
- Increased territory taken up by cafes and restaurants in narrow streets, as well as new benches installed for rest of urban dwellers.

All of the alternative measures mentioned above reduce the total number of street parking lots and leave room for the street space to be used by other categories of users.

Representatives of trade organisations oftentimes seem to be the most vehement critics of parking regulations. They believe that the economic prosperity of urban life is bound up with automobile accessibility. A study conducted in the city of Rotterdam (Holland) study showed that representatives of trade organisations situated in one of the busiest shopping streets of the city significantly overestimated the share of consumers stopping by to shop around when passing by in their private cars[94]. Shops

[94] Giuliano Mingardo et al. (2009). “No parking, still business,” Verkeerskunde, No. 4.

and stores in pedestrian areas where all parking space has been eliminated have more revenues than their counterparts outside the pedestrian areas[95].

It is known that only 16% of visitors prefer to use their private cars to get to the most frequently visited pedestrian shopping areas of the city in Munich (Germany) with 72% of visitors opting in favour of public transport. The rest can be reached by bicycle or on foot[96].

The current trend in Europe is that street space becomes unprofitable for car owners. It is seen as a public asset that should be used more efficiently. In France, for example, underground parking was built in most cities to revive the streets and public spaces that had previously been crowded with cars parked in a chaotic manner.

Reducing the number of free parking spaces in the streets serves as a way to encourage the use of alternative vehicles and improve the environment[97]. The development of the tram network in the city of Strasbourg (France) made it possible to move the street parking lots underground, as well as promoting the construction of park and rides near the key tram stations and expanding paid parking areas.

A new geometry for roadways

In those streets where parking is still permitted, there is a practice of reorganising the space in a way that meets the approved security requirements. In Zurich (Switzerland), parking space organised in chessboard order on both sides of narrow streets serves as a zigzag obstacle to the traffic of cars, which reduces the average speed of traffic.

In Amsterdam (Holland) there are so-called “residential street” zones (“woonefs”), where cars left parked by residents make up winding roads, forcing cars to move slower near cyclists and pedestrians. In Paris and Copenhagen (Denmark), cycling paths were put in place that are protected by parked vehicles, which in turn serve as a barrier between cyclists and vehicles on the move. In Copenhagen and Antwerp (Belgium), there are streets with children's playgrounds organised in the immediate vicinity of the roadway. However, these venues are separated by barriers, such as trees, benches and other structures, alerting motorists to the need to drive with maximum caution and with minimal speed.

Contractual relationship

Technological progress in parking over the past couple of decades has enabled city authorities to ensure that parking policies are implemented in the most effective way. It has become easier for private companies to fulfil their contractual obligations by delivering high-quality services in respect of car owners abiding by parking

[95] Carmen Hass-Klau (1993). “Impact of pedestrianization and traffic calming on retailing: A review of the evidence from Germany and the UK,” Transport Policy, 1 (1), pp 21-31.

[96] Rolf Monheim (2001). “The Role of Pedestrian Precincts in the Evolution of German City Centres from Shopping to Urban Entertainment Centres,” Presented at Australia: Walking the 21st Century, Perth, Western Australia.

[97] GTZ (2010). “Parking Management: A Contribution Towards Livable Cities,” Sustainable Transport: A Sourcebook for Policymakers in Developing Cities. Module 2C Division of Water, Energy and Transport.

regulations and collection of fees. The latest advances in software and hardware have made it possible to ensure an improved interaction between the system and car owners. The following are four types of technologies used for more efficient parking management.

Free parking space electronic tracking system

Calculations indicate that the average motorist in a European city spends on average about 25% of the total time of his or her journey by car in search of free parking space. Real-time timetables placed in convenient locations along the road are designed to facilitate the search for parking space and to guide motorists to the available parking spaces in the nearest parking lot. Almost all major cities in Germany rely on these parking management information systems. The next step in the development of these technologies will be the integration of embedded information systems in the car.

"Smart" metres

Smart parking metres are equipped with magnetic field sources which help to register the metal body of cars in their area of operation. These are directly connected to the police information system sending signals to the nearest parking inspectors in the event of a car winding up in the area of the counter. In turn, the driver of this vehicle receives a notification on his or her cell phone stating that he or she has entered a paid parking area. These metres are installed, for example, in all major cities in France, where they ensure that parking fees are collected in an efficient way.

Payment for parking services via mobile devices or mobile applications

At present, there are various methods to pay for parking space use, including prepaid cards, bank cards, coins. The payment system via telephone or mobile device is convenient for municipalities, as the responsibility for collecting money rests with a third-party company. In this case, there is no chance for paid funds to be lost.

Municipal authorities in those cities that are in the early stages of developing and implementing parking fee collection mechanisms can prevent some problems associated with funds collected coming up short by introducing a payment service for parking via mobile application or directly via phone. This parking regulation method also greatly facilitates and simplifies the engagement of motorists as the payment process becomes much more convenient with them not needing to use cash or rush over to the counter to extend the parking time shortly before it expires.

Parkon cars equipped with a scanning device

Law enforcement methods in the field of parking in Amsterdam have recently been changed in a drastic manner.[98] Now, there is a special car, equipped with six scanning cameras on top of it, circulating around the streets of the city. These cameras are able to produce more than 160 high-definition photos per second at speeds up to

[98] Parking in Amsterdam http://www.iamsterdam.com/en-GB/experience/plan-your-trip/getting-around/parking.

40 km/h. These scanners record the license plates of parked cars through an automated recognition system.

The total level of accuracy of the cameras of one such special car is 98%. The remaining 2% of the unrecognised license plates are cars registered outside the Netherlands. The special car is followed by several parking inspectors on scooters. Their function is to draw up protocols and to issue fines if necessary. Some administrative districts of London are currently using hidden cameras to enforce proper parking rules on the part of motorists.

The development of parking space management policy in the instances mentioned above is targeted at ensuring effective use of urban land, enhancement of the environmental situation, creation of a favourable, safe and comfortable living conditions of the population, stepping up the capacity of main transport routes, providing car owners with accessible and convenient places for parking.

With the world experience summarised, the following main tasks can be distinguished in creating paid parking spaces:

- Higher public safety and comfort.
- Solving the problems related to traffic management and increased capacity of the road system.
- Improved environmental situation in residential and public areas.
- Promoting the use of environmentally friendly transport.
- Attracting investments for the construction of parking lots so that vehicles can be parked outside the central areas of the city.

To achieve effective management of parking space, the main four mechanisms are used: economic impact mechanisms, regulatory influence mechanisms, organisation of design works and contractual relationships.

Continuously introduced technological innovations generate new opportunities for parking regulation and management. A growing majority of European cities are seen switching to multispace electronic parking terminals, which are more practical in terms of controlling the collection of fees from one parking space, as well as the regulation of the rate base. The maintenance costs of these terminals are not high. Also, most European cities provide a service where one can pay for parking via phone or via mobile application. The costs associated with accounting, as well as losses due to theft, fraud or vandalism, can be minimized by transferring these services under a contract to a telephone provider or mobile network operator. This service is more convenient for users.

A new wave of technological innovations in the field of control and collection of parking fees is the integration of electronic metres into new vehicles, which are connected with the navigation system and able to provide information on availability parking spaces and to guide motorists to their location. Navigation systems are also used to inform motorists on parking rates depending on the location, time of day and day of week. On the one hand, it is convenient for the car owner, and, on the other hand it optimises the operation of the parking system.

Tbilisi (Georgia):

Tbilisi City Hall Transport Policy is focused on the public transport and non-motorized mobility. Making Public Transport comfortable, fast, reliable and safe is the main approach of the policy which will result in enhanced use of PT.

Tbilisi City Hall has finished working on the new parking system, which involves zonal parking and increased parking fees. From spring 2018, it will be gradually implemented in the city infrastructure. It will significantly contribute to the reduction of the number of private cars in urban areas and encourage public transport and cycling.

The new zone parking system is aimed at the efficient regulation of parking and the normalization of traffic in the city; Bus Lanes, New road traffic organization schemes and etc. The City Hall has also introduced bus lane arrangement on Pekini and Shartava streets. It is also planned to implement bus lanes on every major street[99].

Figure 2.55. Tbilisi (Georgia)

St. Petersburg (Russia):

The State University “City Centre for Parking Management in Saint-Petersburg” is developing a network of park and rides in order to reduce traffic in the centre of St. Petersburg. Putting them to use will help citizens reduce travel time and avoid traffic jams. Now, the city has 14 park and rides which in total can accommodate 1,559 cars

[99] Based on the answers given by Tbilisi (Georgia) to the UNECE questionnaire.

located in Vyborgsky, Kalininsky, Kirovsky, Krasnogvardeysky, Moscovsky, Nevsky, Primorsky and Frunzensky districts.

Park-and-ride services are free if entered from 06:01 a.m. to 8:00 p.m. and exited until 11:59 p.m. provided motorists present an electronic ticket, confirming that at least one trip to be made by public transport between 06:01 a.m. and 23:59 p.m. during the day after leaving their vehicles on the park-and-ride. Otherwise, car owners must pay for park-and-ride services at the rate of 25 Russian rubles per hour. The same amount is charged in the event of car owners leaving the space after 11:59 p.m. Park-and-rides services are chargeable between 8:01 p.m. to 6:00 a.m..[100]

Figure 2.56. A park-and-ride in Saint Petersburg (Russia)

Chapter 3.1. Public transport as a key element of a “liveable city”

3.1.1. Definitions

3.1.2. Role of public transport as a key element of a city`s liveability (PT infrastructure as an important part of city infrastructure)

3.1.3. PT services quality (affordability, accessibility, safety, security, travel time, punctuality and so on)

3.1.4. Principles of PT routes network planning

3.1.5. Principles of PT mode choice and organisation of its operation

[100] https://www.gov.spb.ru, the official website of the Administration of St. Petersburg.

3.1.6. Engagement with other modes of urban transport
3.1.7. Specific issues of urban public electric transport development
3.1.8 Case studies and good practices
Chapter 3.2. Financing of public transport
3.2.1 Different financing models
3.2.2 Case studies and good practices

Chapter 3: Spatial planning and public transport

3.1. Public transport as a key element of a "liveable city"

3.1.1. Definitions

Urban passenger public transport - passenger transport carrying passengers and luggage within the confines of a city at the request of any citizen or legal entity.

3.1.2. Role of public transport as a key element of a city`s liveability (PT infrastructure as an important part of city infrastructure)

The main goal of modern cities, the meaning of life and doing business in cities is the range of opportunities that extend to the choice in employment, goods and services, maximum labour and sales markets. The way in which each of us is satisfied with our lives is determined, amongst other things, by *being able to have choose* the best workplace, where we can manage to realise the potential of our abilities and receive decent financial rewards; the best goods and services (including in culture, health care, etc.) that meet our personal needs. *Business efficiency is also largely dependent on* the best employees being picked who, although moderately remunerated, will be satisfied with their job. This also applies to suppliers and customers. Being the main mechanism behind economic development, transactions and purchases are the outcome of meetings of people, so the possibility to have such meetings is dependent on mutual transport *accessibility* for people and organisations.

Transport is a key mechanism for *accessibility.* Due to the human daily biological cycle, the time of daily trips (the time that a person is willing to spend on the move in order to access places of his or her interest) normally does not exceed 3-4 hours per day, which is corroborated by numerous surveys and studies. With travel time limited, the number of places and people accessible can be enlarged only by two ways: by driving up occupation density (a trend that can be seen in cities) and by stepping up the travel speed of the transport system (in order to cover as much of the area adjacent to one's place of residence and the places of interest located therein within the time available for travel).

Transport management is associated not only with direct costs, but also with so-called externalities i.e. spillover negative effects in relation to the time consumed by movement, depletion of public resources (territory, energy, clean air), loss of life and damage caused by road accidents. In the early 19th century, prior to mass transport development in cities, these negative effects went unnoticed in comparison to other, more pressing issues (famine, epidemics, shortage of housing, etc.).

Since public transport was invented, it has been aimed at bringing down travel costs, thereby improving in accessibility (when compared against walking) for those people who could not afford private transport vehicles. Initially, it was a way for passengers to simply achieve direct cost savings, which was realised through combining several individual trips into one: people had to agree that, the start and end of the trip would not be door-to-door, but would instead involve common stops convenient for everyone; departure time had to be convenient for several passengers at the same time and they needed to accommodate themselves to it. Also stops reducing the travel speed along the way had to be put in place; buses to reduce the number of variations (routes) in order to increase the capacity of transport vehicles and to cut down the fee were required. Right from the outset, public transport offered a quality of transport service inferior to private motor vehicles (because of the social contract on the mode of transport convenient for a maximum number of people), but the costs were significantly lower (as the majority of population could only afford as much).

Increased transport accessibility for the mass consumer brought about by the inception of public transport was the main factor in territorial expansion, population growth, industrial and economic urban development in the late 19th century. So-called “tram suburbs” kept springing up which represented areas of mass housing along the tram lines radially diverging from the city centre to the outskirts and suburbs. That tram at the time was the main mode of mass urban transport. It should be noted that while the historical centres of cities were planned as pedestrian areas, the historical suburbs in the late 19th century (which by now have generally merged with the city and are adjacent to the city centre) were originally planned and developed to fit public transport (in the first instance, the tram) as the main mode of mass transportation: it did not provide sufficient space for the traffic, storage and parking of cars.

With private cars becoming more affordable in the 1920s, the importance of direct cost savings began to diminish: a growing share of population could afford a car and no longer had to participate in the “social contract” and make concessions for other passengers in plotting a common route. Public opinion and the views of architects and planners (especially in Western countries) all expressed confidence that public transport in the future would not be in demand as “transport for the poor” and all trips would be made by private cars. The costs generated by the road network came to be perceived as “socially necessary”, and therefore their effectiveness was not evaluated, as in the public mind, there were no alternatives to the road network further developing. Starting from the 1930s, areas were built up in a planned manner designed to accommodate cars as the main mode of transport while tram lines, which “impeded car traffic”, were removed en masse (for example, the huge tram network of Paris was completely dismantled in 1936), the development of the metro was retarded with the passenger flow using road public transport decreased.

The massive transition of consumers from public transport to private vehicles led to the issue related to the growth of total costs (extending to direct costs and externalities) for transport system operation aggravating. The main issue was that territories required space for the passage and parking of cars: congestion-free mass transportation of the same number of people by car will take 4 times more space of the road network as compared to bus transport and 12 times more in comparison with the tram. For a car to be parked, more common area in the building is required than for one office employee (i.e. each office building would have to have a parking building of similar dimensions next to it).

Accessibility (the number of places in demand covered) as a target function of the transport system is determined by the *density* in which objects are in relation to each other and the *speed* of transportation. The transportation *speed* considerably decreased due to densely located historical buildings (“tram suburbs”), that were not designed for mass car traffic: the lack of land for the road network to expand led to constant traffic congestion while the construction of multilevel junctions and parking spaces required the urban buildings to be demolished which was unacceptable. In particular, in order to provide for transportation of 100% of population by private transport vehicles, given the building density prevalent in the cities of the socialist camp countries that were designed in the context of a higher population density and reduced car use standards of the time, more than 40-50% of the city territory (road network, parking spaces and vehicle maintenance areas) would have to be have been used for transport needs which would have actually resulted in the destruction of 30 to 40 % of the buildings in these cities.

An attempt to ensure high speed of transportation in new built-up areas through balanced transport management (balance of the road area, flat parking spaces and building density where the demand generated by the building density was to be fully met by motor vehicles without traffic congestions and parking space deficit) led to a substantial decrease in the building *density* a well as to the phenomenon known as “urban sprawl” that stands for low density urban areas sprawling. In both cases, the substitution of public transport with private vehicles, as ironically as it may sound, led to reduced *accessibility*, due to either a drop in congestion-related transportation speed or in the density of buildings in terms of accommodating the road network and parking lots.

Mass car use has led to externalities growing along with the excessive demand for territories and reduced accessibility of transport, air pollution resulted in a spike in morbidity and mortality; noise pollution; shrinking appeal of the historical urban environment (it became “inconvenient” due to the lack of a sufficient number of parking spaces in historical areas, so the expanding roadways at the expense of sidewalks and sprawling parking lots at the expense of lawns detracted from the attractiveness of pedestrian traffic) as well as increased demand for shopping malls in the suburbs adapted for car access; a higher number of traffic accidents; growing direct budget costs for transport services management (construction and maintenance of the street and road network).

Unsuccessful attempts to make the dream come true where every person travels in his or her car led to the need to find efficient transport solutions that serve the target function i.e. *accessibility* (fast transportation speed in dense building areas) with the least *generalised costs* (direct costs of the population and the budget for transport services and externalities affecting the quality of life). The development of public transport systems was the response to that request but now, unlike the 19th century, not only does it save direct costs borne by passengers, but also reduces overall negative side effects i.e. externalities. Therefore, the purpose of public transport was transformed from “transport for the poor” at the end of the 19th century to “transport for sustainable development” by the end of the 20th century, which provided mobility for most of the population with the least negative impact.

1. Road traffic accidents. Road accident statistics in the Russian Federation in regard to accidents caused through the fault of motorists and the number of passengers carried per mode of transport, out of 1 million passengers transported: 6,07 accidents are caused by private vehicle drivers, 0,45 accidents are caused by bus drivers, 0,27 accidents by trolleybus drivers, and only 0,11 accidents are caused by tram drivers (Fig. 3.1). Therefore, a mayor who ensures that passengers are transported by bus instead of by car will reduce the number of road accidents by 13.5 times (for that proportion of the passenger flow which switch over to the bus) whereas when transported by tram, the numbers will go down by 55 times in comparison to car transportation.

Figure 3.1. Number of road accidents caused by motorists per one passenger transported

№	Type of transport	Transportation of passengers, mln. per year	Absolute figures of traffic accidents (due to the driver's negligence)			Number of road accidents per 1 mln. of passengers carried		
			Road accidents	Dead	Injured	Road accidents	Dead	Injured
1	2	3	4	5	6	7	8	9
1	Passenger car	19,027	115,428	13,100	157,846	6,07	0,688	8,30
2	Bus	11,722	5,294	257	8,194	0.45	0.022	0.70
3	Trolleybus	1,483	402	10	434	0.27	0.007	0.29
4	Tram	1,397	149	7	201	0.11	0.005	0.14

A similar pattern is observed for deaths and injuries. Transportation by bus will reduce mortality by 30 times and injuries - by 12 times in comparison with transportation by car. Transportation by tram will reduce mortality by 137 times as compared to transportation by car (4.4 times compared to the bus), the number of injuries - by 60 times (5 times compared to transportation by bus).

In general, a number of sources show a rise in traffic safety in urban areas due to a growing share of public transportation. For example, according to UITP,[101] the level of road accidents on light rail transport (LRT) is 0.47 accidents per 1 million passenger-km, in comparison with 2.86 accidents per 1 million passenger-km for motor vehicles within 15 surveyed European cities. That is, light rail transport in cities of developed countries has proven 6 times safer.

The main risk factor for an accident is the driver. For this reason, the greater the capacity of the vehicle, the less the risk of accidents is per one passenger transported provided that the vehicles are filled up within the permissible limits as there are 10-100 times fewer drivers posing a risk of accidents for each passenger. Rail vehicles have significant advantages due to the certainty of the trajectory, no lane changes, which are additional risk factors for accidents.

2. Environmental pollution. Studies show that emissions of pollutants can be reduced by 1.3-5 times owing to transportation by bus as compared to privet vehicle transportation, and by 4-1,000 times by using rail transport (including energy production) — (Fig. 3.2, 3.3).[102]

Figure 3.2. Emissions by mode of transport, including fuel production and delivery, as well as in traffic, g/pass-km.

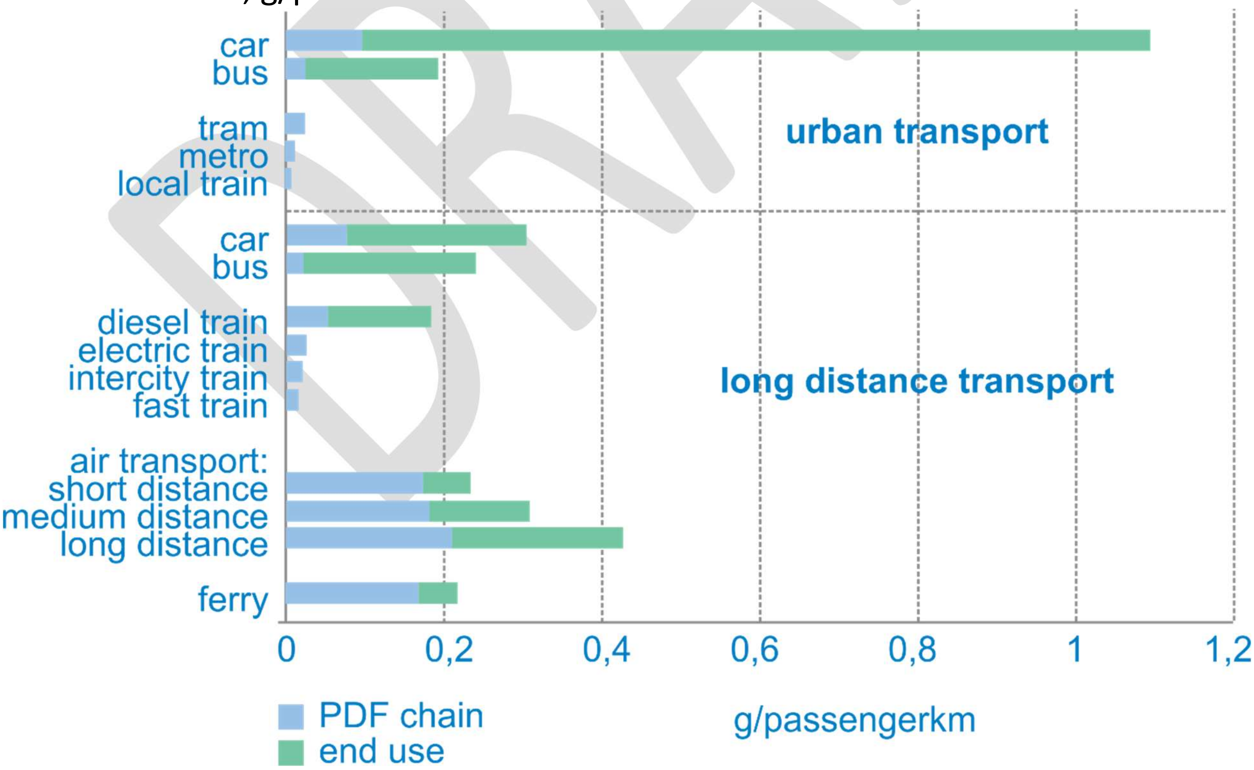
[101] https://www.uitp.org/news/knowledge-brief-LRT

[102] http://www.trafikdage.dk/td/papers/papers96/tr_og_em/kaleno/kaleno.pdf

	CO	HC	NO.	SO.	part.	Co_2	N_20
urban areas							
road transport							
car (**	8.339	1,098	0.799	0.091	0.077	194	0.0497
bus	0.333	0,199	1.170	0.031	0.059	67	0.0262
rail transport							
tram	0.010	0,019	0.029	0.028	0.027	9.2	0.0011
metro	0.004	0.008	0.012	0.012	0.011	3.9	0.0005
local train	0,003	0,006	0.008	0.008	0.008	2.7	0.0003
long distance transport							
road transport							
car (**	2.659	0,308	1.034	0.066	0.079	119	0.0391
bus	0,360	0,245	1.460	0.029	0,163	62	0.0301
rail transport							
diesel tram	0,195	0,179	0.953	0,103	0,023	67,5	0.0003*
electric train	0,014	0,026	0.040	0.038	0.037	12.5	0.0015
Intercity train	0,011	0,019	0.030	0.028	0.027	9.3	0.0011
fast speed train	0,007	0,013	0.020	0,019	0,018	6.1	0.0007
air transport							
short distance (200 km)	0,574	0,234	0,741	0,204	0,007*	217	0,0012*
medium distance (300 кт)	0.605	0,309	1.055	0.210	0,008*	230	0.0012*
long distance (> 500 km)	0,717	0,429	1.799	0.245	0,009*	268	0.0014*
ferry transport	0,344	0,218	4.536	1.610	0,137	220	0.0011*

*** includes only the emissions dunng the production and distnbution of the fuel**
(passenger car fleet at year 1994**

Figure 3.3. Emissions by mode of transport, including fuel production and delivery, as well as in traffic, g/pass-km.



Electric public transport pollutes the atmosphere tens of times less than private motor vehicles even taking into account electricity generated by power plants. In

Manchester, for example, 62% of the electricity that feeds the tram system is generated by wind farms causing zero environmental damage; [103]the remaining 38% of electricity is also produced by relatively ecological sources (hydroelectric power plants, etc.).

In addition to fuel pollution, urban air pollution with microparticles caused mainly by the friction of tyre treads against the road surface, is of great importance. Studies show the total amount of motor vehicles' braking system wear estimated as 8.8 to 20.0 mg/car -km, for buses it is in the range of 47 to 110 mg/car-km.[104] As city buses transports 10-20 times more passengers than cars per kilometer (per day), the bus-related particle emission per passenger-kilometre is 4-5 times lower. The most promising mode of transport in this respect is rail transport with the wheel tread wear significantly less than that of road transport. This being said, the chemical composition of rail dust is less dangerous to the body.

In general, the greater the capacity of the vehicle, the less pollution is generated per passenger transported in standard passenger load on the vehicle.

3. Direct costs related to transport service management. The data obtained by the Centre for Project Infrastructure Economics in the Russian Federation point to the fact that as the capacity of transport vehicles increases, the net cost of passenger transportation decreases (Fig. 3. 4).

Figure 3.4. A comparison of the costs associated with arranging a 10-kilometre route with a peak passenger flow of 2,000 passengers per hour

[103] https://www.tfgm.com/environment/public-transport

[104] Garg B. D., Cadle S. H., Mulawa P. A. [et al.] // Environmental Science and Technology. — 2000. — Vol. 34. — P. 4463–4469.; Sanders P. G., Xu N., Dalka T. M., Maricq M. M. // Environmental Science and Technology. — 2003. — Vol. 37. — P. 4060–4069

№	Indicator (with equal conditions of remuneration of labour and taxation)	Vehicle capacity				
		Low (Ford-Transit)	Medium (PAZ Vector); a fare inspector included	High (LIAZ 5256); a fare inspector included	High (LIAZ 5256); no fare inspector	Very high (Vityaz tram)
1	2	3	4	5	6	7
1	Capacity, persons	22	60	90	90	188
2	Traffic frequency (the number of departures from a station per hour) to service a flow of passengers of 2,000 persons per hour	91	34	22	22	113
3	Required fleet of rolling stock to service a route of 10 km at a given frequency	180	57	33	33	14
4	Rolling stock depreciation costs (including service life), mln. rubles per year	86	33	47	47	28
5	Expenses on drivers (and fare inspectors for medium-capacity and high-capacity buses) mln. rubles per year	183	89	51	33	14
6	Fuel and energy, mln. rubles per year	49	38	33	33	24
7	Rolling stock repair costs, mln. rubles per year	115	69	46	46	32
8	Infrastructure costs (maintenance and repair of a 3.5-m dedicated lane, tramway, energy)	30	30	30	30	40
9	IN TOTAL: the maintenance costs of a 10-km route with a flow of 2,000 people per hour by mode of transport, mln. rubles per year	462	259	207	189	137
10	Cost-to-minimum ratio (tram)	3.37	1.89	1.51	1.38	1.00

3.1.3. PT services quality (accessibility, safety, security, travel time, punctuality, affordability and so on)

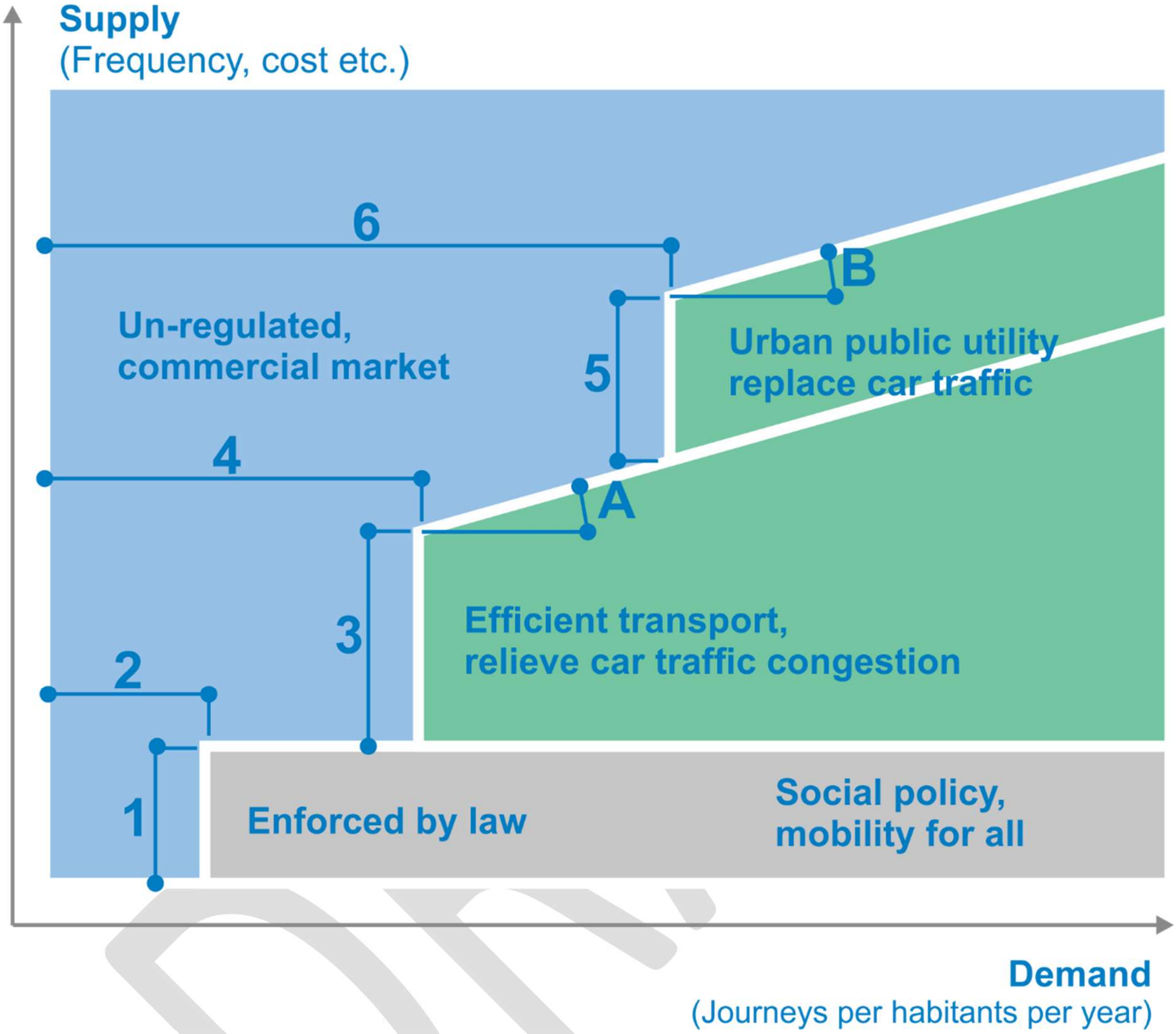
Public transport is inherently a public service. The bigger the number of potential consumers for whom this service is available in terms of the geography, time and price, the greater the benefits of this public transport to society and its efficiency. With the major role played by public transport in urban life as well as the subsidisation of public transport in most cities of the world, it is well-advised to set the minimum requirements for the public transport system to meet personally for each consumer based on the principle of equitable distribution of public resources.

The objectives of public transport vary depending on its function in urban transport, as shown in the figure below. Should there be no political objectives for the development of public transport in the equation, it can be left to the free market to take full control over it. However, if monopolisation is to be avoided, antimonopoly regulation has to be put in place (Fig. 3.5).

To meet the social goals in ensuring mobility for all citizens, levels 1 and 2 must be achieved.

Level 1 is the minimum standard of public transport accessibility which shows the requirements for maximum walking distance, transportation service frequency, transport operating hours for each customer at the place of his or her embarkation (place of residence) and destinations depending on the type of built-up environment, day of the week and year. This social standard must be enshrined in law at an appropriate level.

Figure 3.5. Possible level of quality standards for transport service given different levels of demand[105]



Level 2 shows the level of demand that derives from a politically established limited number of trips to which each citizen is entitled. When there is minimum demand, the quality standards are ensured mainly by enforcing them through budget funds; however, as demand goes up, an increasing amount of revenues covers the cost for maintaining the quality standard.

In order to meet the goal of reducing vehicle use, the levels of service delivery and demand should switch to values 3 and 4 with 3 standing for the improvement in the quality standard needed to convert a part of the private vehicle users into public transport users. This level depends, among other things, on the conditions of urban car use (congestion, parking fees and street-and-road network passage) as well as on passenger transport fare rates. An additional improvement in quality by value A (as shown in Figure 3.5) further boosts demand for public transport. Level 4 shows the

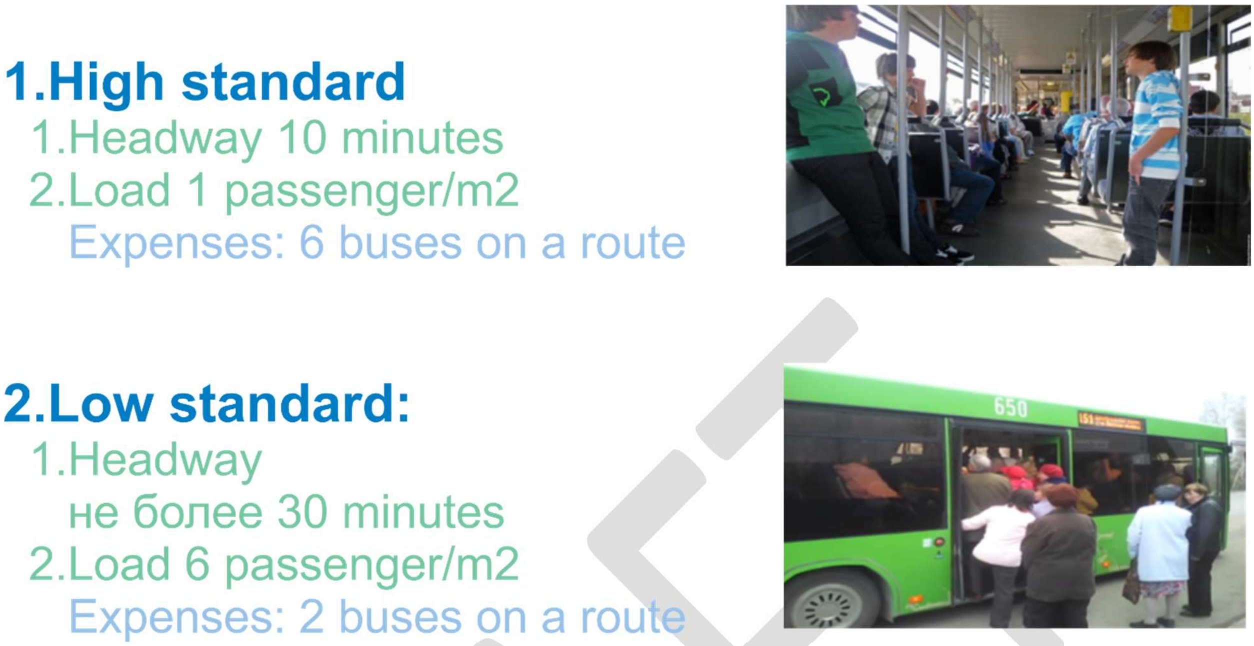
[105] Gustav Nielsen. Public transport — Planning the networks. HiTrans Best practice guide 2 / Guidelines. Skytta, Norway. 2005 — 176 p.

minimum level of demand required to cover the costs for public transport operation in order to manage the quality issue in a way that would compete with the car.

Finally, even more ambitious goals aimed at urban development focused on public transport, yet with no dependence on it, require reaching levels 5 and 6. Level 5 stands for the provision of quality service for all the elements of transport system, 6 stands for the minimum level of demand for this quality level allowing cover the costs of such high-quality service.

The service quality standard is the foundation for designing plans on the development of public transport and route networks. It is this standard that shows a route network developer where the stops should be located in order to ensure pedestrian accessibility to stops from each house, the capacity and frequency of routes required to fill up the rolling stock with passengers no more than the permissible load per 1 m^2 of floor area.

Figure 3.6. Comparison of operating costs at different levels of service quality standards for the same volume of transportation



As shown in Figure 3.6, the same passenger flow of 300 passengers per hour can be ensured by either 6 buses circulating at 10-minute intervals with low passenger load, or by 2 buses at 30-minute intervals with passenger overload. In both cases, the passengers are transported but with a fundamentally different level of quality. Also, transport service costs will also differ by 3 times. The quality level selected, and consequently, the cost, hinges on the political choice of cities and regional administrations.

The Federal Social Standard was developed in order to provide methodical support for Russian cities and regions. The Social Standard relates to delivering transport services for the population with respect to passenger and luggage transportation by motor vehicles and urban on-ground electric transport (approved by the order of the Ministry of Transport of Russia dated January 31, 2017) NO. NA-19-R. The Standard is of recommendatory nature and serves to show which indicators can be used to measure the public service quality and what level of quality is deemed acceptable for city passengers at the federal level. However, given that the financial capacities of passengers and budgets to pay for intracity trips (the operational costs of urban transport systems) vary substantially, the level of quality (and hence the level expenditures of on the part of the population and the budget) is established by each city independently. Cities take on the obligations voluntarily by adopting their own quality standards.

The quality indicators of the Social Standard cover the territorial accessibility from stopping points to places (from the boundary line of a place to the nearest stopping point in the street and road network depending on the category of the place).

The distance to residential buildings should not be more than 500 metres; accessibility to stops of high traffic frequency main routes should not be more than 1,200 metres in compact residence areas covering not less than 600 people within 1,200 metre walking distance; accessibility to stopping points and rolling stock for people with reduced mobility; price affordability of public transport and other indicators.

The fundamental role of the transport service standard is ensured by a social contract related to both the quality and the cost of transport services. Unfortunately, for populist reasons, the authorities establish low transport rates in a number of cities without reimbursing them from budget funds, which leads to operational disruptions and destruction of public transport. The Social Standard enables route network developers to design routes that ensure compliance with the Standard, to calculate the costs necessary for transport network operation as well as to work out the basic tariff required for the operation of the transport system. With expenditures justified, the populism will be replaced by a fair balance of incomes leading to an attainable level of expenses when establishing the rates. This allows for adequate financing of transportation for the sake of compliance with technological requirements.

3.1.4. Principles of PT routes network planning

Researchers and transport planners believe that[106] planning the transport and route network plays a crucial role in determining the success of the public transport system. The quality of transportation, the proportion of public transport in the overall share of transportation (as a criterion of attractiveness) and operating costs are determined by the following key factors:

- An integrated network of all public transport modes providing for convenient and easy transfers at several stops across the agglomeration as opposed to being limited to the train station or another single station in the city centre;
- Reasonable use of transport modes and rolling stock of necessary capacity to match the passenger flow and required efficiency;
- A simple route network with a clear structure of lines easy for every city resident to understand and to remember. This is to be achieved, amongst other things, through a well-conceived long-term strategy for land use, public transport and the road network;
- Straight route lines ensuring the shortest distances and the highest transportation speed; the latter being achieved by meeting the schedule without fail;
- High frequency of public transport circulation across all routes with a reasonably high passenger flow;

[106] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005.

- Coordinated timed schedules for routes with a relatively low passenger flow;
- Efficient main routes through the city centre, local district centres as well as mass interchange hubs connecting the main residential areas and employment areas of the region with the city centre, local district centres and interchange hubs;
- Supporting measures in the nature of the structure of tariffs, fare payment systems, information systems and marketing should preferably be implemented in tandem with restrictive measures for private vehicles which may have a significant impact on the demand for public transport and the success of all other measures.

These aspects all combined together determine the entire scale of possible outcomes ranging from an outstanding success to a complete failure of public transport.

In order to get the most out of development opportunities, a professional analysis of demand and use of all these measures is necessary. The involvement of all stakeholders in the planning process is necessary which requires an institutional framework to bolster these activities.

It is important to point out that the model of "pure competition" is not capable of solving the issue of creating quality public transport. However, a state-owned monopolist company is not likely to achieve necessary success, either.

Researchers point out that the same experience might turn out to be both successful and have a negative impact depending on the context, objectives of public transport development, local cultural, social and political factors, therefore there is no universal recipe for success.

Competition with private vehicles and efficiency as the main criteria for success:

Modern foreign practice determines the creation of competitive alternative to private motor vehicles in urban travel as the criterion for successful management and planning of public transport systems. In order to ensure sufficient funding to meet the required quality level, an effective system both during the construction phase and during operation should be put in place. Operating costs have a direct impact on fare costs, therefore, a successful system requires both delivering high quality and high efficiency to passengers. A route network planned properly can make a significant contribution to both aspects.

It should be recognised that competitive, high-quality public transport can never be cheap. Normally, public transport systems cannot compete directly with private vehicles in cities; the best-case scenario being that they get to retain their share of transportation in the central parts of cities. A higher share of public transport can only be achieved in areas with high quality public transport integrated with urban planning and combined with restrictive measures on private vehicle use, price incentives for use of public transport, cycling and walking.

The objectives of public transport network planning:

When planning a public transport network, the key aspect is to identify the planning objectives and goals, along with the ratio of these objectives and available resources that need to be clearly defined in order to achieve proper execution.

In order to provide transportation to those who are unable to drive private vehicles, it will be sufficient to establish a minimum quality standard for transport service capable of ensuring the transport accessibility to all citizens in the region. Keeping public transport competitive with private vehicles in order to relieve street traffic during peak hours may become a more ambitious goal. However, the idea of creating high-quality public transport capable of replacing private vehicles in cities on a permanent basis in order to shape an environment more attractive for life, including in the long term, is becoming a more ambitious goal.

Definition of the transport network structure:

According to foreign researchers, the essence of public transport is concentration of passenger flows along a small number of routes. Transfers are an integral feature of a large share of public transport journeys. Therefore, the ways of managing transfers and transport services make up the “core” of the strategy of improving public transport.

It is advisable to start the planning off with an analysis of the strengths and weaknesses of the existing network, to study the situation as viewed by different groups of customers, as well as to analyse the network from the point of view of the provider. Thereafter the target network should be identified for the long term. Once this is over, short-term solutions must be worked out. The following structure of work may be considered:

- Infrastructure issues and major high-demand corridors are the ones to be started with.
- The main transport corridors should be provided with as few routes as possible by introducing main (frequent) routes connecting the outskirts through the city centre along the main transport corridors;
- Possible tangential and link routes or corridors that can be serviced together with radial routes have to be planned out in such a way as to form a more complete network servicing the region, with due regard to route integration through convenient transfers;
- Both the urban and regional (agglomeration) route networks should be planned in order to achieve the best combination of routes both for passengers and providers. This can be realised through an integrated system of tariffs (trips should be available within the city along suburban routes using all citywide tickets without limitations);

- A timed schedule (with equal intervals that divided by 60 minutes) on routes with low traffic should be ensured;
- The possible ways to improve access to the main route network by improving the operation of buses, transfers, access for bicycles and private vehicles, as well as road conditions for motorists, cyclists and pedestrians with the aim of accessing the public transport network should be explored.

Understanding the role of planning in different institutional environments:

Successful planning requires studying the organisational structure of transport management, stakeholder interaction, demand for public transport services and changes in the sector.

First of all, it is necessary to understand the imperfections of the market mechanism in relation to public transport. The theory and practice of high quality public transport clearly demonstrate the need for its planning.

Secondly, the extent of planification depends on the degree of transportation regulation in a particular region. In approaching public transport as a public service, the role of planning becomes significantly more important compared to regions where public transport is viewed as a "free market".

Thirdly, the best practice, as has been proven, is to combine the benefits of integrated planning with the advantages of market competition "off-the-route" (the competition should be for the right to run a route without any competition on the route itself). The advantages of the market approach can be gained by bids held to run routes as well as to develop and service the respective infrastructure. Planning and competition are not mutually exclusive; it is rather a matter of a correct division of roles in the institutional environment of transport management.

Taking into account the reformation experience:

There are clear trends in public transport management in cities around the world. The role of the private sector is gaining in significance although every city has a different motivation behind it. Usually, the transport administrations of regions plan transport and route networks, integration of operators and transport modes, as well as determining the requirements for transport service quality on their own. The following are cases of competition "on the road" (operation of various providers in the common transport corridor; each trying to intercept as many passengers as possible) and "off the road" (for the right to conclude a contract to service a route).

The introduction of free "on the road" competition in the UK in 1986 in all the regions except London did not lead to improved service quality or higher demand for bus services. On the contrary, it is London, where transportation is still strictly regulated, that remains the only agglomeration in the UK with a significant increase in the bus passenger flow (a 40% rise between 1982 and 2001).

In many Scandinavian and UK cities, the cost of a bus-kilometre dropped by 10 - 30% in the early years of "off-road" competition in the 1990s. Then, after several years, competitive procurement procedures had led to the number of providers dwindling to about five; all of them being the largest international transport operators. Prices for their services had stabilized, and in some cases, had even gone up. Nowadays, reduced prices are not the main goal behind procurement procedures; the primary aim being improving the quality of transport services. In recent years, the attention has been drawn to contracts which promote the quality and attractiveness of public transport thereby also boosting the share it holds in overall transportation.

The following institutional factors are essential successful public transport planning:

- All large regions with a robust public transport system in place are ones with a strong regional governing body that integrates public transport into a single regional network;
- There are various patterns of regional transport management that have proven to be viable;
- A sustainable public stance on financing the public transport is a prerequisite for quality public transport;
- Providers need economic incentives which can come in different forms;
- Organisational measures are known to play a significant role;
- A strategy of drawing customers to transport services, and promotion of transport services among customers can also do the trick;
- Cooperation with policy-makers across political lines outside the transport field is of great import.

Political support for public transport:

The development of quality public transport in countries of democratic governance is possible only through a certain political support based on trust and confidence, as well as meeting the expectations. Quality solutions and efficient use of resources are preconditions for providing for this support.

To achieve long-term success, public transport should be the "main locomotive" of urban development steadily ensuring high quality year by year. This stability is indispensable for the public transport to influence the developers' initiatives, and to give momentum to the development of new districts. The new districts, in their turn, reciprocate by encouraging the use of public transport.

Capitalising on the synergy of the network effect:

In order to compete with the private vehicle sector in an urban environment in successful manner, two key qualities of public transport are needed: minimum waiting time for public transport and an integrated network of routes servicing all points with high demand for transport. Network planning should aim to concentrate resources on a sufficient number of high-frequency (main) routes that service the major share of demand for public transport in the region. Intervals on the main routes should be from

5 to 10 minutes: this will allow most customers to "forget about the schedule" thus reducing the waiting time.

While intervals less than 5 minutes no longer give tangible benefits to passengers, they are able to trigger traffic congestion, affect the capacity of public transport infrastructure and cause a spike in environmental pollution in densely populated areas. With a high passenger flow, the capacity of standard buses may not be enough. Under such circumstances, the capacity of vehicles en route must be enhanced coupled with the development of rail transport.

Combining network structure stability and adaptability to changing conditions[107]:

The public transport system should have the potential to adapt to shifts in demand taking into account the changes in built-up areas and land use, changes in the nature of employment, housing and other places of passenger attraction. That being the case, the long-term stability of high-quality networks is essential to creating a positive impact on developing the adjacent areas and setting up sustainable transport links. Public transport resources should be focused on servicing major transport corridors in order to be a decent rival to private vehicles. However, such concentration may contradict the need to ensure equal access to public transport for all citizens.

In order for adjacent territories to be successfully developed, including with a focus on public transport, it is necessary to create such a geographical structure of the network that will be in demand and stable in the long-term. The influence of rail infrastructure on the development of adjacent territories can be well traced in world practice. Indeed, the bulk of urban developments in the first half of the 20th century built on rail transport accessibility.

The stability requires some flexibility and readiness to be developed, in particular, with the adjacent territories developing, the route network should have the potential to be extended to the newly developed territories without major changes. Such adaptability is possible when building a system based on as few simple and easily identifiable lines as possible. A network comprising a small number of simple routes has significant advantages over complex networks, allowing customers to easily memorise the network structure, which is critical to the attractiveness of public transport.

The network should be able to adapt to changing loads, especially to growing passenger loads. Optimal intervals of traffic on the route network cannot be planned for years ahead. Generally, transportation intervals and rolling stock capacity are planned for 1-2 years ahead based on the continuous monitoring of the passenger flow, while more long-term forecasts are required as the grounds for construction of a new transport infrastructure and determining the network basic structure to make it adapt better to the future conditions, including with due regard for transport mode

[107] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005

preferences. Light rail transport has the best adaptive ability: the capacity of the rolling stock and carrying capacity can be incrementally increased from 1,000 up to 15 -18,000 passengers per hour without having to substantially restructure the infrastructure. In particular, the erroneous decision to develop transportation in Ottawa (Canada) through dedicated lines for high-speed buses led to these lines overloading and the inability of the bus to cope with the growing number of passengers which resulted in the costly need to re-structure the bus system into a system for light rail transport.

In regions with limited demand (usually regions with low population density), it is necessary to introduce feeder routes to the main line network (mostly ones leading to rail stations and stops). This is the route network in Wünsdorf (Hannover region) (Fig. 3.7).

Figure 3.7. A network of feeder routes to the regional rail transport network, Wünsdorf (Germany)

Network effect[108]:

The public transport route should not be just a line on the map; it must deliver a tangible transport service. In general, there is demand for high-frequency routes which has been backed up by numerous studies. What frequency is to be considered as high depends on the passage conditions of the route: while it is 10 minutes or less for city centres, a 30-minute interval may be quite attractive for suburban areas; on the other hand, an interval of 30 minutes may also be perceived as attractive for downtown areas in cities.

In spite of demand elasticity and service frequency being interdependent in an intricate way, the elasticity ratio is lower than one. This means that doubling the traffic frequency along the route will lead to traffic growth by only 20- 50%, that is, the additional revenue will never cover the increased costs on a particular route. The effects generated by an increased traffic frequency are primarily indirect and associated with a reduction in travel time for the population and decreased vehicle

[108] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005

use. These benefits should be covered by public resources (budget funds) as they may not be covered by the gain in ticket revenues.

The fundamental impact of the frequency of public transport circulation manifests itself in the so-called network effect, where an increase in the frequency of all public transport routes leads to synergy along with an overall boost in the appeal of public transport. The network effect manifests itself in the assumption that most customers make transfers while travelling using the transport network.

Figure 3.8 Comparison of transfer scenarios and network effect with the proportion of routes operating at high traffic frequency increased.

Figure 3.8 on the left shows a low-frequency route network. It is only the limited part of the area within walking distance from the route next to the starting point of the trip that one could get to without having to make a transfer; this means that generally passengers make one or two transfers during their trips. With a low frequency of routes, each transfer will take too much time, so this system can only be suitable for a limited group of customers whose points of departure and arrival are located along the same route.

A network with separate high-frequency routes is shown in the middle of Figure 3.8. In this case, a transfer to a high-frequency route is fast and convenient, but then again transferring from here to the subsequent low-frequency route takes a long time.

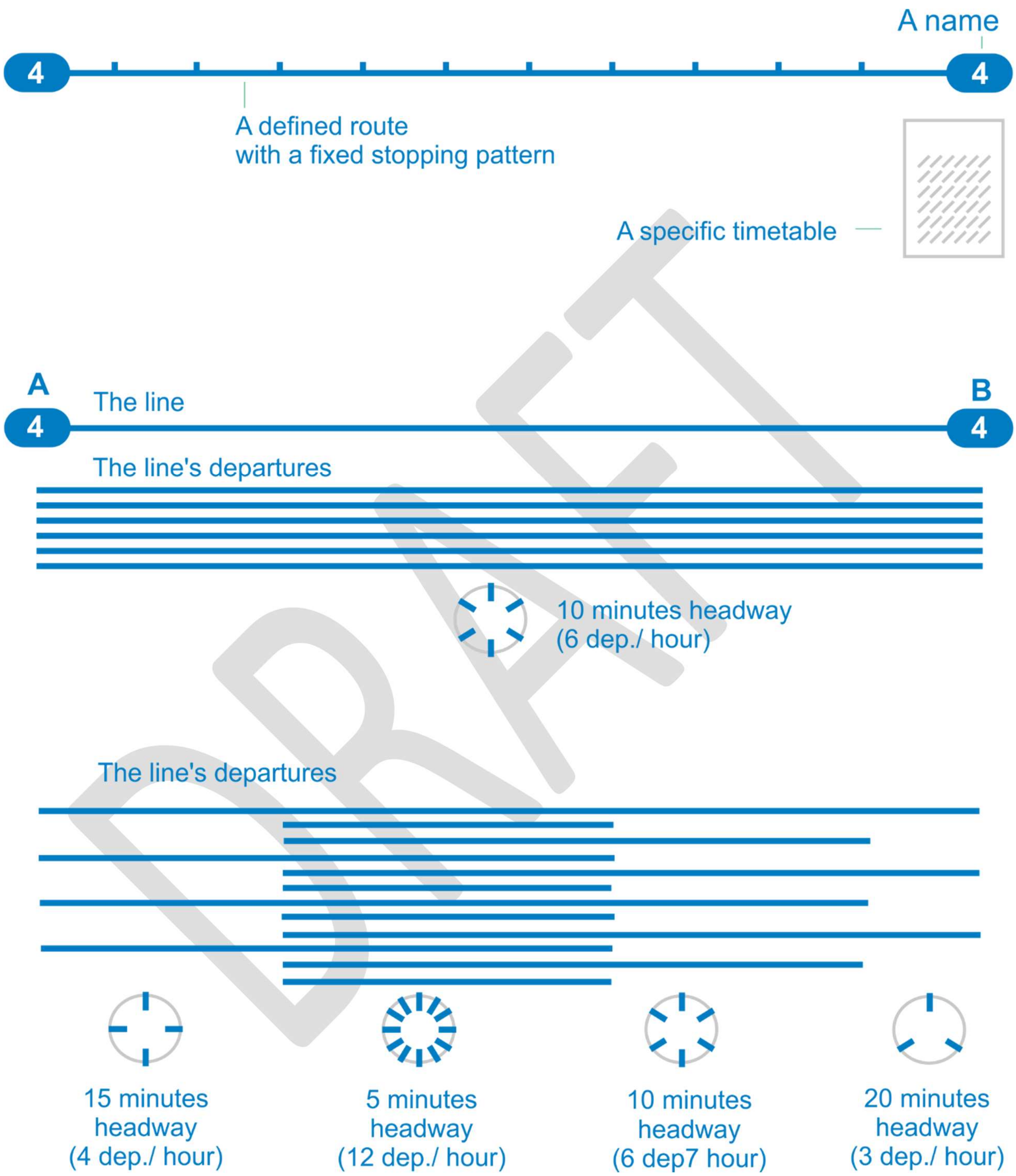
Finally (Fig. 3.8) all major transfers become convenient and fast when the whole city is covered with a network of high-frequency routes thus making it easy for customers to move across the entire high-frequency network. The network becomes useful for customers at any combination of stops, that is, the dependence of the extent to which the network is convenient on the growth in the number of high-frequency routes is quadratic.

The main elements of a route network and the principles behind its configuration[109]:

Figures 3.9-3.11 show main elements of a route network and the principles behind the configuration of routes.

[109] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005

Figure 3.9. Route network elements: route name, continuity of the route, suboptions offered by the route (the frequency is controlled by section)

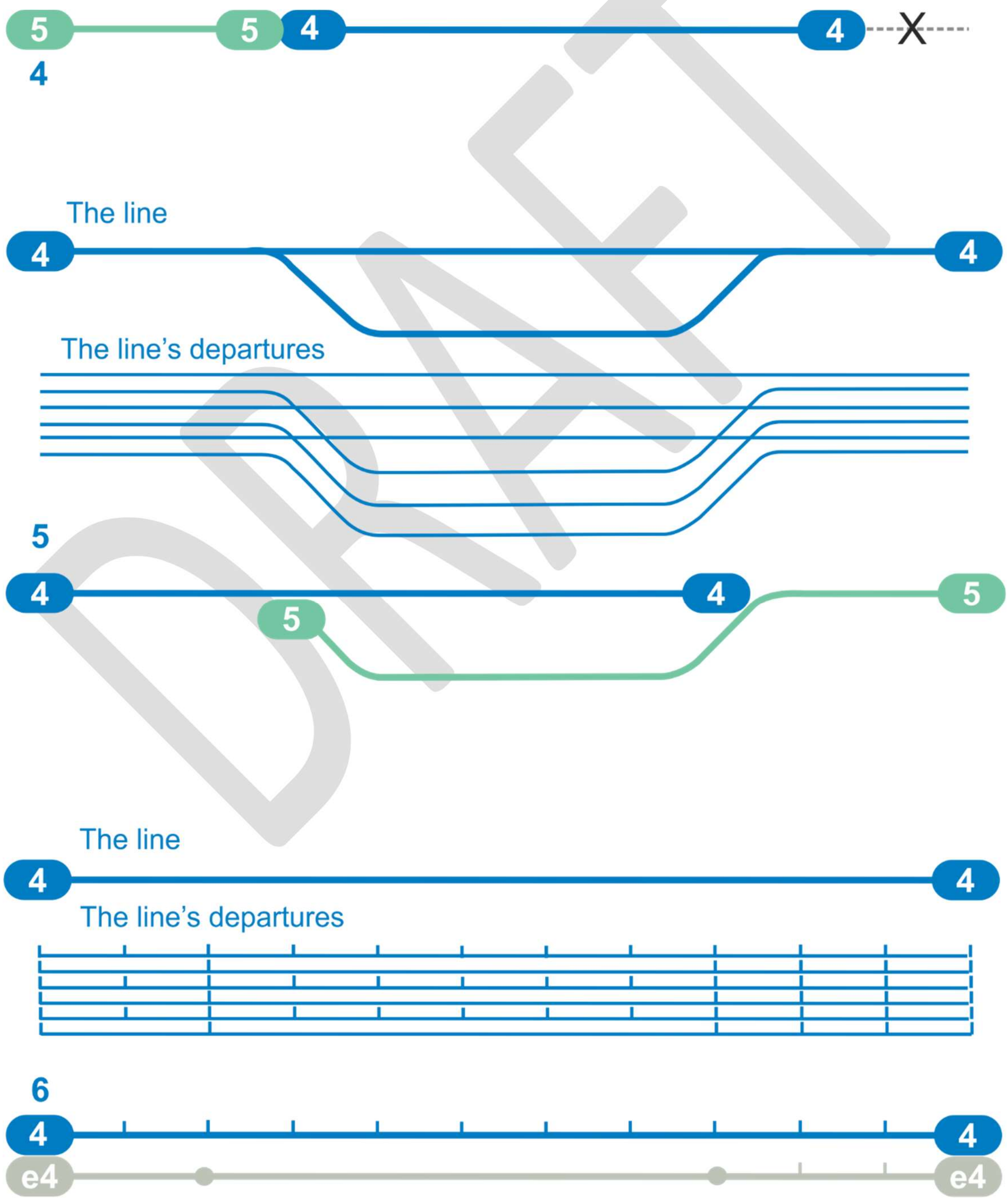


1. A route should be assigned a name (number). A route must follow a specific line with fixed stops in keeping with a fixed schedule.

2. The ideal line circulates between A and B, always along the same route with the same stops. In this example, the route offers six departures per hour with a 10-minute interval.

3. The route may have different frequency at different sections. This allows for adapting the transport capacity to shifts in the demand at different sections as well as reducing the consumption of resources required to run the route without having to change the route itself or to make unnecessary transfers.

Figure 3.10. Route network elements: subdivision of a route into two routes, impermissibility to change roads, a permanent set of stops per route



4. With demand along the route varying significantly, it is possible to divide it into two routes in order to use a rolling stock of different capacities or even different modes of transport. This allows for a more efficient use of resources.

5. A route should not run along different lines at different times. This would blur the understanding of that route in passenger's minds thus complicating its perception. If there is a need to move along different lines, an additional route should be put into operation, as shown in the figure.

6. A route should not have different sets of stops for different departures. Otherwise, the concept of that route would be deprived of its value. If an express service needs to be put in place, the service should be assigned a separate name, as shown in the figure.

Figure 3.11. Options as to informing passengers on the operation of a set of routes

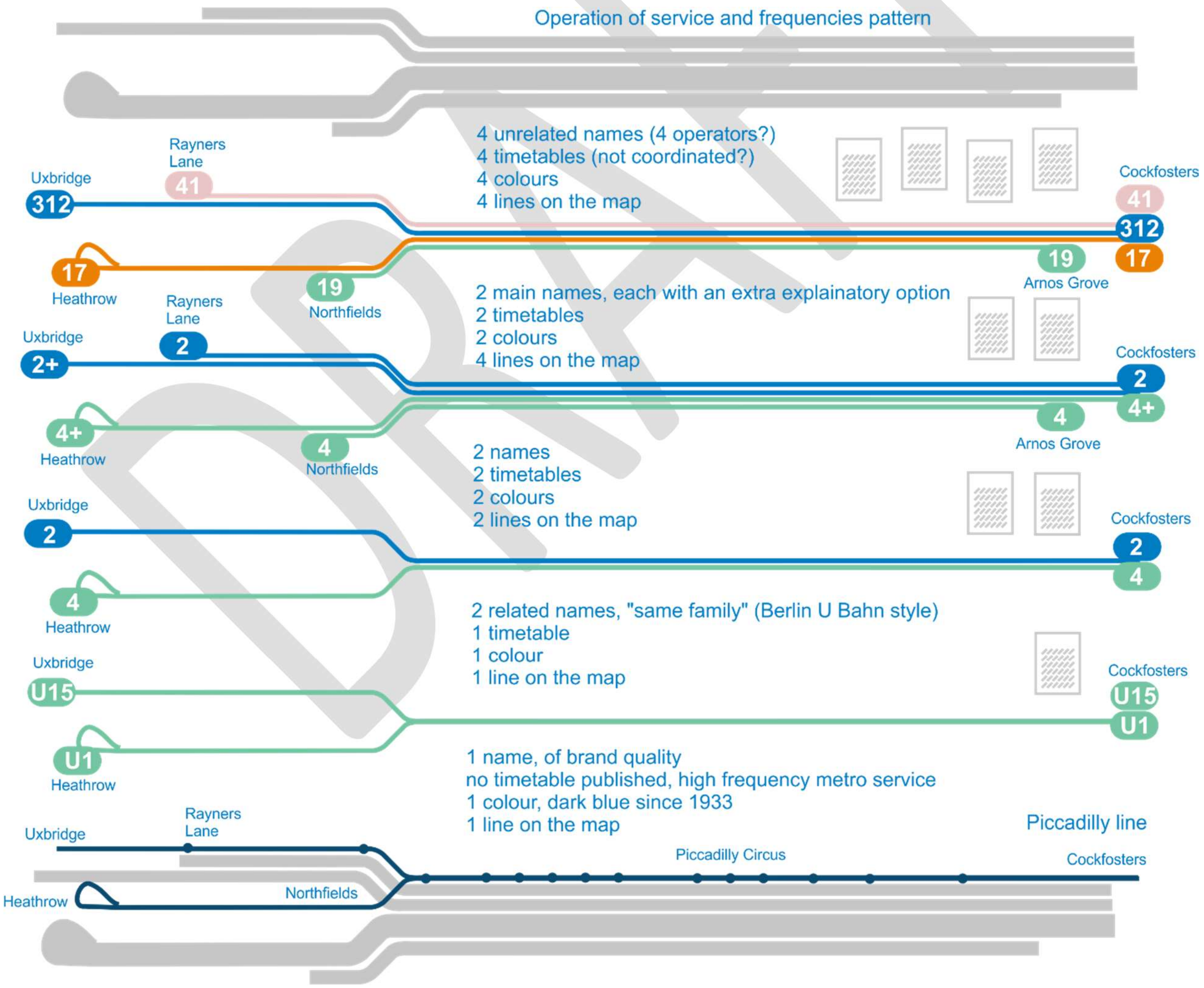
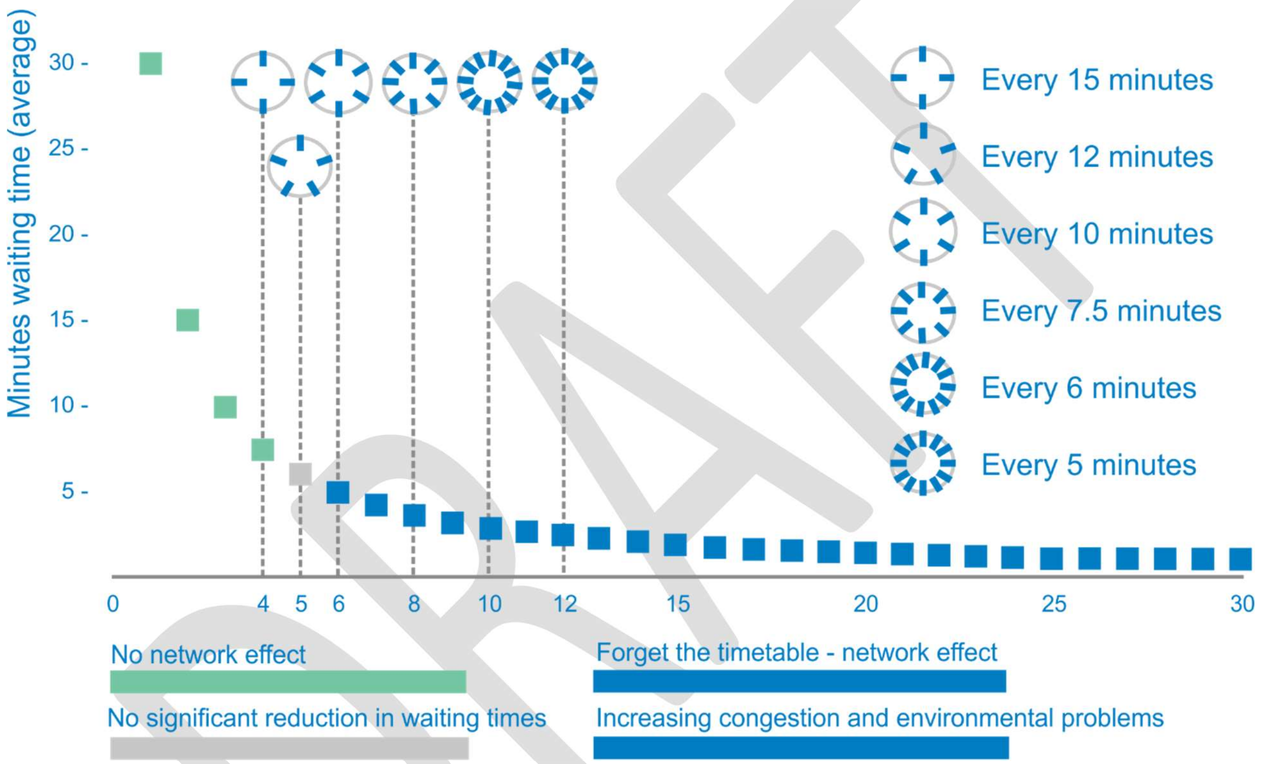


Figure 3.11 shows the different ways used to provide passengers with information on the operation of the Piccadilly line in London. These examples

demonstrate different ways of how this route is perceived and how it is presented in the most simple and understandable manner which exemplifies the best service marketing for the passenger. Obviously, the 4-line option (at the top) is the least convenient one as it provides unwanted information in excess which may overwhelm passengers; the example below, by contrast, conveys the same information, but in a much more concise and understandable form, which has been proven to be true by the London Underground. The same principles should apply to land transport.

Figure 3.12. Criteria for selecting a travel interval for a route



Selecting the right interval (Fig. 3.12) is defined not only by passengers' perception and the network effect (convenience of transfers), but also by street congestion resultant from an excessive traffic frequency. As shown in the diagram, the network effect is observed at a frequency of at least 4 departures per hour (an interval of no more than 15 minutes), and becomes more efficient as the frequency goes up. However, with approximately 12-15 departures per hour (4-5-minute interval) or more, the waiting time undergoes no significant improvements and no longer plays a part in enhancing the network effect; however, at intervals of less than 4 minutes, bus congestion starts to occur (as shown in the picture, Birmingham, UK), especially on multiple routes where the total traffic frequency exceeds 30 departures of all routes per hour. With diesel buses in operation, an excessive frequency also leads to high levels of environmental pollution, increased risk of accidents and greater direct costs (as compared to the tram, a high-capacity transport mode). When planning, the total frequency of traffic at any stopping point should be less than 30 departures per hour.

3.1.5. Principles of PT mode choice and organisation of its operation

The choice of the appropriate mode of transport is determined by the economy behind the transport system, technological requirements and the quality standard of transport service.

The Figure below (Fig. 3.13) shows an example of a comparative calculation of managing transport services on a route of 10 km in length with a passenger flow of at least 2,000 passengers per hour in one direction, which typical of cities with a population higher than 500.000 people in Russia.

Figure 3.13. A comparative calculation of managing transport services on a 10-km route with a passenger flow of at least 2,000 passengers per hour in one direction

№	Indicator (with equal conditions of remuneration of labour and taxation)	Vehicle capacity				
		Low (Ford-Transit)	Medium (PAZ Vector); a fare inspector included	High (LIAZ 5256); a fare inspector included	High (LIAZ 5256); no fare inspector	Very high (Vityaz tram)
1	2	3	4	5	6	7
1	Capacity, persons	22	60	90	90	188
2	Traffic frequency (the number of departures from a station per hour) to service a flow of passengers of 2,000 persons per hour	91	34	22	22	113
3	Required fleet of rolling stock to service a route of 10 km at a given frequency	180	57	33	33	14
4	Rolling stock depreciation costs (including service life), mln. rubles per year	86	33	47	47	28
5	Expenses on drivers (and fare inspectors for medium-capacity and high-capacity buses) mln. rubles per year	183	89	51	33	14
6	Fuel and energy, mln. rubles per year	49	38	33	33	24
7	Rolling stock repair costs, mln. rubles per year	115	69	46	46	32
8	Infrastructure costs (maintenance and repair of a 3.5-m dedicated lane, tramway, energy)	30	30	30	30	40
9	IN TOTAL: the maintenance costs of a 10-km route with a flow of 2,000 people per hour by mode of transport, mln. rubles per year	462	259	207	189	137
10	Cost-to-minimum ratio (tram)	3.37	1.89	1.51	1.38	1.00

According to the calculation performed in the context of one Russian city with a population of over 600,000 residents, at least 91 minibuses, 34 medium-capacity buses, 22 large-capacity buses and 11 "Vityaz" articulated trams are required in order for a passenger flow of over 2,000 passengers per hour to be serviced with the capacity of transport vehicles calculated as per the standard of 4 persons/m^2 of free floor area. The high frequency of bus traffic requires a dedicated lane whose costs must also be taken into account.

Given the costs associated with drivers' salaries, repairs and depreciation of rolling stock and infrastructure, tram transportation appears to be the most economical option in this case. The calculation indicates that transportation by high-capacity buses will be 38% more expensive than transportation by tram, transportation by medium-capacity buses will be 89% more expensive than transportation by tram, transportation by small-capacity buses will be 3,37 times more expensive than transportation by tram. The economic advantages of large and extra-large capacity transport vehicles are achieved by a manyfold gain in the labour efficiency of drivers without operating costs substantially increasing. It is obvious that this calculation is fair when the rolling stock is filled up to the extent close to standard load. The task of the transport planner is to select the rolling stock and intervals in such a way so that all vehicles are filled up to the extent as close as possible to the permissible load density during peak hours but without exceeding it.

When choosing the mode of transport, the main criterion technology-wise should be the maximum capacity of transport modes. With a passenger flow of more than 3,9-4,000 passengers per hour, the frequency of extra-large capacity buses will exceed 30 crews per hour, which will not allow for stable conditions for transportation through intersections at the same level. With the passenger flow that high, the use of rail transport is dictated by the technological conditions. Apart from the capacity criterion, another engineering requirement is room left for passengers with reduced mobility to be seated (passengers with prams, disabled people, passengers with bicycles, etc.). Generally, small-capacity buses are not technologically capable of accommodating passengers travelling with prams and therefore it is recommended to use at least medium-capacity vehicles equipped with a low-floor platform for the convenience of persons with reduced mobility. It is advisable to avoid the use of ramps and other special devices intended for pickup of low-mobility passengers, since their use significantly increases the embarkation time causing delays in the schedule as well as overload the rolling stock. The infrastructure (landing platforms) must be fitted up in the proper way.

Environmental requirements encourage the gradual transition to electric transport, that is the tram, trolleybus, electric bus, and urban electric train. China for a time pursued a programme under which substantial state subsidies were allocated for electric buses capable of being charged by their operators, which led to an explosive development in production of electric buses in China (over 95% of the world fleet of electric buses). Once the co-financing programme was discontinued, it turned out that the most cost-effective type of charging was dynamic charging by the contact network, which allows rolling stock to charge while in the depot or at the final station with no downtime which leads to a reduction in overhead expenses on batteries and their transportation. The problem with charging is the electrical contact area which limits the current and battery charging speed: the energy transferred to the battery per unit of time is about 100 times less as compared to the energy a classic diesel-fuelled bus receives over the same period of time. Therefore, every 20-30 km, a typical distance for turnaround trips in major cities, the electric bus requires at least 10-15 minutes of net charging time at the final stations (excluding the separate spare time for late arrivals used up whenever a vehicle arrives behind schedule). This means that each hour of a turnaround journey involves at least 10 minutes of downtime which adds to the need for more rolling stock en route (and more drivers), as well as driving up the costs of running the route by 15-16%. Extending the autonomous operation of electric vehicles entails an increase in the dimensions of batteries and higher rolling stock prices so the charging process at the final station also results in an increase in the cost of each rolling stock unit.

In view of the strengths of dynamic recharging, a number of cities have decided to restore the trolleybus contact network: for example, Prague (Czech Republic) has already built a contact network section to provide dynamic charging for the electric bus route with similar plans announced for Berlin and Dresden (Germany). A number of cities in China, which have the greatest experience in recharging electric buses by the operators themselves, are seen restoring and building trolleybus contact network sections to provide dynamic charging for electric buses.

Requirements aimed at reducing the number of road accidents and the mortality rate resultant therefrom, along with the demand to curb direct costs, lead to the largest-capacity transport vehicles being recommended for operation with a view to cut down the number of vehicles engaged in transportation. In planning a network, a balance must be struck between increasing capacity and maintaining acceptable intervals. For example, with a capacity of 188 persons per one tramcar and a passenger flow of 188 passengers per hour, the tram, if selected as the appropriate mode of transport with adherence to the requirement to meet the standard passenger load, will result in traffic intervals of one hour, which is inadmissible from the perspective of service quality. The job of the transport planner is to establish the maximum possible capacity at acceptable traffic intervals (usually not more than 10 minutes during peak hours). The optimal solution is to select the capacity of rolling stock, at which the interval of transportation is kept down to no more than 10 minutes during the whole day, shrinking to possibly 6-8 minutes at peak periods.

In order to ensure that vehicles of the largest capacity are filled up with passengers as per the standard at reasonable intervals (about 8 minutes during peak hours), a high concentration of passenger flow must be achieved on a small number of routes by reducing the overall number of routes. In this regard, the transport systems of cities in developed countries such Germany, Switzerland, Austria, etc. have no more than 1-2 routes per street, which consequently helps ensure that large and extra-large capacity vehicles are filled up in conformity with the applicable passenger density standard while also saving costs for transport services.

3.1.6. Engagement with other modes of urban transport

The quality of transfers between routes and modes of transport is critical for building up a public transport network that is competitive with private cars in cities. The difference in travel time, journey comfort and orientation convenience between well-placed and misplaced transit stations is truly significant.

High-quality transfers, which may be potentially required in a greater number of intersections are necessary to shape a network effect that would maximise the benefits of a simple but efficient route network with a small number of high frequency routes. Inadequate quality of transfers requires extra direct routes with less traffic frequency which results in a route network that is fragmented, difficult to perceive and constantly changing. With the capacity of vehicles in operation decreased, the efficiency of the network will decline and the ways for efficient rail transport operation that could provide for the greatest advantage in terms of quality, safety, environmental friendliness and transport economy will shrink in numbers.

The greatest network effect can be attained by introducing convenient transfers at all the intersection points of two or more routes for the purpose of creating new transportation capabilities. Most of such intersections are ordinary crossroads, it is therefore important that traffic is designed to be managed with a focus on the priority of convenient transfers for passengers. In particular, this is achieved through the physical proximity of stopping points to crossroads and to each other with the shortest distance between them, as well as, if possible, arrivals of transport vehicles common stopping station at intersections.

Large interchange hubs serve to connect the urban space with the transport system. These are regional and local activity centres, which provide for transfers while also being major places of attraction for passenger flows. These hubs are often located within areas of employment, commercial activity and public service and, in some cases, areas of high population density.

Figure 3.14. Minimum walking distance represented in the practice of efficient Freiburg's interchange hubs

Interchange hubs for "seamless" transfers in Freiburg (Germany), Fig. 3.14: main railway station; main hub of tram lines (designed in conjunction with the pedestrian area for easy transition between routes), transfers from suburban feeder buses to trams; park-and-rides ensuring transfers to the tram outside the city centre.

As can be seen from the given examples, the walking distance is minimised in each case. A passenger simply needs to go downstairs or use an elevator at the station; a passenger simply needs to cross two tramlines to make a transfer at the city centre square; when making a transfer from suburban buses, passengers arrive at the same platform as the tram headed for the centre so a passenger needs to walk 4-5 metres (the width of the platform) in order to make a transfer.

Figure 3.14. Minimum walking distance from railway transport to the metro at the Rechnoy Vokzal interchange hub, Novosibirsk (Russia)

The quality of the transportation chain depends on the quality of the weakest link. In this regard, the walking distance to stopping points should also be factored in as a component of the public transport system. The walking distance should be as short as possible, which is partially achieved by stopping points located efficiently as well as by a comfortable network of pedestrian paths illuminated and protected from dirt and noise going through an attractive urban environment. The more attractive the pedestrian route is, the greater the distance that pedestrians are inclined to walk.

Cycling can drastically reduce travel time in areas with less population density located more than hundred metres away from stops. The speed of cycling is 3-4 times higher than that of walking. This means that there will be 10 times more areas (and places) within the same time range for cyclers than for pedestrians. Convenient bike access routes to public transport stops will add to the appeal of combined “bike-bus” and “bike-train” trips. It is important to fit up railway stations, tram and bus stops with parking spaces for bicycles.

Private vehicle access to public transport is a common solution for low population density areas located at a distance from public transport stops. There are two practices to achieving that known in the world:

- Park & ride: A driver and accompanying passengers leave their private vehicle on a parking lot and continue with their trip by public transport;

- Kiss & ride (drop-off at public transport stops): A relative or other fellow traveller drives a over passenger to a public transport stop or meets him or her at a stop in his or her private vehicle.

The efficiency of park-and-rides is dependent on the traffic frequency on the route, the transportation speed and the proximity of parking space from public transport vehicles taking into account the fee of park-and-rides in comparison with the parking fees in the city centre. Convenient access to public transport stops from the adjacent road network is an advantage.

A park-and-ride can be free of charge (with the fee included in the ticket price) provided that there are practically no other buildings in the surrounding area that made accessible by it. Free parking is inadvisable in cases where there is high demand for parking in the area adjacent to a PT station (which often is the case near railway and metro stations): in this instance, a more effective solution would be to locate office, business or residential buildings in the immediate vicinity of a PT station.

3.1.7. Specific issues of urban public electric transport development

Urban public electric transport has traditionally been seen as being separate from bus transport because of both its linkage to infrastructure and general service technologies that are fundamentally different from the diesel transport technologies.

It should be noted that a simplified view of transport modes as being strictly separated impedes the integration of transport modes into a single system. Ultimately, it is time saving, safety, environmental friendliness and cost affordability that are of the utmost concern to the passenger, the final effects of the transport system operation, rather than the specific type of engine or the name of transport mode. For example, the metro, the urban railway and the tram came to be as a single mode of transport, but due to departmental disunity they were gradually divided, generating a disintegration and causing unnecessary transfers. In our day and age, this disunity can be eliminated by the reverse integration of transport modes, for example, by constructing tunnels and underground stations for rail transport and the tram similar to the metro, by introducing single tickets used in the metro as well as delivering high-frequency service, a successful example of which is the Moscow Central Circle which ensures intra-city railway transportation with intervals of 5 minutes with tickets shared with the metro. The system operates during the day and integrates rail transport into citywide transport (Fig. 3.14).

Figure 3.14. Installation of escalators and waiting halls in railway stations in a similar manner to metro stations as part of the efforts aimed at the integration of railway transport into the public transport system of Moscow (Russia)

Similarly, the conventional bus - trolleybus division is effaced with the introduction of an electric bus, that is a trolleybus with autonomous capabilities. In order for the electric bus to run, it needs to pass approximately 20-25% of the route under the contact network to have sufficient time to charge. As a result, a significant part of the bus routes in any city with a trolleybus network can be converted into electric buses.

Electric traction provides the following significant advantages as opposed to diesel operation:

- zero exhaust (no air pollution) en route and at stopping points;
- noiseless operation (minimum noise level possible);
- lower vibrations in the cabin;
- energy saving (minimum energy consumption);
- smooth acceleration and braking, no gearshift;
- maximum engine thrust at any speed;
- increased reliability of transport vehicles;
- no engines running at idle speed;
- low operation costs;
- high attractiveness for the population;

- reduced private motor vehicle use; less pressure on roads due to the higher quality of trips.

These advantages encourage cities to transition to electric motor transport vehicles, including public transport. While the use of electric transport may have been earlier constrained by the need to develop the power network infrastructure, now, thanks to the development of autonomous trolleybuses, diesel buses can be substituted en masse with electric buses (buses dynamically charged by the contact network, Fig. 3.14D) requiring no significant investments (except for increasing the capacity of substations if needed).

Electricity rate regulation for urban electric transport (tram, trolleybus, metro) is an essential issue related to promoting the development of electric transport for passenger transportation. Today, in a number of countries, for example, in the Russian Federation, power for electric transport enterprises is supplied at rates similar to those offered for industrial enterprises, taking into account maximum power consumption costs. Although such rates are proven to effectively balance consumption peaks for the industry, it is not the case for urban electric transport, as consumption peaks are an objective attribute of urban transport. It should be mentioned that fuel for bus transport is supplied at the same preferential prices as for the general public, which, therefore, can be construed as a disguised subsidy for the less efficient and less environmentally friendly mode of bus transport to the detriment of the development of urban electric transport. Given that the only end user of urban electric transport is the population and the role of urban transport is a life support system, the introduction of special reduced electricity rates for urban electric transport seems well-advised, for example, by setting electricity rates for urban electric transport at the same levels as for the population. Such measures have already been applied in some countries, such as Ukraine.

In recent years, there has been a trend towards excessive stimulation of private electric vehicles use. The best efforts have been made in Sweden, where electric vehicle owners, along with the available significant discounts on the purchase of an electric car, have been granted free parking as well as dedicated public transport lanes. The final effect of excessive stimulation of private electric vehicle use has turned out to be negative: public transport has lost its advantages on the dedicated lanes as they have, too, come to be overwhelmed with traffic, the attractiveness of private vehicle trips has improved significantly, resulting in higher vehicle use and its adverse consequences — environmental pollution (for example: tire tread friction), road accidents and traffic congestion. The means that measures taken to promote electromobility while being generally effective in mitigating the environmental impact should under no circumstances encroach on the priorities of public transport over private vehicles.

3.1.8 Case studies and good practices

Case studies and good practices in public transport planning, financing and management are given below.

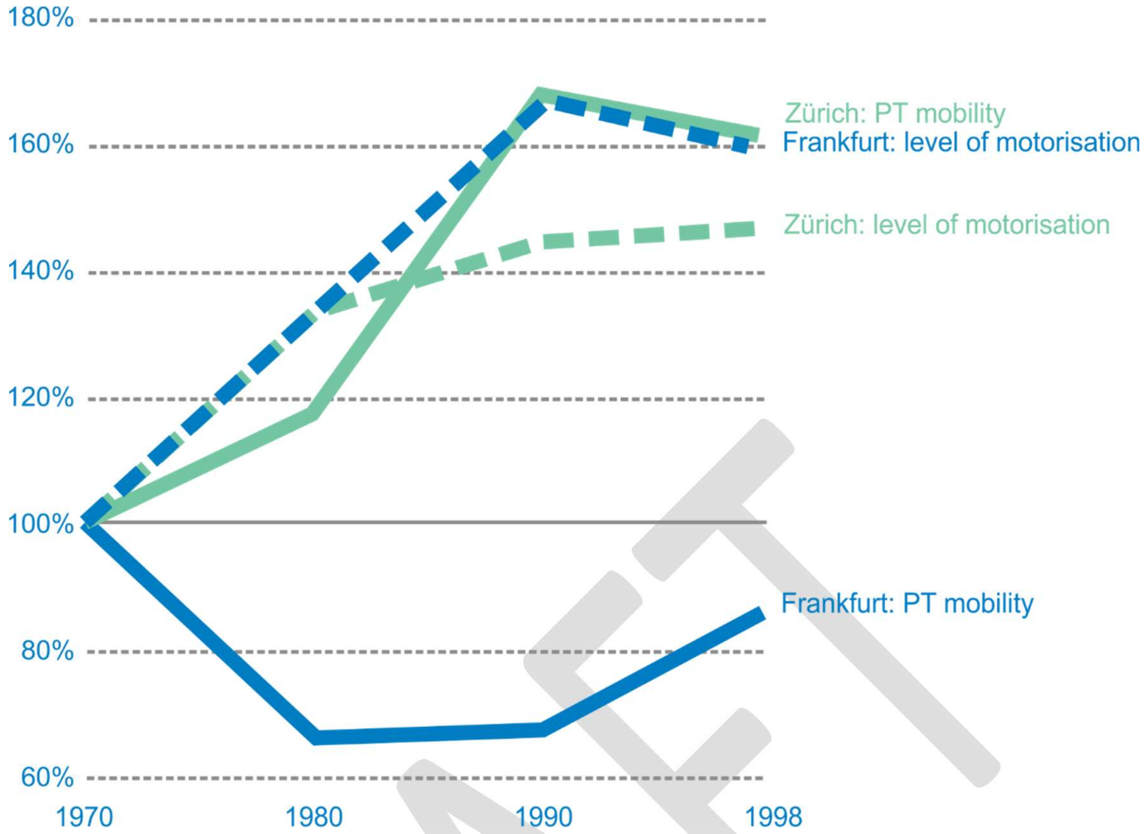
Experience of Zurich (Switzerland) in transport planning. A number of comparative studies point to public transport in Zurich being one of the world leaders. Both the level of service provided and the demand for public transport significantly exceed the average levels in similar cities. For example, in 1998, the public transport mobility of Zurich (trips per year per resident) amounted to 531, which is almost 60% higher than the performance of Germany's best transport system in Munich (335). In downtown Zurich, citizens make more than 2 PT trips per day, and more than 50 PT trips per year in the suburbs. Zurich has the highest index of PT mobility along with the densely populated Hong Kong (China). While in most cities the share of public transport has declined in recent decades, in Zurich, on the contrary, it has increased over the past 25 - 30 years.

There is a striking difference in public transport demand levels between Zurich and Frankfurt (Germany) (Fig. 3.15). In Zurich, public transport mobility has increased by 60% since 1970, which is higher that the level of motorisation. The share of public transport in transportation has been rising for 20 years. In Frankfurt, motorisation has gone up by 60%, while the use of public transport has declined by 14%. Comparison of mobility in Zurich and Stuttgart between 1976-1988 demonstrates similar results. Between 1980 and 1990, the share of public transport in Zurich increased not only in the city centre but also in the suburbs and outskirts, which stands in contrast with most other European cities where private vehicle transportation in the suburbs is growing much faster than public transportation (Figure 3.14).

Figure 3.14. Share of public transport among motorised journeys in European cities

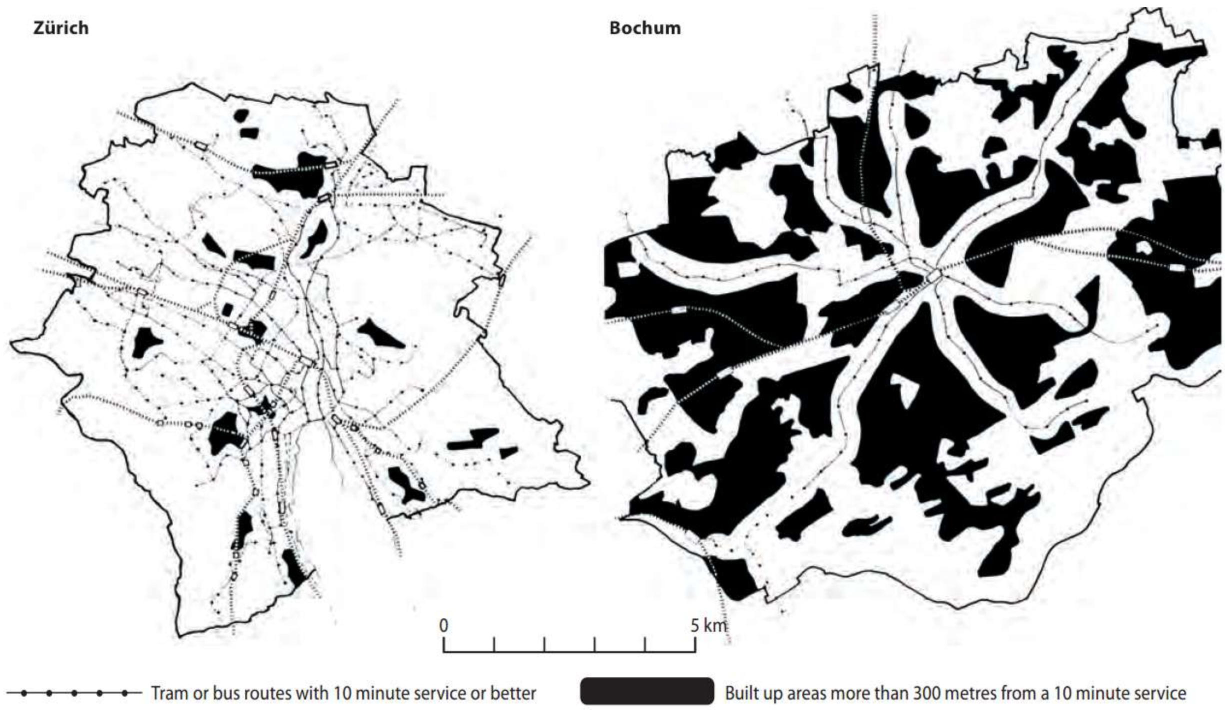
City	Share of public transport	Relevant year
Zürich	57%	1992
Helsinki	40%	2000
Frankfurt	39%	1998
Munich	37%	1997
Oslo	37%	2000
Freiburg	35%	1998
Karlsruhe	27%	1992
Gothenburg	24%	2000

Figure 3.15. Changes in the level of motorisation and mobility of population as regards PT use in Zurich and Frankfurt between 1970-1998



An analysis of the Zurich route network showed that the key factors in the appeal of public transport in Zurich are the high density of the route network and high traffic frequency. A comparison of the zones accessible on foot in Zurich and Bochum (Fig. 3.16) shows that Zurich has a significantly higher density of transport services, where more than half of the tram and bus routes operate at an interval of 6 minutes with this level of service maintained for 100 years. Zones outside the 300-metre walking distance from PT stops in Zurich serviced at intervals of no more than 10 minutes occupy a miniscule share within the city while in a typical European city such zones account for a significant proportion.

Figure 3.16. Comparison of PT accessibility in Zurich and Bochum (Switzerland)



A comparison of service density (Fig. 3.17) shows that the service area of Zurich is about 3 times bigger than that of Bochum.

Figure 3.17. Comparison of service density indicators of public transport in Zurich and Bochum (Switzerland)

Indicator	Units of measure	Zürich	Bochum
Line density	Km of streets along which public transport operates, per km^2 of territory	3.0	1.7
Route density	Km of routes per km^2 of territory	4.9	2.5
Stopping points density	Number of stops per km^2	5.6	3.8
Service density	Number of transport departures from stops on a weekday per km^2	2440	460
The amount of service delivered in both directions:	Average number of departures per stop		
Rush hours		408	92
Off peak hours		294	85
Late evening		177	41

In addition, Zurich has its routes going not only towards the city centre and back as it also boasts link routes. The routes make up a network within which with the waiting time during transfers is little thanks to short intervals. When demand is weakening not allowing for short intervals, timed schedules are put in operation at intervals multiple of 60 minutes, which are repeated every hour and coordinated in hubs between train, tram and bus routes (Figure 3.18).

To achieve high coordination, all routes operate on a strict schedule; the schedule requiring priority for public transport. These measures have been implemented in Zurich for more than 30 years.

The transportation speed in Zurich is not very high, but the decrease in speed, unlike in other European cities, is not caused by traffic congestions or waiting times at traffic lights. The main reason behind the transportation speed being moderate is the need to make frequent stops with more time spent by passengers getting in and out at stops than in any other system.

A comparative analysis of 43 public transport systems of the world's cities conducted by UITP confirms that Zurich, along with Bern (Switzerland), delivers transport services of outstanding quality. Also, Zurich has a relatively high index of convenience in relation to private vehicle trips from the perspective of road network quality, transportation speed, parking availability in the city centre and private vehicle use costs.

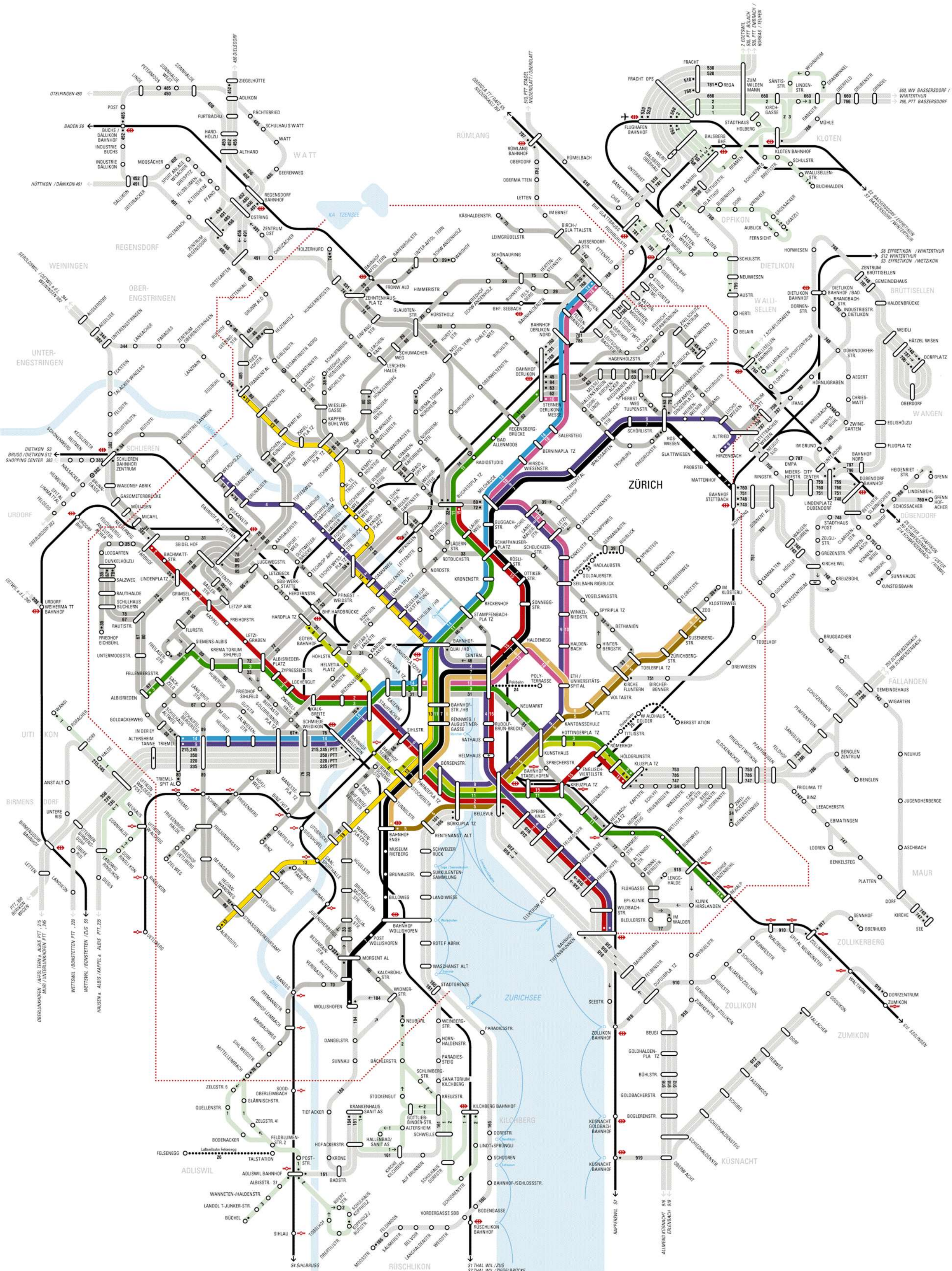
It should also be noted that citizens in Zurich have voted twice against the construction of a metro line, since a cost comparison of the projected growth in taxes and the potential gain in transport service quality unequivocally proves that a metro in Zurich would be inefficient, given the agglomeration population of over 1.05 million citizens. It proved to be much more practical and prudent to focus on maintaining the high quality of tram, suburban railway and bus service as a single integrated network (Fig. 5).

The main conclusions on the reasons behind the outstanding success of Zurich's public transport:

- A high-quality public transport system which rests on a system of tram lines and railways is able to challenge transportation by private vehicles and become the main mode of transport in a city where citizens welcome public transport, even without imposing strong limitations on private vehicle use;
- The key principles behind the appeal of public transport are the network characteristics of the system. It is a fully integrated system (in terms of tariffs and schedule) with a high (6-10 minutes) traffic frequency on most of the routes and numerous convenient interchange hubs, which has been operating steadily for many years;

- Preservation and development of street transport (tram and bus) without an expensive metro system put in place is an important aspect of success where a substantial condition is to give priority in street traffic to the tram and the bus.

Figure 3.18. Integrated network of all modes of transport in Zurich. Coloured are tram lines; black thin lines are railways, grey lines - buses, the red dotted line is the edge of the tariff zone.



Experience of Jönköping (Sweden) in route network modernisation. In 1996, Jönköping, a city in Sweden (with a population of more than 80,000 people), completed the upgrading of its bus route network. The entire network is built around three diametrically routes, each crossing the city all the way through with the rest of bus routes acting as feeders for the three main diametrical routes.

The three main routes are designed as per the same principles according to which the tram lines are usually designed after “the image of a tram” with straight and fast routes, high speed transportation, punctuality throughout the entirety of the urban built-up area (Fig. 3.19). This was achieved by implementing a number of necessary measures, namely, traffic management and traffic light cycles introduced with priority given to public transport (Fig. 3.20), dedicated lanes and road sections for public transport traffic only (Fig. 21), optimised location of stopping points, informing passengers on the location of buses en route by electronic displays in real time (Fig. 3.22).

Figure 3.19. Integrated bus network with three main and diametrical routes (shown in red, yellow and green colours) in Jönköping (Sweden)

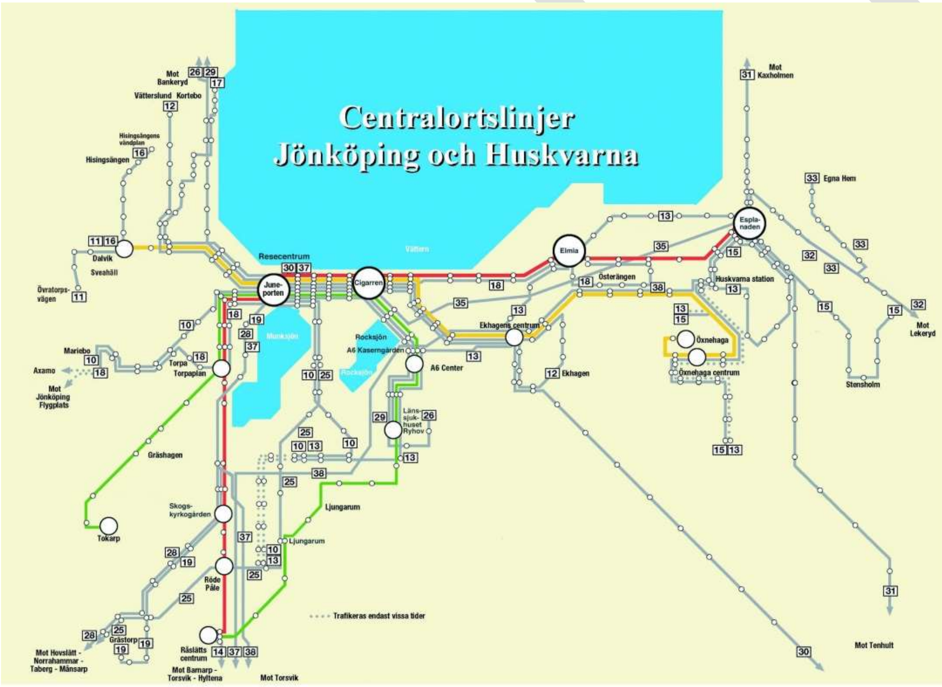


Figure 3.20. Priority PT transit across intersections in Jönköping (Sweden)

Figure 3.21. Dedicated roadway for public transport traffic only in Jönköping (Sweden)

Figure 3.22. Information board at a PT stop showing the departure time of the next bus in real time, Jönköping (Sweden)

New, low-floor articulated buses equipped with four wide doors (two for embarkation, two for disembarkation) were put into service on the routes, an electronic integrated fare payment system featuring a very simple rate menu was introduced making bus trips fast and reliable. Fast and efficient transportation drew enough passengers to the main routes to warrant operating at intervals of 5-10 minutes almost throughout the entire day. Small intervals encourage passengers from the suburbs to make transfers from the local routes to the three main routes during their trips. Other routes (except for the main routes) operate at an interval of 30 minutes almost all day.

The main and local routes feed passengers to the station; a coordinated schedule for the first and last routes is introduced. The regional system of tariffs is a fully integrated one. The single railway and bus transport interchange hub (TIH) provides passengers with access to complete information on the network, waiting conditions and catering. The TIH project envisages a minimum walking distance from trains to buses, that is the bus landing platforms are located very close to train platforms.

The results of the retrofitting works were nothing if not impressive. The passenger flow grew by 15% between 1996-2002, while prior to that it had been steadily decreasing by 1- 2% per year. Similar cities in Sweden, which have not yet carried out such reforms still have the passenger flow decreasing by 1- 2% per year. The proportion of public transport in Jönköping rose from 19% to 22%. PT mobility increased to 143 trips per year per capita, which is one of the best results among similar cities. The share of expenses covered by ticket revenues went up to 68%, whereas this figure stood at only 32% in 1986 and 13% in 1996.

Copenhagen's experience in developing a main route network. The Copenhagen Region is vigorously working to improve the speed, reliability and appeal of bus transportation. Measures taken to improve the transportation speed include road traffic management, in particular dedicated lanes, installation of barriers allowing buses only to enter certain sections of the road network intended for buses only, increase of interstop intervals by moving and closing down some PT stops, priority of passage at intersections, forward-direction passage for buses coming from right-turn lanes and street load management by traffic lights.

Another significant measure is to optimise the route network by setting up main lines. Six bus routes are designated as main city routes (A-buses) operating at intervals of 3-5 minutes throughout the day, which means that passengers can use the bus without having to consult the schedule first. There are also six suburban express routes (S-buses) designated complementing the network of commuter S-tog trains. The buses operate in full tariff and route integration with the network of S-tog suburban trains and metro, together making up the framework of the Copenhagen transport system (Fig. 3.23).

A-buses (yellow with a red angle) and express S-buses (yellow with a blue angle) are marked as high-level service buses. The buses are covered with their distinctive colours with special symbols also present at the stops, making it easy to spot them in heavy urban traffic (Fig. 3.24).

Figure 3.23. The network of main-line A-buses in Copenhagen (Denmark) (red-lined) and suburban express S-buses (blue-lined) complements the network of commuter S-tog trains (S-marked) and metro (M-marked), collectively forming the framework of the Copenhagen public transport with a full tariff integration.

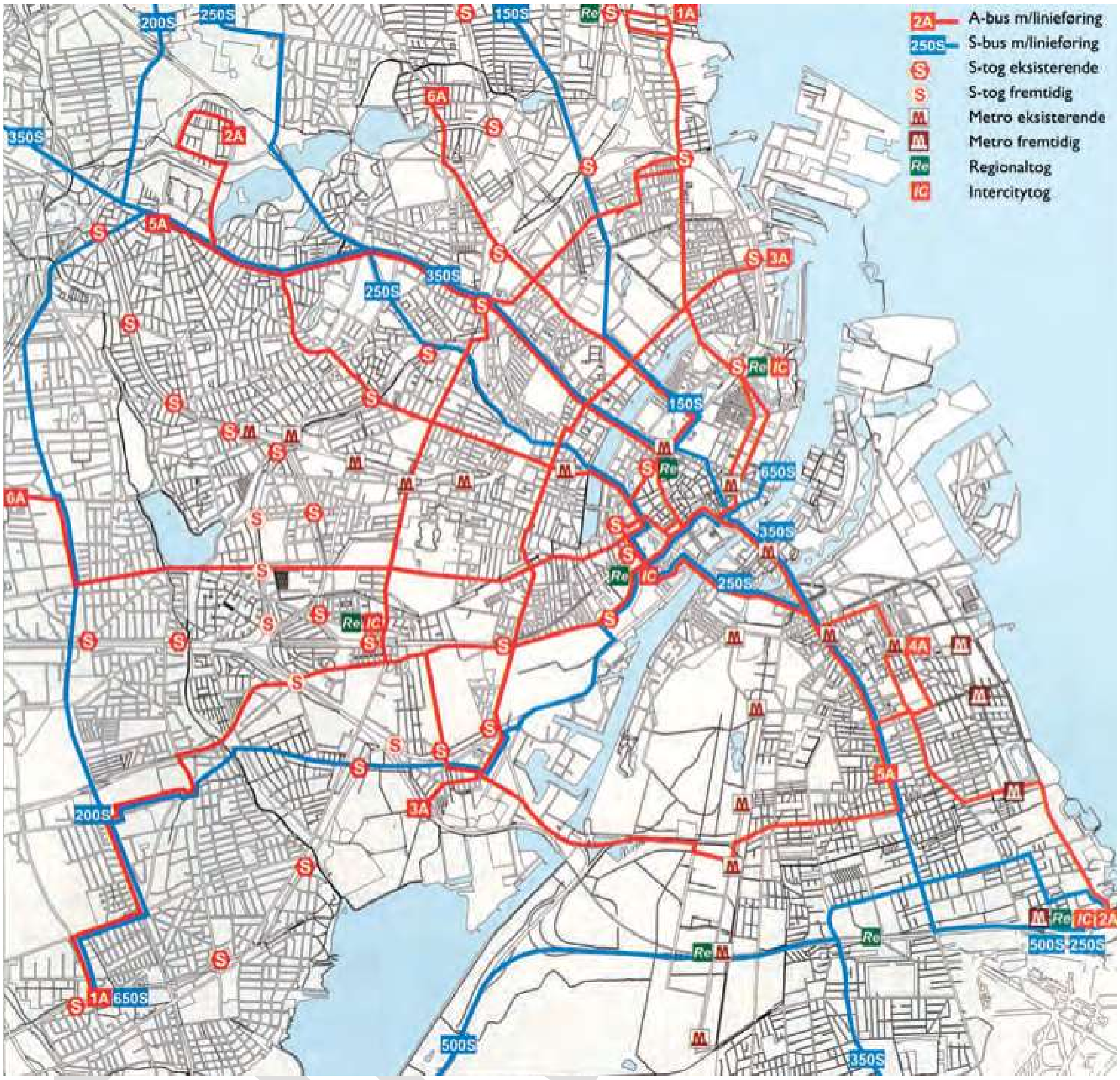


Fig. 3.24. Copenhagen (Denmark). Left: S-bus (suburban express), right: A bus (main-line city bus, 3-5-minute interval during the day)

Experience of the city of Lemgo (Germany) in managing a route network in a small city. The German city of Lemgo (a population of more than 40,000) is one of the most successful small cities in managing bus traffic. City buses are all unified under a single corporate style that stands for durability and stability of bus traffic with no advertising allowed for these buses. Three diametrical routes pass through the city centre; the fourth route encompassing the industrial zone. Each of the diametrical routes delivers transport services in the area accessible for 8,000 residents on foot, departing on a timed schedule every 30 minutes throughout the day with a doubled frequency at peak hours (Figure 3.25). In the late evening, buses are replaced by taxis to match the level of demand.

Figure 3.25. In the city of Lemgo (Germany) a unified style, unified information support and coordinated timed schedule have been developed for city buses

There is a transfer terminal between all four routes with one compact central platform in the centre of the city. Thanks to the timed schedule, all buses converge in the city centre at the same time which allows passengers to transfer within one minute with no time wasted waiting for buses to come (Fig. 3.26).

Figure 3.26. In the city of Lemgo (Germany) a unified style, unified information support and coordinated timed schedule have been developed for city buses

The new bus traffic management system was introduced in 1996 due to a very low demand for bus transportation despite the system having been retrofitted in 1992 with four routes operating with an interval of one hour introduced. A comparison of the effect before and one year following the integration of the new system:

- 960,000 new customers and 240,000 customers who started to use the system more frequently;
- 80% of passengers serviced by the new system are new passengers, those who did not use bus transportation prior to the new system being introduced;
- Subsidies per 1 passenger decreased drastically from 7.5 euros to 0.45 euros;
- 70% of the costs are covered by travel revenues.

A survey conducted in the city centre showed that the bus system has a significant impact on citizens choosing to come around more often to the city centre to do the shopping. Bus passengers visit the city centre more often and spend more money in shops than motorists.

Cambridge (UK) — experience of barring private vehicles from entry to the historic centre. Radical measures were necessary to tackle the issue of the historic centre being overwhelmed by vehicles. The implementation of this scheme required the support of the majority of the population which was achieved through numerous consultations with the public, involving citizens in the decision-making process as well as promoting the proposed decisions.

Barred entry into city centre for private vehicles and improved bus services resulted in a record-breaking demand for public transport with 27,000 passengers arriving at the centre by bus daily. The goal to drive up the public transport passenger flow by 20% within 4 years was achieved in 3 years with the flow having climbed by 30%.

The scheme is backed by local citizens, as the bus service functions in a reliable and convenient manner and the urban environment in the city centre has improved. Bollards (automatic cylinders which move out of the roadway surface to block passage) grant access to public and service transport and prevent other private vehicles from entering quite efficiently (Fig. 3.27).

Figure 3.27. In Cambridge (UK), bollards serve to block entrance into the city centre for all modes of transport except PT and service vehicles

Edinburgh, Scotland: experience in assessing the socio-economic effectiveness of decisions taken. The evaluation process of the Transport Initiative of Edinburgh and South East Scotland is an example of the British approach to developing urban transport policies, including public transport and congestion payments (fees for entry to congested road areas). The city describes the objectives, indicators of their evaluation and the data necessary to evaluate the project (Fig. 3.28).

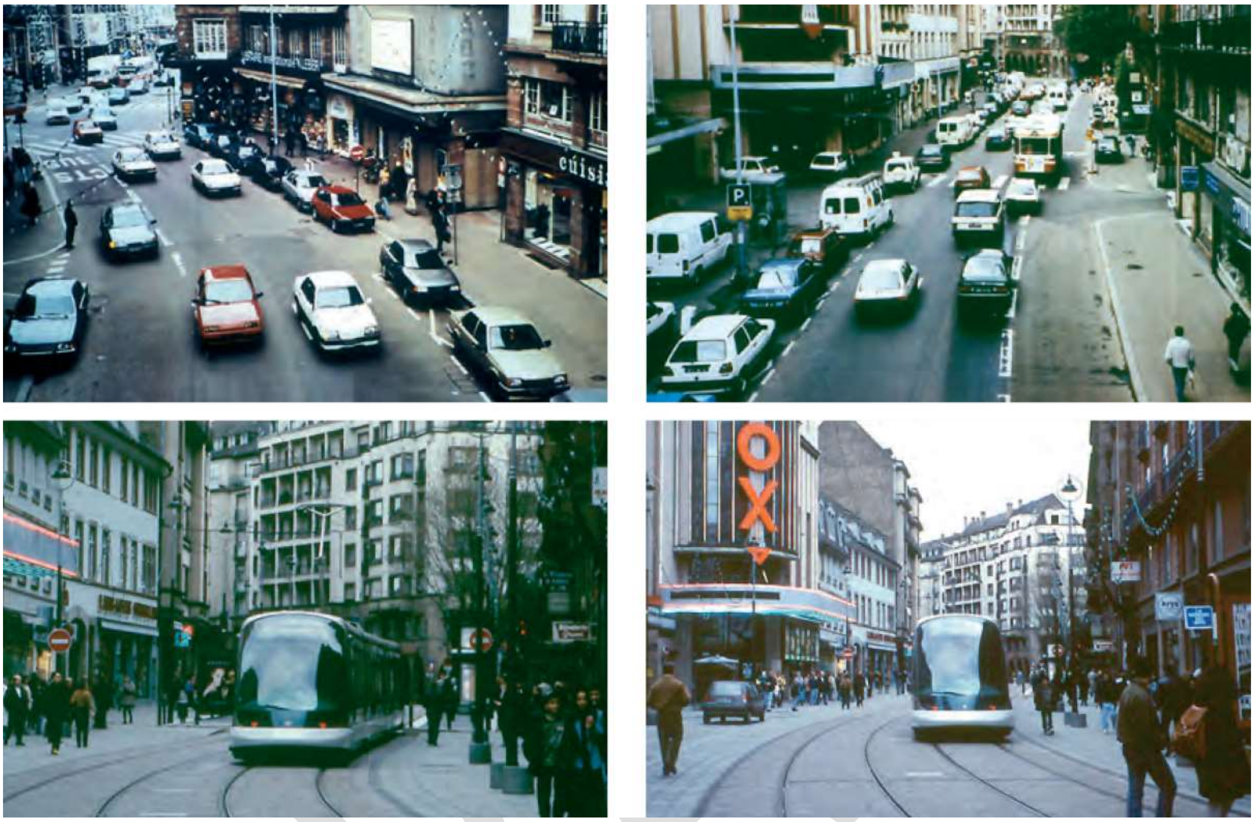
Figure 3.28. An example of evaluating urban transport policy measures for decision-making in the city of Edinburgh (UK)

Objective	Measures	Data
Cost-effectiveness	Reduced travel time	Transport modelling
	Transportation reliability	Transport modelling
	Operating costs	Analogue objects
	Capital expenditure	Analogue objects
	Payments	Transport modelling

	Taxes and budget efficiency	Financial and transport modelling
Local economy	Increase in employment level Economic impact	Economic model Economic model
Environment	Air quality Pedestrian environment Visual environment disturbance Reduction of green space Noise	Transport modelling Qualitative evaluation Qualitative evaluation As per the settings of the project Transport modelling
Safety	Prevention of road accidents Personal safety	Transport modelling Qualitative evaluation
Accessibility	Accessibility measures Remoteness	GIS/Transport modelling Transport scheme evaluation
Integration	User-friendliness Effect by slow modes of transport Integration with urban planning	Qualitative evaluation Mode of transport Transport modelling, qualitative assessment
Social integration	Effect by income groups Accessibility for low-income persons Revitalization of territories	GIS GIS/Transport modelling Building modelling/quality assessment
Health	Life expectancy	Qualitative evaluation
Risk management	Public and political approval Technological risks Financial risks Security risks	Consultations Expert opinion Financial model Qualitative evaluation
Financial matters	Revenue collection Capital expenditure structure “Unproductive” expenses (interest on loans, etc.)	Transport modelling Project schedule, cost structure Financial model

Strasbourg, France: the experience of altering the transport policy following an evaluation. The new tram system of Strasbourg has changed the urban environment and the transport accessibility for shopping streets in the city centre. A comparison of the situation “before and after” (Fig. 3.29) reveals how greatly the passenger flow has increased in the shopping streets of Strasbourg following the ban on road traffic and the introduction of a tram-pedestrian street.

Figure 3.29. In Strasbourg (France), the ban on road traffic and the introduction of a tram-pedestrian street in the city centre has significantly boosted the influx of visitors to the stores located in the city centre



Norway, the experience of linking land use and transport planning. Norway has proposed a way of evaluating areas by their accessibility by different modes of public transport. That allows for choosing a specific area for certain types of activity (Fig. 3.30). An example from Trondheim (Norway) is presented below (Figure 3.31). Concentrating jobs in Zone A will maximise the demand for public transport while reducing the demand for private vehicles.

Figure 3.30. The methodology used to evaluate territorial accessibility by public and private transport with the aim to link land use and transport development in Norway

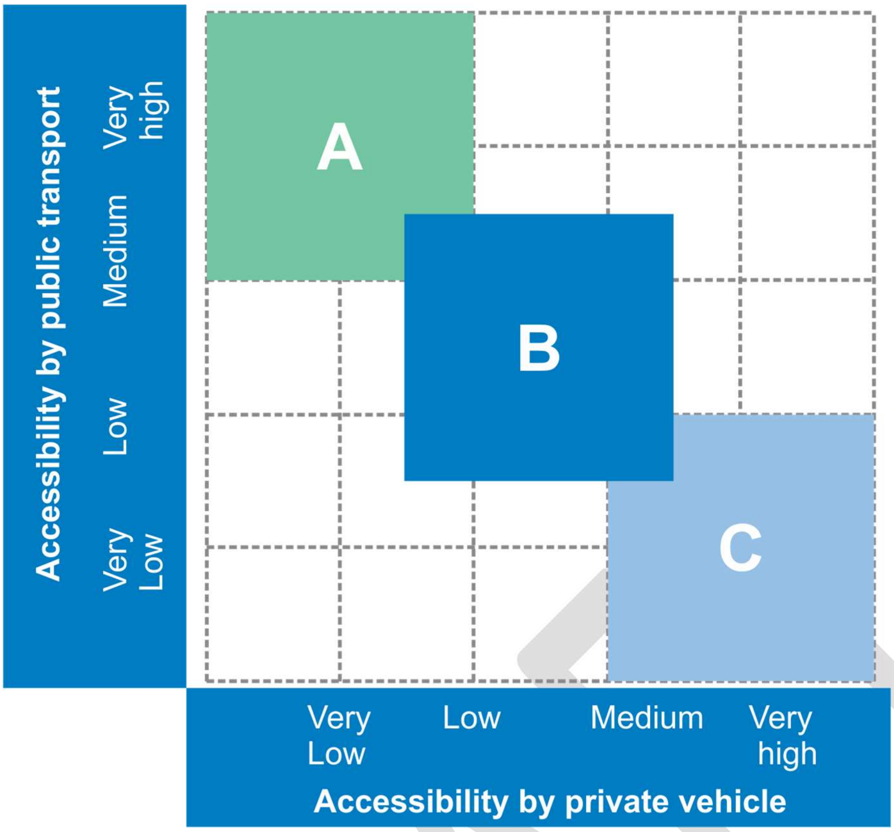
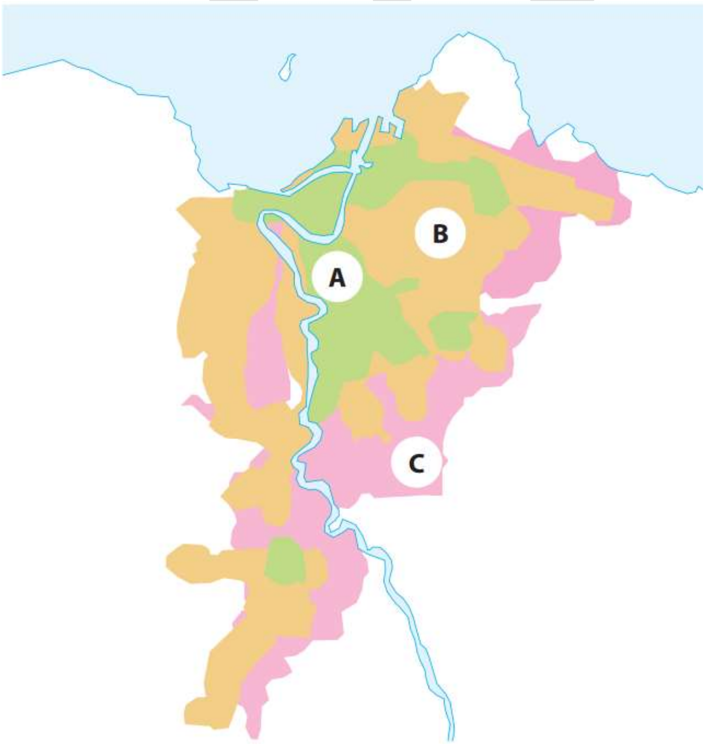


Figure 3.31. An example of evaluating territorial accessibility by public and private transport with the aim to link land use and transport development in Trondheim (Norway)



Stockholm, the experience of modelling and developing a tram-line Project Feasibility Study. In Stockholm, the construction of a tangential tram line was evaluated twice: in 1988, a detailed evaluation was conducted followed by a broad evaluation in 1991. The broad evaluation showed that demand would be three times lower than indicated by the detailed evaluation in 1988.

Such a high difference in the results stemmed from errors in information on the future tram line and its connections to the transport model of 1991. In 1988, a three-month modelling study allowed for more detailed transport zoning as well as pedestrian links between built-up areas adjacent to the tram line to be introduced into the model; in 1991, the same modelling study was carried out based on the existing urban “in three hours” model (part of the city transport plan), without due regard to the pedestrian connections between the tram line and the adjacent built-up area. All that led to the findings of the 1991 study being three times lower in relation to the actual figures.

Despite these errors, the tram line was built and went on to become a great success for the Stockholm region (Fig. 3.32). This experience serves to illustrate the importance of devoting adequate attention to detail and setting aside sufficient time for transport models to be elaborated in a quality manner.

Figure 3.32. In Stockholm (Sweden), the tram line was built despite the passenger flow shown to be three times lower by the repeated transport modelling study. Now the tram line is in high demand among passengers

Sweden has carried out a study into the effectiveness of various public transport projects in the Nordic countries. In order to compare different projects, the unit costs per one attracted (additional) passenger were selected as the main criterion (Figure 3.33).

Figure 3.33. An efficiency comparison of public transport projects by unit cost per each additional passenger won over by the public transport of Scandinavian cities

Measure taken, city	Efficiency, in Euros per 1 new passenger
Information Ticket Centre, Oslo (Norway)	0.00*
Increased train traffic frequency, Stockholm (Sweden)	0.07
Combined measures, Kristiansand (Norway)	0.34
Flexible bus service, Gothenburg (Sweden)	0.35
Main bus route, Stockholm (Sweden)	0.36
Reduced fare, Kristiansand (Norway)	0.37
Bus transportation by demand level, Gren (Norway)	0.48
Marketing campaign, Sundsvall (Sweden)	0.52
Combined measures, Drammen (Norway)	1.17

Zero tariff, Kristinehamn	1.38

While in no way universal, these indicators and the approach itself are very efficient in making policy decisions on urban transport given adequate awareness of the particularities of each project.

In order to compare service quality in different cities of the world, a passenger satisfaction index is applied to complement the other objective-assessment indicators. The index involves a number of indicators which evaluate the subsystems and aspects behind the operation of the transport system. The overall satisfaction index for the period 2001-2004 in a number of cities and a comparison of Helsinki (Finland) against average indicators are presented below (Figure 3.34, Figure 3.35).

Figure 3.34. Passenger satisfaction index (the share of residents satisfied with the quality of public transport services)

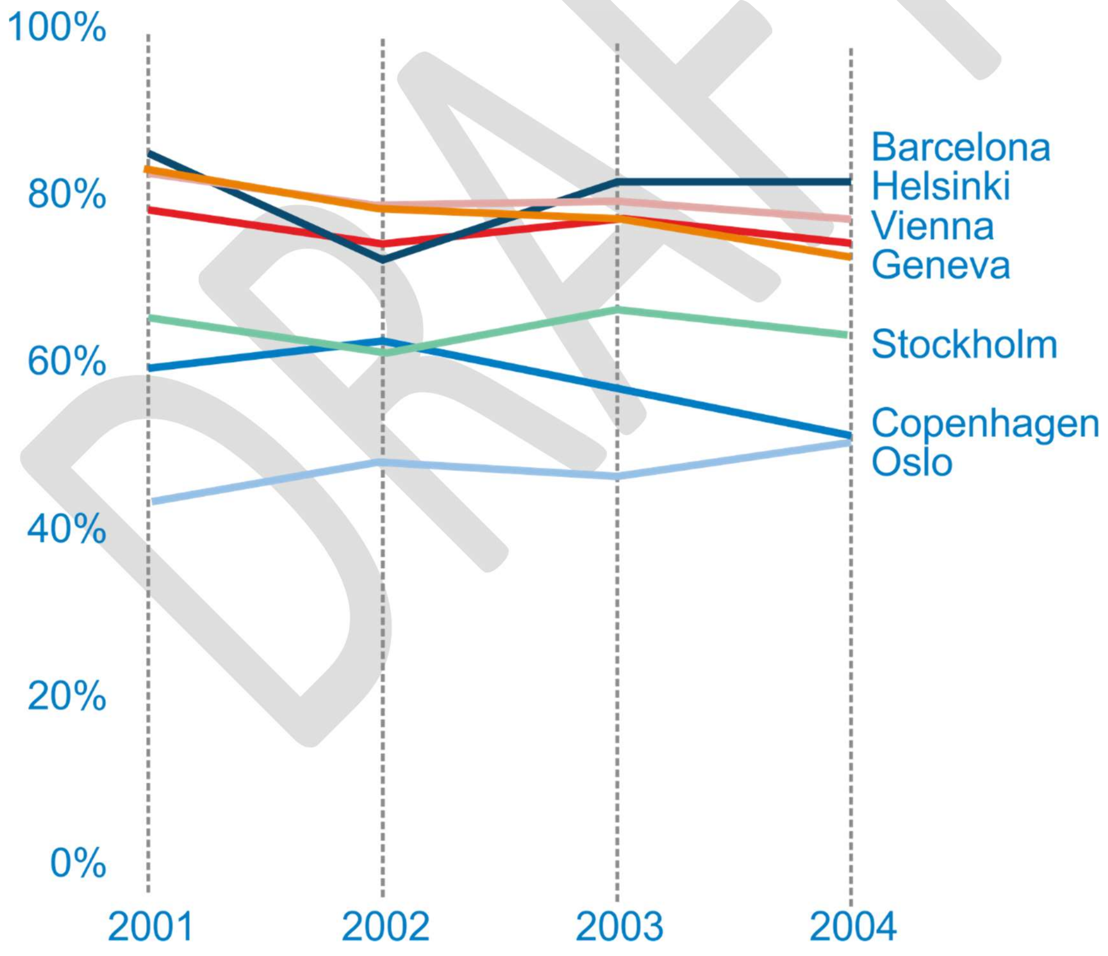
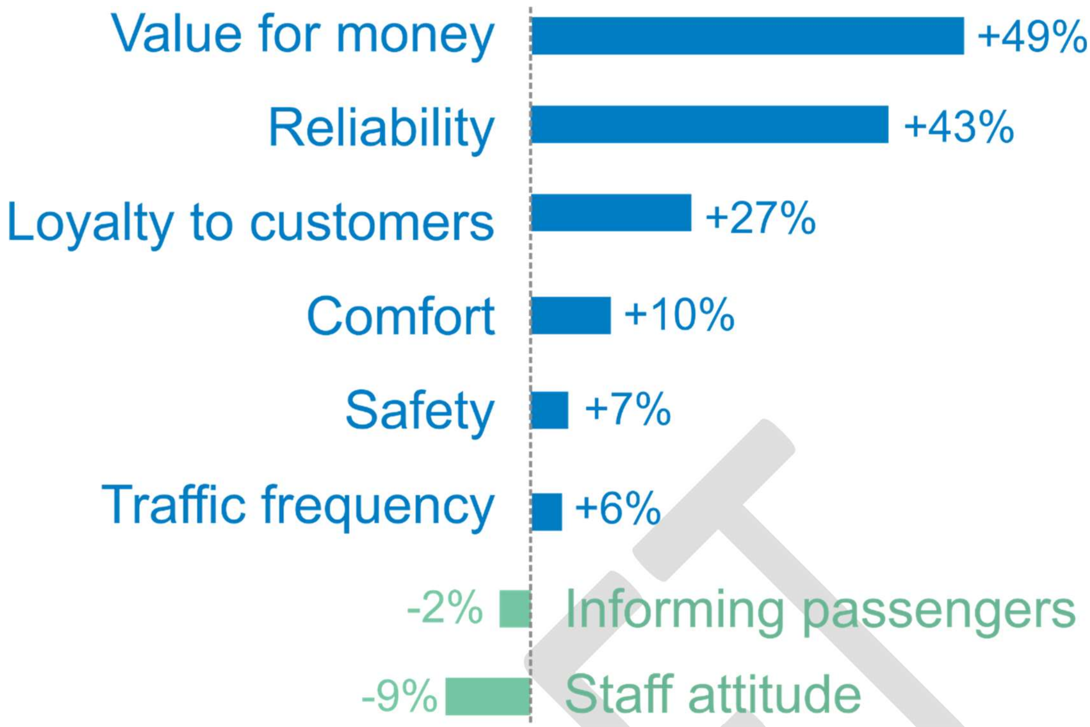


Figure 3.35. Satisfaction of Helsinki (Finland) citizens with public transport in 2002 against the average indicators of European cities



In a number of Russian cities, tram tracks are separated from the carriageway by a curb stone in order to ensure reliable operation of tram transport. Tram platforms for embarkation and disembarkation are being improved to ensure convenient entry for passengers with reduced mobility, that is women with prams, passengers carrying luggage, elderly people and disabled passengers.

Figure 3.36. Separation of tram tracks in Lenin Street in Perm (Russia)

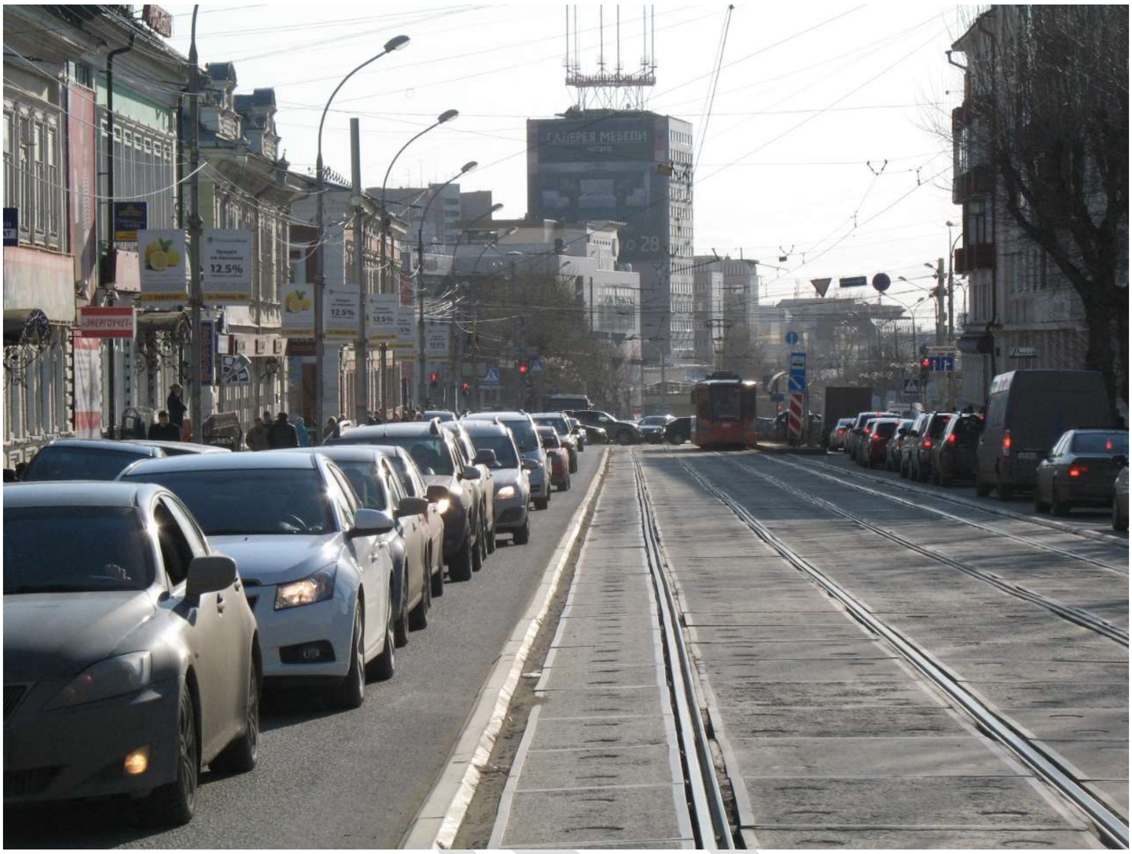


Figure 3.37. Fenced-off tramways in Kaliningrad (Russia)

Figure 3.38. Installation of tram platforms in Lesnaya Street in Moscow (Russia)

Figure 3.39. A tram line efficiently isolated with a curb on the Boulevard Ring in Moscow (Russia)

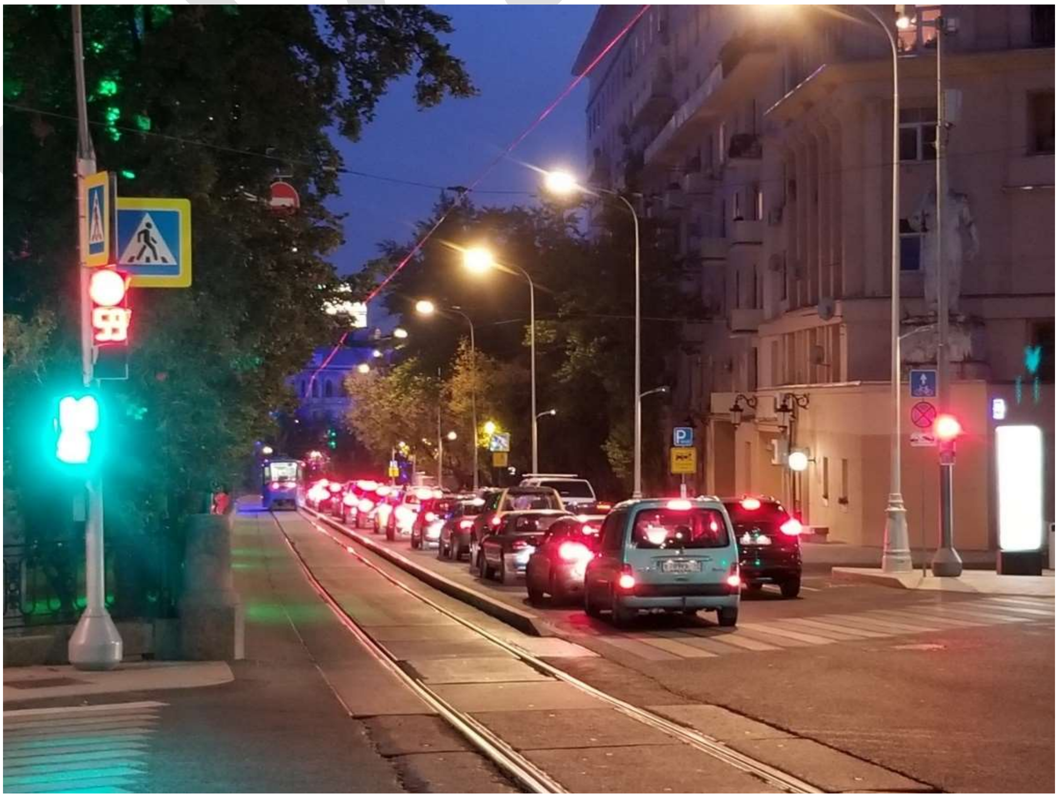


Figure 3.40. Installation of a tram platform on Lenin Avenue in Yekaterinburg (Russia)

Figure 3.41. Construction of a new tram line in the centre of Yekaterinburg (Russia) in 2016

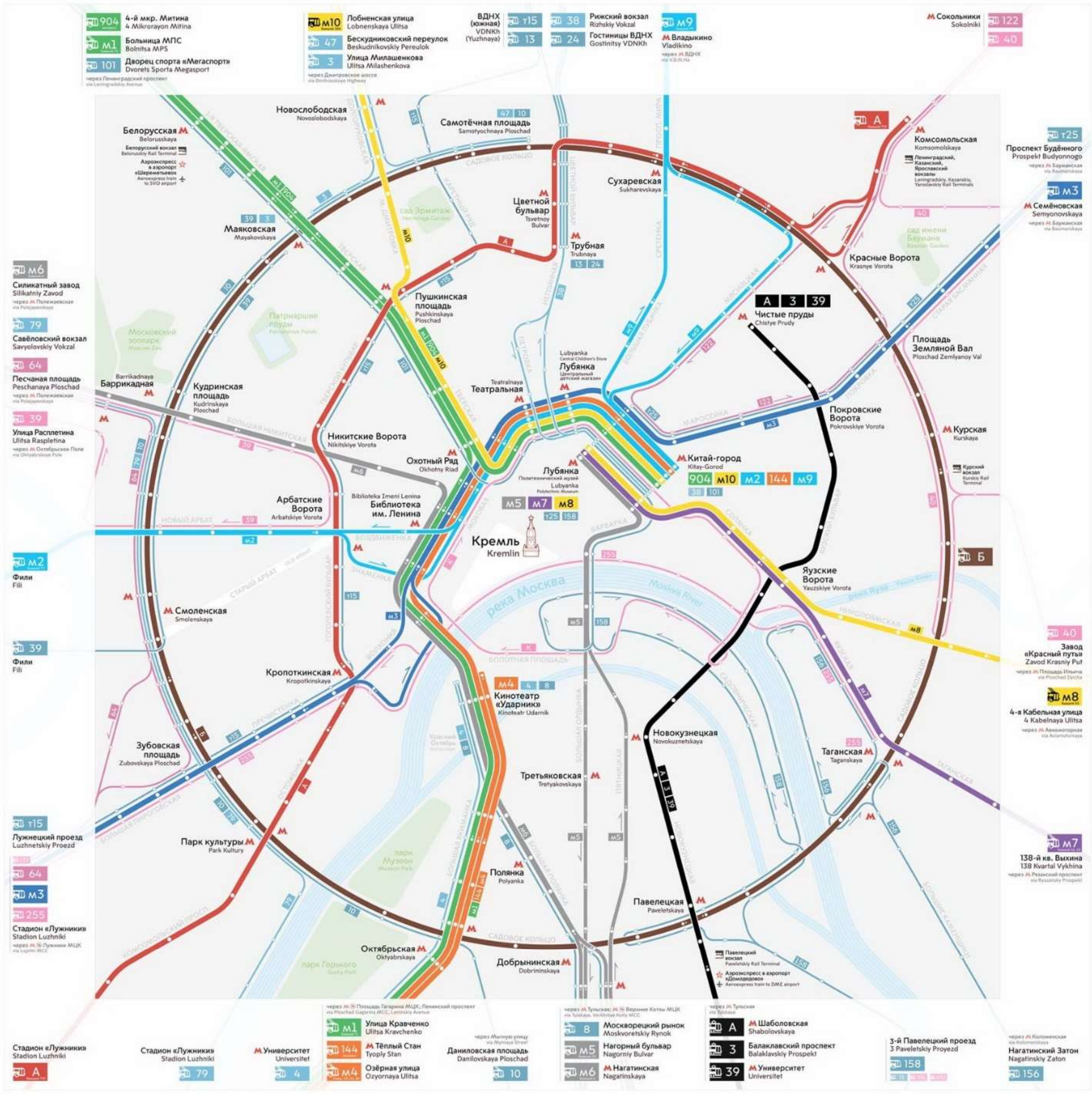
Elimination of back-up routes and creation of a main route network in Russia. The route network Magistral was designed in 2013 and implemented in 2016 for the central part of Moscow where public transport traffic is allocated a dedicated lane opposite to one-way vehicle traffic around the Kremlin. This helped restore two-way public transport connections lost when the one-way ring traffic pattern around the Kremlin was introduced for private vehicles in the 1990s.

The Magistral network has made the routes in downtown Moscow simple and clear to understand and the traffic frequency has become high (Fig. 3.42). The routes are divided into categories: main routes (high-frequency traffic throughout the day to connect with districts within the city), district routes (to ensure transportation of citizen from the districts to the metro and the main network), social routes (which connect to all places of social significance within a district without transfers operating on a timed interval of 30 minutes).

Figure 3.42. Moscow (Russia). The scheme of the Magistral route network in the Moscow centre is simple, understandable and convenient for passengers

Схема маршрутов наземного транспорта центра Москвы

Surface Transport Network in Central Moscow



Магистральные маршруты — интервал 5–10 минут

High-frequency routes — Service every 5–10 minutes

А	Комсомольская (вокзалы) — Сухаревская — Цветной бульвар — Бульварное кольцо — ул. Остоженка — Комсомольский проспект — Фрунзенская — Стадион «Лужники»
Б	По Садовому кольцу: Курская — Павелецкая — Парк Горького — Парк культуры — Смоленская — Маяковская — Сухаревская
м1	ул. Кравченко — Ленинский проспект/Площадь Гагарина МЦК — Октябрьская — ул. Б. Якиманка — Библиотека им. Ленина — Тверская ул. — Белорусская — Ленинградский проспект — Волоколамское шоссе — Больница МПС
м2	Китай-город — Лубянка — Библиотека им. Ленина — ул. Новый Арбат — Кутузовская — Кутузовский проспект — Парк Победы — Багратионовская — Фили
м3	Стадион «Лужники» — Б. Пироговская ул. — ул. Пречистенка — Кропоткинская — Лубянка — ул. Покровка — Бауманская — Электрозаводская — Семёновская
м4	Кинотеатр «Ударник» — ул. Б. Якиманка — Октябрьская — Ленинский проспект/Площадь Гагарина МЦК — Ленинский просп. — ул. Кравченко — Юго-Западная — Озёрная ул. Часть рейсов следует укороченным маршрутом: «Кинотеатр „Ударник" — ул. Кравченко»
м5	Лубянка — ул. Большая Ордынка (обратно: Пятницкая ул.) — Добрынинская — Тульская — Варшавское ш. — Верхние Котлы МЦК — Нагорная — Нагорный бульвар
м6	Нагатинская — Верхние Котлы МЦК — Тульская — ул. Б. Полянка — Б. Никитская ул. — Улица 1905 года — Беговая — Полежаевская — Силикатный завод
м7	Лубянка — Китай-город — ул. Солянка — Таганская — Нижегородская ул. — Нижегородская МЦК — Рязанский просп. — Рязанский проспект — 138-й кв. Выхина Часть рейсов следует укороченным маршрутом: «Лубянка — Карачаровский путепровод»
м8	Лубянка — Китай-город — ул. Солянка — Николоямская ул. — Площадь Ильича — шоссе Энтузиастов — Авиамоторная — 4-я Кабельная ул.
м9	Китай-город — Лубянка — Проспект Мира — Рижский вокзал — Алексеевская — ВДНХ — ул. Академика Королёва — Телецентр — Владыкино
м10	Китай-город — Новослободская — Савёловский вокзал — Тимирязевская — Петровско-Разумовская — Дмитровское шоссе — Бескудниковский бул. — Лобненская ул.
144	Экспресс-маршрут: Китай-город — Моховая ул. — ул. Б. Якиманка — Октябрьская — Площадь Гагарина МЦК — весь Ленинский проспект — Тропарёво — Тёплый Стан
904	Экспресс-маршрут: Китай-город — Тверская ул. — Белорусская — Ленинградский проспект — Волоколамское шоссе — Тушинская — Пятницкое шоссе — 4-й мкр. Митина Часть рейсов следует укороченным маршрутом: «4-й мкр. Митина — Белорусский вокзал»
А	Чистые пруды — Бульварное кольцо — Новокузнецкая ул. — Павелецкая — Дубининская ул. — Тульская — Шаболовская — Октябрьская
3	Чистые пруды — Бульварное кольцо — Павелецкая — Тульская — Верхние Котлы МЦК — Нагатинская — Симферопольский бул. — Балаклавский проспект
39	Чистые пруды — Бульварное кольцо — Павелецкая — Тульская — Ленинский проспект/Площадь Гагарина МЦК — ул. Вавилова — Университет

Районные маршруты — интервал 10–15 минут

Local routes — Service every 10–15 minutes

3	Маяковская — Долгоруковская ул. — Новослободская — Савёловский вокзал — Бутырская ул. — Дмитровская — Фонвизинская — ул. Милашенкова
4	Кинотеатр «Ударник» — Октябрьская — Ленинский проспект/Площадь Гагарина МЦК — Ленинский проспект — Ломоносовский проспект — Университет
8	Кинотеатр «Ударник» — ул. Б. Полянка — Добрынинская — Тульская — Варшавское шоссе — Верхние Котлы МЦК — Нагатинская — Москворецкий рынок
10	Самотёчная площадь — Садовое кольцо — Смоленская — Парк культуры — Парк Горького — Октябрьская — Мытная ул. — Даниловская площадь
13	Трубная — Цветной бульвар — Самотёчная площадь — Достоевская — Марьина Роща — Шереметьевская ул. — ул. Академика Королёва — ВДНХ (южная)
т15	Лужнецкий проезд — Б. Пироговская ул. — Кропоткинская — Бульварное кольцо — ул. Каретный Ряд — Достоевская — Марьина Роща — ул. Академика Королёва — ВДНХ (южная)
24	Трубная — Цветной бульвар — Олимпийский проспект — Марьина Роща — Шереметьевская ул. — ул. Академика Королёва — Владыкино — Гостиницы ВДНХ
т25	Лубянка — ул. Маросейка — ул. Покровка — Старая Басманная ул. — Бауманская — Электрозаводская — проспект Будённого
38	Китай-город — Лубянка — Неглинная ул. (обратно: ул. Петровка) — Трубная — Цветной бульвар — Олимпийский просп. — Трифоновская ул. — Рижский вокзал
39	Маяковская — Садовое кольцо — Смоленская — Киевский вокзал — Кутузовская — Парк Победы — Багратионовская — Фили
47	Самотёчная площадь — Долгоруковская ул. — Новослободская — Савёловский вокзал — Бутырская ул. — Петровско-Разумовская — Дмитровское шоссе — Бескудниковский пер.
79	Савёловский вокзал — Беговая ул. — Улица 1905 года — Краснопресненская — Садовое кольцо — Парк культуры — Фрунзенская набережная — Стадион «Лужники»
101	Китай-город — Лубянка — Тверская ул. — Белорусская — Ленинградский проспект — Больница им. Боткина — Дворец спорта «Мегаспорт»
156	Нагатинский Затон — Коломенская — проспект Андропова — ул. Симоновский Вал — ул. Большие Каменщики — Таганская — Котельническая набережная
158	Лубянка — Китай-город — Космодамианская набережная (обратно: Садовническая ул.) — Павелецкая — Кожевническая ул. — 3-й Павелецкий проезд

Социальные маршруты — интервал до 30 минут

Specialized routes — Service every 30 minutes or better

39	Никитские Ворота — Краснопресненская — Улица 1905 года — Хорошёвское шоссе — Полежаевская — Хорошёво МЦК — Октябрьское Поле — ул. Расплетина
40	Сокольники — Комсомольская (вокзалы) — Новорязанская ул. — Стар. Басманная ул. — Курская — Площадь Ильича — Рабочая ул. — Завод «Красный путь»
64	Стадион «Лужники» — Спортивная/Лужники МЦК — Б. Пироговская ул. — Садовое кольцо — Смоленская — Краснопресненская — Полежаевская — Песчаная площадь
122	Сокольники — ул. Сокольнический Вал — Верхняя Красносельская ул. — Краснопрудная ул. — Комсомольская (вокзалы) — Мясницкая ул. (обратно: ул. Покровка) — Лубянка
255	Стадион «Лужники» — Спортивная/Лужники МЦК — Б. Пироговская ул. — ул. Пречистенка — Кропоткинская — Кремлёвская набережная — Верхняя Радищевская ул. — Таганская
К	Кольцевой: Охотный Ряд — Лубянка — Китай-город — ул. Солянка — Раушская набережная — Кинотеатр «Ударник» — Библиотека им. Ленина

3.2. Financing of public transport
3.2.1. Different financing models

The key issue in choosing between the regulation of public transport and the free transport market has remained controversial for decades. To date, experience the development of urban transport systems around the world has shown that the most effective management model is that of coordinated development of urban transport as a single system (i.e. centralised planning of routes and their parameters for the whole city, forbidding providers from designating routes independently, etc.), while competition is maintained through bids for the right to operate scheduled routes in accordance with the established parameters.

Different approaches to the objectives and principles of public transport networks generate different approaches to urban transport planning (Figure 3.43).

Figure 3.43. An analysis of differences in terms of the transport policy between Great Britain and France[110]

	Great Britain Objective: improve the efficiency of transport systems by reducing road congestion	France Objective: develop liveable cities by replacing private vehicles with alternative modes of transport
Political context	Less emphasis on curbing private vehicle use. Since bus transportation outside London is deregulated, most urban transport is not part of the planning objectives for the authorities.	French legislation on urban transport demands reduced private vehicle use. Light rail transport is seen as one of the key tools to achieve this goal.
	Local government initiatives are limited with modest budget funds. Dependence on the central government for most of public transport financing.	Efficient city administrations with influential mayors who are leaders, sufficient local sources for financing public transport.
	Light rail transport is deemed as only one of the transport solutions, without taking into account its impact on urban	The revival of cities through high-quality public transport management is a source of political status and pride for cities

[110]HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005.

	planning and building development	
	The government's responsibility is limited to public transport infrastructure and bids for non-commercial (social) routes. Too weak a position to achieve integration of rail transport and competing bus operators.	Significant involvement of the government in all the aspects of public transport, namely in infrastructure, bids for transportation, ownership of operators.
	Lack of organisational unity between the central government (infrastructure financing) and regional transport administrations responsible for transport planning and operation.	Separation of organisational objectives between urban and regional public transport. Integration of regional and city tariffs (among several modes of transport) is rare.
Characteristics of LRT projects	Provides regional transportation along commuter "suburb - agglomeration centre" routes.	Improves primarily urban transportation in the agglomeration centre with less focus on the suburbs.
	There is no relation between LRT projects and the private vehicle use reduction policy	LRT projects are coordinated with measures to reduce vehicle use
	In many cases, the use of the existing railway (currently unutilised) infrastructure and its corridors for laying out routes for LRT	Generally, a completely new LRT infrastructure: measures to revitalise streets along the LRT corridor cost up to 50% of the overall LRT construction expenses
	Minimising budget financing and risks by involving private capital	Completely budget financing
	A long period from initial works to commissioning	Typically, just a few years from the proposal phase to commissioning works
Common features	LRT is considered as the best (even the only) opportunity to ensure that sufficient priority is given to public transport in the city streets in both countries.	
Cities for analysis	Manchester, Sheffield, Birmingham, Croydon	Lyon, Marseille, Montpellier

The authors' analysis has revealed significant differences in approaches to the development of urban transport systems in Great Britain and France; the differences being caused by different social and political backgrounds of the two countries.

In the UK (much like, for instance, in South America), the model of free competition "on the route" was selected as the main model for transport market management: each provider had the opportunity to independently choose a route for servicing and transporting passengers without any approval from the authorities. Initial competition tended to be shortly replaced by a market consolidation coupled with a decline in innovations designed to boost passenger demand. This forced the authorities to come back to market regulation, at least for the purpose of ensuring territory coverage, integration and maintenance of the set service quality.

The “en route” competition allows providers to compete with each other for passengers, with or without restrictions, which best corresponds to the “free competition” model; in practice, the complete absence of restrictions in developed countries does not occur with at least requirements established for transport safety.

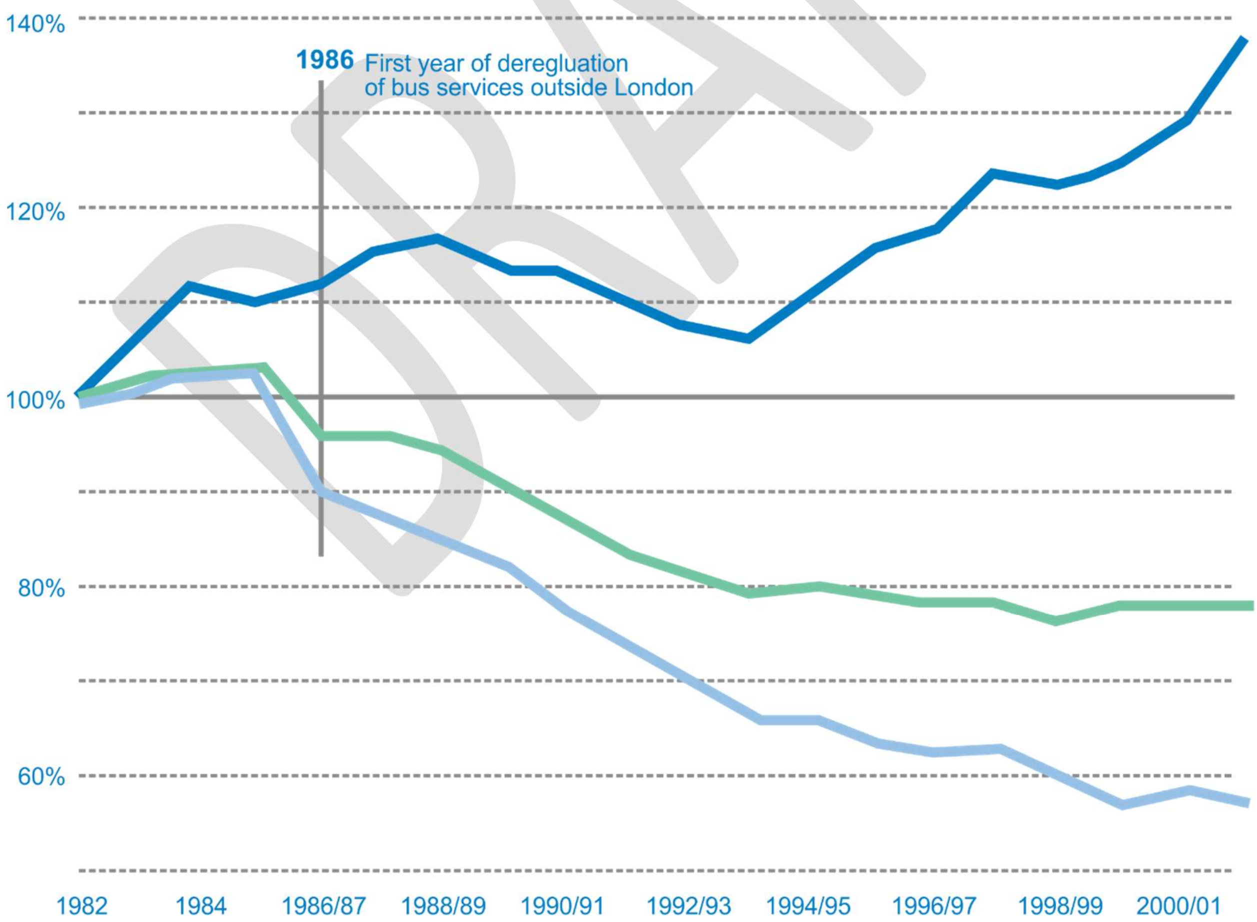
Regular bus transportation was deregulated in the UK (except London) in 1986. Operators enter the transport market freely through a registration process where a company should not obtain the right to work on the route as it is enough to have a transportation license and meet the applicable safety requirements. Immediately following the deregulation, operating costs and subsidies decreased significantly with the amount of traffic slumping at the same time. A period of intense competition was followed by a consolidation of the market by five large private companies that dominate all over the UK. In general, the transportation market in the UK was completely divided between these five companies and direct competition between them “on the route” was minimised: in practice, each operator works exclusively in its own territory.

Until recently, the only right of the transport authorities in transportation management was that of setting up social routes in areas that were not covered by the free market but had the need for transport services for social reasons. This means that transport administrations do not possess the tools for development of route networks as a whole nor for transportation integration. Some experts point out that the idea of improving quality through market competition has failed. The outcome of a shift in demand for transportation in the cities of Great Britain had proven much less efficient than in London, where the route network was still regulated by the authorities (Fig. 3.44).

In October 2001, the British government vested the local authorities with the power to set the quality parameters of transport service for local buses (so-called quality contracts) and to contract for those routes for which the model of “free competition” had failed to provide quality standards at the expense of budget. The Transport Act (2000) gave local authorities and operators the right to work together under a PPP model with the intention of delivering transportation services in accordance with established transport quality standards.

The disintegration of rail and bus transport systems in the Tyne-and-Wear county which had built an LRT system prior to the deregulation coordinated with bus transport by feeder routes and an integrated fare payment system was an example laying bare the disadvantages of the “on the route” competition. Following the deregulation, this coordination was eliminated: the LRT which earlier had drawn passengers in the whole region by means of feeder bus routes had its coverage area limited to stations located within walking distance for pedestrians. In addition, bus operators set lower rates by duplicating LRT lines, which further brought down the LRT passenger flow, decreased the efficiency of rail transport to the point where its operation had to be reduced. On the other hand, with the extension of the LRT line to Sunderland, the passenger flow of bus operators will be decreased by 12- 15%, which in turn will destabilise local bus operators, while the performance of the LRT will also remain insufficient. Such competition is detrimental to all of the operators in the region and the transport system as a whole.

Figure 3.44. The change in demand for bus service in the UK resultant from the deregulation policy and "on the route" free competition



Significant differences are observed in the LRT systems development schemes in the UK and continental Europe. LRT is not as successful in the UK as it is on the Continent, oftentimes not living up to the projected passenger flow due to lack of necessary integration with bus transport, unavailability of necessary park-and-ride spaces and restrictive measures on private vehicle use, deficit of video surveillance which would strengthen control over fare payments. PT trips come with no subsidies which also reduces the demand and need for LRT in the UK.

From the passengers' viewpoint, inadequate LRT - bus integration constitutes the biggest cause behind the waning attractiveness of further LRT development. The distinction between “social” and “commercial” services, enshrined at the legislative level of the UK, actually prohibits tariff integration and other kinds of integration, which makes the transport system inconvenient for passengers.

Unlike the UK, light rail transport on the Continent follows a separate lane with priority at crossroads and is fully integrated into the public transport system (bus routes are focused on feeding passengers to LRT and the tariff system is integrated). In France, the introduction of LRT also involves street-level reorganisation, which contributes to understanding that the construction of a tram line brings about improvements in the urban environment. It is understood that in most cases LRT travel rates should be subsidised.

In Valencia, an operator insisted that the organisation in charge of road traffic management give priority to tram traffic at intersections. Cities that have succeeded in attracting passengers (Zurich, Munich, Stockholm) have combined public transport development efforts with restrictive measures on private vehicle use (paid parking, tolled road passage in some sections).

In London, unlike other cities in the UK, there is a policy of strict regulation of the transportation market. Transportation is the sole responsibility of the Transport for London, which has the power to designate routes and schedules as well as other aspects related to the operations of providers. The tender commission arranges bids for the right to operate a route. A selected provider has no right to change routes, schedules, violate the requirements to rolling stock, but, however, has freedom in terms of tools (used for rolling stock maintenance) provided that they meet quality requirements.

In the late 1980s, the municipal operator had a good position, but was then divided into several operators, that began to compete not “on the route”, but “for the route”. Transport for London and providers sign gross-cost contracts under which it is mileage that is charged according to the schedule established by the customer, regardless of the number of passengers transported. All revenues from the fare are collected by the customer (Transport for London).

The purpose of the contracts in London is to get the best price for a product, the quality of which is specified in great detail in the terms of the contract. The cost of transportation in London diminished by almost 30% between 1986 and 1999 with the price of a mileage kilometre down by 46%.

Demand for transportation in London has risen as a result of London's economic growth and public transport priority policy, along with a "for the route” competition contract system which sets out the quality requirements.

The 2009 Guidance on Local Transport Plans in [111]Great Britain (hereinafter referred to as the Guidance) is a regulatory act issued under the Transport Act 2000 and the Local Transport Act 2008 The Guidance identifies the need for developing local transport plans (LTP), which are drawn up for five years ahead for different regions except London. The plan can be adjusted if necessary. It is also possible for a new local transport plan to be designed and put into effect ahead of schedule.

The Guidance shows the relation of the transport planning process with the Local Transport Act 2008, lists the main provisions for implementing the strategic policy followed by the authorities under local transport plans as well as presenting the key steps in ensuring the high quality of transport plans. The Guidance also provides a detailed list of authorities and organisations involved in the development of local transport plans.

To integrate bus transport with other modes of transport, separate planning is no longer provided for bus transport (bus service is viewed in conjunction with other modes of transportation, which is deemed to be more effective). LTP is developed through consultations with interested organisations, operators, and most importantly, members of the general public. It is necessary for LTP to:

- account for the environmental situation and policies, be in harmony with environmental conservation efforts;
- take measures to ensure equal access to transport space for persons with disabilities and reduced mobility;
- plan for development and use of parking space;
- provide charging stations for electric vehicles.
- LTP's contain a description of the strategic transport policy and measures for its implementation.

The implementation of local transport plans is accompanied by local district agreements that stakeholders are invited to become a party to with the involvement of the public.

Factors of public transport success. The main criterion of successful public transport development, based on the purpose of public transport as a tool to reduce externalities (adverse consequences of the operation of the transport system), according to experts, is often the share of passenger demand that has been shifted to

[111] Guidance on Local Transport Plans. UK. July, 2009. — 49 p. [Russian translation: Guidance on Local Transport Plans. United Kingdom of Great Britain and Northern Ireland. July 2009 — 49 p.].

public transport (owing to its appeal) which leads to less externalities in the transport system.

Among experts of 20 cities (including: Madrid, Barcelona, Berlin, Copenhagen, Helsinki, London, Munich, Zurich and Vancouver), a survey was conducted in order to [112]identify the factors that determine the successful transport system: the most instrumental factors were assigned 3 points, the moderately instrumental ones had 2 points, and insignificant ones had 1 point, while negative factors were given minus 2 points. The results of the expert survey are shown below (Fig. 3.45).

[112] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005

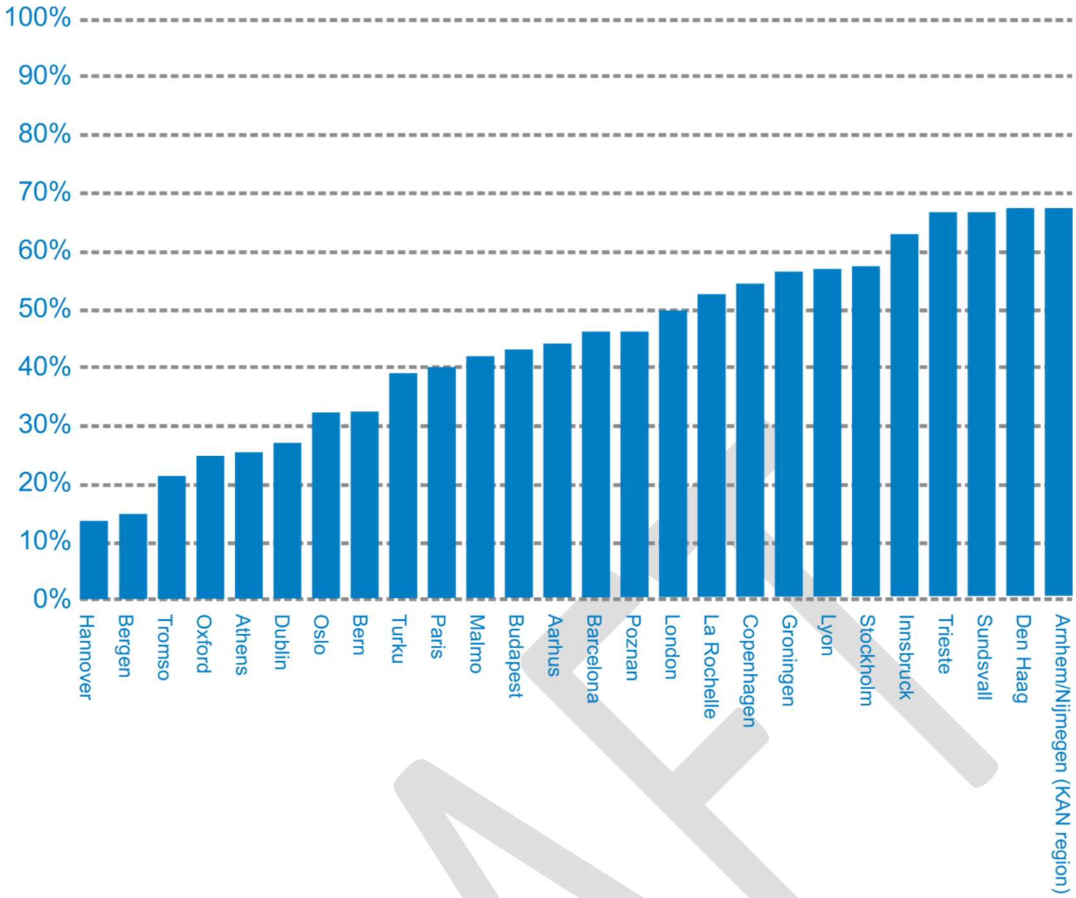
Figure 3.45. Key factors in achieving success in urban transport systems development. The maximum score corresponds to the most important factor of success

Key factor	Point
Political or structural factors	
Regional management of the transport system	28
Political consensus	9
Public support	9
Political leader	7
Administration and control by the central government	4
Stable political situation	10
Transport policy	
Infrastructure investments or subsidies	29
Competitive procurement process in place to select an operator for a route	19
Parking restrictions (paid parking)	9
Integration of transport and land use	16
Low fares for public transport	13
Integrated tariff and ticket system	32

As is evidenced by the survey, the most important political factors are coordinated planning and control over the transport system at the level of the whole region (agglomeration) while the most critical factor of the transport policy is an integrated tariff (ticket) system, as well as adequate financing (investment or subsidies).

The level of subsidies for public transport varies widely across cities around the world. Data on the level of subsidies are shown below (Figure 3.46).

Figure 3.46. Level of subsidies for public transport in the world's cities (share of costs covered by subsidies)



Large PT infrastructure development projects **are mainly financed** by central governments (by way of loans and grants), whereas local projects are funded via local budgets and taxes funds. In some regions (e.g. Stockholm), the authorities have the power to raise taxes to finance infrastructure development. Rolling stock is retrofitted through leasing schemes.

Contracts with providers and quality control. In practice, there are two fundamentally different types of contracts for route transportation: the gross cost contract and the net cost contract. With the gross cost contract, all revenues from fares are collected by the customer, whereas the net cost contract implies that all revenues are collected by the operator on its own. Under the gross cost contract, a subsidy paid by the customer may actually be reduced if the customer sees a high collection of revenue. From the standpoint of authorities, the gross cost contract offers significant benefits, especially for routes with latent demand, which, with high quality transportation service in place, can allow for a significant revenue growth and a reduction in subsidies.

A possible disadvantage of the gross cost contract in some cases is the low involvement of the operator in quality improvement, especially in countries with a high share of personal transport, where transportation quality is a significant factor in increasing the share of public transport. In order to prompt an operator to improve quality, payments under the contract in Norway are tied to a growth in the passenger flow (with a bonus paid for achieving a certain level of growth). This is the case in New

Zealand. It should be noted that with integrated planning, such decisive factors as the schedule, frequency, route roads are already defined and do not depend on the operator; however, the dependence of the operator's remuneration on the number of transported passengers stimulates the operator to break the schedule, leading to overtaking other vehicles on the same route and “long waiting time” at stops so that the cabin can fill up with more passengers. These measures do not result in an improvement, but instead translate into a deterioration of transportation quality.

Tendering proceedings in Oslo (Norway) include not only bonuses, but also penalties for breach of contractual terms. The contract defines the level of service. The amount of the contract can be increased or reduced by 3% per year depending on the achieved quality of service. The transportation customer is constantly monitoring the quality level with more than 1,000 inspections carried out per month. Along with inspections, surveys among passengers are conducted.

Five Oslo transport operators publish their service quality performance indicators on a monthly basis. These indicators have a bearing on monthly payments under the concluded contracts. The monitoring results are reported monthly to the operators' staff, so the culture of quality improvement extends throughout the entire company.

The operator pays a fine for each detected violation. For example, in 2004, a fine of 610 Euro was imposed for each of the following violations:

- departure from a stop before the time set in the schedule;
- violations in selling tickets to passengers;
- violations in the transportation vehicle type or its colour design;
- malfunction of exhaust filters.

A fine of 360 Euros is imposed for the following violations:

- No announcement of the next stop;
- Lack of information on the tariffs, schedules, quality guarantees for the passenger;
- The driver does not wear the prescribed uniform.

Regulation and coordination are recognised as the best practices. The central government can have a significant impact on urban transport management through creating an appropriate regulatory environment and legislation.

The example of **Great Britain** shows how the privatisation of bus transport has negatively affected the integration of transport systems in cities. While the municipality of Tyne-and-Wear managed to maintain the elements of integration as the LRT system was built long before the bus transport privatisation and deregulation, the Manchester region seems unable to achieve the necessary tariff integration with bus transport, except for single trips, which reduces the attractiveness and effectiveness of LRT.

The collaboration of local and regional authorities and the establishment of regional transport administrations responsible for coordinated transport planning and financing is a major prerequisite for making a product that meets the needs of citizens and corresponds to economic interests. It is much easier to provide for an effective “for the route” competition rather than a destructive “on the route” competition in such an integrated environment.

The examples of Zurich and Stuttgart (Germany) corroborate this assertion. In Madrid, Spain, funding comes from two levels of the budget (local and regional). In Valencia (Spain), the lack of coordination between local and regional authorities has led to a deterioration in the environment for development of a rail transport system as the local authorities failed to integrate LRT with bus transport (through a replacement of duplicating bus routes with feeder routes to LRT system) and continued to promote the vehicle use policy, including in central districts of the city. However, the new investment policy of the regional authorities has helped to achieve the necessary coordination.

Coordinated planning is an essential factor. A comparison of the public transport development in Toronto (Canada) and Melbourne (Australia) between 1960 and 1990 speaks to a significant success in Toronto as opposed to Melbourne against a number of indicators (Figure 3). .47).

Figure 3.47. A comparison of public transport development indicators of Melbourne and Toronto in the period of 1961-1991

Indicator	Melbourne		Toronto	
	1980-81	1990-91	1980-81	1990-91
Population, mil.	2.7	3.0	3.1	3.9
Population mobility by public transport, trips per year	95	97	213	233
Changes in PT mobility between 1960-1990	-56%		+22%	
	1964	1986	1964	1986
Share of public transport among all motorised transport trips	42%	19%	33%	33%
	1961	1991	1961	1991
The level of motorisation, unit per 1,000 residents	224	496	298	500

Foreign studies of differences in public transport services in these cities have led to the following conclusions on the key advantages of public transport in Toronto in comparison to Melburn which have maintained the high use of public transport in Toronto:

- High-quality bus service in Toronto and its well-designed integration with rail transport, vs. low quality bus transport and its integration with rail transport in Melbourne;
- More intensive and efficient use of Toronto rail systems through integration with bus transport;
- The combination of rail and bus transport in Toronto has become more attractive to citizens than the combination of park-and-ride spaces and rail transport in Melbourne given the lack of an attractive feeder bus routes.

3.2.2. Case studies and good practices

Sweden switched from a state monopoly to a contract system in 1989. Most of the contracts are gross cost contracts paid by the mile (regardless of the passenger flow) with the authorities developing a route network (including schedules and common rates), and bids put out for operators to service routes.

In the first round of tenders held in Stockholm, the state company Swebus won 79 lots while the municipal company SL Buses won 98% of lots in the next round. Prior to that, the companies had cut down labour costs, which still remained higher than those of private operators. Competitive procurement process has led to a reduction in public transport costs.

In Denmark, the state provider Copenhagen Transport held bids for transport service in 1989. The company turned into a regional transport administration with a whole set of objectives encompassing defining a route network for the region, holding bids for transportation, doing marketing and engaging with passengers, integrating information on transport operation, introducing a single tariff and ticket system. 8 out of 11 municipalities outside the metropolitan region eventually transferred transport management functions to companies in the same manner.

In Finland, tenders for transportation have been held since 1994. Between 1994 and 1999, transport costs were reduced by 25 to 33 percent for regional bus transportation and by 15 to 20 percent for urban transportation.

In general, in a number of countries, tender procedures have led to market consolidation: small operators having left the market or subcontracted by the larger ones. As a result, transportation costs in Helsinki went up again by 5- 20%.

In Germany, the transportation market is strictly regulated. Municipal transport enterprises are gradually being privatised. As in any other countries, the demand for public transport in Germany is falling, albeit to a lesser extent due to the high integration level of public transport, which makes it more attractive. 24 bus routes for which bids were organised in Munich in 1996-1999 resulted in a 26 percent reduction in costs, while the quality of transportation improved.

The most important source of financing is the national fuel tax, which is specifically aimed at the public transport infrastructure development, covering 70-85% of the capital costs of projects in urban areas of Germany.

In France, public transport is under strict control of the state. However, a significant share of the market is contracted among large private operators, which may explain French private companies entering the international urban transport market.

The unique experience of France explains the potential for intensive development of public transport rail systems in the country. Since 1982, local authorities have enjoyed the right to impose a local tax on personal income for urban enterprises staffed with more than 9 employees. The tax fee can be used both for developing infrastructure and for subsidising the operating activities of public transport, improving the pedestrian and cycling infrastructure and improving the public space. The maximum tax level is 0.55% in cities with a population of up to 100,000 residents and up to 1.0% in larger cities. In order to encourage the development of rail transport, the cities which have made that decision are entitled to raise this tax up to 1.8%.

The idea of the tax is to improve working conditions for enterprises in cities through the development of public transport and urban space. The improvements caused by rail transport are more significant, which justifies a higher tax level.

Financing structure for public transport in France (infrastructure and operations):

- Transport tax: 41%
- Subsidies of local budgets: 17%
- Central government: 7%
- Loans and other sources: 17%
- Travel revenue: 18%.

Chapter 4: Urban transport systems and the environment

4.1 Urban transport policies with environmental focus

4.1.1 Active mobility and co-modality. Mobility as a Service (MaaS)

4.1.2 Urban carsharing systems, car-pooling, ~~park-&-ride (P+R)~~, bicycle-sharing systems

4.1.3 Case studies and good practices

4.2 Urban transport technologies and alternative measures reducing environmental impact

4.2.1 Electric and hybrid urban transport (electric cars, busses, trams, LRT lines)

~~4.2.2 Active mobility and co-modality~~ (4.1.1)

4.2.2 Case studies and good practices

4.1 Urban transport policies with environmental focus

Definitions

Mobility-as-a-Service (MaaS) – the concept which integrally relies on using information and communication technologies to place the user at the centre of transport services and offer a personalized way of movement taking into account individual needs. MaaS integrates all kinds of modes of transport into a single service available upon request. Services are provided through a single monthly payment account. Under the MaaS scheme, users are able to purchase a package of transport services that meets their needs and preferences (for example, a business package, a family package, etc.).

Intelligent Mobility (IM) - a new approach to the organization of transport operations which incorporates automation, the use of digital technologies, mobile devices and open data (Big Data).

Mode of transport — mode of transport is a term used to distinguish substantially different ways to perform. The most dominant modes of transport are air, water, and land transport, other modes also exist, including pipelines, cable transport, and space transport. Human-powered transport and animal-powered transport are sometimes regarded as their own mode, in general, transportation is used for the movement of people, animals, and other things. Each mode of transport has a different technological solution. Each mode has its own infrastructure, vehicles, and operations, each mode also has separate subsystems.

Transport – transport or transportation is the movement of people, animals and goods from one location to another. Modes of transport include air, rail, road, water, cable, pipeline, the field can be divided into infrastructure, vehicles and operations.

Human-powered transport – human-powered transport is the transport of person and/or goods using human muscle power.

Light Rail Transit (LRT) - it covers all types of rail transport which are divided from the total flow of vehicles along most of their lines. They stretch on the ground, along flyovers or through shallow tunnels. LRT is positioned at the intersection of the traditional tram and the metro in terms of operational speed and transportation capacity. This category includes, among others, the high-speed tram and the light metro.

Carsharing — the type of vehicle use in which one of the parties does not own the car. This is an option to rent a car from specialized companies (most often for intra-city and/or short trips) for a short period of time or from individuals (the period and distance of the trip notwithstanding,) realised by agreement. This kind of car rental is convenient for those who seek to use a vehicle on an off-and-on basis or for those who require a car different in the brand, body type and carrying capacity from the one normally used.

Carpooling - sharing of a private car with the help of online travel search services. Furthermore, fuel costs are distributed proportionally and the best route for all parties taking the trip is selected without significant deviations from the main route of the driver (the car owner).

Carpooling (eng. car + pool) or ridesharing (eng. ride + eng. share) - sharing of a private car through online search services.

Park-in-ride - a location in a city or near that city where a person is welcome to park his or her car for a small fee and transfer to any type of public transport to get to the city centre.

Intermodal system - a kind of multimodal transport system, in which the integration of different modes of transport leads to achieving maximum efficiency of use of each of them. Within this system, passengers are given the opportunity of intermodal travel. Integration provides for coordination within the network (street and road network connectivity, availability of a system of main and feeder routes, well-designed hubs, continuity of routes), coordination of the timetables of different modes of transport, availability of general tariffs, availability of information on all modes of transport, shared image of the transport system, etc.

Transit Oriented Development (TOD) - a land-use pattern that envisages multi-storey buildings densely located within walking distance (400 - 800 meters max) from mass public transport (rail or bus) stations with the density and number of floors in the buildings always diminishing as the distance from the centre increases and an environment attractive for passengers in transit created.

Shared street or shared space - one of the types of streets with priority pedestrian traffic. Such a street either has no sidewalks or they are on the same level with the roadway so that pedestrians and motorists can use the space together on the terms of self-organisation. With drivers having to be more attentive, the car traffic substantially gains in uniformity thereby improving the safety of pedestrians[113].

Connected and Autonomous Vehicles (CAV) - connected vehicles use communication technology to interact with the driver, other cars on the road, the infrastructure and the 'Cloud' and autonomous vehicles are self-driving.

Intelligent Transport Systems (ITS) - a system integration of modern information and communication technologies and automation equipment with transport infrastructure, transport vehicles and users geared towards enhancing the safety and efficiency of the transport process and the comfort of drivers and users of transport.

ITS - the interaction of Information Technology and Telecommunications to enable information to be used by the public and through private administration, that is applied to transport.

Multi-modal - a combination of the use of different modes of transport in one trip.

MaaS Provider - stakeholder that designs and offers the MaaS value proposition.

[113] https://city4people.ru/post/blog_540.html, https://city4people.ru/post/blog_634.html

Data Provider Acts - Stakeholder that acts as a data broker.
Transport Operator - Stakeholder that provides transport assets and services[114].

4.1.1 Active mobility and co-modality. Mobility as a Service (MaaS)

Transport plays an essential role in economic growth and globalisation, but most of its types, when operated, generate various adverse effects on the environment and public health and, in consequence, on the population's quality of life and the economy (air pollution, noise pollution, accident rate, transport delays, etc.). The transport of passengers or cargo is carried out through one or more modes of transport; each having its strengths and weaknesses. In cities, users are seen choosing between modes of transport or a combination thereof guided by criteria such as cost, accessibility, time of travel, comfort of travel, number of transfers, etc. However, environmental and safety requirements are often not sufficiently taken into account by users in planning their trips. In view of that, the authorities are faced with the goal to provide users with the safest and best quality alternatives in their choice of travel/transport planning options.

In 2006, the European Commission (EC) introduced for the first time a new concept of "co-modality" into the transport policy to define a global approach to the choice in modes of transport and their combinations. Co-modality was understood to mean "use of different modes on their own and in combination" in the aim to obtain "an optimal and sustainable utilisation of resources". The concept of co-modality brought a new approach to the European transport policy, under which the goal was not to oppose one mode of transport to another (in particular, to oppose private vehicle use to its alternatives) but rather to achieve an optimal combination in the use of different modes of transport.

The concept of co-modality for urban passenger transport implies the construction of urban transport systems that would achieve a combination of priority development and joint use of mass passenger transit (public passenger transport), collective use systems for passenger transport, various types of small electric mobility and various types of active mobility. This being the case, public passenger transport (primarily electric) and non - motorised modes of transport should be prioritised in the construction of urban transport systems.

Co-modality (intermodality) means the creation of an integrated mobility system that promotes synergy between multiple modes of transport. There are two key benefits from combining cycling and public transport. Firstly, it creates a bridge between two important transport modes that together offer sustainable transport from door to door for longer distances. It provides a solution to many PT users to shorten the first and last miles to and from PT stops and hubs. Secondly, as it was told

[114] https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf, Transport Systems Catapult 2016, Exploring the Opportunity for Mobility as a Service in the UK

earlier, it adds the health benefits of physical exercise to the daily life of people even if most of the distances are travelled by PT.

In order to improve intermodality between PT and cycling it is vital to link train stations and PT hubs to a complete network of cycle routes in the city and create bicycle parking facilities in key locations around the PT network. PT organizations and companies should offer accessible services and information for cyclists as part of their services to the customers. PT ticket systems need to offer financial incentives and tickets that promote flexible mobility such as the inclusion of bicycle rental schemes and bicycle parking. But even when not combined with PT, cycling still solves problems of congestion, traffic and overcrowded PT. This demonstrates the flexibility and efficiency of cycling as a mode of transport.

A viable alternative to private vehicles represented by reliable public transport serves to cut down the number of individuals prone to private car use while contributing to the growing number of multimodal trips with individuals combining cycling with other modes of transport. On the other hand, the creation of an efficient cycling and walking infrastructure in cities establishes an enabling environment for the development of public passenger transport.

There are two positive aspects to the use of “active modes of transport” (cycling and walking, scooters, skates, roller skates, etc.) - firstly, it curbs the use of other modes of transport (mostly, private motor vehicles), thereby reducing the burden on the urban transport system, cutting down the emissions of pollutants, noise, etc., and, secondly, it enhances the physical activity of the population thus reducing morbidity and mortality resultant from hypodynamism.

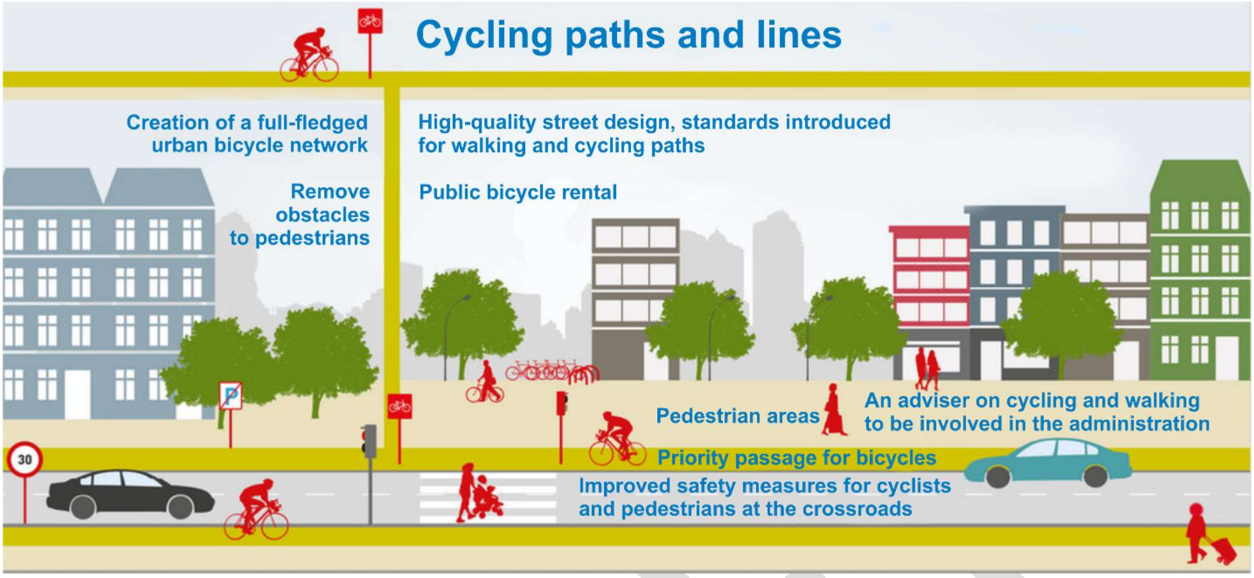
Figure 4.1. Benefits of cycling

Active mobility can be used both independently (for cycling trips up to 3-5 km and walks up to 1-2 km) and as part of combined (intermodal) transport chains, especially in conjunction with public transport. If transport correspondence end points are close to each other, travel distances to be travelled will be short and the way to cover them will be by non-motorised ways (for example, by bicycle or on foot). This usually happens in the city centre and other places of concentration of urban activity. However, in large cities with long distances of travel, there is a need for high-speed urban transport where different modes of transport, including cycling and walking, are efficiently integrated.

In his book "Copenhagenize", Mikael Colville-Andersen, Danish cyclist, notes: "In cities with good bicycle infrastructure, public transport is also excellent. Perhaps the thing is that when the city administration begins to calculate the capacity of streets not in terms of privately owned cars, but in people, the most natural thing is to construct cycle lanes or public transport dedicated lanes."

The primary factors promoting the development of cycling and walking in cities are: availability of appropriate infrastructure (cycle lane networks, cycle routes, sidewalks and walkways, pedestrian areas), the arrangement of bicycle rental services, the organisation of cycling and pedestrian traffic, with high safety for their traffic ensured (Fig. 4.2).

Figure 4.2. Encouraging cycling and walking in cities[115]



Some examples. In the 1970s, in Portland, Oregon, cycling was no more popular than in other cities in the US. Over 40 years, the city has invested around $60 million in cycling infrastructure equivalent to the cost of one mile (1.6 km) of the city's freeway. Nowadays, people cycle to and from work in Oregon 14 times more often than on average in the US.

The same also holds true for many European cities. By the 1960s, cars had begun to dominate road traffic in Amsterdam and Copenhagen, as well as in typical American cities. This gave impetus to changes in the transport policy in countries and cities from financing the development of highways to the creation of extensive urban networks of cycle roads with a focus on putting in place safe cycling lanes separated from road traffic.

Nowadays, in the Netherlands, 36% of people choose the bicycle as their main mode of transport with this figure even higher in cities. This said, in Copenhagen, which has invested $150 million in cycling in the past decade alone, 62% of people go to work or school by bicycle — 7 times more often than by car.

Cycling is a system linked to and within the mobility systems of urban and rural areas. Leading European countries such as Denmark and The Netherlands are no longer the only countries with developed cycling policies. Many cities have recognized the importance of cycling and are integrating this mode into their sustainable mobility plans. Cycling is a good feeder system for public transport and therefore the link to public transport (PT) is a key feature for cycling as a system.

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[115] https://sutp.org/files/contents/documents/resources/J_Others/GIZ_SUTP_Infographic-10-Principles-for-Sustainable-Urban-Transport_ru.pdf

Recently, cities and regions in Denmark, Germany, and the Netherlands work on "cycle highways". These highways are particularly noteworthy because of their focus on speed and convenience for cyclists and allow direct connections to certain areas. They are also opportunities for leisure while promoting sustainability and a healthy lifestyle. A good example is the fast cycle route between the Dutch cities of Arnhem and Nijmegen. More cycle highways are being planned in Germany and Netherlands.

Terrain, climate and cycling can not be contrasted against each other.

Figure 4.3. Winter bike parade in Moscow (Russia)

Copenhagen is known for the fact that during snowfalls municipal vehicles first clean the cycle lanes, and only then the motorways.

Seasonality and weather are believed to have a strong influence on cycling, but this is often not the case. For example, in the Yukon Territory located in northern Canada, there are two times more people cycling than in California whereas in hilly San Francisco, there are two times more cyclists than in relatively flat Denver.

Obviously, the heat can be a problem, so the modern rules which prompt developers to provide for showers at work are of paramount importance. However, climate, terrain and other local factors cannot be viewed as insurmountable obstacles to driving up the number of cyclists as the facts bear out the opposite.

By way of response to growing transport demand, as well as consumer and business needs and preferences, cities, in order to ensure seamless multimodal urban mobility, should seek to expand the supply of quality public passenger transport services and opportunities to ensure active mobility on offer for users as well as transforming this supply from "providing transport services" to "providing transport solutions". This transformation can be achieved by combining improving the current supply of public passenger transport services and enhancing the quality of passenger services through the expansion of the supply of services via partnerships and alliances with third parties, and promoting the use of the mobility capabilities of Internet service aggregators.

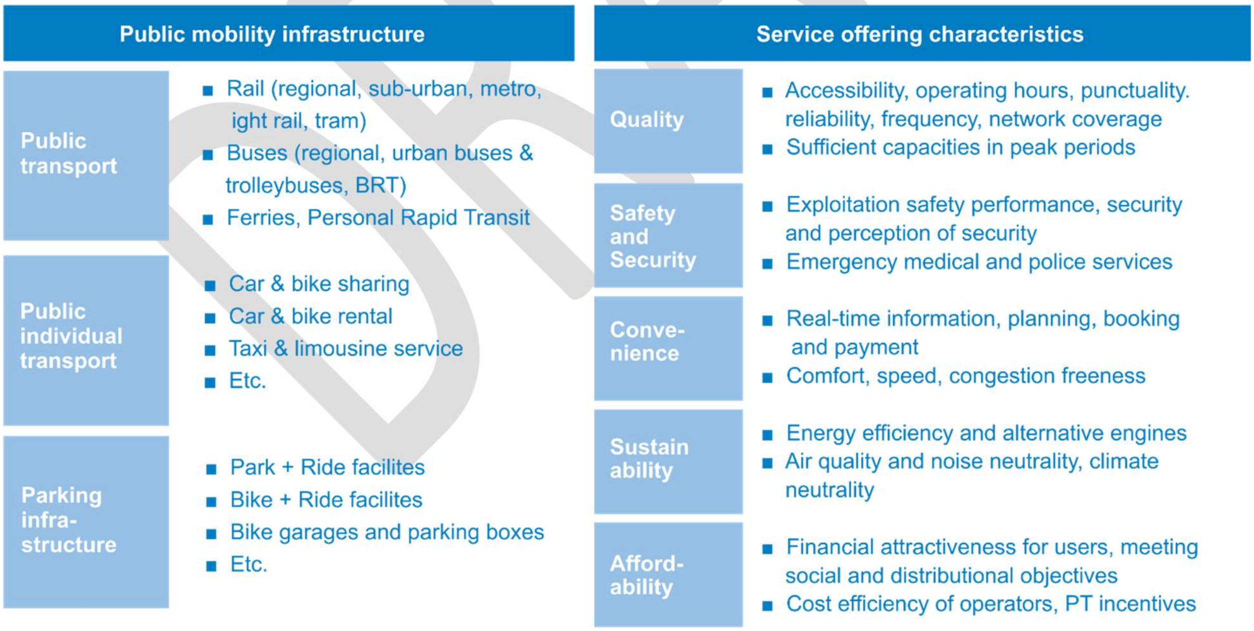
The supply of urban mobility services can be divided into three main categories, of which the first two are core mobility services (Figure 4.4):

- establishment and maintenance of appropriate infrastructure, efficient distribution of mobility between the available modes of transport and mobility;

- provision of key quality indicators for public passenger transport and other modes of transport of shared use: safety and security, convenience, accessibility, reliability, etc.;

- design of additional mobility services that promote the use of public transport, shared transport and active mobility along with the basic services.

Figure 4.4. The key components of public mobility services[116]



The application of "smart" information and communication technologies in transport enables the concept of "smart" mobility, which is one of the initiatives aimed at creating and operating "smart" cities. "Smart mobility" is an approach to improving

[116]https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

urban mobility through a variety of measures, goals and information content available thanks to modern information and communication technologies117. Compared to traditional urban mobility, “smart” mobility pursues the goal of ensuring wider user access to the most “sustainable” ways and technologies of transit in cities and stimulates people to take advantage of these opportunities (examples of such solutions include the use of autonomous vehicles, electrical/shared vehicles, inclusive of bicycles, private electric transport)[118].

Intelligent Mobility or IM is defined as the use of technology and data to create connections between people, places and goods in all modes of transport use which is becoming a real part of urban life.

Intelligent mobility implies a brand-new approach to transport, including automation, the use of digital technologies, mobile devices and open data.

Now the concept of “Mobility as a Service (MaaS)” is regarded as the first stage of IM development which has seen the widest implementation within the standards of “smart cities”.

MaaS is a new concept that offers consumers access to various types of vehicles and ways of multimodal city trips. MaaS can be perceived by passengers as the “best choice” which can change the way in which we now move around. MaaS mobility may sway users in favour of foregoing car ownership in the foreseeable future.

The MaaS concept is implemented through the creation of a digital platform combining urban and commercial transport services (including transport sharing services and active transport services). Urban citizens simply need to be aware of departure and destination locations so that the best route can be calculated via different modes of transport. The functions cover planning, ordering of and payment for trips on a “door-to-door” basis. Beyond that, the route and modes of transport can be adjusted based on current-traffic data.

FROM **MASS** TRANSIT TO **MAAS** TRANSIT: THE CORE ELEMENTS OF THE MAAS ECOSYSTEM[119].

“By 2025, private cars might become obsolete. With growing congestion along with innovative transport options, mobility as a service - using public and private transportation seamlessly and on demand — is gradually becoming a reality”, - Warwick Goodall, Director in the Public Sector Technology practice, Deloitte UK.

[117] Clara Benevolo, Renata Dameri, and Beatrice D’Auria, “Smart mobility in smart city: action taxonomy, ICT intensity and public benefits”, in Empowering Organizations: Enabling Platforms and Artefacts, Teresina Torre, Alessio Mario Braccini and Riccardo Spinelli, eds. (Cham, Switzerland, Springer, 2016).

[118] Ke Fang, “Smart mobility”: is it the time to re-think urban mobility?”, Transport for Development Blog, 29 April 2015.

[119] The Rise of Mobility as a Service: Reshaping How Urbanites Get Around, Warwick Goodall, Tiffany Dovey Fishman, Justine Bornstein, and Brett Bonthron, Deloitte Development LLC, 2017, https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/consumer-business/deloitte-nl-cb-ths-rise-of-mobility-as-a-service.pdf.

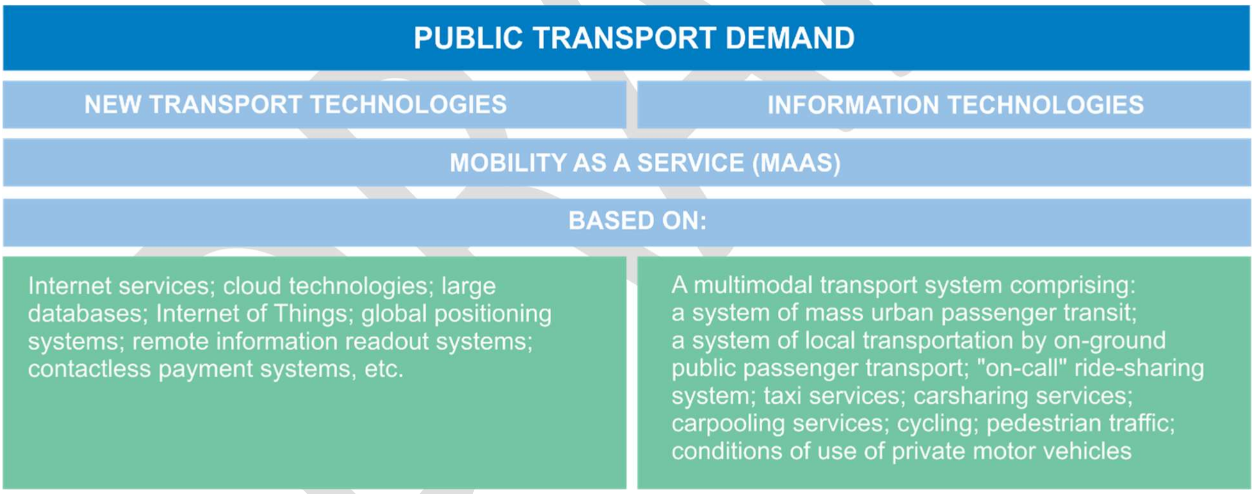
With urban population density continually growing, MaaS offers an alternative way to move more people and goods in a way that is faster, more environmentally friendly and more economical. By adding more variability to the transport supply, MaaS is transforming the traditional transport system into a much more flexible one.

Mobility as a Service represents a shift from “mobility management” to the personalisation of transport services.

There are the following prerequisites for the deployment of Maas in cities:

- availability of a modern system of multimodal public passenger transport;
- high Internet penetration in cities; creation of data sets on population movements;
- development of shared car use systems (taxi, carsharing, ridesharing, carpooling);
- development of non - motorised modes of transport for travel over short distances (up to 5 km);
- development of Internet services and mobile applications of transport services, introduction of integrated fare systems.

Figure 4.5. Integration of transport and information technologies



Three substantial components behind the existence of a modern system of multimodal public passenger transport can be distinguished:

1) Ticket menu.

Purchasing tickets for public transport trips makes up an important economic aspect in choosing a mode of transport, especially if the trip involves multiple routes or modes of transport. If a passenger buys a ticket in one bus, he or she does not have to buy another ticket when changing to another mode of transport. This economic aspect is of great significance. Normally, this requirement is met by creating temporary tickets which one can use to transfer an infinite number of times from one vehicle to another for a certain time period (the period of time ranging between 30 minutes, an hour, a half, a day, a week and so on). The practice of selling such tickets can be found in many cities. Figure_shows an example of Trojka card in Moscow (Russia).

Figure 4.6. Example of Troika card design in Moscow (Russia)

2) Punctual timetables.

Travel time is the most important factor in determining the quality of travel for the user. The predictability and punctuality of public passenger transport arrivals and departures must be under strict control. A passenger should know exactly when and how he or she can travel on the desired route, and should be confident that the bus/tram/trolleybus will arrive at the stop point at the scheduled time. This can be achieved by two ways: either by ensuring a short traffic interval (no more than 5 minutes, e.g. for the metro), or providing for strict compliance with timetables (e.g. for commuter trains).

3) Ensuring convenient transfers.

The system of transfers between public passenger transport routes should be intuitive to passengers. That can be achieved by informing passengers and convenient transport navigation. Also of importance is the need to make sure that timetables for different routes are interconnected with a view to minimize the time spent by passengers waiting for their transfers.

Figure 4.7. Some mobile apps used in urban transport in Moscow

The Moscow Metro:

Planning routes to any location in Moscow and Moscow region (metro + ground public municipal passenger transport + Moscow Central Circle + commuter railway transport).
“Troika” card balance management and topping up.

Mosgortrans:

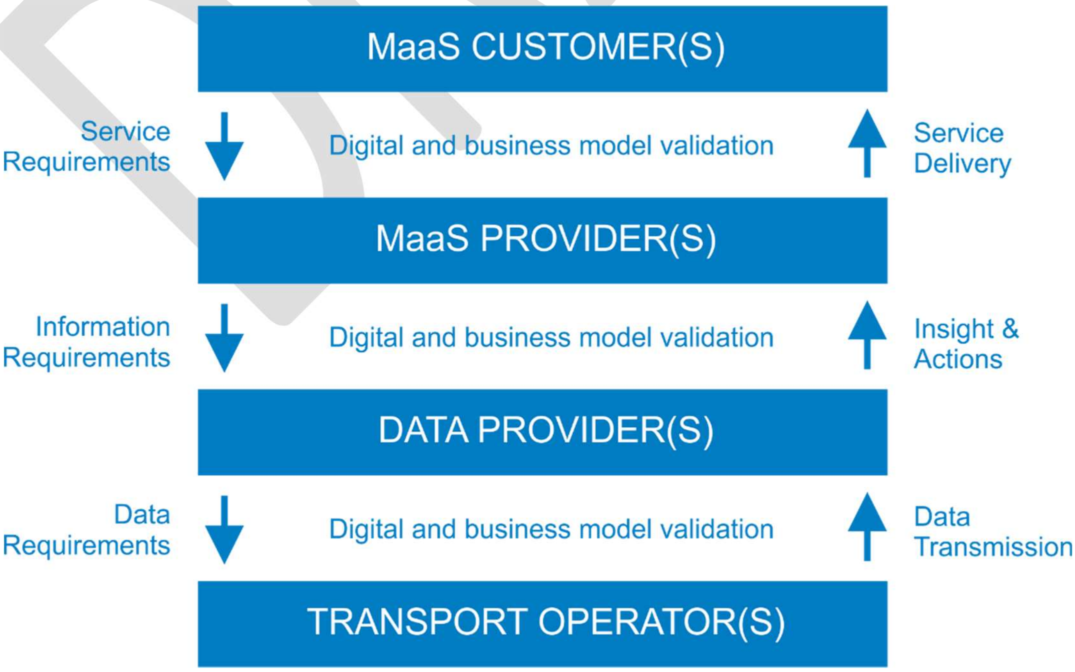
Tracking the movement of on-ground transport.Calculation of the route, time and cost of trips (bus, tram, trolleybus, Moscow Central Circle, Aeroexpress), including walking time, exit reminders. Route planning taking into account the location of cycling paths and parking lots.Planning routes for people with reduced mobility.

Velobike:

Determining the places where to rent bicycles, checking the availability of “Velobike” bicycles currently not in use:bicycles, rent payments, bike-route planning, assistance in the event of break-downs.

Figure 4.8 illustrates the significance and position of each user and element in the MaaS concept. Cumulatively, the parties involved make up a value chain that supports delivery by building an effective business model through digital technology[120].

Figure 4.8. Simplified layout of each user and element within the MaaS concept



[120] https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf, Transport Systems Catapult 2016, Exploring the Opportunity for Mobility as a Service in the UK.

MaaS in cities builds upon the system of urban public passenger transport. To ensure that it functions efficiently within the MaaS concept, it is necessary to:

- ensure a rational planning for the route network;
- ensure that transportation is organised efficiently, including in terms of the choice of carriers and connection with non-motorised modes of travel (cycling and walking);
- resolve issues related to financing urban public transport;
- ensure effective supervision of the quality and safety of transport.

In the last decade, motorists and passengers have been increasingly making use of new digital technologies represented by a variety of mobile applications and programmes along with information capabilities for fast and comfortable travel. Mobile applications and travel planning programmes that aid users in identifying and comparing different travel options have come to be commonplace and accessible in almost every city. The next natural step would be to bring all these options together on a common platform. This would enable planning trips across a whole variety of modes of transport, offering flexible payments and personalisation based on user preferences in terms of time, comfort, cost, reliability and convenience. With so many options at hand, users of the transport network should be able to easily plan, pay for and meet their transport needs.

MaaS is a user-oriented system in which smartphones play a pivotal role. That being the case, the efficient operation of MaaS requires smartphone access to 3G / 4G / 5G networks, a stable connection for dynamic updating of information about travel options and a non-cash payment system in place.

The following components are of key importance for MaaS system:

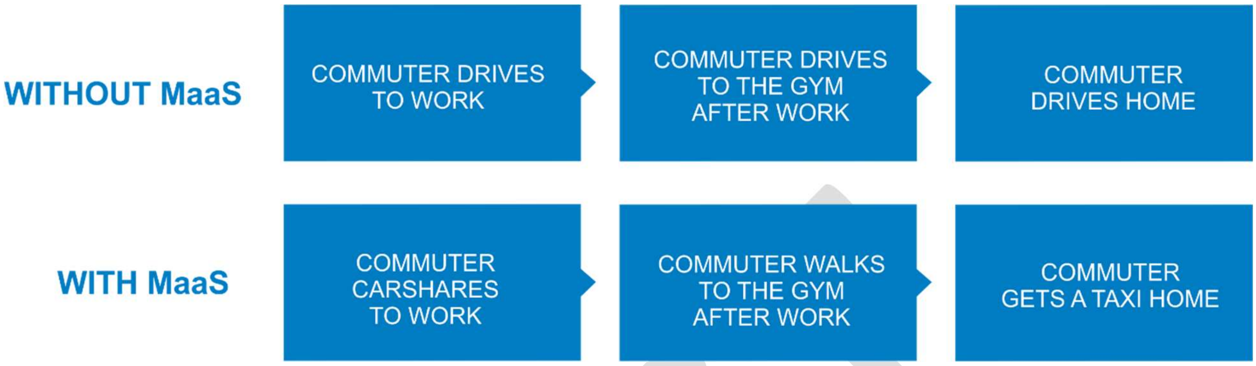
- Infrastructure;
- Data providers/telecommunications companies/payment systems;
- Transportation operators;
- A trusted mobility advisor to connect the services of public and private operators, handle orders and send payments and transactions through a single gateway.

Fig. 4.9 shows the alternative options for building a trip with/without the MaaS concept.

Figure 4.9. A theoretical example to show how the servitisation and data sharing capabilities of MaaS may be used by the consumer (illustrated in This example illustrates the potential for a MaaS Provider to address their customer's lifestyle needs and by being successful in this, support behaviour change)[121]

[121] https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf, Transport Systems Catapult 2016, Exploring the Opportunity for Mobility as a Service in the UK.

Figure 4.9. Example of a MaaS system operated for a user who seeks to cut down on using his or her personal vehicle[122]



The strengths of the MaaS concept for its various users can be set forth in the following way:

- **users** are provided with full personal mobility depending on their specific situation, circumstances and transport needs;
- transport and other **operators** involved in the process can boost their profits;
- **local governments** and municipalities come in for extra trust from the population with the latter positively evaluating their efforts owing to the improved transport services for citizens, the availability of data on modes of transport, budget savings and savings in the personal expenses of users of the transport network, improved air quality and environmental conditions in cities, reduced congestion, etc.
- for **third-party companies**, the MaaS platform is a potential source of revenues as well as a base for integration of additional services.

MaaS also offers a broad range of additional benefits:

- Improved quality of travel planning and convenience (i.e., on-demand trips, personalized, seamless and predictable trips);
- the redistribution of passengers to the most efficient modes of transport in terms of costs and other factors;
- Overall travel time being reduced thanks to high awareness of traffic conditions, network conditions and modes of transport;
- better monitoring, management and planning of mobility services;
- potential reduction of transport congestion and the environmental impact of transport;
- reduced mobility costs by expanding the pool of suppliers and improving accessibility;

[122] https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf, Transport Systems Catapult 2016, Exploring the Opportunity for Mobility as a Service in the UK.

- stimulating rising incomes for transport service providers through tapping new sources of revenue or expanding the market;
- improving the regional response to the evolution and emergence of new transport services[123].

Ticketless travel is a key component of any MaaS model. With a smart card or smartphone, a user can freely use any mode of transport and make the transfers necessary for his or her trip. The current MaaS offers include two types of payment — a monthly single ticket/subscription or a pay-as-you-go option. The monthly subscription enables the operator, both a public company and a third party, to "buy" services for users in bulk, and then offer a discount on transport service. The pay-as-you-go option works like most applications to plan the route in advance: one trip can be put together from several components with the user paying separately for each part of that single trip[124].

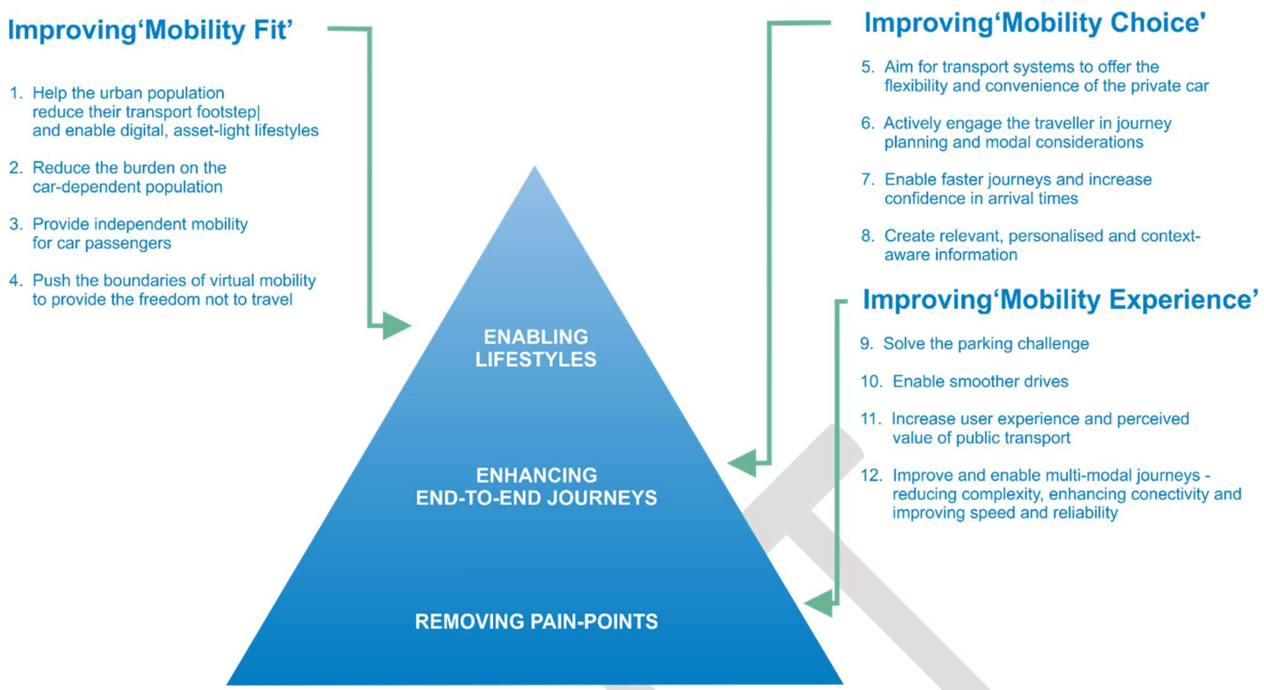
The introduction of the MaaS models enables to: improve the available experience of mobility by "ironing out the kinks" in urban transport systems; enhance the choice of modes of transport and travel by providing for "door-to-door" travel; "adjust" mobility to the needs of customers, ensuring a high quality of life (Fig. 4.10).

Figure 4.10. The Traveller Needs Capability Challenges[125]

[123]http://www.ttf.org.au/wp-content/uploads/2017/09/Mobility-as-a-Service-September-2017.pdf, Mobility as a Service. The next transport disruption.L.E.K. Consulting in partnership with Tourism & Transport Forum Australia (TTF) and the International Association of Public Transport Australia & New Zealand (UITP), 2017.

[124] Per-Erik Holmberg et al., *Mobility as a service: Describing the framework*, Viktoria Swedish ICT AB, January 15, 2016, Maria Kamargianni et al., *Feasibility study for 'mobility as a service' concept in London*, UCL Energy Institute and Department for Transport, May 2015, https://www.bartlett. ucl.ac.uk/energy/docs/fs-maas-compress-final.

[125] https://ts.catapult.org.uk/wp-content/uploads/2016/07/Mobility-as-a-Service_Exploring-the-Opportunity-for-MaaS-in-the-UK-Web.pdf, Transport Systems Catapult 2016, Exploring the Opportunity for Mobility as a Service in the UK.



A major factor in the successful operation of MaaS systems is the collaboration of all its its components and parties involved. The private sector may seek to get involved in advancing the system in pursuit of profits, while public institutions may be looking to benefit the population (congestion reduction, higher productivity of the transport network, environmental conservation and improved urban air quality, lower number of traffic accidents and less need for parking space).

Future iterations of MaaS should create an integrated mobility system, more flexible than the available transport network, a system with the offer of services matching the actual transport demand, one offering the most convenient, safe and economical modes of travel.

While the MaaS system boasts a huge potential for further development through the introduction of new technologies and innovations, both in transport and in information and communication, MaaS and IM are merely the first steps towards a more durable solution — the introduction of intelligent mobility based on Connected to Autonomous Vehicles (CAV). Connected vehicles rely on communication technologies to interact with the driver and other vehicles on the road, infrastructure and the "cloud", while autonomous transport services units ensure transportation without being under the control of the driver.

Substantial elements of the urban transport system integrated with public passenger transport and incorporated into the MaaS systems should be the different passenger carsharing systems (taxis - traditional and those operated through aggregators of on-line services, carsharing, ridesharing, carpooling), which is a rapidly developing sector of the economy of shared use.

4.1.2 Urban carsharing systems, carpooling, ridesharing, bicyclesharing systems

Sharing economy is on the list of ideas that will change the world in the near future according to Time magazine. The concept of collaborative consumption was first put forward by economists Rachel Botsman and Roo Rogers in their book “What's Mine Is Yours: The Rise of Collaborative Consumption” (2010). The term “collaborative consumption” is used to describe an economic model based on the collective use of goods and services, barter and lease instead of ownership. The idea behind the concept is that it is often more profitable and convenient for the consumer to pay for temporary access to a product than to own it. PwC estimated that in 2015 (no later studies have yet been conducted) there were over 300 companies operating in different sectors of the collaborative consumption economy in Europe. Various online platforms in this field are expected to generate a world market with a volume of up to 335 billion USD by 2025. In contrast, businesses that build on the collaborative consumption model come under criticism for ignoring the contradictions between self-sufficient small transactions and the global corporations that manage them, violation of labour rights, circumvention of state regulation and tax evasion.

Transport services are now a major sector of collaborative consumption. Owning a personal vehicle is growing increasingly burdensome for people: firstly, the value of the car drops considerably once it is put to use, which does not make this purchase an effective investment; secondly, current operating conditions for cars in cities serve to render them more difficult, inefficient and costly for the owner. By contrast, users moving away from car ownership by switching to carsharing services can bring about major social effects such as growing well-being of the population achieved through saving on car purchase; reducing the space taken up by parked cars; lower consumption of resources used for the manufacture of cars and their components, less waste associated with the operation and scrapping of vehicles, reduced pollutant emissions (by transport companies relying on environmentally friendly vehicles and by cutting down the excess mileage of vehicles in search of parking spaces). That notwithstanding, it should be taken into account that introducing mechanisms of collaborative consumption in the transport sector may initially not produce a proper social effect and, on the contrary, lead to certain negative outcomes while public awareness about it is being raised. For instance, the introduction of measures to regulate the access of cars to certain urban areas and other measures pursued by the city authorities aimed at discouraging the use of privately owned cars may, in some cases, encourage increased use of shared motorised transport services without users giving up on their own vehicles. The lack of adequate legal regulation in place to govern the activities of operators of online platforms may cause a legal vacuum in transport safety along with an increase in the road accident rate.

As applied to the transport system, shared use mechanisms are represented by the following online services: taxi order (ride-hailing Uber, Gett, Yandex, etc.), short-term car rental (carsharing), fellow travellers search (carpooling or ridesharing). The commonplace application of such services has become a reality thanks to the following technological advances:

- GPS devices used to determine the driver route and organise a shared trip;
- Smartphones that enable users of a service to request for a trip regardless of the location;
- Social networks that make the service transparent while also bolstering the level of driver - passenger trust.

Ride-hailing:

Ride-hailing systems are advancing at a rapid pace. For instance, over the six years since its inception, Uber has expanded its presence to more than 500 cities and 70 countries around the world[126]. Services like Uber pursue the goal of encouraging consumers to give up on private cars in favor of taxis. Uber has spawned a new term "uberization", which refers to companies that go from being suppliers of specific goods to being service providers. In this sense, Uber and similar companies offer not the car itself, but the service of moving from one location to another. This business model brings down significantly operating costs as compared to traditional ones.

Car sharing systems:

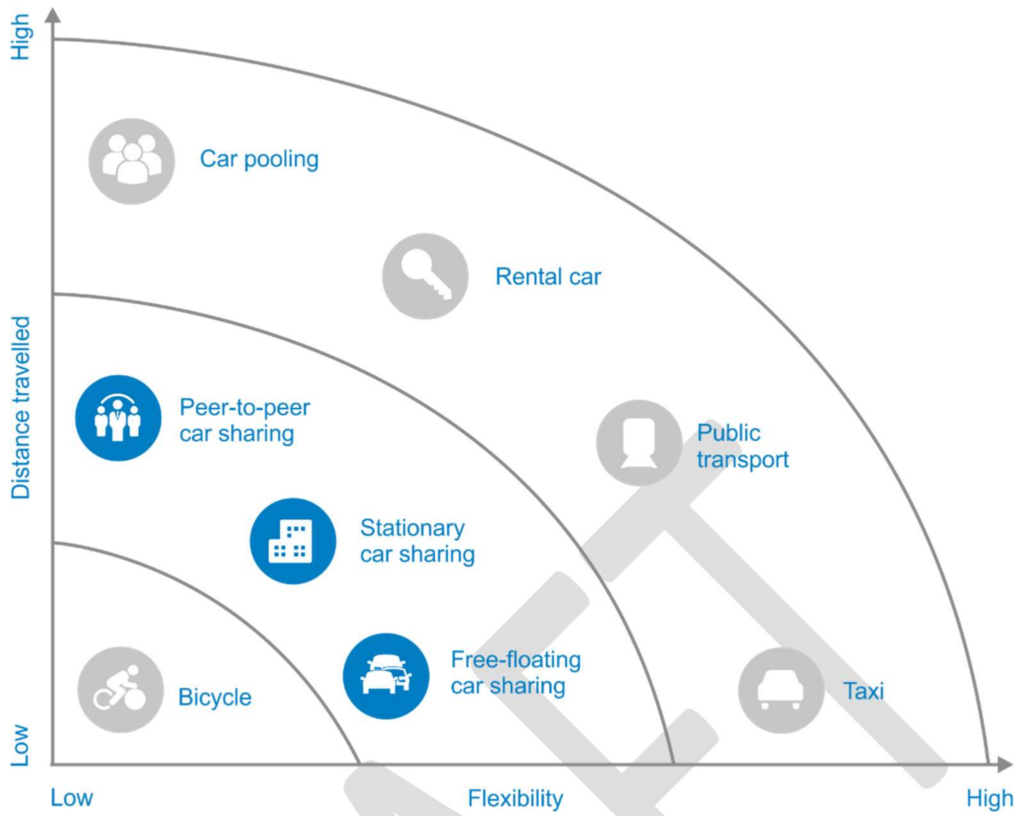
Owning and servicing a private car has long since turned into a problem for some car owners as opposed to being convenient. These days not only does one have to wash and refill one's car, but also to pay for parking, insurance, maintenance, etc. Against this backdrop, car sharing projects which are based on the idea of a car being temporary used by different people have gained tremendous popularity.

In 2014, carsharing had almost as many as 5.000.000 users worldwide, up from 350.000 in 2006, and the number of users is projected to exceed 23.000.000 worldwide by 2024 year (Fig. 4.11)[127].

Figure 4.11. Areas of application of different public transport services

[126] Uberestimator, "Uber cities," http://uberestimator.com/cities, accessed October 24, 2016.

[127] Navigant Research, Global carsharing services revenue is expected to reach $6.5 billion in 2024, https://www.navigantresearch.com/newsroom/global-carsharing-services-revenue-isexpected-to-reach-6-5-billion-in-2024.



Nowadays car sharing systems are seen undergoing rapid development in major cities. This is evidenced by the global trend of capital investments in this market by companies coming from different areas of business, including leasing and transport companies as well as the automotive industry.

Carsharing is derived from the combination of the words “car” and “sharing”. Carsharing refers to joint use of a car representing a short-term car rental service where users are charged by the minute.

There are two carsharing models in the world depending on who owns the fleet:

- B2C (business-to-customer) - a company purchases cars for subsequent rent. This model is operated, for example, by Zipcar, StattAuto and GoGet;

- P2P (peer-to-peer) - a company rents private cars from owners who seek to earn extra money on their cars which they are not currently using with the company renting the vehicles to customers. This is the way RelayRides, Whipcar, Wheelz and GetAround are run.

One of the aims of car sharing services is to urge potential car owners to abandon the notion of car ownership.

The fleets of carsharing companies range from dozens to thousands of cars in major cities. All the locations where the cars are parked can be viewed via the mobile app or on the website of the car sharing operator.

A driver can take and leave a car in one of these parking lots. The key strength of car sharing is the short-term nature of car rental. The convenience of that is that a driver can take a car for any period of time charged by the minute for actually using the car, for example, when a person is running late and they just need to drive a couple of streets. The user is charged per the time spent in travel and idle time with refueling costs covered by the carsharing operator. As a result, an individual gets a private car for a short period of time, which only takes a mobile application installed on their phone with a bank card tied to the app.

Carsharing is not to be confused with regular car rental. If used within the confines of one city, carsharing services are much more convenient and offer several advantages as compared to normal rental:

- One is not required to sign a contract and fill out the relevant rental paperwork every time the need for a car arises as the service is provided through a mobile application. All it takes is for one to fill in one's personal data once, enter into the contract and obtain permission to use any of the operator's cars;
- Carsharing services are available around the clock. Therefore, a person never has to wait for a rental center to open to rent a car. All issues in the nature of choosing a car, booking it, opening it, finding a place to return it can be dealt with in a matter of minutes on the smart phone screen.
- The most important difference is the period of car rental. When renting at a rental agency, there is no way to rent a car for 10 minutes, for example. The very fact that the car will have to be returned to the same location alone renders it impractical.
- There are several more strengths to it such as:
- Economy: users say that they tend to pay less than when servicing their car or using a taxi. Many even end up renouncing their own cars or putting on hold their plans of buying a new car;
- Free parking: car sharing operators enjoy preferential parking conditions, including in the city centre. And that incurs no expenses for drivers. Once the car is parked, the temporary rental ends;
- car refuelling compensation: A refilled tank is by default included in the cost of each minute spent in travel, so if the fuel level in the car nears the critical point along the way, the carsharing company will cover all costs;
- environmentally-friendly use of cars: this effect is achieved thanks to operators choosing only modern car makes with high environmental protection properties for their fleets. Apart from that, statistics in many countries indicate that with the advancement of car sharing, residents of megacities have been seen cutting down the total time of trips, thus mitigating the environmental impact on the atmosphere and ecology in their cities.

Implementing carsharing models, however, is not without difficulties. Congestion is a challenge for carsharing operators as it makes planning and managing the fleet more difficult preventing users from returning cars to the parking lot in time. In order to offset this imbalance to some extent, operators in congested cities often deploy a large fleet of vehicles thereby being able to meet users' orders even during congestion.

This certainly results in excess expenditures and cars standing idle in between the rush-hours. In addition, traffic jams make it difficult for customers to plan their expenses as some companies charge penalties for delays in returning cars. Mindful of this, some operators offer users rates with flexible time intervals for car return or special conditions of reimbursement for unused hours.

To develop carsharing, experts recommend that operators should be exempt from a number of restrictions that apply to drivers of private cars, and in some cases, they should be given certain privileges: exemption from parking fees and entry fees to the city centre, and access to designated lanes in exceptional cases.

The primary legal barriers to the development of car sharing imposed by legislation are related to establishing the legality of this type of activity, because, much like in the other examples of sharing economy, issues associated with defining the responsibilities of parties, exercising control over the activities of users, economic transparency and many others are inherent in the car sharing. Furthermore, carsharing operators entering new markets are often faced with fierce competition from similar modes of transport, such as taxis and conventional car rental.

Car sharing users are exposed to the following disadvantages:

- Potentially poor condition of the car, as some customers tend to take less care of car sharing cars than others so the fleet inevitably deteriorates in appearance, both externally and internally;

- lack of cars in crowded points of attraction. For example, finding a free car in the city centre can prove extremely hard during rush hours in the morning and evening on weekdays with people in a rush to get to work or home.

Figure 4.12. Car sharing business model archetypes[128]

	Traditionalists	Citizen networkers	Mobility integrators	Innovative OEMs
Unique Selling Proposition	■ Mainly low-cost cars ■ Full service model ■ Broad range of vehicle types	■ "Virtual" fleet made up of vehicles from participating owners ■ Usually large selection of cars	■ PTOs enlarging their service portfolio in order to offer door-to- door mobility ■ Strong PTO brand	■ Premium cars also ■ User communities ■ Value add location based services ■ Strong OEM brand
Advantages	■ Lower usage fees ■ Booking possible without smartphone usage skills ->Appropriate for older customer groups	■ Insurance included ■ Cheaper compared to car sharing/rental ■ Suitable for less density populated areas	■ Leveraging existing customer base ■ Integration into own intermodal apps (e.g. Qixxit) and mobility cards (e.g. BahnCard)	■ Mainly free floating1' -> spontaneous hire ■ Intermodal apps (e.g. moovel) ■ Usually minute based charging
Disadvantages	■ Mainly station based services ->Less flexbility ■ Sometimes complicated processes for customers	■ Critical mass decisive ■ Car theft issues ■ Neighborhood based geographic scope ■ No full service model	■ Mainly station based services -> Less flexibility ■ Sometimes complicated processes for customers	■ Higher usage fees ■ Smartphone usage skills needed ■ Booking in advance (> 30 minutes before) not possible
Examples	■ Greenwheels/StattAuto ■ Stadtmobil ■ Communauto	■ Tamyca ■ Jolly Wheels ■ RelayRides ■ Getaround	■ Deutsche Bahn - Flinkster ■ Veolia Transdev - Autobleue ■ Keolis - Autocool, Lilas, Auto'Tao, IDElib'	■BMWDriveNow ■Daimler car2go ■Volkswagen Quicar ■Citroen Multicity

[128] https://www.uitp.org/sites/default/files/members/140124%20Arthur%20D.%20Little%20&%20UITP_Future%20of%20Urban%20Mobility%202%200_Full%20study.pdf, Arthur D. Little and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

Moscow (Russia):

Carsharing was launched in Moscow in 2015 preceded by the city bike rental system starting in 2013 and followed by electric scooters rental opening up in 2018. Now the car sharing network in Moscow encompasses 11.000 cars whereas the bike rental network boasts 4.300 bicycles stationed at 430 locations and 2.950 electric scooters. The number of users rises with every year. Currently, there are more than 30.000 carsharing trips and over 27.000 bicycle trips per day in Moscow.

In early autumn, 2018, there were 15 carsharing operators registered in Moscow; all of them offering different car makes, prices and parking areas. While most of them are only available within the Third Ring Road, there are also services that cover remote areas and enable users to get to or from the airport by car.

In Moscow, all the companies that provide carsharing services are obliged to comply with several conditions designed by the Moscow Transport Department:

- round-the-clock operation;
- cars not older than 3 years;
- environmental status of Euro - 4 or higher;
- cars must be marked with the logo “Moscow Carsharing” on a compulsory basis;
- availability of a GLONASS satellite system in and remote access to cars.

However, each operator has different coverage areas. The contract offered by each company specifies in clear terms the conditions for concluding that contract. Often this is the minimum age and seniority of the driver[129].

Figure 4.13. Carsharing motor vehicles in Moscow (Russia)

[129] http://voditeliauto.ru/poleznaya-informaciya/online/carsharing.html as well as based on the answers given by Moscow (Russia) to the UNECE questionnaire.

Figure 4.14. Carsharing motor vehicles in Moscow (Russia)

Car-pooling/Ride-sharing:

Carpooling (eng. car + pool) or ridesharing (eng. ride + eng. share) - sharing of a private car through online search services. Furthermore, fuel costs are distributed proportionally and the best route for all parties taking the trip is selected without significant deviations from the main route of the driver (the owner of the car) unlike riding in a taxi in which case the costs are paid by the passenger and the direction of the trip is not limited by the driver or hitchhiking where in fact it is only the driver who pays while following his route strictly. Theoretically, ridesharing leaves room for potential transfer of control over the car to one of the passengers, but this is rarely seen in practice. The following types of carpooling are distinguished depending on the method of planning a joint trip:

Classic - usually a long (from 100 km) trip, planned in advance (from 1 day to several months);

Dynamic - travelling over short distances in urban space (1 — 100 km) with alternatives available (by own car, public transport, taxi, bicycle or on foot);

Regular — the users, the route and the schedule of the trip are constant.

The first projects that were reminiscent of carpooling emerged in the 1990s just to immediately meet with obstacles like the need to build up a user community and a convenient way of interaction with each other. Gradually, the telephone initially used to organise travel was replaced by the Internet, e-mail and smartphones with major companies developing special user communities.

With carpooling, one can take up free seats in private cars, which reduces the total fuel consumption, specific pollutant emissions (per 1 passenger) and transport costs of those taking the trip. Beyond that, the regular use of shared journeys is proven to reduce traffic, help to ease road congestion during peak hours and reduce the environmental impact of vehicle emissions. Passengers and drivers can use carpooling just once or regularly. This service is particularly effective in areas poorly covered by public transport.

A study conducted at the University of California Berkeley in 2010[130] shows that about 20 percent of respondents are willing to do ridesharing at least once a week. Also, carpooling is more popular among those who travel in the same direction every day (by 30%) than those who travel on casual trips. The biggest obstacles that hamper the development of carpooling are short trips and increasing travel time.

One of the potential drawbacks of carpooling may be the economic damage suffered by regular public passenger transport operators so private and public taxi and bus companies oppose this service.

Carpooling advantages:

- Savings on fuel, repair, parking and fees;
- Reduced traffic congestion thanks to car enthusiasts and fellow traveller riding together in one car;
- Reduction of emissions of pollutants and climate gases;
- Avoiding stress and driving load. Taking turns day-by-day allows carpooling users to alternate in driving;

[130] Elizabeth Deakin, Karen Trapenberg Frick, Kevin Shively. Dynamic Ridesharing // Access. — 2012. — № 40. — C. 23—28.

- Shared rides help to make new acquaintances. With modern society focused on individualism and independence of everyone, such an opportunity can prove of high value.

Potential carpooling disadvantages:

- The driver is responsible for the delay should their car vehicle involved in a car accident;
- Drivers sometimes have to come and pick up their passengers which extends their travel time;
- It is hard for municipal authorities to organize and support the operation of carpooling;
- Risk of riding with a fellow traveller with criminal intent.

Bicycle-sharing systems:

Nowadays, there are more than 1.000 public bike-sharing systems operating in more than 50 countries around the world, up from 11 cities around the world in 2004[131].

Now presented in hundreds of cities across the world, dockless bike-sharing systems are becoming even more ubiquitous. The extent to which the adoption of bike travel reduces CO2 emissions depends on the characteristics of the shift in an individual's transport behaviour, and in particular the mode that it replaces. Mobike, for example, has estimated that 4.4 million tonnes of CO2 equivalent emissions have been saved globally as a result of the ridership that it has made possible.

Bike-sharing systems have seen extremely rapid growth in recent years (in the case of Mobike, services have expanded to over 200 cities in 15 countries, with 200 million registered users, 9 million bikes in daily operation, and 30 million rides per day). The fact that these systems have become so widespread so quickly attests to a demand for passenger transport that had thus far been largely unmet. This type of on-demand transportation is an example of how the Internet of Things (IoT) technology is changing transport. Such systems also collect large amounts of data on user patterns, which could potentially be used to analyse transit systems. The activity of these systems generates an enormous amount of data, on the order of tens of terabytes per day. As more and more people use dockless bike-sharing systems on a regular basis, these systems are becoming a fixture in the landscape of transit options, bringing more areas within range of public transit systems and therefore effectively increasing public transit ridership[132].

For example, besides being good for the environment, climate, personal health and fitness, many Germans simply love cycling for very practical reasons: It allows

[131] Rosamond Hutt, *Mapping of bike-sharing data will change the way you see these cities*, World Economic Forum, August 10, 2016, https://www.weforum.org/agenda/2016/08/ what-bike-share-data-can-tell-us-about-our-cities/.

[132] https://www.itf-oecd.org/sites/default/files/docs/policy-priorities-decarbonising-urban-passenger-transport_0.pdf, POLICY PRIORITIES FOR DECARBONISING URBAN PASSENGER TRANSPORT © OECD/ITF 2018

them to avoid congestion or the annoying search for parking space (which accounts for more than 20 percent of inner city traffic), making cycling a time-saving and convenient alternative to the car. Hence, the obvious benefits of bike-sharing are reduced congestion and improved air quality, but also increased accessibility of public transit by complementing public transport services: commuters can use shared bikes to travel to the bus or train station, covering the last mile to and from work[133].

However, to make this work, a fleet of shared bicycles must be available at each station. This can be best ensured with a high number of bikes available at the most attractive hot spots. Smart pricing systems can help guide the supply, for example by introducing virtual "bonus zones" to attract users to leave or to pick up a bike at a specific location to better balance out demand and supply.

Today, a lot of cities around the globe have their own bike-share systems, and more programs are starting every year. The largest systems are in China, in cities such as Hangzhou and Shanghai. In Paris, London, and Washington, D.C., highly successful systems have helped to promote cycling as a viable and valued transport option. Each city has made bike-share its own, adapting it to the local context, including the city's density, topography, weather, infrastructure, and culture. Although other cities' examples can serve as useful guides, there is no single model of bike-share.

Many of the most successful systems share certain common features:

• A dense network of stations across the coverage area, with an average spacing of 300 meters between stations;

• Comfortable, commuter-style bicycles with specially designed parts and sizes that discourage theft and resale;

• A fully automated locking system that allows users to check bicycles easily in or out of bike-share stations;

• A wireless tracking system, such as radio-frequency identification devices (RFIDs), that locates where a bicycle is picked up and returned and identifies the user;

• Real-time monitoring of station occupancy rates through wireless communications, such as general packet radio service (GPRS);

• Real-time user information through various platforms, including the web, mobile phones and/or on-site terminals;

• Pricing structures that incentivize short trips helping to maximize the number of trips per bicycle per day.

4.1.3 Case studies and good practices

Almetyevsk (Russia, Republic of Tatarstan):

133 The Bike-share Planning Guide, ITDP, https://www.itdp.org/wp-content/uploads/2014/07/ITDP_Bike_Share_Planning_Guide.pdf

In 2017, a bicycle rental system was put in place for citizens and visitors in the city of Almetyevsk. The spots where a bicycle can be picked up or dropped off are designated with special markings around the city. The service “Gobike” enables users to get to virtually any destination within the city at little expense as well as to keep statistical records of all renters by age, sex and cycling times.

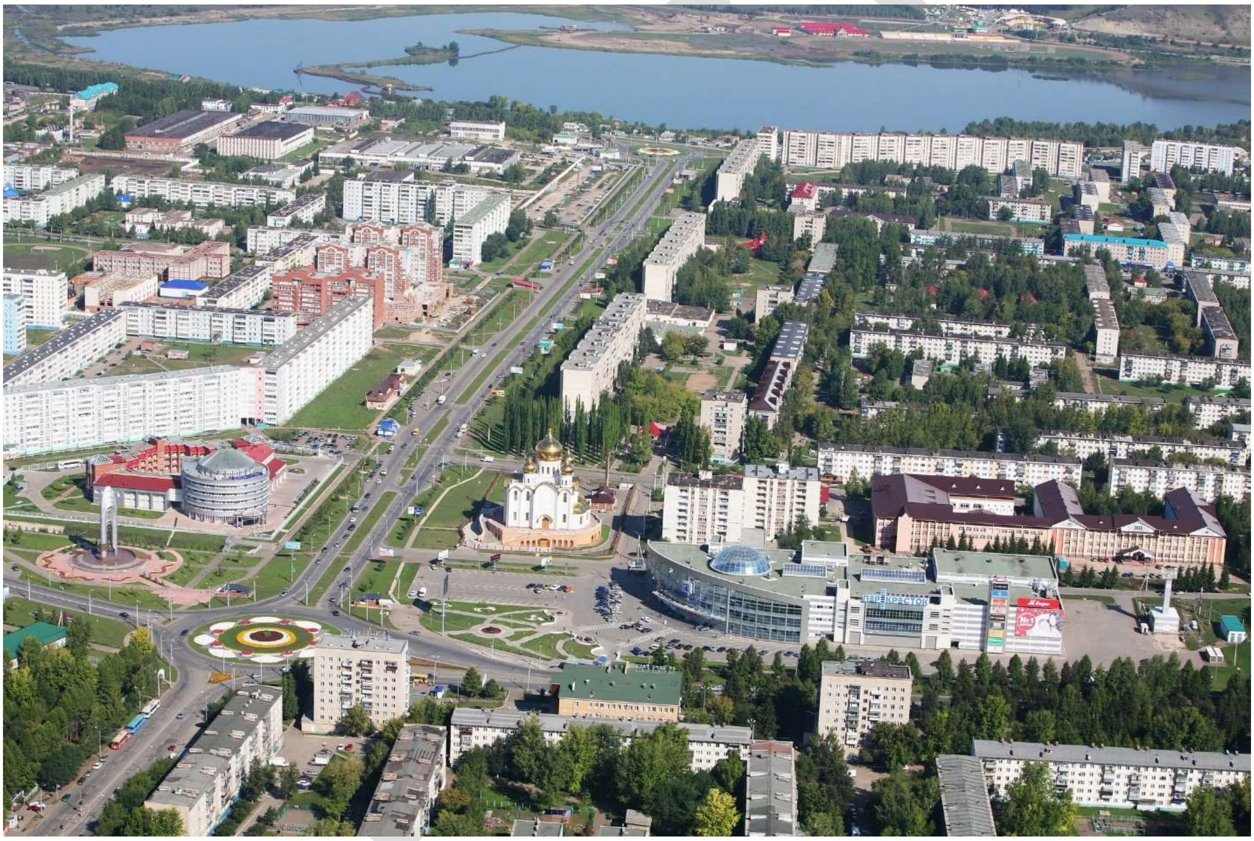
In addition, in 2017, the project “Gobike” introduced the service of dockless bicycle rental through a mobile application. A bicycle can be rented by a user installing the app on his or her smartphone. The cost of half an hour trip is 10 Russian rubles. To this end, 300 vandal-proof bicycles equipped with satellite navigation and smart solar-powered locks were purchased. An attempt to pick the lock sends an online signal to the control centre. Each bicycle is tracked by GPS for safety and security purposes.[134]

Figure 4.15. Project “Gobike” in Almetyevsk (Russia, Republic of Tatarstan)

Figure 4.16. Project “Gobike” in Almetyevsk (Russia, Republic of Tatarstan)

[134] Based on the answers given by Almetyevsk (Russia, the Republic of Tatarstan) to the UNECE questionnaire.

Fig. 4.17. Almetyevsk (Russia, Republic of Tatarstan)



4.2 Urban transport technologies and alternative measures reducing environmental impact

4.2.1 Electric and hybrid urban transport (electric cars, busses, trams, LRT lines)

The challenge of enhancing the energy efficiency of motor vehicles is part of the overall goal pursued by the world community to save energy resources, reduce environmental pollution and avert severe climate change. Setting aside emissions of harmful (pollutant) substances that have been well-regulated for a long time, it should be pointed out that according to the International Organization of Motor Vehicle Manufacturers, such emissions account only for not more than 1/5 of the emissions of so - called greenhouse gases contributing to global warming. However, this problem is of concern to the world community as the world vehicle fleet is growing rapidly and expected to double by 2050 as compared to the beginning of the century.

Figure 4.18. The Well-to-wheel GHG emissions in the RTS and 2DS scenarios of ETP 2017, 2015-2060[135]

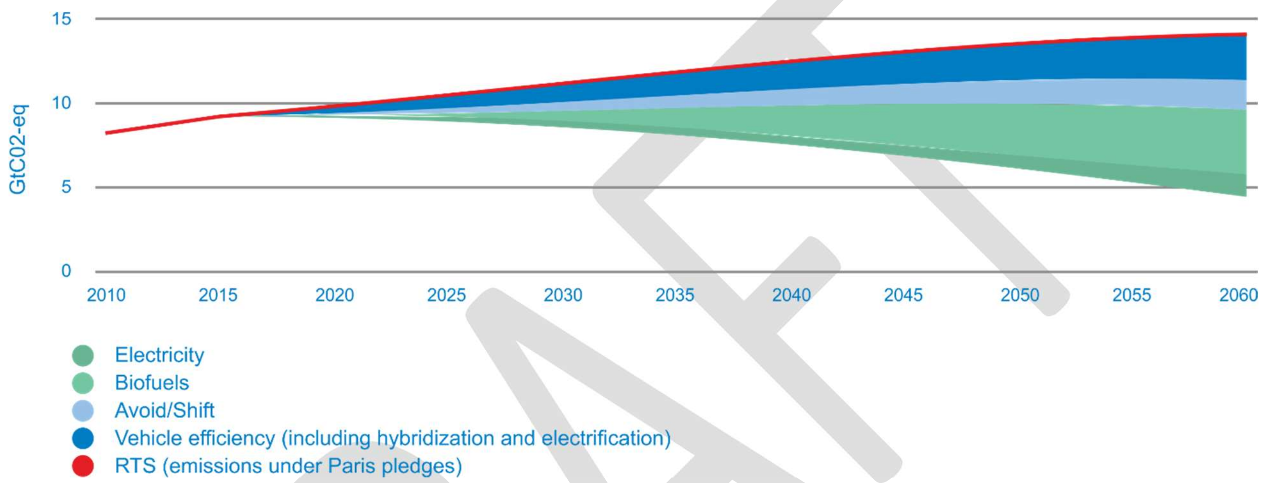


Figure 4.19. Specific mileage emission values for different vehicle groups[136]

[135] https://www.iea.org/topics/transport/, International Energy Agency

[136] http://docs.cntd.ru/document/1200113823, GOST R 56162-2014 Air pollution emissions. The method used to calculate vehicles emissions under summary computational modeling for urban settlements

Car group name	Group number	Emission of a pollutant, g/km						
		CO	Nox (calculated as N02)	CH	Soot	SO_2	Formaldehyde	Benz a pyrene
Passenger cars	I	3,5	0,9	0,8	0,7-10 -2	1,5-10 -2	3,2-10^{-2}	0,3-10 -6
Vans and minibuses up to 3.5 t	II	8,4	2,1	2,4	3,8-10 -2	2,8-10 -2	8,4-10^{-2}	0,8-10 -6
Trucks from 3.5 to 12 t	III	6,8	6,9	5,2	0,4	5,1-10 -2	2,2-10^{-2}	2,1-10 -6
Trucks over 12 t	IV	7,3	8,5	6,5	0,5	7,3-10 -2	2,5-10^{-2}	2,6-10 -6
Buses over 3.5 t	V	5,2	6,1	4,5	0,3	4,2-10 -2	1,8-10^{-2}	1,8-10 -6

Transport accounts for more than a 50% contribution to local and regional air pollution with more accurate proportions depending on both the pollutant and location.

The regional-level transport impact (from several hundred to several thousand kilometres) on the environment can be include:

- emissions of pollutants aggravating precipitation acidification and eutrophication of water bodies: sulfur dioxide SO2 and nitrogen dioxide NO2;
- environmental effects coming from extraction, processing and consumption of material and energy resources, both renewable and non - renewable;
- unintentional transport of living organisms with persons or goods in transit or in the structure components of vehicles leading to the introduction of these organisms into ecosystems not adapted to their existence.

The most obvious of transport impacts on the environment and human health is seen locally as all transport activities begin and end (and are carried out, in many cases) in places of residence and economic activity of people).

Most studies break down the life-cycle assessment of vehicles into four stages (Fig. 4.20).

Figure 4.20. Vehicle life cycle[137]

Main stages	Stage composition
Fuel production	Extraction and transportation of raw materials; construction of processing plants; fuel technological production process; fuel distribution; refuelling of vehicles.
Manufacture of vehicles	Extraction, transportation and processing of raw materials; processing of raw materials; construction of plants; production of components; transportation of components, assembly, distribution of vehicles, disposal/recycling/waste burial
Operation of vehicles	Mileage (specific) emissions taking into account operational features, age, etc.
Maintenance, repair and service of vehicles	Production of components; distribution; construction of infrastructure, maintenance.
Recycling / scrapping / burial of vehicles	Collection of vehicles out of service, disassembly, sorting of spare parts and materials, recycling/scrapping/burial of materials.

Energy generation techniques are important for life cycle assessments. Studies aimed at life cycle assessments usually draw on the concept of "generating mix". This concept implies the calculation of the share of different sources of electricity production (generation) (hydro, thermal, nuclear, wind, solar power plants, etc.) in the country for which the study is being conducted.

Life cycle assessment studies show that rail transport, including high - speed lines, and urban electric transport affect environment and public health to a considerably lesser degree.

The use of electricity in urban transport is an effective solution to the problems of emissions of pollutants and climate gases. While electricity is generated at thermal power plants, the discharged pollutants are captured and neutralized at a stationary emission source (a power plant pipe), which is incomparably more effective than combating the emissions from hundreds of thousands of mobile sources (cars).

The electric transport operated in cities includes:

- public rail electric transport (tram (LRT), metro, urban and suburban commuter trains);
- urban public non-rail electric transport (trolleybus, electric bus);
- other types of public electric transport (funicular, monorail, cable car);

[137] http://eco-madi.ru, Ecotransport: textbook / S.V. Shelmakov — M.: MADI, 2018. 199 p.

- electric vehicles and cars that run on hybrid propulsion systems;

- small electric mobility means (electric bicycle, electric scooter, gyroscooter, etc.).

Electric transport - tram (LRT), trolleybus, electric bus, metro, funicular monorail, cable car, string transport, urban and suburban commuter trains.

The modern world practice (for instance, the practice of the International Association of Public Transport) views the trolleybus as an electric type of bus while increasingly regarding the tram (light rail transport, LRT) as metro. The type of (electric) traction operated takes a backseat to the track structure, i.e. the extent to which the public transport line is segregated from the road traffic.

Public urban land electric transport that operates within a dedicated infrastructure serves to overcome the challenge of increasing the transport system capacity in cities with a minimum environmental burden as electric traction has the following significant advantages over internal combustion engines:

- zero emissions while en route and in embarkation areas;
- Relative silence (minimum noise level possible);
- no vibration in the cabin;
- higher energy efficiency;
- smooth acceleration and braking, no gearshift;
- maximum engine thrust at any speed;
- increased reliability of vehicles;
- no engines running at idle speed;
- low operation costs.

Surveys demonstrate that urban on-ground public electric transport is perceived by the population as more attractive when compared to traditional busses, especially when operated within a dedicated infrastructure while meeting high transport service quality standards. This leads to reduced use of privately owned vehicles as well as easing the burden on the street and road network.

Certainly, the development of the tram and trolleybus in no way implies that bus traffic in the world is dwindling on a large scale. In places with the passenger traffic less than 500 passengers per hours, building a trolleybus line is not economically viable, so the largest number of urban and agglomeration routes remain covered by busses.

Certainly, the development of the tram and trolleybus in no way implies that bus traffic in the world is dwindling on a large scale. In places with the passenger traffic less than 500 passengers per hours, building a trolleybus line is not economically viable, so the largest number of urban and agglomeration routes remain covered by busses.

With a passenger traffic from 500 to 1.000 — 1.500 passengers per hour, a trolleybus line becomes an optimum viable option. A higher passenger traffic calls for a tram line. If the passenger traffic is higher than 18.000 passengers per hour, the section of the tram line should have no crossings in the same level (a flyover or a tunnel)[138].

As compared to road transport, rail transport has the following benefits[139]:

- higher carrying capacity;
- reduced need for passenger transportation areas;
- less energy consumption (due to reduced friction in motion);
- less need for staff per passenger;
- lower operating costs (owing to less staff and energy consumption);
- no emissions from the wear of tires and pavement;
- no other vehicles on the dedicated line (owing to the railway-design track);
- higher traffic safety (less manoeuvres, no others vehicles on the road).

Rail urban land electric transport to the maximum extent meets the main requirement of public passenger transport, i.e. ensuring sustainable development of cities by decreasing environmental impacts and reducing the use of resources.

Kazan (Russia):

Pursuant to the principles of transport system sustainable development, the city of Kazan is contributing to the development of urban on-ground electric transport, including by creating a support tram network, maintaining and developing a trolleybus network, renewing the rolling stock of trolleybuses and trams.

The most common method used to ensure high reliability and speed in Kazan (as in many cities in the UNECE region) is to segregate routes of communication, including by physical isolation of tram tracks and introduction of dedicated lanes for road traffic. The introduction of priority public transport lanes in the main streets thereby establishing transport links between the residential areas and the city centre and the streets with access to external roadways[140].

Examples of urban on-ground electric transport operated in Russian cities are presented below (Fig. 4.21).

Fig. 4.21. Kazan (Russia)

[138] journal “Tekhnika zheleznykh dorog” (Railway Engineering), No. 4 (36), by S.S. Zakirova, V.A. Matrosova, E.V. Matveeva “The situation with urban electric transport in Russia”.
[139] http://mapget.ru/strategy/rol-get/
[140] Based on the answers given by Kazan (Russia) to the UNECE questionnaire.

Fig. 4.22. Kazan (Russia)

Fig. 4.23. Kazan (Russia)

Fig. 4.24. Volgograd (Russia)

Fig. 4.25. Volgograd (Russia)

Moscow (Russia):

The following approaches are included in transport projects that are being implemented in Moscow to ensure public transport priority passage:

- Segregation of tram tracks (road markings and signs, curb stone);
- reconfiguration of traffic lights (shorter duration of red lights for public transport);
- dedicated lanes for public transport;
- optimisation of dedicated lanes for public transport (reduction of gaps in the dedicated lanes, separation of dedicated lanes by “buffer” markings, creation of double dedicated lanes, physical isolation of dedicated lanes);
- other types of traffic management optimization[141].

Fig. 4.26. Moscow (Russia)

Fig. 4.27. Moscow (Russia)

[141] According to the response of Moscow (Russia) to the UNECE questionnaire.

Moscow (Russia):

Currently, a tram tracks overhaul program is under way in Moscow under which over 60 kilometers are expected to be replaced by 2020. The tram tracks, the surface cover, the contact network and the drainage system will be completely replaced in the course of the overhaul works.

More than 60 kilometres of tram tracks will be repaired until 2020. This will provide for higher roadside stops in some streets; the noise level of trams will be decreased.

The design of the facilities to be overhauled and tram tracks to be reconstructed mainly draws upon terrain geodetic plans at a scale of M 1:500 and refined geodetic surveys. In designing new tram lines in the area of existing urban development, as well as in emerging areas of the city, design works build on the project of the infrastructure lines layout that is executed in conformity with the Master Plan for Urban Development and Transport Systems[142].

Fig. 4.28. Moscow (Russia)

[142] According to the response of Moscow (Russia) to the UNECE questionnaire.

Fig. 4.29. Moscow (Russia)

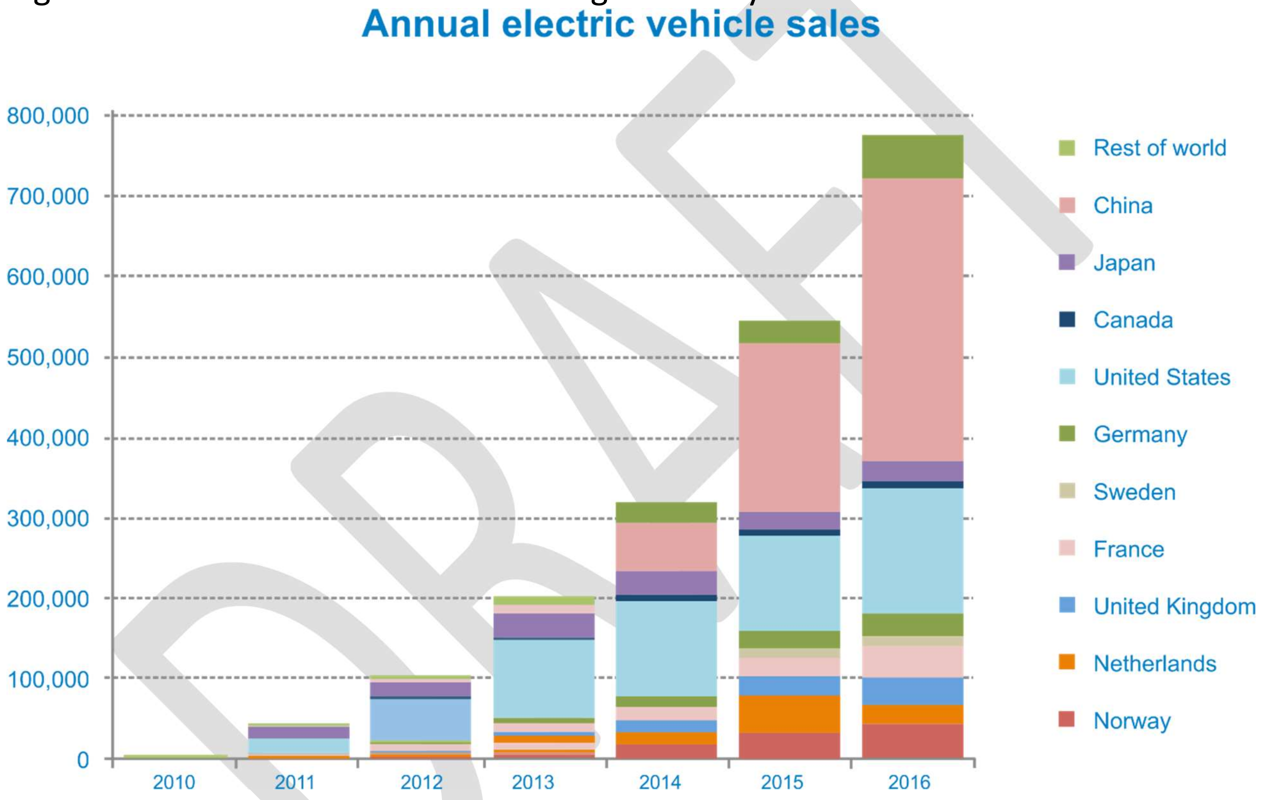
Fig. 4.30. St. Petersburg (Russia)

Fig. 4.31. St. Petersburg (Russia)

Another important area of development for e-mobility around the globe has been the growing demand for electric-drive cars, i.e. electric cars and “plug-in” hybrids.

According to EV-Volumes, the first half of 2016 marked the most successful period for this class of cars: Sales of global electric vehicles (of any type) mounted by a record 49% compared to the first half of 2015 whereas global sales of conventional cars saw an uptick of 5%, The growth of the passenger electric transport market was ahead of the traditional one by 10 times, and yet, its share still accounted for just 1% of the total car market[143].

Figure 4.32. Electric Vehicle Sales Rising Gradually[144]



European countries together with China and Japan are the ones setting the pace of development in this sector of automotive industry with these countries introducing government support programs showing no hesitation in to resorting to measures that may seem drastic. As an example, Germany, Norway and the Netherlands are planning to abandon vehicles with internal combustion engines at the national level. In Japan, charging stations have recently outnumbered petrol stations while China is taking the lead in sales of electric vehicles.

Due to considerable air pollution in major cities, the UK has resolved to completely abandon the sale of cars with gasoline and gas engines by 2040.

[143] http://www.forbes.ru/biznes/338511-elektromobili-budushchee-uzhe-zdes.

[144] Presentation by Michael P. Walsh, International Consultant, Founding Chairman Board of Directors, International Council on Clean Transportation, Moscow, Russia, May 19, 2017.

On the image side, things are rapidly changing for electric vehicles with an increasing number of brands, including major actors such as Mercedes, BMW and Ford designing concept cars and manufacturing battery-powered cars. Although the development of charging infrastructure may be a challenge in many cases, networks of charging stations keep advancing rapidly, covering not only cities but also non - urban road infrastructure.

If electric transport comes to be the main mode of transport, the amount of CO_2 in the atmosphere may see a sharp drop. According to Eurelectric, a European association, the electric car produces 66 g. of CO_2 per 1 km of mileage whereas a traditional car running on gasoline produces 124 g. This represents the key environmental aspect behind replacing traditional fuels with electricity. Secondary effects can be achieved through the development of non-carbon energy, including renewable energy in which case transport emissions would go down even further and greenhouse gas emissions coming from electricity production would be significantly lowered.

Expanding the use of electric vehicles offers a number of other benefits. In accordance with electric vehicles[145]:

1. Will create jobs economy wide - 200 thousand are estimated by 2030 as a result of the lower total costs of ownership;
2. That there are sufficient recharging points in western and northern Europe today for the early market & that just 5% of charging happens at public recharging points;
3. Are lower C02 today even when compared on a full life-cycle basis and even in countries with the least green electricity;
4. Battery cells will be manufactured in the EU and there are sufficient raw materials available;
5. Are affordable. With very modest tax breaks they are already cheaper on a total cost of ownership for the first owner. For second and third owners, there are substantial savings in running costs and maintenance.

A host of studies show electrification of cars creates jobs across the EU economy, contrary to recent remarks by the Commission officials, carmakers and some trade unions on "factory closures." The Commission's impact assessment shows 30% and 40% reduction targets increase the number of jobs in Europe and the greater the reduction the higher the number of net jobs created, 86-88,000 by 2030.

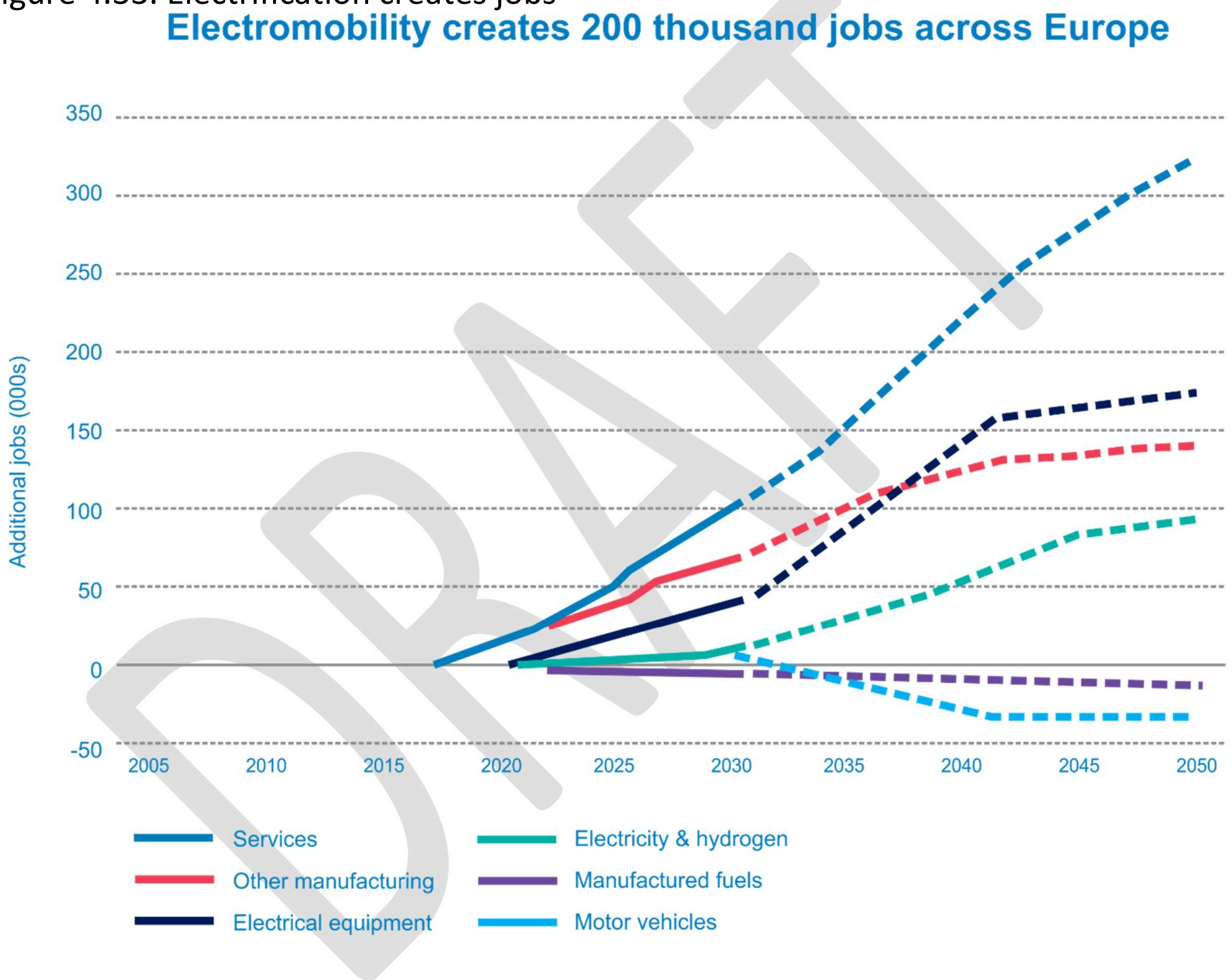
Other studies also show a net positive impact, such as the study by Cambridge Econometrics (endorsed by BMW, VW, Daimler, Renault-Nissan and Toyota) - that finds a shift to plug-in vehicles will create 206,000 net additional jobs in Europe by

[145] https://www.transportenvironment.org/what-we-do/cars-and-co2/publications, Transport & Environment, Brussels, Belgium, 2018.

2030, including in construction, electricity, hydrogen, services and most manufacturing sectors. This shows jobs in automotive manufacturing only declining after 2030.

The real risk to jobs is that in the future electric vehicles would be supplied from China and not built in the EU. In the last 12 months alone, EU carmakers invested 7 times more into electric vehicle production in China than in Europe, owing largely to the Chinese EV quota policy. Setting a 2025 C02 standard is urgently needed to accelerate investment and transition to e-mobility in Europe, which will secure industry longterm competitiveness and manufacturing jobs here.

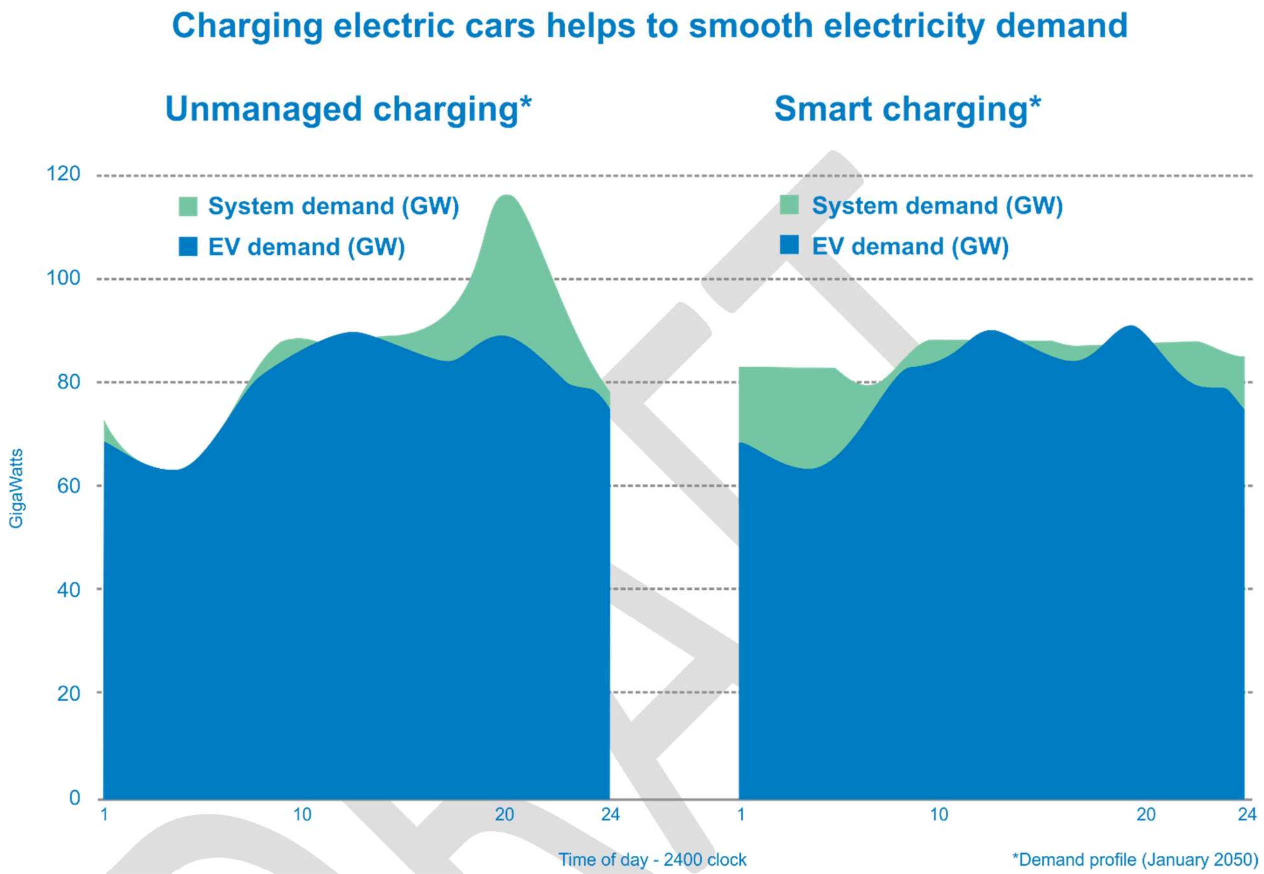
Figure 4.33. Electrification creates jobs



To 2020, there is enough EV chargers to the expected number of plug-in cars on EU roads according to the reports from member states. Around 1,000 ultra-fast (150-350 kW) charging sites are already planned for 2020, or one site every 34 km on the strategic EU road network allowing drivers to replenish up to 400 km driving in 15 minutes. By 2020 there will be nearly 5000 medium-fast chargers and 220.000 regular chargers across Europe. More than 90% of new EV sales are in Northern and Western European countries where 80% of planned public charging points will be concentrated.

Fears that charging of EVs will cause widespread blackouts are scaremongering. A recent study by McKinsev shows that the expected ramp up of electric vehicles by 2030 will not cause significant increases in power demand.

Figure 4.34. Impacts on the electricity grid are manageable

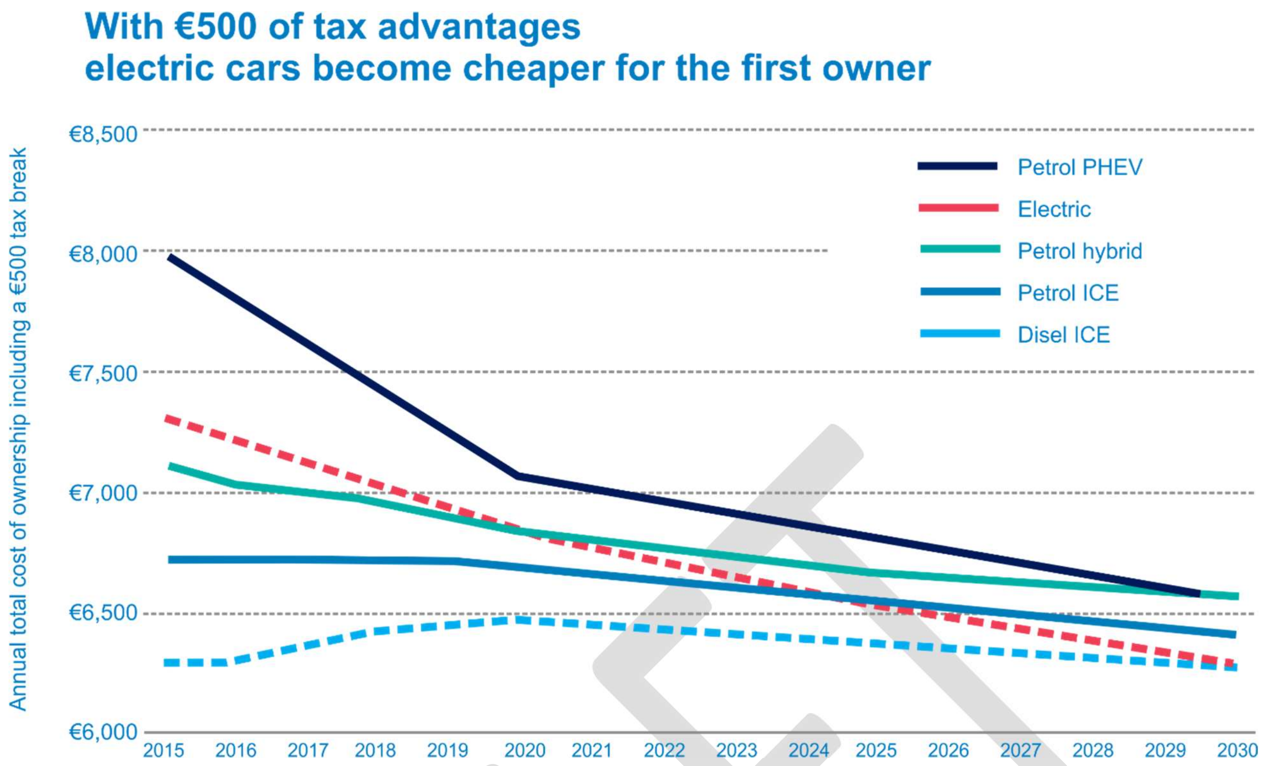


While purchase prices for most EV models remain higher than comparable diesel and petrol cars, the total costs of ownership (TCO) are lower taking into account how much it costs to fuel, maintain and insure the car. A study by the EU Consumer Organisation (BEUC) shows that by 2024 the average 4-year cost of running an electric vehicle will match that of a petrol car, and a diesel one by 2030 with tax breaks of just €500 per year.

More recent studies are even more positive, with EVs already cheaper to own and run in the UK, Japan and US markets with current incentives. For the second and third owners EVJs are substantially cheaper with much lower operating and maintenance costs.

The rapid decline in battery prices and technology is continuing with cell prices expected to drop further. The price of lithium-ion batteries is dropping rapidly and is expected to drop by another third by 2025, making EVs competitive on purchase price by 2025.

Figure 4.35. Electric cars have lower total costs of ownership



While electric cars have zero tailpipe (or tank-to-wheel) emissions, there are upstream emissions from manufacturing the battery and from electricity generation But analyses of full life cycle CQ2 consistently show on average battery electric vehicles emit less C02 over their lifetime than diesel cars. A meta-analysis of 11 independent LCA studies done in recent years concludes that a battery electric car over its lifetime produces 50% less C02 emissions than an average EU car today.

In Europe, when the latest grid intensity figures are taken, even a EV charged on Polish electricity produces 25% less C02 than a diesel car. As the EU power sector decarbonises the benefit over oil becomes ever greater.

Battery cell manufacturing today is largely in China and South Korea but as the market expands so does production into Europe, where the electricity is less carbon intensive reducing emissions by 65%. At least 5 gigafactories are already planned by early 2020s addressing the environmental concerns of cell manufacturing and creating jobs.

EV technology (i.e. plug-in hybrid and battery EVs) presents a promising option for technological advancement in urban travel, offering the potential for efficiency improvements of up to 100% relative to ICE vehicles. Direct-charging electric battery vehicles, in particular, present the most attractive option long term, even compared to other zero-emission technologies. The well-to-wheel (WTW) energy efficiency of direct-charging battery EVs is 73%, versus 22% and 13% for hydrogen fuel cell and power to liquid vehicles, respectively. Electric vehicles will also be increasingly attractive from a financial point of view, given that the price of electricity is expected to fall as new solar and wind energy sources become operational. Continued technological advancements are also reducing the price of EV batteries and increasing their range, both of which increase their appeal among potential buyers. Despite these favourable trends, public policies will need to be put in place in order to accelerate the adoption of EVs.

The way in which EVs complement other sustainability measures should also be taken into account when designing new technologies and solutions. EVs can, for example, contribute to the development of the smart grid by charging during off-peak hours, providing back-up power to the grid, and facilitating the incorporation of clean energy charging stations into grids and buildings. The former strategy would reduce ownership costs for consumers, and the latter could include, for example, battery leasing schemes and OEM activities that would be profitable for businesses. Innovative solutions for advancing e-mobility will notably involve a wide range of stakeholders, including new technological actors, mobility operators, cities and public authorities, infrastructure developers, city planners, electricity utilities, after-sales and end-of-life actors, as well as NGOs. Ongoing issues that will need to be addressed in the continued development and rollout of EVs include designing battery leasing operations, reducing the lifecycle emissions of new e-mobility technologies (e.g. EV batteries), automating e-mobility options, and adapting EV designs for shared use146.

Electric buses arrive on time147. Urban buses are the first transport mode where electrification is having a significant impact today. This trend is driven primarily by the rising awareness of toxic air pollution in our cities from internal combustion engines and supported by the compelling economic, comfort, and noise advantages. We expect urban buses to be the first transport mode to reach zero emission thanks to electrification.

Fig. 4.36. St. Petersburg (Russia)

[146]https://www.itf-oecd.org/sites/default/files/docs/policy-priorities-decarbonising-urban-passenger-transport_0.pdf, POLICY PRIORITIES FOR DECARBONISING URBAN PASSENGER TRANSPORT © OECD/ITF 2018

[147] https://www.transportenvironment.org/publications/electric-buses-arrive-time, Transport & Environment, Brussels, Belgium, 2018.

Moscow (Russia):

The Moscow transport system is working to improve the network of urban on-ground passenger transport routes with a view to enhance the mobility of citizens, relieve road network congestion and improve the environmental situation in the city. To that end, from 2021 onwards the plan is to purchase solely electric buses for public transport routes, retrofit the bus fleets and other infrastructure of transport facilities to accommodate electric buses and to establish a network of charging stations for electric buses.

A number of advantages that operating electric buses brings around as compared to the other types of public transport are worthy of mention, such as: maneuverability, environmental friendliness, noise-free operation, ease of use, no consumption of hydrocarbon fuels and no need for periodic upgrading (reconstruction) of the overhead system, possibility of energy recovery, etc.

Electric busses in Moscow are fitted up with the most advanced equipment, including climate control systems, video surveillance and satellite navigation, USB connectors for charging mobile devices and access to Wi-Fi[148].

Fig. 4.37. Moscow (Russia)

[148] According to the response of Moscow (Russia) to the UNECE questionnaire.

Fig. 4.38. Moscow (Russia)

The impressive deployment of electric buses in China has been the center of much attention, but what is the situation in Europe? Are electric buses ready for mass deployment or will the Old Continent by lagging behind? This paper examines the trend, the economics and challenges to conclude that electric bus market is on the verge of a tipping point in Europe.

The European market is quickly ramping up. In 2017, the number of electric bus orders more than doubled (from 400 in 2016 to more than 1,000); the next years are projected to follow the same tendency as manufacturers scale up production and their offerings. In 2018, the market share is estimated to be around 9%, marking the transition from niche to mainstream and the beginning of a steep and necessary uptake curve.

Diesel buses are a heavy cost on society and the climate through air pollution, noise and greenhouse gas (GHG) emissions. Electric buses already offer a better total cost of ownership (TCO) than diesel buses when these external costs are included. When only health costs are considered (air quality and noise), electric buses are roughly on parity with diesel buses.

Electric buses offer many additional benefits compared to their fossil counterparts. They have superior image and comfort, avoid stranded assets from investing in gas infrastructure, use locally produced (renewable) energy and ensure energy sovereignty by displacing oil consumption. The bottom line is clear, the earlier cities transition to a zero-emission bus fleet, the better. To expedite this transition, cities, procurement authority and public transport operators need to:

- Embrace the future and start to procure electric buses en masse to replace their aging and polluting fleets and to live up to some of the century's biggest challenges.
- Communicate to manufacturers urging them to ramp up scale of production which in turn would reduce prices.
- Have a TCO-focused approach by shifting from upfront payments to lease or loan payments aligned with the durability of the asset to cover full lifetime over a long period of time.
- Include external costs in the tendering process when comparing different options.
- Seek and encourage new financing mechanisms from traditional funding institutions.

Insofar as for freight vehicles are concerned, of particular interest is an example of the electric motor train designed in Sweden that is powered by the overhead system (Fig. 4.39).

Figure 4.39. Traffic of electric road-trains along the experimental track (VOLVO, Sweden, 2016)

In early 2017, there were about 12.000 cars with hybrid engines registered in Russia (about 30% being “plug-in” ones) and 920 electric vehicles; 339 of them registered in Moscow and Moscow region. One of the key challenges is the lack of charging infrastructure (in the first instance, fast charging stations within 15 - 60 minute-drive distance). In 2017, there were around 100 such stations in Russia. By the end of 2018, an additional 129 such stations will be deployed in Moscow alone (for the moment, the figure stands at about 40). In the near future, It is planned to put in place 2.000 charging stations across the nation (Moscow, St. Petersburg, Krasnodar, Samara, Kaluga).

Figure 4.40. Kalina-Ellada, a Russian-made electric car

Figure 4.41. KAMAZ-2257E, a Russian electric bus.

The following measures should be mentioned among those aimed at promoting the development of environmentally friendly transport in the Republic of Belarus:

- electric vehicles are exempt of the state fee for issuing a permit to gain access to road traffic;
- battery charging devices imported by legal entities or individual entrepreneurs into the Republic of Belarus are free from the value-added tax collected by customs (when imported from a member of the Eurasian Economic Union).

In 2018, the programme to create a state charging network for electric vehicles was approved. It was adopted for the purpose of creating a nationwide extensive network of charging stations for electric vehicles that would ensure comfortable and unimpeded traffic of electric vehicles in the Republic of Belarus as well as compliance with global standards. The programme also envisages:

- deployment of 1.304 EV charging stations by 2030;
- installation of 25 super-fast EV electric charging units in the cities under regional subordination (in Minsk and along the main highways with a distance between the two nearest stations of 120 - 150 kilometres);

The programme is planned to be implemented in 3 stages:

- by 2021, 431 charging stations will be deployed in Minsk and priority locations in regional centres and along roads of categories “M” and “M/E”;
- by 2022 – 2025, it is planned to increase the number of charging stations up to 10.000 contingent on the further growth in the number of electric vehicles in Belarus;

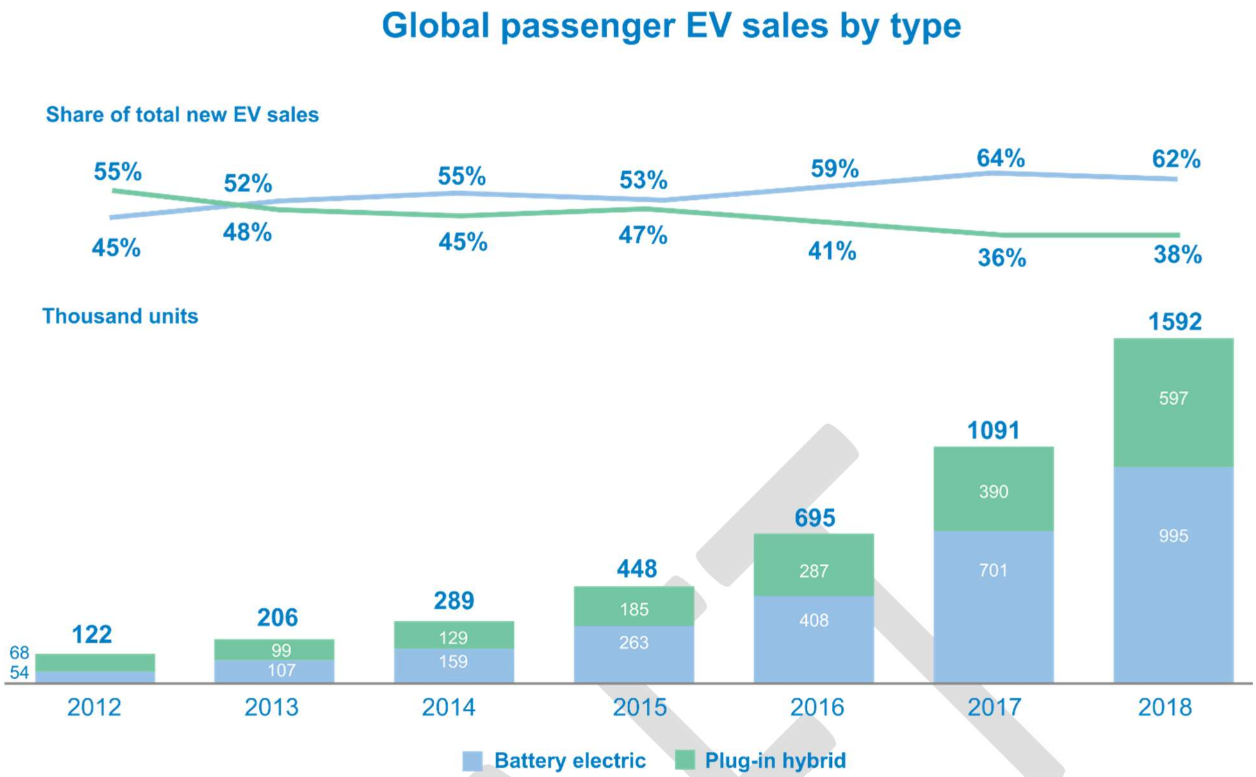
- by 2026 - 2030, up to 25.000 contingent on the further growth in the number of electric vehicles[149].

Figure 4.42. A charging station and electric vehicle in the Republic of Belarus

A new study undertaken by the International Energy Agency Global Electric Vehicles Outlook150 on the development of electric transport suggests that the number of electric vehicles and electric-drive hybrid vehicles had passed the 3.000.000 mark by the end of 2017. In the course of the year 2017, the number of these vehicles went up by 56% compared to 2016. IEA experts believe that state support coupled with lower battery production costs are the key reasons behind the record-breaking spike in the number of electric vehicles. The factors of further growth for the global fleet of electric vehicles are: development of EV charging infrastructure, ramping up the manufacture of batteries and stable supply of materials needed for their production.

Figure 4.43. Global passenger EV sales by type[151]

[149] Based on the answers given by the Republic of Belarus to the UNECE questionnaire.
[150] https://webstore.iea.org/global-ev-outlook-2018, Global EV Outlook 2018, International Energy Agency, France, 2018.
[151] https://bnef.turtl.co/story/evo2018?teaser=true, High-level findings of the Electric Vehicle Outlook 2018 are available in a free public report, Bloomberg the Company & Its Products, Bloomberg New Energy Finance.



China is the leading market for EV sales: in 2017, 580.000 electric vehicles were sold in China which accounts for about half of the EV's sold around the world. Sales grew by 72% as compared to 2016. The United States has come in second with 280.000 in 2017 (up from 160.000 in 2016).

Northern Europe is another hub for electric transport development. The share of electric cars last year accounted for 39% of new cars sold in Norway, making the country the world leader in the market of electric cars according to this measure. Electric cars accounted for 12% of all car sales in Iceland, and 6% in Sweden.

Among the developed countries Germany and Japan are also worthy of mention; both witnessing a significant uptick in the EV fleet: sales in both countries more than doubled last year compared to 2016.

But the gain in electric transport sales is not limited to cars. Sales of electric buses rose up to 370.000 in 2017 from 345.000 in 2016, while the number of electric two-wheeled vehicles reached the 250.000.000 mark. China accounts for more than 99% of mobile vehicles in these two segments. However, European countries and India have also demonstrated an increase in the fleet of electric buses and electric-drive two-wheeled vehicles.

According to IEA, the EV charging infrastructure is expanding rapidly: the number of EV charging points has increased to 3.000.000 all over the world, of which about 430.000 units are publicly available, and about a quarter are equipped with fast chargers.

In the last few years, cities in most countries have experienced a rapid growth in the use of "small" electromobility vehicles such as electric scooters, electric bicycles, segways, gyroscooters, etc . Fig. 4.44. presents some of the most common types of "small" electromobility vehicles and their applications.

Figure 4.44. "Small" E-Mobility vehicles

Type of vehicle	Definition	Use	Notes
Electric bicycle (e-bike, pedelec) 	A bicycle equipped with an electric drive that partially or completely propels it	Same as a regular bicycle. Requires no driving licence or license-plate number. May be operated by people of different ages and health status	Range: 25 - 50 km (rarely up to 100 km). Weight: 20 - 50 kg. Maximum speed: generally, up to 50 - 60 km/h
Segway 	Electric self-balancing vehicle equipped with 2 wheels on both sides of the driver	Can move on asphalt and soil. Used by police, postal workers. Fairly fast and maneuverable	Fairly expensive. Weight: approx. 40 kg. Mileage: up to 39 km Maximum speed: up to 50 km/h
Gyroscooter 	Self-balancing scooter, private electric vehicle. Different from the segway in that it has no steering column	banned from use on roads and sidewalks in a number of countries	Possible injuries in the event of a fall

Monowheel (unicycle) 	Electric self-balancing scooter with a single wheel and two stands.	Used as daily urban transport and for walking in a number of countries (China). Banned from use on roads in some countries. A unicycle rider is considered as a pedestrian In the Russian Federation	Weight: 8.5-22 kg Speed: 10 to 35 km/h Travel range: 10 to 130 km Riding requires protective equipment. Powerful monowheels are the safest
TWIKE 	Human-electric hybrid vehicle. Three-wheeled electric vehicle with an additional pedal drive. Sometimes viewed as a light electric vehicle.	Operated on the road	Speed: up to 85 km/h Range: up to 150 km/h (without pedalling) Weight: approx. 250 kg
Tricyclopod 	Three-wheeled motorised (usually electric) vehicle operated by one person in a standing position	Designed for short local trips on flat urban roads and sidewalks, shopping, police officers on patrol	Speed: 25-40 km/h

4.2.2 Case studies and good practices

Almetyevsk (Russia, Republic of Tatarstan):

The municipal district of Almetyevsk entered into a pilot project in order to expand the network of vehicle gas filling stations across the Republic of Tatarstan within the state programme “Development of the Gas Motor Fuel in the Republic of Tatarstan in 2013-2023”. In addition, this municipal district is an active participant in the federal programme for renewal of rolling stock by busses and special equipment which run on gas fuel. The biggest carrier in Almetyevsk is an active participant in the federal programme aimed at subsidizing the purchase of busses running on gas fuel (Nefaz, PAZ and Gazelle Next). One of the criteria for rolling stock selection is the environmental qualities of vehicles.

The resultant reduction in fuel costs is 2,5 times; the decrease in harmful emissions discharged into the atmosphere - 2-5 times.[152]

Figure 4.45. Busses running on gas fuels in Almetyevsk (Russia, Republic of Tatarstan)

Basel (Switzerland):

The development of the Tram Network in Basel (Switzerland) has reached a new dynamics, after many years of no significant changes. In order to encourage modal shift from cars to public transport and to optimally connect new residential areas to public transport, the Tram Network should be completed by prolonging some of the existing lines and closing the network gaps with new tram network segments. Both cantons Basel-Stadt und Basel-Landschaft agreed in 2012 with the study commission Tram Network Region Basel 2020 (shortly TN 2020) to develop a common strategic tram network planning. The study commission TN2020 should clarify which additional tram infrastructure elements – and in which temporal sequence – should be built in

[152] Based on the answers given by Almetyevsk (Russia, the Republic of Tatarstan) to the UNECE questionnaire.

the region of Basel. Action goals relevant from an urbanistic perspective, included in the study commission are:

1. Attractive public transport supply for passengers. The public transport share should be increased by ensuring the accessibility of important residential- and workplace areas through fast, frequent comfortable connections.

2. Consideration of ecology and city image. Interventions in the city- and landscape image, as well as noise pollution should lie within acceptable limits.

3. Optimal implementation of plans. The realization must be done in stages and without operation losses. Moreover, the network should have potential for expansion.

Various boundary conditions have changed since 2012. The most prominent change is the dynamic urban development in Basel. Based on an efficiency analysis and on the inclusion of planned site development, new tram projects and prioritizations have emerged. The overall traffic model of Region Basel (GVM) serves as a central guideline for efficiency analysis.

A good example is Tram Klybeck. The tram serves as a development motor in the city planning. A new neighborhood with around 5'000 workplaces was developed on the former working site Klybeck. Additionally, 10'000 people will live there in the future. The neighborhood needs a connection to the tram network, which was taken into account by the former urban planning projects[153].

www.klybeckplus.ch

Finland:

According to the National Energy and Climate strategy of Finland, the physical share of biofuel energy content in all fuels sold for road transport will be increased to 30 per cent by 2030. Finland's target for vehicles using alternative fuels is that all new vehicles sold in Finland are compatible with alternative fuels already in 2030. Vehicles that can be powered by either electricity, hydrogen, natural gas/biogas and/or liquid biofuels, also in high concentrations, will be included in the target. The target for 2025

[153] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.

is that 50% of new cars and vans could be powered by an alternative fuel, and the goal for 2020 is a 20% share of these vehicles. The target set for heavy-duty vehicles is that 60% of new trucks and buses would be compatible with an alternative fuel by 2025, with a 40% share already in 2020.

In addition, the Ministry of transport and communications has prepared a programme for promoting walking and cycling. The programme seeks to enhance the requirements necessary for walking and cycling in Finland's municipalities, support the reduction of greenhouse gas emissions in traffic and promote public health. We have set as a target that the number of journeys made by foot and by bicycle will increase by 30 % by 2030[154].

Tyumen (Russia):

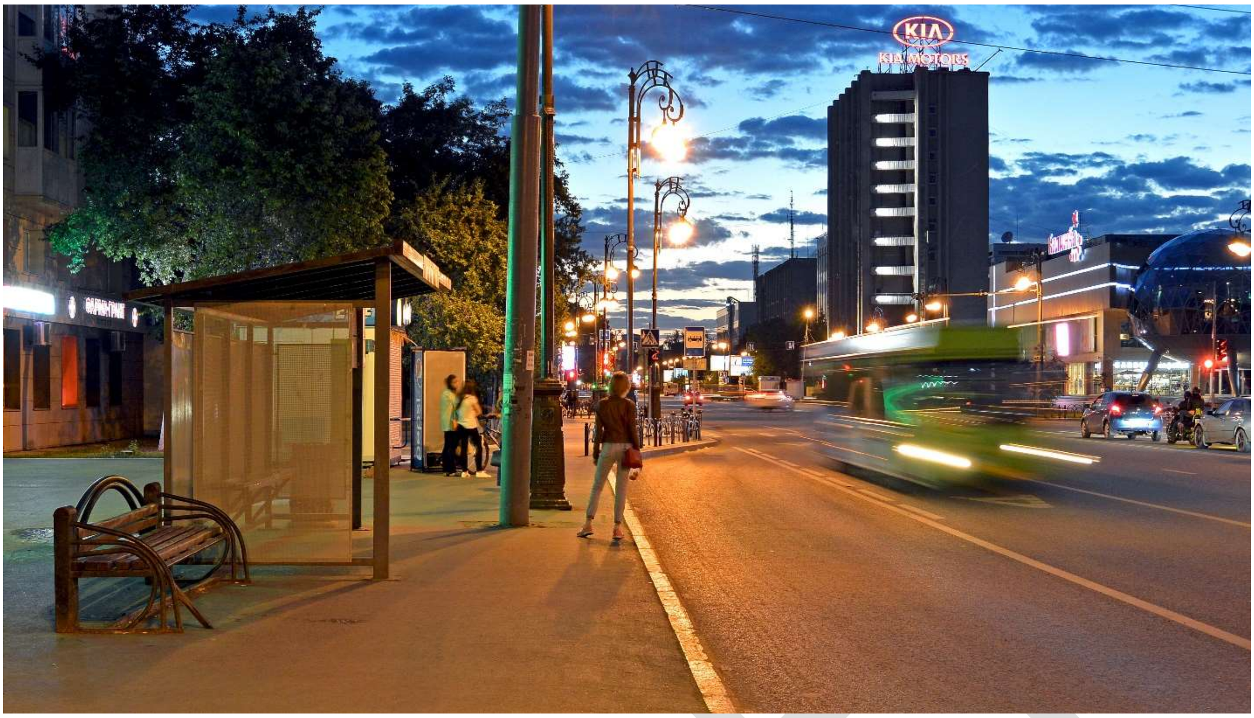
Tyumen operates a system of dedicated lanes on roads in order to ensure high reliability and speed of public passenger transport.

Lanes designated for route transport vehicles have proved to be an effective way in ensuring stable operation of urban public transport thanks to increased regularity and operational speed by 12- 15% and bus travel time reduced by more than 10% on the same road section.

In order to calculate the feasibility of dedicated lanes for public transport in Tyumen, the criterion for selecting road sections is the availability of three-lane traffic in one direction, the intensity of public transport higher than 40 units per hour, the absence of numerous entry and exit points to the surrounding areas. Sections of dedicated lanes for route vehicles on individual streets are envisaged in road traffic management projects following the respective decisions taken by the Urban and Territorial Commissions on Road Safety under the Administration of the city of Tyumen. Consequently, 22 km of dedicated lanes for route vehicles have been put in place in Tyumen, including on the following road sections[155].

Fig. 4.46. Tyumen (Russia)

[154] According to Finland's response to the UNECE questionnaire.
[155] Based on the answers given by Tyumen (Russia) to the UNECE questionnaire.



Tyumen (Russia):

Charging infrastructure for electric vehicles is being developed in the city of Tyumen to promote environmentally friendly transport. These activities are being implemented by utility providers within their own financial and business operations.

It is important to point out that regular passenger transportation on visitor route No.10 (Aviaexpress) that connects the major transport hubs i.e. the Roshchino Airport, the Railway Station and the Bus Terminal is carried out by one electric bus. The costs borne by the carrier purchasing the electric bus are reimbursed through subsidies from the Tyumen city budget[156].

Fig. 4.47. Tyumen (Russia)

[156] Based on the answers given by Tyumen (Russia) to the UNECE questionnaire.

Fig. 4.48. Tyumen (Russia)

Chapter 5: Urban transport systems, health and quality of life

5.1 Interlinkages between urban transport and health
5.1.1 Time spent in transport ~~(incl. walking times to and waiting times at stations/ bus stops,~~ VVTS, etc.)
5.1.2 Pollution and physical health
5.1.3 Traffic accidents
5.1.4 Stress, noise and mental well-being
5.1.5 Case studies and good practices
5.2 The concept of active mobility and its health dimension
5.2.1 Case studies and good practices
5.3 Urban mobility needs of vulnerable groups (incl. women, children, elderly and disabled persons)
5.3.1 Case studies and good practices

5.1 Interlinkages between urban transport and health

5.1.1 Time spent in transport

In the urban passenger transport system, the key participant is the passenger, whose activity is determined by a variety of strategies and alternatives (different ways and routes that can be chosen) as well as the target function (minimization of the losses associated with movement).

With higher demand for efficient urban mobility, urban dwellers tend to choose between urban public transport and private cars; that choice of passengers being determined by the money and time spent on the trip and the ease of movement.

The probabilistic nature of the duration of the trip (unreliability of the trip) is to some extent intrinsic in all modes of transport, but it is of the utmost significance in relation to urban passenger transport.

Improved reliability of public transport connections is often achieved by tighter control over timetables, effective traffic and operational management, providing online information to passengers at stations and by means of apps in relation to public transport expected time of arrival (departure), route number and actual time of arrival of the next vehicle, automated monitoring and control of the operations of the transport system through integrating terminals, stations, transport companies and vehicles within a single information space.

Moscow, in concluding gross transport contract, has a zero tolerance for "ahead-of-schedule" practices (through departure before the scheduled time) with a permissible delay of 2 minutes maximum.

In the Republic of Belarus, regular-traffic urban and suburban passenger transportation vehicles are allowed to arrive at a station not later than 5 minutes relative to the time on the schedule; long-distance road passenger transportation vehicles - not later than 10 minutes relative to the time on the schedule[157].

Reduced travel time is achieved by transport planning and demand management techniques. It should be noted that the target is not to reduce the time, but to increase the correspondence speed within the transport system (taking into account arrival at the place of embarkation, waiting time, trip, transfers). Citizens determine for themselves the time that they are willing to spend on transport; with improved transport opportunities, many prefer not to reduce the time in travel, but to enlarge the radius in which to find jobs and for other visiting purposes which is made possible by expanding the area achievable within an acceptable travel time (up to 1.5-2 hours). The objective target, determined exclusively by the actions of the planner (regardless of the choice of citizens) is not the time which citizens spend on travel, but the speed of transport correspondence ensured by the transport system.

Increased transport correspondence is achieved by solving the following transport planning tasks:

1. Improving the reliability of correspondence, i.e. achieving the same travel time regardless of congestion and other accidental circumstances, which makes providing for a “cushion of time” in trip-planning unnecessary;
2. Reduced waiting time, including at interchange stations.
3. Reduction of distances at interchange stations;
4. Increased speed of traffic;
5. Reduced on-foot door-to-vehicle; distances;

The reduction of waiting time for public transport is mainly achieved by dividing routes into trunk routes (operating throughout the day at intervals of up to 10 minutes on main connections with the highest passenger traffic) and others. This makes it possible to keep most passengers waiting for public transport no more than 10 minutes. For passengers taking other routes, waiting time is decreased through by arranging timed traffic throughout the day (with intervals being a multiple of 60 — for example, 12, 15, 20 minutes) so that passengers can easily commit to memory the schedule and show up by the time the bus arrives.

Shorter distances at interchange stations are ensured through careful planning of interchange junctions aimed at reducing each extra metre of walking distance, replacing stairs with mechanized ascending and descending means. Transfers between motor vehicles and public transport are possible through planning for Park & Ride parking lots where parking levels are located directly above the station.

Reduced door-to-vehicle walking distance is achieved by the introduction of transport service standards that limit the walking distance from buildings to stations and (if applicable) parking lots.

[157] Based on the answers given by the Republic of Belarus to the UNECE questionnaire.

Mainly with public transport, increased speed can be achieved effectively thanks to dedicated lanes with priority passage. As will be shown below, increased speed of private vehicles generally leads to a rise in traffic accidents.

Reliable transportation is ensured by balancing capacity and the number of crews passing per unit of time (demand). With private vehicles, including cycling modes of transport, reliability (i.e. the balance of demand and supply capacity) can be achieved chiefly by demand management methods — price demand management (paid parking, paid travel through congested road areas) with a quality alternative ensured represented by public transport.

The distribution of street space between modes of transport is determined by the carrying capacity, i.e. the number of passengers that a system can handle per one available lane. The carrying capacity of a 3.5 m wide strip for buses and bicycles is approximately the same — about 4.000 consumers per hour, which is about 4 times higher than the carrying capacity of motor vehicles (about 1.000 — 1.200 passengers per hour). Rail transport has the highest carrying capacity of all: with intersections in one level, it is able to handle up to 12.000 consumers per hour, without intersections — up to 50.000 per hour. Accordingly, when there is a lack of capacity, space is first allocated for rail transport, then for pedestrians, non-rail public transport and cycling transport with the rest distributed for private motor vehicles; with a lack of capacity (for motor vehicles), the fee for travel through the road section is upped but an alternative represented by transport with maximum carrying capacity is offered (rail transport, in its absence - road public transport as the most universal kind, and also cycling as an addition to public transport).

Reliability is best achieved for public transport, where the number of crews (demand) is determined by the scheduled and can be calculated accurately from the capacity of the infrastructure. Under gross contracts (the carrier is paid by the city for on-schedule mileage regardless of the number of passengers carried with penalties for violation of the schedule), it is in the interest of the carrier to adhere to the schedule (supervised by the navigational transport marks); no “chasing” passengers and higher ticket revenues. In this case, the planner calculates the maximum number of public transport crews that the system can handle without delay, and plans the route network in such a way so as to have the number of crews per hour at every section corresponding to the capacity of stations and crossroads.

Higher capacity of public transport infrastructure is achieved through:

- separation of tram tracks and providing dedicated lanes for road transport to exclude the influence of traffic factors and road accidents;

- creation of priority passage systems at crossroads (adaptive traffic light cycles) to mitigate the factor of a transport vehicle arriving at the wrong phase of the traffic light cycle by accident;

- providing a convenient environment for passenger embarkation and disembarkation (construction of elevated platforms up to 30 cm, a higher number of doors) to reduce the likelihood of delays during embarkation;

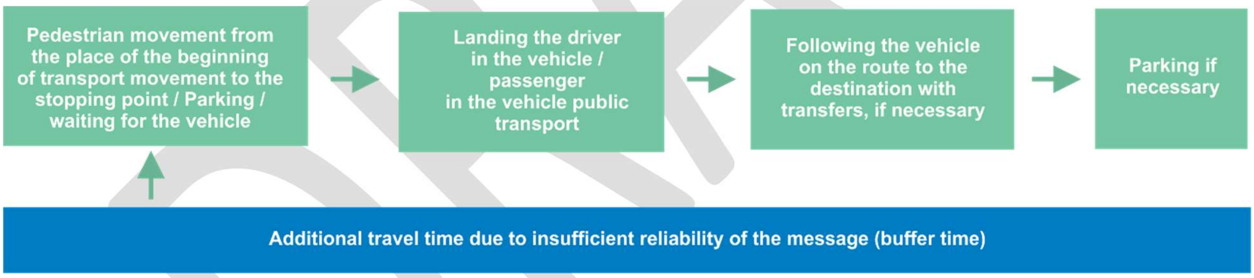
- ensuring that the activities of carries are financially sound to provide for timely repairs and to avoid breakdowns of vehicles and tracks.

Travel-time variability translates into significant personal extra costs of time and money for passengers. In consequence, faster and more reliable urban transport connections save passengers' time so that the time saved can be put to more efficient use.

Cost estimation of the time spent by drivers/passengers on transport travel is needed to determine the effectiveness of projects for the development of transport systems and improvement of road traffic management by comparing the costs of these projects with the achieved social result in an equivalent value form.

Estimates show that the free time of a working person is approximately 7 hours a day with about 8 hours a day accounting for work, 9 hours spent on sleep and personal needs. If a person spends 1.5 hours a day on trips on a daily basis, then transportation “strips” him or her of 20% of free time. With a growing urban population, the daily time in travel rises reaching 2 hours or more in large cities.

Figure 5.1. Total time spent on travel



In this case, the buffer time represents the additional (absolute and specific) time expenditures on the trip due to transport connections lacking in reliability. Buffer time (T_b) is estimated as time expenditures required to achieve the goal of the travel with a given reliability, such as 90% or 95% reliability (Fig. 5.1). Accordingly, *Tb* is defined as the difference of:

$$T_b = T_{90\%(95\%)} - \overline{T},$$

$T_{90\%\,(95\%)}$ – time in travel 90% or 95% of availability;

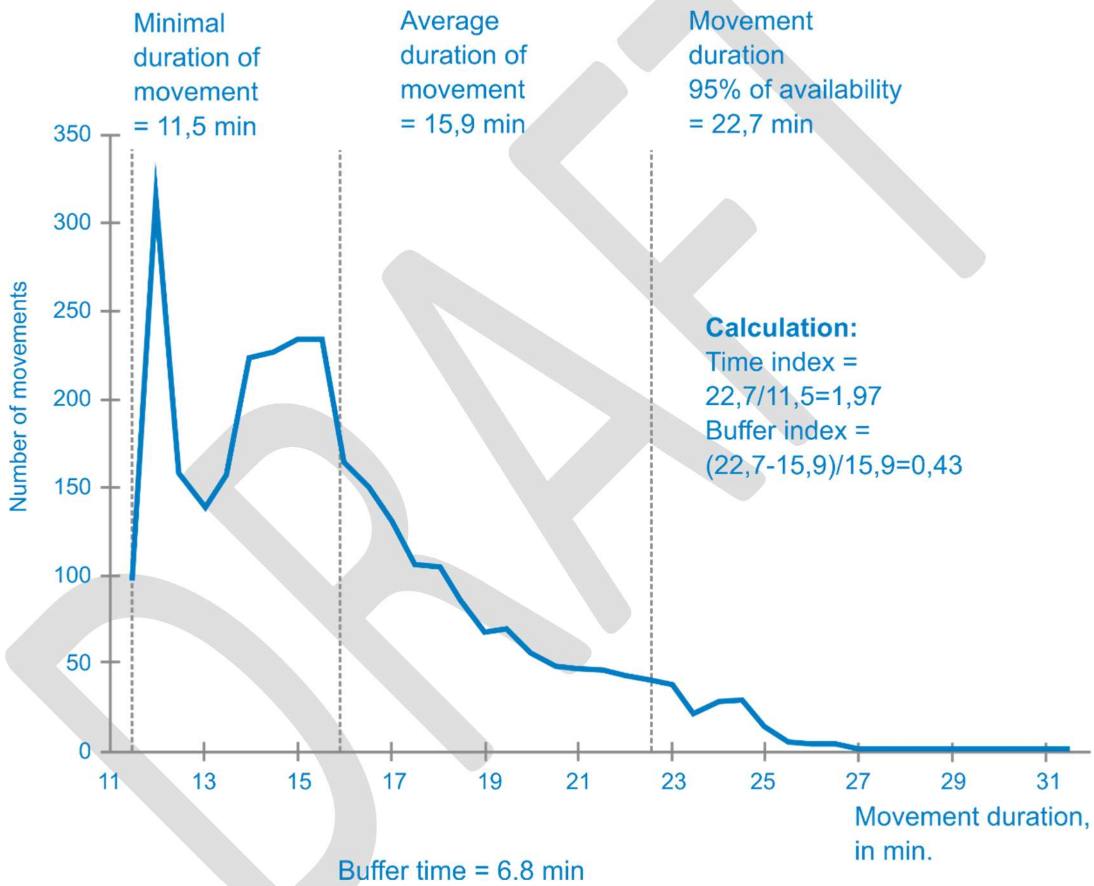
– average time in travel.

“Buffer index”, the relative value associated with T_b, is defined as

$$I_b = \frac{T_b}{\overline{T}} 100\%,$$

The availability index (90- 95% here) shows how many trips need to be guaranteed for planning purposes within the travel time allocated. Assuming that the index stands at 90%, then in 10% of cases (i.e. on any of 10 working days or on average 1 time in 2 weeks), a passenger will be running late. With the availability index up to 95%, passengers will be late no more than once in 4 weeks.

Figure 5.2. Estimation of buffer time T_b and the buffer index I_b



The indexes listed above characterize the reliability of how the urban street and road network or the road network function. That being the case, the time buffer (T_b)can be employed by using the cost of one passenger hour, vehicle-hour, etc., to estimate the additional economic costs to be borne by the user (driver or passenger) as additional time expenditures stemming from the transport system functioning unreliably.

In Moscow, Prague and a number of other cities, buffer time is taken into account at public transport final stops in order to send the wagon en route on time even following late arrivals to the final destination. In accordance with international practice, the buffer time should be approximately 10% of the estimated time of a turnaround trip. In Moscow, the buffer time is defined as the difference between the times of 90% availability (to ensure timely dispatch in 90% of cases) and 40% availability (to increase the speed of correspondence by route).

The time spent by people on transport movements is usually characterised as spent uselessly and irrationally, as opposed to the time expenditures on work, rest, education, communication, etc. The movement involved in the process is in itself not necessary, except when the trip is being taken so as to derive pleasure from the movement itself.

Those for whom travel is part of business activities (drivers, salesmen, those headed for meetings, etc.) see higher travel time leading to unproductive working time loss and lost productivity.

Unreliability of a trip is quantified from the distribution of probabilities of travel time along the route under examination depending on the length of the route and the traffic conditions. The buffer time set aside also depends on how significant the purpose behind the trip is whether it is “a meeting convened by the Minister” or a person running late for a meeting.

For a passenger choosing between travel options, it is not only the “time - money” chain that is important, but often also the “time - money - service” chain. The desire of passengers to pay for reduced travel time during which they experience comfort or discomfort due to various factors varies considerably. In practice, the list of such factors covers many conditions: stressful driving in heavy traffic, waiting at stopping points, the effects of weather, crowds, uncomfortable seats, lack of personal safety, etc. However, it is quite difficult to assign comparable values to all of these conditions and to measure the strength and duration of their effects.

Of interest is the fact that when choosing the desired transport mode, passengers often are not guided by the real physical time spent, but instead proceed from their psychological assessment the duration of the time. The time spent in travel for the most part represents overhead time in an individual's life, hence the interest in minimizing the time spent en route.

To obtain a gross cost evaluation of the time spent in travel, a gross figure calculated based on the state's GDP or the GRP of a given region can be applied. In this case, the cost of one hour per person can be determined by the formula[158]:

$$S^{ВО}_{ч-ч} = \frac{ВВП}{365 \cdot 24 \cdot N},$$

where Sвоч-ч is a gross estimate of cost of one hour/person in rub.;

[158] Organizatsiya dvizheniya (Traffic management): Resource Book/under the editorship of S.V. Fedotov. — M.: FGPU ROSDORNII, 2010. 416 p. - 500 copies.

GDP — indicator of the gross domestic product of the country in rub.;

365 — number of days per year;

24 — number of hours per day;

N — number of economically active individuals in a country or region, in persons

Thus, the socio - economic effect of reducing the time spent by passengers in travel when using public passenger transport on a certain route can be determined by the formula:

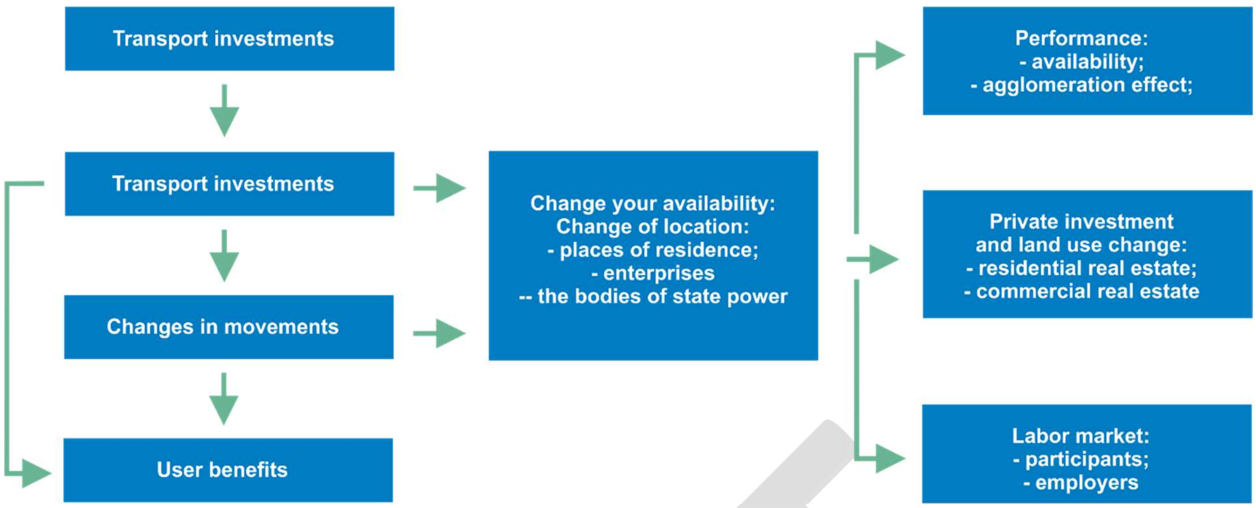
$$Э_t = \sum_{i=1}^{n} l_i \; S^{ВО}_{ч-ч},$$

where $\sum_{i=1}^{n} l_i$ – represents the total loss of time between adjacent stopping points of public passenger transport in the area under examination over a certain period of time. However, this approach produces a fairly average cost estimate of passenger travel time.

Figure 5.3 presents a diagram which shows the relationship between direct passenger benefits, improvements in road traffic conditions and broader economic consequences presented by French scientist Venables (2015)[159]. The group of effects shown in the figure on the left is estimated by demand forecasting methods using standard economic approaches. Direct passenger benefits take into account the overall improvement of welfare resultant from margin transport improvements, provided that the various industries receive a steady income and markets are filled and competitive. The central field in the figure can be characterised as changes in the economic geography or land use, which are often overlooked in strategic transport models. The implementation of a transport project offers opportunities for changes in the economic well-being of the population not encompassed by direct benefits for the passenger. These potential benefits are identified in the right-hand column in the figure as broader economic impacts (indirect economic effects).

Figure 5.3. A diagram that shows the relationship between direct passenger benefits, improvements in road traffic conditions and wider economic impacts, Venables (2015)

[159] Venables, A.J. (2016), "Incorporating Wider Economic Impacts within Cost-Benefit Appraisal", Quantifying the Socio-Economic Benefits of Transport, Paris, France, 9-10 November 2015



While the first Value of Travel Time Savings (VTTS) studies were carried out in English - speaking countries, some efforts to elaborate national models based on systematic data collection have also been made in the Netherlands, Switzerland, Scandinavian countries, as well as in Great Britain, Latin America and Asia.

It is generally accepted that the value of travel time savings (VTTS) for business travel is equal to the hourly cost of gross employment *(the income of an employee excluding costs but including non - cash payments and and payroll taxes).* As different countries have different tax structures, labour markets, information resources and analysts' perceptions of the social groups studied, the definition of hourly income differs as well.

The cost of the time in travel saved depends on the particular passenger, circumstances and conditions of the trip and possible travel options. There can be no certainty that these factors will be stable. However, a large proportion of individual trips, such as trips to and from work, share similar purposes with their daily or weekly schedule repeated. By focusing on comparing several modes of transport and route options (for instance, tolled motorways as compared to parallel free highways), researchers can obtain an approximate explanation of the transport-related decisions of passengers with a controlled number of variables.

The value of travel time savings comes in useful in assessing the social benefits that are derived from transport projects and solutions, but it is difficult to use it for predicting the number of passengers who choose a particular mode of transport or route.

In general, there is broad consensus on the approaches adopted to measure the value of travel time savings, the significant variables and categories used, and the extent of similarity between the specific recommended values.

The value of reduced travel time of a passenger expresses three aspects.

Firstly, the time saved on the trip can be used for productive work thereby yielding monetary benefits either to transport users themselves or to their employers.

Secondly, this time can be used for rest or other pleasant or necessary activities not related to work.

Thirdly, the travel conditions throughout the trip or part thereof may be uncomfortable and cause stress, fatigue and discomfort in passengers, so reduced travel time under such conditions may prove to be more valuable than saving time under more comfortable travel conditions. These aspects define the differences in VTTS valuations. However, such valuations should factor in the possibility of using travel time for remote work (mostly given the advancement of modern technologies), for physical exercise (cycling), etc.

5.1.2 Pollution and physical health

Motorised transport is the largest consumer of motor fuels, the combustion of which by internal combustion engines results in emissions of climate gases and, most importantly, CO2 (Fig. 5.4) in addition to emissions of pollutants. The volume and composition of pollutant emissions discharged by motor vehicles depend not only on the environmental performance of rolling stock (Fig. 5.5), but also on the quality of the motor fuels used (most importantly, sulphur content), as well as the technical condition of vehicles in operation.

Fig. 5.4. Specific emissions of different environmental classes of petrol-fuelled vehicles, g/km.

STANDARD	CO	HC	NMHC	NOx	HC+NOx	PM
Euro-1 (1992)	2,72 (3,16)	-	-	-	0,97 (1,13)	-
Euro-2 (1995)	2,2	-	-	-	0,50	-
Euro-3 (1999)	2,3	0,2	-	0,15	-	-
Euro-4 (2005)	1,0	0,1	-	0,08	-	-
Euro-5 (2009)	1,0	0,1	0,068	0,06	-	0,005
Euro-6 (2015)	1,0	0,1	0,068	0,06	-	0,005

Fig. 5.5. Specific emissions of different environmental classes of diesel-fuelled vehicles, g/km.

STANDARD	CO	HC	NMHC	NOx	HC+NOx	PM
Euro-1 (1992)	2,72 (3,16)	-	-	-	0,97 (1,13)	0,14 (0,18)
Euro-2 (1995)	1,0	-	-	-	0,7	0,08
Euro-3 (1999)	0,64	-	-	0,50	0,56	0,05
Euro-4 (2005)	0,50	-	-	0,25	0,30	0,025
Euro-5 (2009)	0,50	-	-	0,18	0,23	0,005
Euro-6 (2015)	0,50	-	-	0,08	0,17	0,005

One passenger car absorbs an average of more than 4 tonnes of atmosphere oxygen each year releasing approximately 800 kg of carbon, 40 kg of nitrogen oxides and almost 200 kg of various hydrocarbons[160]. The transport pollutants emitted cause both local exposures (CO, hydrocarbons) and local and more global (regional, interregional) effects (NOx, SOx, PM).

It is important to point out that each of the transport air pollutants is specific in its own way in terms of its effect on human health. Air pollution by carbon monoxide (CO) results in anemia and cardiovascular diseases, headaches, a feeling of weakness and impaired productivity. Sulphur dioxide (SO_2), combined with suspended particulate matter and moisture causes lung disease. Nitrogen oxide (NO) causes irritation of the upper respiratory tract as well as contributing to the development of anemia and heart disease. Lead causes a long-term adverse impact on human health resulting in hematopoiesis derangement and damage to the liver, kidneys, immune system. Aldehydes can boost the body's susceptibility to viral diseases, irritate the lungs, cause bronchitis and pneumonia. Studies indicate that particulate matter (PM) emissions from diesel engines are particularly dangerous. This component of diesel emissions is a product of incomplete combustion of motor fuels. “Particulate matter” is strictly speaking a complex mix of different solid and liquid particles different in size. The most hazardous to health are ultrafine carbon particles of less than 2.5 microns which penetrate deep into the human lungs with its carrying extensive surface acting as a carrier of adsorbed organic carcinogen substances.

Fine particles PM2.5 when inhaled also lead to adverse effects on the cardiovascular system as well as the respiratory system. Atmospheric PM2.5 pollution translates into an increase in the number of heart attacks, strokes, chronic bronchitis, asthma attacks and higher infant mortality.

Solid carbon particulates that are part of the PM are called “black carbon” (BC). Black carbon emissions from diesel-fuelled vehicles, along with severe health effects, produce an impact on the climate as they produce a significant light-absorbing effect.

Physicians and environmentalists estimate that motorised transport significantly decreases the average life expectancy of the population (Fig. 5.6).

Figure 5.6. Factors determining health status and life expectancy

[160] Molodyye uchenyye – promyshlennosti, nauke, tekhnologiyam i professional'nomu obrazovaniyu:problemy i novyye resheniya (Young scientists to the industry, science, technologies and professional education: problems and new solutions) Collection of scientific reports of the VII International Scientific and Practical Conference. — M.: MSIU., 2007. 624 p.

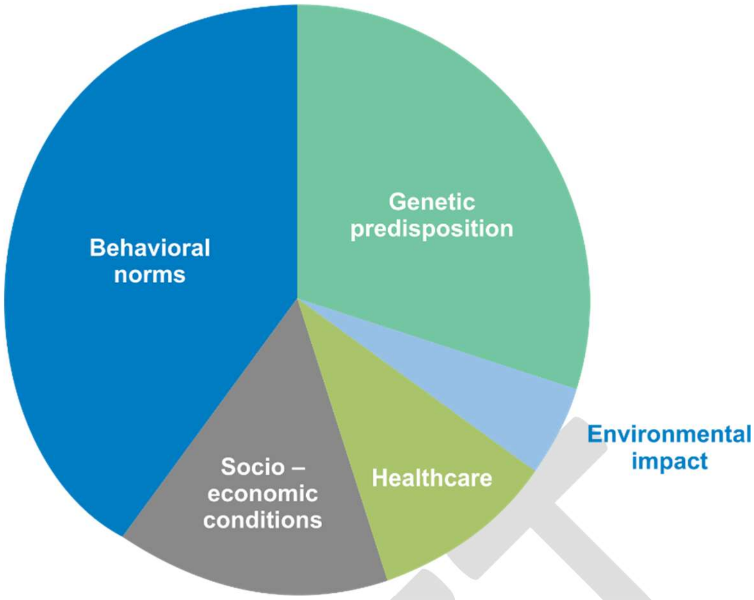


Figure 5.7 lists the results of a study conducted jointly by scientists from 3 countries (Austria, France and Switzerland) that point to motor vehicle emissions making a substantial contribution (in the range of 42-56%) to the negative effects produced by air pollution on public health.

Figure 5.7. Impact of motor vehicle emissions on public health

Indicator	ADDITIONAL CASES OR DAYS DUE TO ENVIRONMENTAL POLLUTION					
	Cases or days due to general air pollution			Cases or days due to air pollution by road transport		
	Austria	France	Switzerland	Austria	France	Switzerland
Number of premature deaths in the long term (adults > 30 years)	5600	31700	3300	2400 (42%)	17600 (56%)	1800 (55%)
Number of admissions to hospitals with respiratory diseases	3 400	13 800	1 300	1500 (44%)	7700 (56%)	700 (54%)
Number of admissions to hospitals with cardiovascular diseases	6 700	19 800	3 000	2900 (43%)	11000 (56%)	1600 (53%)
Number of days of disability (adults > 20 years)	3 100 000	24 600 000	2 800 000	1 300 000 (42%)	13 700 000 (56%)	1 500 000 (54%)

Another transport factor leading to a negative impact on public health is traffic-induced noise. Being the main source of noise in cities, motorised transport causes various painful reactions among the population. Road traffic is the major source of noise in cities with the noise level augmenting as the intensity and speed of traffic rises. According to the WHO, about 40% of the European population is exposed to traffic-induced noise with levels of more than 55 dBA LDN. Together with the general irritating effect, noise causes stress and a rise in blood pressure in exposed individuals. Stress increases the risk of cardiovascular diseases as well as resulting in sleep disorders, reduced rate of learning in children and ringing in the ears (WHO — Regional Office for Europe, 2011). Several studies demonstrate that the risk of cardiovascular disease is higher in people exposed to traffic-induced noise in the range of 55-60 dBA. Higher noise exposure also increases the risk of stroke, especially in the elderly.

The noise level is influenced by a number of factors:

- traffic flow intensity (the highest noise levels are recorded in the main streets of major cities at a traffic intensity of 2.000 — 3.000 cars per hour);

- traffic flow speed (a gain in the speed of vehicles is followed by increased engine noise, the noise of wheels rolling on the road and air resistance);

- traffic flow composition (freight vehicles produce more noise than passenger traffic, therefore the growing proportion of freight rolling stock involved in the traffic flow leads to an overall increase in the noise);

- engine type (diesel, petrol, electric);

- type and quality of road surface (the least noise is produced by asphalt concrete surfaces with cobblestone, stone and gravel respectively resulting in an incremental gain in the noise level. Any type of defective road surface with potholes, open seams and surface disconnections in it, as well as holes and subsidence result in increased noise);

- spatial planning decisions; (longitudinal profile and winding streets, different-level transport junctions and traffic lights influence the way in which engines operate thus influencing the level of noise generated. The height and density of buildings determine the distance of noise propagation from highways. For example, the width of acoustic discomfort zones along highways in the daytime can reach 700 — 1.000 m depending on the type of the adjacent buildings);

- green spaces available (there should be sanitary protection areas with trees and bushes along highways on both sides in order to prevent the spread of noise to nearby areas).

Various measures can be taken to ease the negative effect of traffic noise, such as speed reduction, the redistribution of intense traffic flows in road networks to remove them from residential development zones, separation of flows by sanitary protection zones from residential areas, etc.

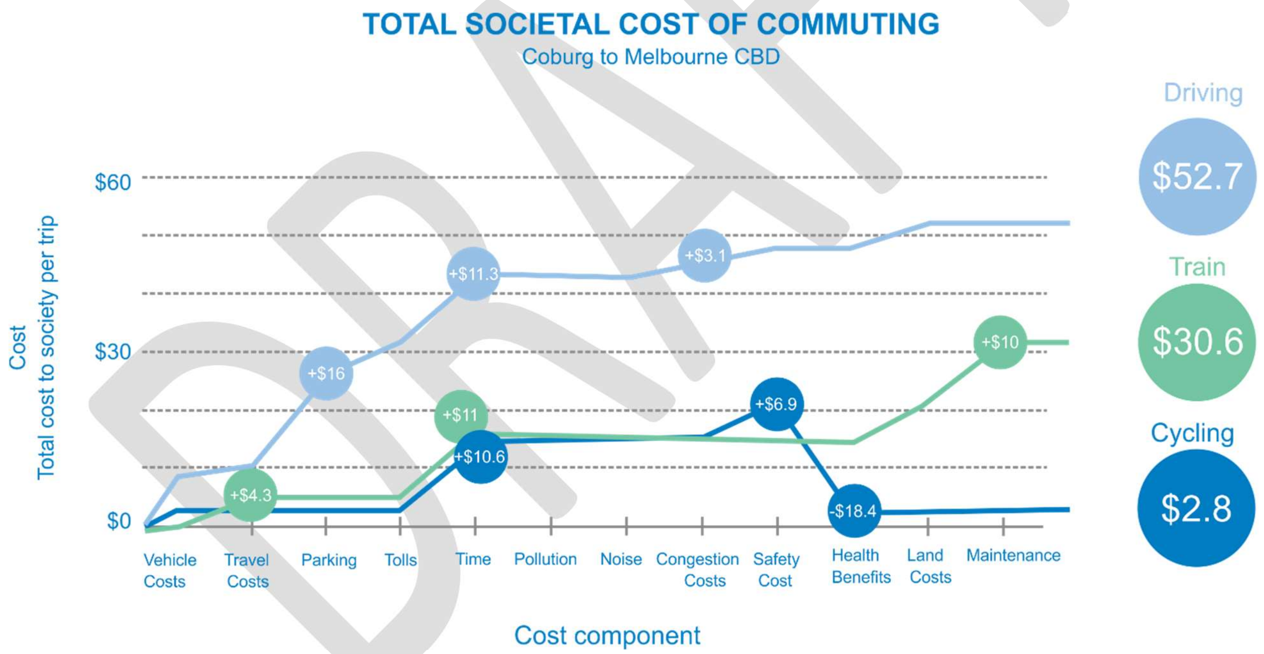
Promoting the widespread use of private vehicles for travel in cities along with a number of other reasons (widespread development of the Internet and its various services, automation of many labour processes, etc.) all lead to a high incidence hypodynamia among the population.

Around 1.9 million people die of hypodynamia and related diseases per annum. According to WHO experts, over 600.000 people annually fall victim to sedentary lifestyles in Europe and Central Asia. Over time, hypodynamia leads to bone mass loss, articular and spinal degradation; reduced lung capacity and pulmonary ventilation. Hypodynamia weakens the tone of arterial and venous walls also causing low blood pressure, reduced oxygen supply to tissues and affecting metabolic processes. Hypodynamia is one of the causes of obesity, diabetes and depression[161].

Estimates indicate that 6% of those who have died of a heart attack, 7% of those who have died of type 2 diabetes, and 10% of those who have died of cancer could have survived if they had done physical exercises to the necessary extent on a regular basis. Experts observe that physical activity of at least 30 minutes per day mitigates the risk of developing a number of the most common non-communicable diseases[162].

With Melbourne used as an example, researchers from Australia showed that travelling by car costs society 19 times more than cycling (Fig. 5.8)[163].

Figure 5.8. A study conducted in Australia used Melbourne as the premise for a comparison of cycling costs against motor vehicle use costs



In 1984, Gladsakse, a town situated northwest of Copenhagen, set the goal to improve street safety through traffic calming and bicycle infrastructure development. 94% of the urban road network was fully rebuilt, the maximum traffic speed cut down to 30-40 km/h and a protected cycling lane was put in place. A study by a group of experts from the Aalborg University demonstrated that the measures taken had saved the city budget a substantial amount of funds. At the time when the data were collected, the city had invested 24 million euros (1.6 billion rubles) in traffic-calming

161 https://www.newsru.com/world/13may2008/hypodinam.html
162 http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/
163 http://blog.deloitte.com.au/divorcing-growth-car/?fbclid=IwAR059hS_5eSGJ-lUi9KkV57QGkS9hpy_nV56R6NXt_THK80eCmQzqQAhvlw

measures and development of cycling infrastructure benefiting by saving 66 million euros (4.2 billion rubles) in the healthcare sector. According to calculations, these innovations have helped avoid 4.500 road accidents, while the share of bike trips has grown by 15%[164].

Copenhagen itself has long been a role model for cities striving to develop cycling. Copenhagen takes its cycling infrastructure very seriously. All cycling routes (more than 28) going from the suburbs to the city centre are structurally segregated from the roadway as opposed to just being drawn on the edge of it. The capital region now boasts more than one thousand kilometres of dedicated cycling paths and several hundred kilometres of cycling lanes. Investments in cycling infrastructure can be explained not by environmental concerns, but by mere financial gains. The cost of one kilometre of a cycling path pays off after five years thanks to the improved health of those who regularly use it. Road traffic on these segments of the road is reduced by 10%, with cycling traffic going up by 20%. Approximately 41 percent of citizens travel to work or school by bicycle. They save the state budgets a tremendous amount to the tune of 235 million euros per year. The redistribution of space from cars, an economically less efficient mode of transport, to fit bicycles, more modern and economically efficient, is very profitable.

41% of people in Copenhagen get to and from work by bicycle. They save the state budget 235 million euros per year. - Mikael Colville-Andersen, The Guardian.

Copenhagen has the most law-abiding cyclists in the world: only 7% of them violate traffic regulations to some extent with only 1% committing gross violations, for example, running a red light or riding on the sidewalk. The good design in place encourages compliance with the rules. According to the Copenhagen authorities, compelling cyclists to comply with the rules is a very simple task, all it takes is a good infrastructure to be built for them (to separate the cycling paths from the car flow and pedestrian sidewalks) and a place in the urban landscape.

With a safe environment created, the general population is encouraged to cycle. First of all, this is achieved through dedicated infrastructure and attaching higher priority to the bicycle as a mode of transport.

A sense of safety is no less important than safety itself for the citizens of Copenhagen. Citizens in a city should both feel safe and be safe.

Copenhagen adopted the concept long ago. The city has built an infrastructure suitable for 99% of the population, not just for those who cycle around wearing fancy

[164] https://politiken.dk/indland/art5635124/Gladsaxe-satsede-p%C3%A5-cykeltrafik-og-sparede-over-en-kvart-milliard-kroner?fbclid=IwAR3gYhhJPPmy1hrfE5Ixcmk0ki7tF4yLgLwv7HBBtE2_HJjt4NrQ6t8w580

cycling shorts. The infrastructure is being put in place not for those who already cycle but for all who could cycle, i.e. for all people regardless of the age and income level[165].

Fig. 5.9. Citizens of Copenhagen (Denmark) ride the bicycle not for entertainment, but for personal mundane trips to and from work/school

Successful examples of that are also found in other European cities. Only ten years ago, cities like Paris, Seville, Barcelona, Bordeaux and Dublin had next to zero cyclists. Nowadays, however, these cities have undergone upgrading and gone back to cycling in which process they are aided by the right infrastructure in combination with measures taken to slow traffic, tighten speed limits and provide an effective bike rental system.

Annual investments of 400-600 million euros in cycling pays off for the Netherlands by more than 18 billion euros per year in health care alone[166].

Almaty (Kazakhstan): Strategy of sustainable transport in the city of Almaty:

In 2013, Almaty, the largest city of Kazakhstan (with a population of 1.7 million people), developed a strategy of sustainable transport with technical support from the

[165] http://letsbikeit.ru/2015/02/copenhagen-cycling-innovation/

[166] https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2015.302724?journalCode=ajph&fbclid=IwAR3RJeLUt6op0piF9Ih4LzyBzu8NwKgp063UkXn2Ar85Z3T7JNJQTXtKSjg, American Public Health Association — Dutch Cycling: Quantifying the Health and Related Economic Benefits

United Nations Development Programme - Global Environment Facility "Sustainable Transport in Almaty". Among the main drivers of change, the development of high-speed corridors for public transport as well as the development of infrastructure for non-motorised traffic were put forward.

A new street format was proposed and designed which has a green corridor combining the unconditional priority of public transport with bicycle and pedestrian infrastructure in one of the busiest streets in Almaty.

The project for the first BRT line designed in 2015-2016 builds on transport modelling and passenger flows estimation data. The pilot area of pedestrian space reconstruction with a segregated bicycle arranged was completed in 2016.

The first section of the high-speed bus corridor - the BRT line with a length of 8.7 km (out of 22.4 km) was finished in 2018 now servicing 26 routes with a traffic of more than 140.000 passengers daily. Both buses and trolleybuses operate within this corridor. Its main section stands out due to the axial location of dedicated lanes for public transport, which gives it an inarguable advantage over private vehicles. The experience of Almaty is unique, as it has managed to avoid the need for construction of overpasses for stations owing to the open-type BRT. There are the following advantages: saved surrounding space, minimum station-to-sidewalk distance, accessibility for people with reduced mobility; passengers have become able to gather on and leave stop platforms quickly with the height of the platform allowing for unhindered boarding or disembarking from low-floor public transport vehicles for people with reduced mobility. The reduction in travel time for public transport users is more than 20%. In December 2018, new articulated 18-metre buses were put into service and electronic timetables were put in place. The year 2018 was also marked by a mass replacement of rolling stock in bus fleets with Euro-2-3 buses replaced with Euro-5 ones.

Altogether, in 2018, over 100 km of dedicated lanes for public transport and more than 80 km of cycling paths were commissioned, an urban bike rental system was put in place and mass cycling events were held to promote sustainable types of movement around the city.

The city is rapidly progressing towards driving out private cars with a view to curb emissions from motor vehicles[167].

Figure 5.10. Towards sustainable urban mobility in Almaty (Kazakhstan)

[167] Based on the information provided by the Mayor's Office of Almaty (Kazakhstan) and the UNDP-GEF Project "Sustainable Transport of Almaty", 2018, https://alatransit.kz/ru

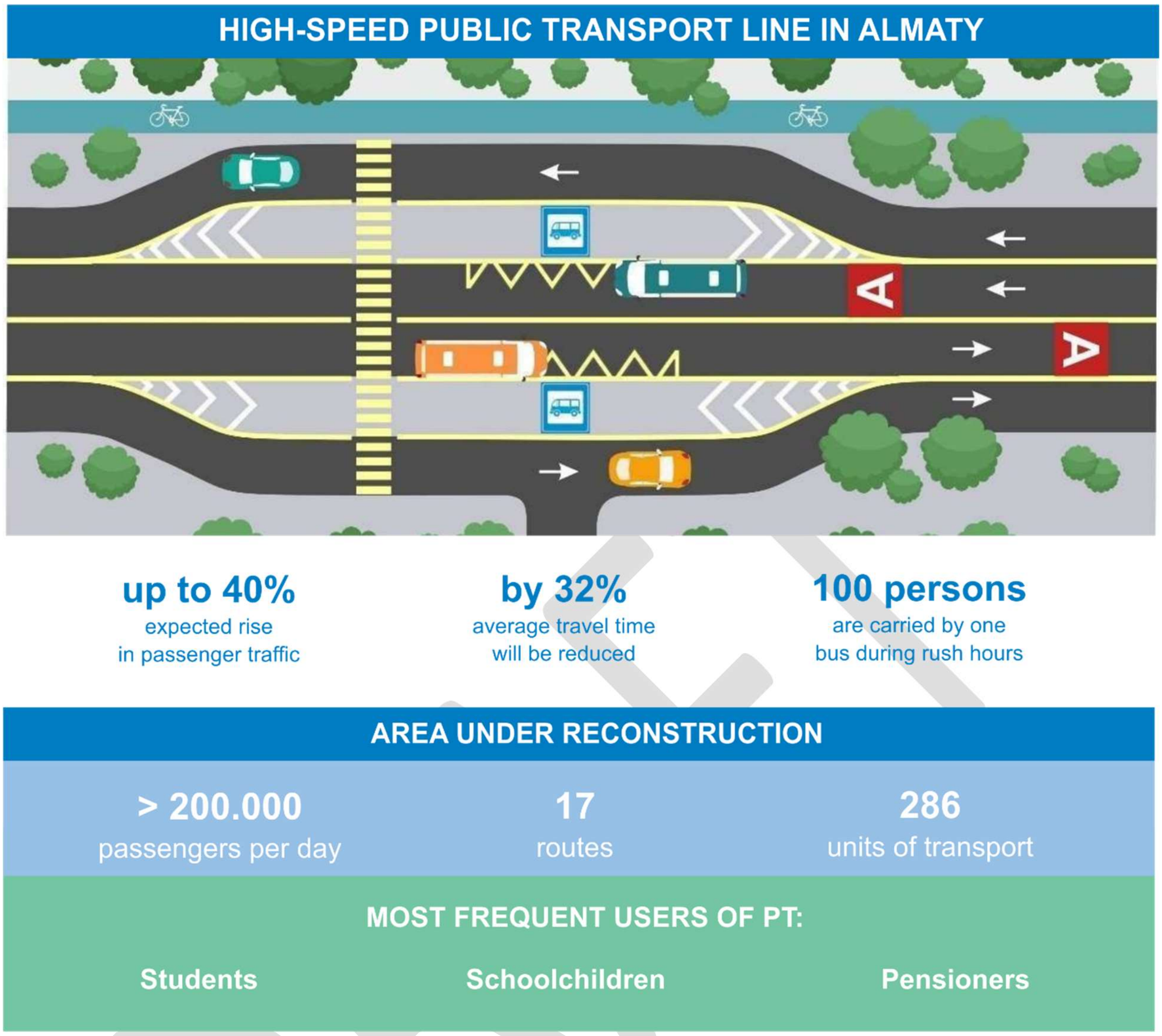


Figure 5.11. Almaty (Kazakhstan)

Figure 5.12. Almaty (Kazakhstan)

Figure 5.13. Almaty (Kazakhstan)

The main messages can be summarized in four points:

- health goes beyond physical health and includes social and mental components;
- all the principles of health action must be mobilized and articulated: prevention, protection, access to care and health promotion;
- the problem of social inequalities in health should be treated in the same way as the previous points.

5.1.3 Traffic accidents

Around 1.25 million people are killed in road accidents all over the world with between 20 million and 50 million people suffering non-lethal injuries, many of which lead to disabilities. Road accident victims, their families and countries in general suffer significant economic losses. These losses come down to treatment costs, as well as lost productivity of those who have died or been left disabled following injuries as well as their families who need their time free from work or studies to tend to their relatives who have suffered injuries. On average, road accidents cost countries 3 to 5% of GDP. 90% of road deaths occur in low- and middle-income countries despite accounting for only about 54% of all motor vehicles in the world. Almost half of the world's road deaths happen among “vulnerable road users” i.e. pedestrians, cyclists and motorcyclists. Road accidents remain the leading cause of death of young people aged 15-29 years. Studies show that 40-50% of drivers exceed the maximum speed limit. Male drivers, young people and people driving under the influence of alcohol are more likely to be involved in high-speed road accidents. If no consistent countermeasures are taken, road accidents are projected to be the seventh primary cause of death by 2030. The 2030 Agenda for Sustainable Development sets out an ambitions objective: By 2020, halve the number of global deaths and injuries from road traffic accidents[168].

Motorists often protest against speed limit reductions for fear that “traffic in the cities will grind to a halt.” In reality, however, this is not the case. The higher the speed of cars, the greater the distance between them, so fast driving is no guarantee of high-capacity streets. On the contrary: it is believed that optimum capacity in urban environments can be achieved at speeds of 50 to 65 km/h. With the speed limit down to 30 km/h, travel time goes up by a few minutes only. Quiet streets are quieter and more convenient for the elderly and children, which obviates the need for a certain number of car trips. For instance, with the speed limit in a block below 30 km/h, a child can get to school by themselves, unaccompanied by adults.

There is no doubt that high speed cuts down the travel time of drivers and passengers, and yet it often happens to be the source of a large number of road safety risks. High-speed motorways are designed for fast traffic, but the situation in mixed-use areas should be quite the opposite. Nonetheless, many countries still prioritize traffic speed of movement over safety. Statistics on speed limitation in different countries are shown in Figure 5.14, which illustrates the need for speed control measures. Moreover, many countries lack regulatory frameworks to enforce speed limits in different situations. In some countries, there are national regulations with speed limits of up to 50 km/h, while even 30 km/h may be unsafe in many urban situations.

Figure 5.14. Urban Speed Laws[169]

[168] https://www.who.int/ru/news-room/detail/05-05-2017-speed-management-key-to-saving-lives-making-cities-more-liveable, WHO, 2017
[169] http://www.sum4all.org/publications/global-mobility-report-2017, The Global Mobility Report, 2017: Tracking Sector Performance. Washington DC., Creative Commons Attribution.

While the number of road accidents is on the decline, 26.000 people a year are still killed on the road in Europe, 38% of them in cities. Pedestrians and cyclists are at the highest risk. Roads are 8 times more dangerous than other settings[170].

The safety of people in the city may be affected by a combination of various factors, but the speed of vehicles is the biggest one of them.

Speed control measures include the following:

- Construction or re-construction of roads with traffic - restraining components added such as roundabouts and artificial elevations;
- speed limits to be established as per the functional purpose of each road;
- enforcing compliance with speed limits through the use of manual and automated control measures;
- equipping new vehicles with on-board technologies such as allowed speed maintenance and autonomous emergency braking technologies;
- raising awareness about the dangers and hazards of speeding.

Cyclists dislike riding among cars while pedestrians are stressed out by cyclists riding near them and so on. What is the solution? Everyone should have their own space: roads for cars, cycling paths for bicycles, dedicated lanes for public transport and sidewalks for pedestrians.

THE WIDER THE LANES, THE HARDER IT IS FOR THE DRIVER TO STAY WITHIN THE SPEED LIMIT

The wider the car lanes, the more difficult it is to stay within the speed limit as even responsible drivers are tempted to succumb to the urge to step on the gas while

[170] From a presentation of Anthony D. May, Professor of Transport Engineering, University of Leeds, UK.

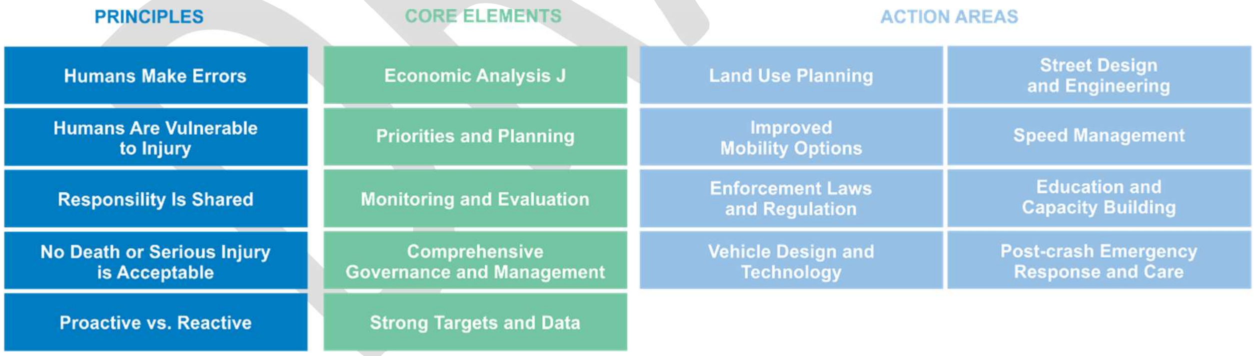
driving along a wide road. Making lanes narrow can boost the safety of streets, keep drivers abiding by the law to a greater extent as well as leaving room for cycling paths, public transport lanes and sidewalks.

Targets of two SDGs relate directly to road safety. SDG 3 - to ensure healthy lives and promote well-being for all at all ages - includes a target to halve global deaths and injuries from road traffic accidents by 2020. SDG 11, which seeks to make cities inclusive, safe, resilient, and sustainable, incorporates a “Safe System” approach by focusing on access to safe, affordable, accessible, and sustainable transport systems and improving road safety by creating more public transport systems for all by 2030.

The “Safe System” approach to road safety is the best and fastest way to reduce traffic fatalities. Its widespread application will be necessary to meet the SDG target of halving the number of global road deaths by 2030. Beyond saving lives, the approach yields many other benefits, including economic, health, and environmental improvements. A “Safe System” for all road users addresses wider land use and mobility patterns in addition to design, enforcement, education, vehicle safety, and emergency response.

The “Safe System” approach requires a shift in responsibility from the people using roads to the people designing them. It is a systemic approach that integrates core management elements and action areas to create a safe mobility system.

Figure 5.15. Principles, Core Elements, and Action Areas of the “Safe System” approach[171]



The “Safe System” approach as it pertains to cycling traffic safety: ensuring high safety for cyclists calls for a “pre-emptive”, proactive approach which requires that the transport system be designed (or re-designed) in such a way as to meet the needs and take into account the special features of all users. If the goal is to increase cycling traffic, the policy of the authorities should be aimed at stepping up the safety of the system, not only at gradually improving the safety of the behaviour of cyclists and other traffic users in an environment where the system is imperfect and unsafe.

171 http://pubdocs.worldbank.org/en/912871516999678053/Report-Safe-Systems-final.pdf, Sustainable & Safe: A Vision and Guidance for Zero Road Deaths, World Resources Institute, Washington, 2018

Key principles of the “Safe System” approach:

- Functionality (functional classification of urban roads, alignment of traffic modes and management with the defined classes);
- Uniformity (separation of road users in space and time depending on their mass, speed, dimensions, etc.);
- Predictability (design of the road environment should provide predictability for traffic situations and aid cyclists and drivers in avoiding mistakes);
- “Forgive mistakes” (whenever a road accident does occur, it is necessary to avoid it having serious consequences). As for cyclists, possible obstacles in the bicycle infrastructure must be eliminated while taking into account the behaviour pattern of motorists and cyclists, etc.;
- Users should be aware of the risks associated with cycling (in particular, training programmes adapted to specific user groups are required).

The leading improvements in the “City for People” come down to ensuring safety for all road users (pedestrians, cyclists and motorists). The disastrous frequency of people dying often boils down to the geometry of streets that provokes high speeds, crossings put in place improperly, and scarce and dangerous cycling paths. Such places cannot be fixed altogether, but they need to made safer given the concerns listed above.

The key to real change in road safety is shifting responsibility from people who use the road to people who design, set policy, execute operations, and otherwise contribute to the mobility system. An overemphasis on victim behavior and personal responsibility has long relieved pressure on governments to take responsibility and act to protect their citizens. This mindset needs to change, in terms of both public expectation and political and professional perceptions of responsibility[172].

5.1.4 Stress, noise and mental well-being

5.1.5 Case studies and good practices

Basel (Switzerland): methods are employed to ensure the safety of cyclists and pedestrians:

The parliament has determined the requirements for safe street infrastructure in the Law for Street Traffic as a part of Via Sicura. The Federal Government and the cantons are obliged to appoint a representative for traffic safety. In order to support the authorities to complete these complex tasks, the Swiss Federal Road Office (ASTRA) has developed six infrastructure safety instruments (ISS), whose application leads to an increase in safety both for new street projects and for the rehabilitation of existing streets.

[172] http://pubdocs.worldbank.org/en/912871516999678053/Report-Safe-Systems-final.pdf, Sustainable & Safe: A Vision and Guidance for Zero Road Deaths, World Resources Institute, Washington, 2018

The issues of bicycle traffic within the public space are laid down into the authority binding cantonal Cycling Structure Plan, as well as the coordination with other planned projects and the inclusion of bicycle traffic in the main planning and large projects. The Cycling Structure Plan consists among other things of the main bike route network with its connections towards the neighboring municipalities, as well as the intended future connections. Whether and when a cycling project is realized is specified in the secondary procedure (implementation program). The bike route network of the Cycling Structure Plan has been verified according to the quality requirements. The prioritization of the cycling development measures for the following 10 years is based on this, considering existing known problems. The prioritization of the bike routes took place based on the principle, that the highest utilization should be achieved at the locations where most cyclists can profit from it. The potential number of cyclists has been determined based on the overall traffic model. The implementation should be coordinated with the maintenance measures at the location. The cantonal business model regarding infrastructure is used for the respective coordination.

The National Swiss Norms VSS are used for the planning, projecting and building of road infrastructure. Additionally, the Cantonal Guideline for the Design of Pedestrian and Bike Traffic provides further principles and indications[173].

Figure 5.16. Basel (Switzerland)

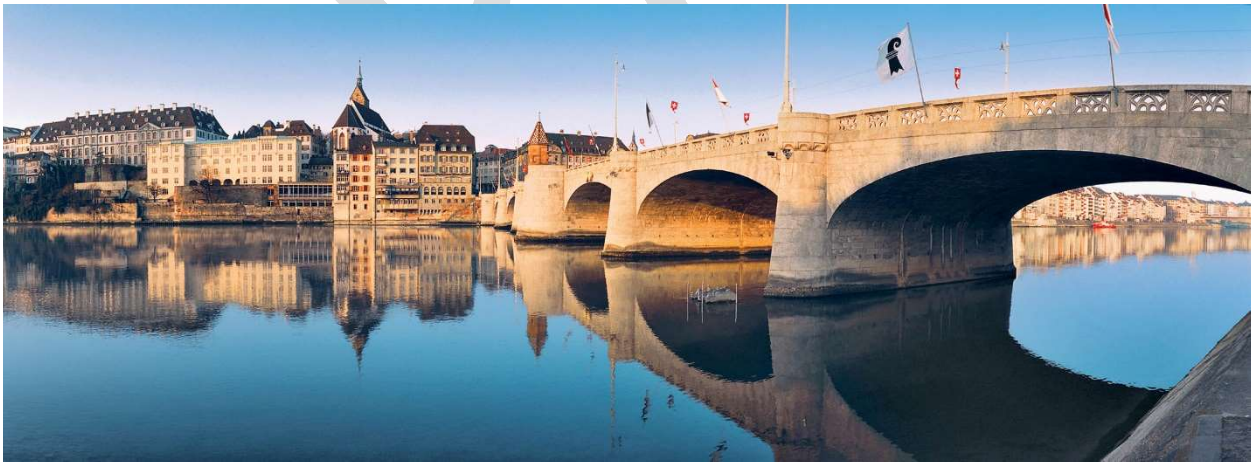


Figure 5.17. Basel (Switzerland)

[173] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.

France: taking the walking bus to school:

Inspired by the experiences of the Nordic and some English-speaking countries, around 350 French towns and cities have created school walking buses. The walking bus is an eco-citizen mode of transport based on parents or other community members providing pedestrian accompaniment to groups of children, from home to school, on safe, marked out routes. There is a “timetable” where the bus leaves the neighbourhood “stops” as a set time in the morning. It leaves the school after the last lesson when all “passengers” are ready.

As well as improving the children’s health and reducing motorised traffic and pollution, the walking buses teach children how to behave safely on public roads, it provides fun, and reinforces social links between children of different ages.

City councils can support schools to create walking buses, put up bus stop signs and shelters, and, if requested, provide insurance and high-visibility jackets. Some provide a small trailer in which school bags can be transported.

France: pedestrian signs with walking times:

The city centres lend themselves to walking yet many people still choose to get about using individual motorised transport. The main criteria when choosing a mode of transport for daily journeys is time and the ease of signalling to indicate how to get from one place to another. Pedestrian signs with walking times expressed in minutes help to show that many places "are closer than we think". Public Health France piloted a scheme in 9 cites. They found it was important to show the average journey time (and not the distance in metres) on the sign and a large number of signs were need so that the pedestrian was able to find their destination. An evaluation of the signage showed that 91% of inhabitants appreciated the new pedestrian signs and 86% said they would use them. Since the pilot scheme there has been exponential number of French towns and cities putting up ‘timed’ walking signs. For example, Grenoble city council has put up 270 signs on 30 kms of streets and plans to further expand the scheme[174].

Finland:

In improving road safety for pedestrians and cyclists, one of the most efficient means is improving the quality of infrastructure. The safety of different modes of transport is at its best when each mode has its own allocated route. Many Finnish cities have planned and started to implement a quality corridor network for cycling. Its purpose is to act as a fast lane for commuter cyclists moving between areas. This means improving existing routes but also building many new cycling paths. In addition to these quality corridors, Finnish cities have also put effort into improving the cycling conditions in centres. In these areas, the purpose is to integrate cyclists and pedestrians into the general flow of traffic when speeds are moderate (under 30 km/h). In busier routes, the target is to build cycling paths or as a minimum bicycle lanes.

The purpose of the new Road Traffic Act is to improve road safety. The obligation to anticipate and to behave cautiously in traffic will be laid down in acts and no longer in decrees. This will improve the position of vulnerable road users.

Government resolution on improving road safety sets a long-term vision that no one would be killed or seriously injured on the road. National strategy for walking and cycling 2020 aims that walking and cycling have their own positions in the transport system recognised alongside other modes of transport. Key measures to improve traffic safety include tighter speed control of motor vehicles, safe traffic arrangements particularly at junctions and crossings and the use of reflectors and helmets.

The new road traffic act, which enters into force 2020 e.g. clarifies the use of road markings for cyclist crossing, offers new ways to promote cycling such as cycle street and possibility for contra-flow cycling on one way streets. National guidelines for planning the pedestrian and bicycle traffic are maintained by The Finnish Transport Agency. City of Helsinki has introduced new guidelines for bicycle infrastructure especially for cities.

Lowering of speed limits systematically in housing areas to 30 km/h. Strategy and yearly budget to implement different measures to improve pedestrian safety (e.g. new pedestrian crossings, elevated pedestrian crossings, improved lighting). Use of structurally separated bicycle lanes when possible (city of Tampere)[175].

Figure 5.18. Oulu (Finland)

[174] Based on the answers given by France to the UNECE questionnaire.

[175] According to Finland's response to the UNECE questionnaire.

Figure 5.19. Oulu (Finland)

Moscow (Russia):

Since 2015, Moscow has been working to deliver "My Street", an urban space improvement programme. The reconstruction and improvement of the road network has seen 150 transport patterns implemented that balance out the interests of all citizens in the city: pedestrians, PT passengers, cyclists and motorists. 327 streets, squares, highways and public spaces have been undergone improvement and reconstruction. These efforts have translated into better street capacity.

A broad range of activities is covered by the programmes under way in order to ensure the safety of pedestrians. Those include:

- additional illumination for pedestrians, crossings and approaches to them,
- safety islands put in place to act as measures to calm vehicular traffic in places where unsignalled pedestrian crossings are located,
- re-engineering unsignalled pedestrian crossings into signalled ones,
- putting in place "elevated" pedestrian crossings,
- widening sidewalks in the area of crossings (creating "ear-shaped spaces") thereby reducing the length of crossings and improving pedestrian-driver visibility,
- imposition of speed limits in areas of cyclist and pedestrian traffic, including by forcing speed limitation by installing humps.

More information about the urban improvement projects carried out in Moscow can be found at: https://www.mos.ru/city/projects/mystreet/[176].

Figure 5.20. Moscow (Russia)

[176] According to the response of Moscow (Russia) to the UNECE questionnaire.

Almetyevsk (Russia, Republic of Tatarstan):

In order to ensure a safe environment for the traffic of pedestrians and cyclists, ever since 2016, Almetyevsk has been implementing the municipal programme on "Promotion of cycling and development of cycling infrastructure in the municipality of Almetyevsk for 2016 - 2020".

The launch of the project was preceded by major efforts aimed at studying the public opinion about the current situation and prospects of cycling development. Respondents aged 15 to 60 and older participated in the survey. The results of the survey revealed that more than 22.000 bicycles were owned in Almetyevsk with the owners eager to put them to active use for trips around the city but the high intensity of car traffic coupled with the lack of bicycle infrastructure posed a very high risk to their health.

Copenhagenize Design Co., based in Denmark with international experience in cycling, was contracted to provide more professional insight for the implementation of the project.

Between 2016-2018, 90 km of cycling paths and 37 km of adjacent sidewalks were built.

Under the project, bicycle traffic lights, bicycle handrails, road signs, cycle metres, bicycle parking lots were installed and road markings were put in place[177].

[177] Based on the answers given by Almetyevsk (Russia, the Republic of Tatarstan) to the UNECE questionnaire.

Figure 5.21. Almetyevsk (Russia, Republic of Tatarstan)

Figure 5.22. Almetyevsk (Russia, Republic of Tatarstan)

Tyumen (Russia):

In 2015, the City Administration of Tyumen designed a concept to develop a network of cycling paths in the city and took measures to build bicycle infrastructure in the city.

The main objectives behind the concept are the development of cycling traffic and cycling infrastructure as a necessary element of urban planning policy aimed at creating a comfortable living environment for Tyumen residents and providing conditions conducive to promoting mass use of bicycles for recreational, physical and sports activities and as a mode of transport to improve the environment in the city.

The primary goals pursued by the Concept are to improve the safety of cycling on the road network of the city of Tyumen, to foster a positive attitude towards cyclists as road users and to construct cycling paths for mass cycling. The information campaign has an important role to play as it calls on all road users to behave properly on the road and comply with traffic regulations.

In accordance with the Concept for the development of the network of cycling paths and the pattern for the development of the network of cycling paths in the city of Tyumen, the Tyumen Administration plans to build cycling paths with a total length of 195.30 km, the route network of which will cover places of public recreation (parks, squares, boulevards), educational institutions, etc.

Now, residents have the opportunity to build their bicycle route including 56.29 km of cycling paths.

Bike rental services (including electric bicycles) are provided by commercial entities. Bicycle parking lots are being constructed both within bicycle paths, and directly in places of intensive public use (malls and office centres, shops, etc.) funded by the economic entities involved.

Pedestrian infrastructure in Tyumen is being developed as part of the efforts aimed at the design, reconstruction and overhaul of motor ways and improvement works in parks, squares and boulevards[178].

5.2 The concept of active mobility and its health dimension

5.2.1 Case studies and good practices

5.3 Urban mobility needs of vulnerable groups (incl. women, children, elderly and disabled persons)

5.3.1 Case studies and good practices

Chapter 6: Information Technologies and Intelligent Transport Systems (ITS)

6.1 Definitions
6.2 Use of ICT for traffic management purposes
6.2.1 CCTV for monitoring, safety and security purposes (bus, taxi lanes, parking facilities)
6.2.2 Urban traffic light management systems
6.2.3 E-tolling and parking payment systems
6.2.4 Case studies and good practices
6.3 Use of ICT in public transport
6.3.1 Use of telematics, public transport e-ticket applications
6.3.2 Traveler comfort: GPS route schedules, public transport Apps
6.3.3 Case studies and good practices
6.4 Intelligent Transport Systems (ITS) in urban transport
6.4.1 Increasing safety, security and efficiency of urban traffic flows through ITS
6.4.1.1 Improved quality and availability of data for transport users and authorities
6.4.1.2 Remote urban traffic control, monitoring and enforcement
6.4.1.3 Automatic incident detection, variable message signs and rerouting of traffic
6.4.2 Case studies and good practices

6.1 Definitions

Connected and Autonomous Vehicles (CAV) - connected vehicles use communication technology to interact with the driver, other cars on the road, the infrastructure and the 'Cloud' and autonomous vehicles are self-driving.

[178] Based on the answers given by Tyumen (Russia) to the UNECE questionnaire.

Intelligent Transport Systems (ITS) - a system integration of modern information and communication technologies and automation equipment with transport infrastructure, transport vehicles and users geared towards enhancing the safety and efficiency of the transport process and the comfort of drivers and users of transport.

GLONASS is a global public-use navigation system. In transport, an intelligent transport system is utilized, one that is designed for efficient management of traffic flows, boosting the capacity of the road network, prevention of traffic congestion, reduction of traffic delays, improvement of road traffic safety, raising awareness of the traffic situation and optimum route options, ensuring the seamless movement of urban on-ground passenger transport[179].

6.4 Intelligent Transport Systems (ITS) in urban transport

Nowadays, digital technologies are being vigorously integrated into urban transport systems. Intelligent Transport Systems (ITS) based on the most advanced information and control technologies are being widely implemented in order to optimize traffic flows. These systems are interconnected elements of transport infrastructure that provide automated transmission of information in real time and are available to all users in the transport process on a free-of-charge basis. The establishment of ITS is inextricably bound up with the expanded use of the latest information and communication technologies.

Intelligent Transport Systems are a comprehensive tool that relies on electronic, telecommunication and information technologies to improve the operation of the transport system which enhances efficiency, safety, productivity, energy conservation and environmental quality[180].

Digital technologies enable building a “smart” transport system which makes it possible to increase passenger traffic in a steady manner, improve engagement with passengers, guarantee the availability of transport service whenever the need for it arises. In particular, intelligent solutions allow for processing data coming from rolling stock and infrastructure as well as monitoring transport disruptions, so that they can be identified early long before they may translate into grave consequences.

Globally, ITS are applied in various domains ranging from addressing public transport-related problems by significantly enhancing road safety, eliminating congestion in transport networks, increasing intermodal transport productivity (including motorised, railway, air and maritime transport) to environmental and energy issues.

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[179] http://transport.mos.ru, Unified Transport Portal of Moscow (Russia).

[180] Johann Andersen and Steve Sutcliffe, “Intelligent transport system (ITS): an overview”, IFAC Technology Transfer in Developing Countries, vol. 33, No. 18 (July 2000).

As ITS represent service systems, their architecture should be based on information that is provided to users on the potential needs for its services. In world practice, five primary types of ITS users are defined: motorists, pedestrians and cyclists, public transport passengers, carriers; transport operators and transport infrastructure services.

ITS are developed by methodologically building on a system approach in which ITS systems are formed as systems rather than separate modules (services). A single open system architecture, information exchange protocols, shipping document forms are established together with standardisation of the parameters of technical means of communication, control and management, management procedures, etc.

Now, the following basic technologies for transport infrastructure and vehicles are seeing the most vigorous development:

- Traffic management on motorways;
- Commercial transportation;
- Prevention of vehicle-to-vehicle crashes and enhancing the safety of their traffic;
- Electronic transport service payment systems;
- Emergency management;
- Main street network traffic management;
- Management of rectification of the consequences of road accidents;
- Information management;
- Intermodal freight transport;
- Weather control on roads;
- Operation of roads;
- Public transport management;
- Information for traffic users.

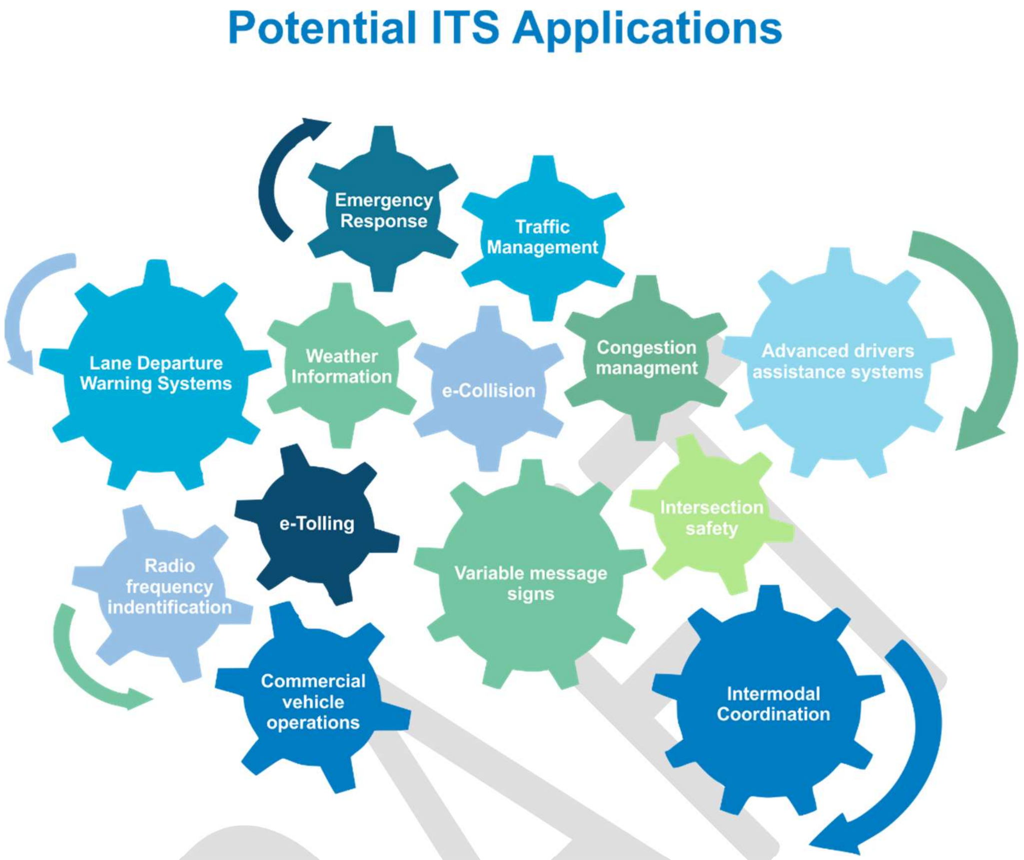
Enables Intelligent transport systems (ITS)

- Intelligent transport infrastructure (weather information, e-tolling and e-surveillance/ monitoring, …);
- Intelligent vehicles (vehicle-vehicle & vehicle-infrastructure, vehicle-human communication);
- Importance of the human factor.

ITS in urban transport:

- Improving traffic flow (traffic management);
- Improving road safety;
- Improving security and reducing crime;
- Improving public transport;
- Improving freight efficiency;
- Lessening environmental impact.

Figure 6.1. Potential ITS Applications



Over the decade since Intelligent Transport Systems have been tackling road traffic issues, they have been intensely implemented by the leading countries of the UNECE region and have demonstrated their potential as cleaner, safer and more efficient urban transport systems.

Intelligent Transport Systems can give cities a new approach to the use of available resources and infrastructure as advanced technologies can facilitate the sustainable operation of existing infrastructure with moderate expenses incurred, which in turn could assist in reducing the need for new construction.

Use of modern information and communication technologies, including smart mobile devices, wireless telecommunications systems and computing systems, as one of the Intelligence Transport Systems, has helped to resolve a number of urban traffic issues.

Intelligent Transport Systems can help solve issues related to improving road traffic efficiency in a prompt manner with immediate outcomes. In addition, newer technologies that use big data analytics, automated and connected vehicles, and the concept of "smart cities" with smart mobility have drawn the attention of policy-makers as potential solutions to urban traffic issues. With a growing number of national and local initiatives, the demand for intelligent transport systems development in the UNECE region is mounting.

The successful implementation of intelligent transport systems calls for intersectoral and coordinated institutional arrangements encompassing the public and private sectors, as well as harmonization of the activities of various stakeholders. For example:

(a) Respective governments and ministries need to establish a dynamic environment for cooperation and collaboration in the field of intelligent transport systems. At times, however, each government entity is engaged in the development of Intelligent Transport Systems without consulting the other stakeholders involved. This is likely to lead to an almost insurmountable incoherence between the activities of organisations which pursue the development of intelligent transport systems in the region;

(b) Long-term national strategies and plans that are premised on the consensus of all stakeholders serve as a bedrock for the effective use of Intelligent Transport Systems. Countries should work out a comprehensive vision, detailed objectives and short-, medium- and long-term action plans. With a number of countries in the region still in the early stages of development of Intelligent Transport Systems, there is a need for more systematic national policies and plans;

(c) Coordination of Intelligent Transport Systems at the regional level is required, taking into account the specific circumstances of the region. Many Intelligent Transport Systems projects are drafted and implemented at the local level with no regard for the regional dimension, which, among other things, extends to consistent system standards and architecture. Regional standards will facilitate the effective alignment between different types of services and smooth delivery of services, bearing in mind that standards enhance compatibility between different systems as well as interoperability between the elements within a single system[181]. In a similar fashion, the architecture of regional Intelligent Transport Systems, which defines the functions of system components, will strengthen an integrated approach to the deployment of technologies for development of harmonised intelligent transport systems at the regional level.

A sound regulatory framework is essential for the overall management of the planning, implementation and delivery of services provided by intelligent transport systems and for managing them in compliance with relevant standards and requirements. Explicit regulations can further facilitate effective policy-making, sound investments and consistency in technology development. For example:

(a) Only a few Member States of the region have regulations directly related to Intelligent Transport Systems. Still, the definitions and descriptions laid down in such regulations do not necessarily meet specific system requirements. There is a need to

[181] European Committee for Electrotechnical Standardization, “The importance of standards” (last accessed: July 25, 2018).

update existing regulations to address issues related to Intellectual Transport Systems in order to support faster and more coherent development;

(b) In accordance with the institutional arrangements, the regulatory requirements envisage the involvement of different entities, including not only transport - related agencies but also agencies that deal with technology. At times, this leads to inconsistencies in regulations, which may hamper the coordinated implementation of systems, the installation of compatible systems, the justified prioritisation of services provided within the scope of Intelligent Transport Systems and the planned allocation of funds for technological projects;

(c) Recent improvements in the technology of Intelligent Transport Systems herald dramatic changes in urban transport systems. One of the latest most revolutionary technologies, as emphasized above, is the production of autonomous vehicles. Existing regulations do not adequately reflect the emerging technologies for the production of autonomous vehicles due to the diversity of autonomous vehicle systems. Given the widespread proliferation of autonomous vehicles in the near future, policy makers in the region need to understand and discuss specific regulatory issues related to autonomous vehicles such as, for instance, the ways in which autonomous vehicles and traditional vehicles are reflected in regulations as well as operational aspects of autonomous vehicles that require regulation.

Many Member States are vigorously implementing projects in the domain of Intelligent Transport Systems, whose success requires significant support for their implementation. Besides helping to address urban traffic issues, the introduction of Intelligent Transport Systems can produce a positive impact on the environment and development.

Artificial intelligence, the Internet of Things, and big data analytics can be used as major tools in automating and developing transport systems.

Connected Intelligent Transport Systems, carsharing, e-ticketing systems, e-tolling, autonomous vehicles and smart mobility are currently the concepts that are being discussed the most by UNECE Member States as Intelligent Transport Systems of the future.

With Connected Intelligent Transport Systems, the focus is chiefly on the relationship between each component of the transport ecosystem: motorists, pedestrians, vehicles and infrastructure. In shared Intelligent Transport Systems, all required information is transmitted to all these components followed by drivers carrying out the necessary actions to avoid potential harmful consequences (e.g. collisions and other accidents) and road congestion where it can be predicted.

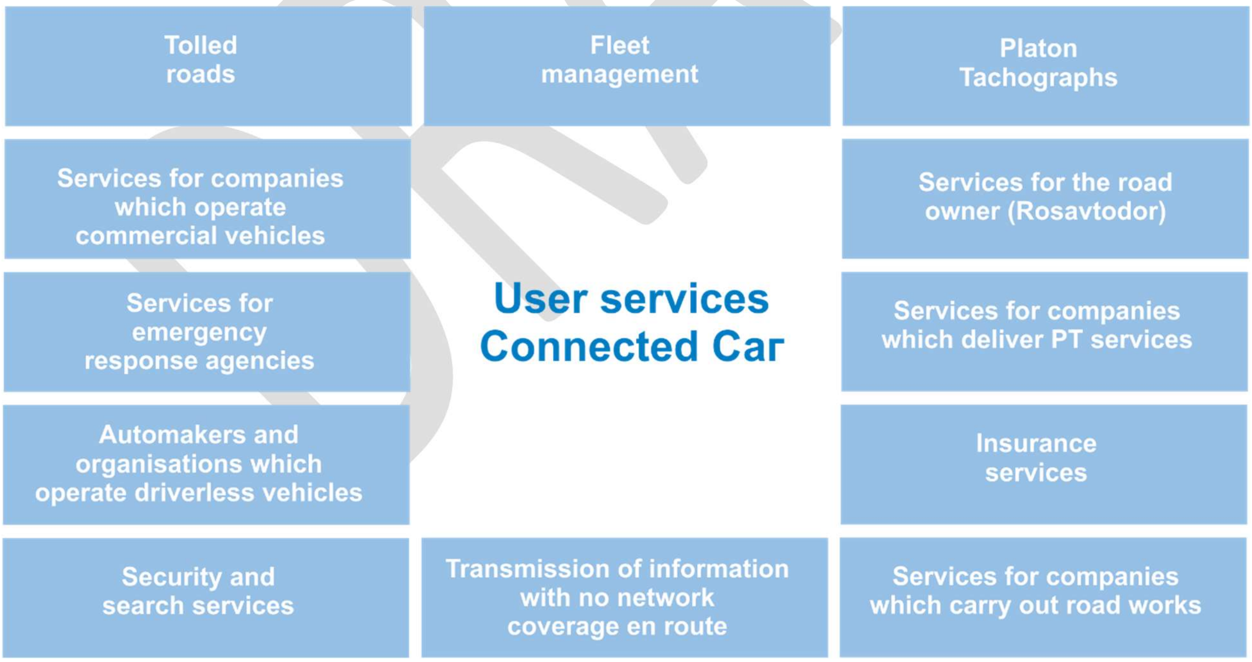
6.4.2 Case studies and good practices

The global trend is the use of automated control systems for driving, traffic and supervisory actions:

- On-board telematics — control of components and systems of vehicles (parking assistance, lane maintenance, prevention of collision with vehicles ahead);
- Road infrastructure telematics - information and navigation functions, automated traffic control system (ATCS);
- Automated control of compliance with traffic regulations - traffic cameras in place to capture traffic regulations violations and send them to control (supervisory) bodies;
- Telematics of economic entities — management of passenger and cargo transportation (optimisation of timetables, loading, etc.)

The term CAV can denote many different things. A vehicle can be automated to a varying degree and/or connected to different extents. The broad definition of these two components is Cooperative Intelligent Transport Systems (C-ITS): CV refers to vehicles with increased connectivity which makes them communicate with their environment (including infrastructure and other vehicles). This can provide information about road, traffic and weather conditions, routing parameters as well as ensuring a wide range of connectivity services. It is fair to say that CV refers a broader set of applications than CITS does (including automotive entertainment), so the two terms are not necessarily interchangeable, but are closely related between each other.

Figure 6.2. User services (connected cars)



Connected and Autonomous Vehicles (CAV) provide accessibility and mobility for individuals with reduced mobility (older persons or disabled persons) who are not able to use traditional vehicles.

Vehicles with higher automation will use information from on-board sensors and systems to understand their own location in the environment and navigate through it with little or no human effort for some or all trips.

Republic of Belarus:

In the Republic of Belarus, road passenger transport operators widely use automated systems of dispatching control and passenger transport operations control by advanced means of information and communication, which allows for coordination, control and management of traffic of all modes of transport on the route network.

In 2014, Minsk kicked off the implementation of contactless smart cards and a system of automated payment and travel control for urban municipal passenger transport. This system allows for trips to be paid both by a paper one-time ticket (coupon) by marking it in an electronic compost, and by an electronic travel ticket (contactless smart card) by marking it in the validator.

Passengers are now able to use a single tool to pay for services of all types of urban transport, one that is easy to obtain, top up, as well as being able to use a smart card and pay only for those trips that have actually been made. Carriers have been given the opportunity to fully track the services actually delivered which yields benefits in the form of higher profitability, less costs borne due to having to purchase paper travel tickets, full reimbursement of funds spent on the transportation of passengers enjoying the travel benefits from the budget.

Passengers are kept up-to-date on the schedule of urban passenger transport by timetables that the stations are equipped with, through printed and electronic media as well as through the websites of carriers and passenger transportation operators or special Internet services. In particular, State Enterprise "Minsktrans" uses the Internet services of "Virtual Timetable at Stations" and "Rational route" to find the optimal route, taking into account the traffic of public transport in real time[182].

Moscow (Russia):

ITS in Moscow include: road user information subsystem, automated traffic management system, photo and video recording and televiewing system. ITS are designed to harmonize the traffic flow, as well as to ensure a rapid response to emergency situations. Currently, 100% of the territory of Moscow is covered by Intelligent Transport Systems.

The creation of a system that informs passengers about the arrival time of on-ground passenger transport involves the installation of timetables at the stations. The timetables display information about the number of vehicles en route, the final destination station and the estimated time of arrival at a particular station.

[182] Based on the answers given by the Republic of Belarus to the UNECE questionnaire.

At the same time, data on the location of vehicles en route is transmitted to the mobile applications of the Moscow Transport System. Mobile applications display vehicle traffic based on navigation data obtained from on-board equipment via mobile cellular network.

Beyond that, one can get information about the routes, traffic intervals, up-to-date data on the traffic of buses, trolleybuses and trams, as well as the estimated time of arrival of transport vehicles at stations through the mobile application “Mosgortrans”.

At the same time, since 2018, Moscow metro cars have been equipped with passenger information screens (currently 8.720 screens in more than 230 trains, 4-8 screens per car). Substantial operational information about the operation of urban passenger transport is prioritised so it is broadcast online. One of the primary channels of engagement and provision of information about the operation of transport is social networks: (VKontakte (vk.com), Twitter (twitter.com), Instagram (Instagram.com), Facebook (facebook.com), Odnolassniki (ok.ru)[183].

Basel (Switzerland):

In Basel (Switzerland) the transport companies are responsible for customer information. The canton Basel-Stadt as purchaser of services formulates the requirements for the quality standards. In Basel, the stops with high number of passengers are equipped with a screen for Dynamic Passenger Information (DFI). Moreover, the BVB operation center informs the customers about current matters through the speaker and/or screen announcements at the stops, and in trams and buses[184].

Link: http://www.bahnonline.ch/bo/1330/neue-led-anzeigetafel-fuer-bahnhof-basel-sbb.htm.

[183] According to the response of Moscow (Russia) to the UNECE questionnaire.
[184] Based on the answers given by Basel (Switzerland) to the UNECE questionnaire.

Autonomous vehicles, also known as driverless cars, automated cars or self-driving vehicles, can drive with minimal human intervention. One of the widely accepted definitions of autonomous vehicles is: "Vehicles which move without the direct intervention of the driver in managing the processes of control, acceleration and braking and which are designed in such a way that when driving autonomously these vehicles do not require the driver to be keep an eye the road at all times"[185].

Ensuring data protection is a major issue. In a world where mobile devices of communication and data exchange have become widespread, traditional IT methods of computer networks protection are no longer sufficient, particularly with regard to the issues of IT public transport security. There is a growing need to respond to cyber threats promptly and properly. To that end, it is necessary to develop and enforce rules of guaranteed network equipment cyber security, to resort to artificial intelligence technologies, self-learning systems and automatic data processing means. At the same time, any innovations and technologies are introduced better and quicker through joint efforts involving developers, operators, regulators and authorities.

Figure 6.3. Example of an autonomous traffic structure in the Russian Federation

Figure 6.4. Development and prototyping of traffic management models based on technical systems and services of autonomous transport systems

[185] Center for Advanced Automotive Technology, "Connected and automated vehicles".

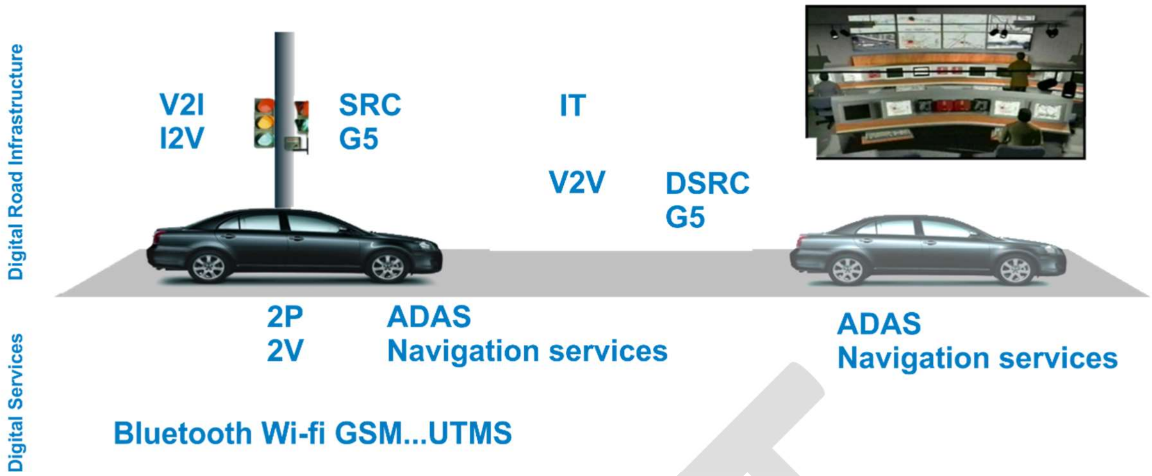


Figure 6.5. Autonomous car and cooperative environment. Traffic safety

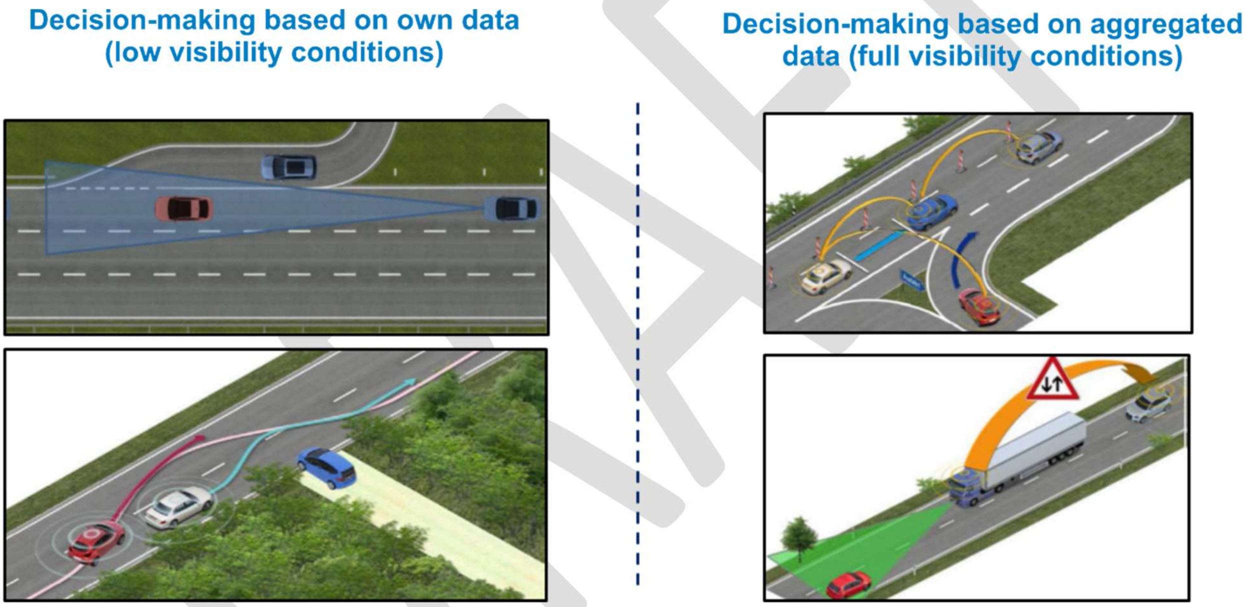


Figure 6.6. Autonomous car and cooperative environment. Harmonisation of flows

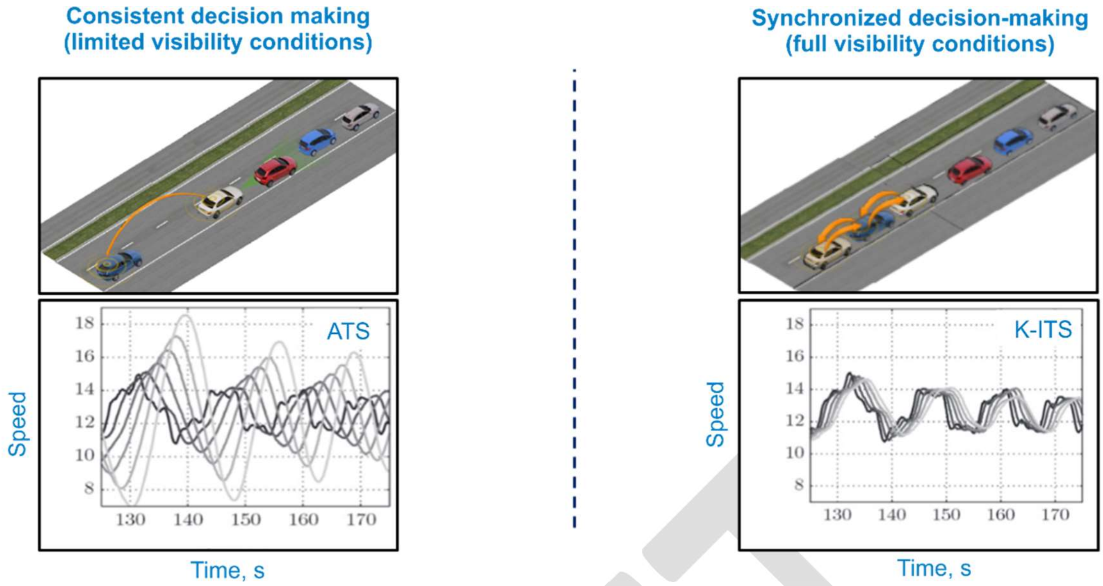


Figure 6.7. Digitalisation of urban and suburban transport using an example of the largest urban agglomerations of the Republic of Tatarstan. Introduction of modern technical equipment

Moscow (Russia):

Moscow, much like all megacities in the world, is seething with vehicles. Road infrastructure is often overwhelmed. Traffic jams and low traffic speed around the city are one of the major challenges that the Russian capital is faced with. Digital technologies allow efficient use of personal and public transport. In the long term, they will help achieve increased mobility of citizens, higher levels of safety and comfort of urban trips and general optimisation of traffic flow management.

The Smart City 2030 mobility strategy is geared towards the city transitioning from traditional transport systems to intellectual mobility systems.

The Digital Mobility objectives:

The virtual presence of a Moscow citizen is made equivalent to his or her physical presence through the use of digital technologies;

Less time required for moving around the city;

Convenient digital environment for travel, domestic and international tourism;

Fostering opportunities for new communication technologies.

Digital Mobility indicators:

Average travel time spent by passengers on public transport in the morning peak hours from residential areas near the Moscow Ring Road to the city centre;

User satisfaction with public transport services;

Proportion of “zero” emission vehicles available in vehicle sharing services;

Share of ICT sector in the GRP of Moscow;

Annual number of foreign tourists visiting Moscow;

Annual number of Russian tourists visiting Moscow;

Objectives:

Establishing conditions to ensure maximum mobility for Muscovites;

Implementing the Mobility as a Service (MaaS) concept, which involves real-time selection of optimal route parameters, travel time, cost, comfort level and environmental impact;

Creating an urban personalised online intelligent mobility service;

Creating road transport infrastructure for the use of driverless vehicles;

Launching driverless vehicles in Moscow;

Ensuring use of exclusively environmentally friendly electric public transport in Moscow;

Improving the safety, comfort and environmental friendliness of the Moscow transport system through digital technologies;

Reducing the average time of urban travels by ITS and digital services;

Improving the efficiency of traffic management and reducing road accidents by Big Data analytics and other digital technologies;

Synchronised and harmonised development of transport infrastructure of Moscow and Moscow region;

Abandoning private vehicles in favor of public transport, carsharing, logistics services in lieu of physical travel, remote workplaces, remote reception of information and data through Internet-of-Things sensors, video surveillance systems, information services.

Figure 6.8. Moscow transport system projects (Russia) 2010 — 2016[186]

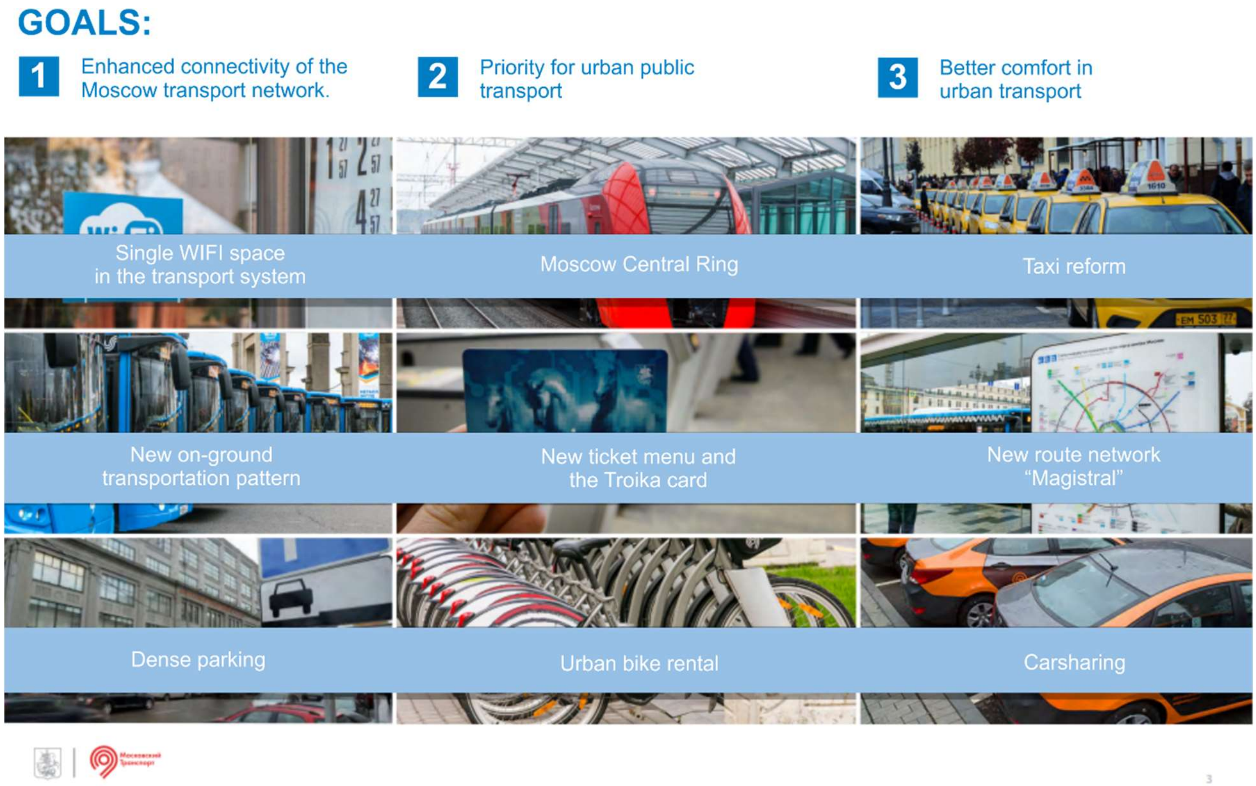
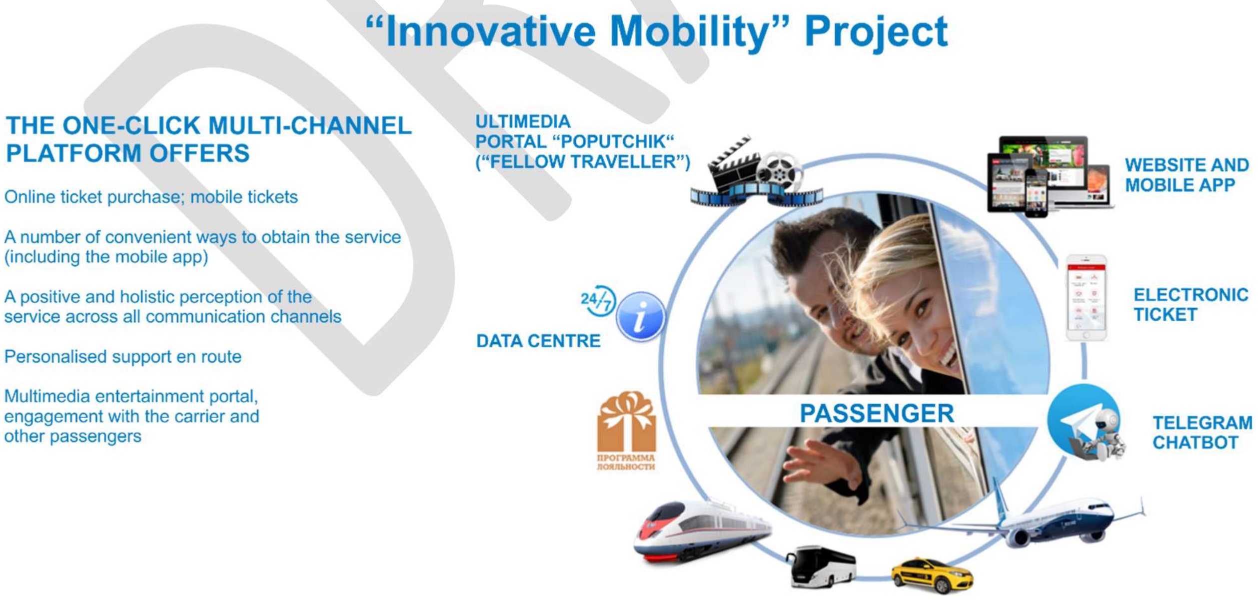


Figure 6.9. Project "Innovative Mobility in Moscow" (Russia)



Moscow Central Ring (MCC) in Moscow (Russia), a joint project of the State Unitary Enterprise "Moscow Metro", Open Joint Stock Company "Russian Railways" and Joint Stock Company "MKZhD", is intended to become an integral part of the

[186] http://transport.mos.ru, Unified Transport Portal of Moscow (Russia).

modern transport system of the city distributing passenger traffic in the capital of Russia.

General characteristics of the project:

- Travel time of electric trains — 90 minutes;
- Route length — 54 km;
- Number of stations — 31; all adapted for barrier-free movement of passengers with reduced mobility;
- Traffic intervals — 5 minutes during peak hours and 10 minutes during non-peak hours;
- The line is operated by 42 “Lastochka” electric trains;
- Working hours: 5:30 am to 1:00 am.

In total, the Moscow Central Ring has 31 transport interchange hubs; each of them providing a transfer to on-ground public transport. On both sides of the railway there are convenient access roads, turning platforms for buses, and new stations.

Passenger traffic was launched on the Moscow Central Ring in 2016. Until 2020, it is planned to develop the areas adjacent to the transport interchange hub Moscow Central Ring. Thus, abandoned industrial areas will be developed once again and built up by business and shopping centres, hotels and residential buildings. The developed transport infrastructure will considerably enhance the accessibility of many areas.

In total, the Moscow Central Ring has 177 pairs of trains circulating per day on weekdays, and 150 pairs on weekends. With the capacity to accommodate 1.500 passengers, electric trains “Lastochka” are adapted for people with reduced mobility, passengers travelling with children and are convenient for transportation of bicycles and baby strollers. The trains are equipped with toilets, climate control and Wi-Fi[187].

Figure 6.10. A diagram showing the Moscow Metro and the Moscow Central Ring

[187] http://mosmetro.ru/mcc/ps/


Московский Транспорт
Аэропорт Шереметьево
Ховрино
Речной вокзал
Водный стадион
Войковская
Сокол
Аэропорт
Динамо
Белорусская
Маяковская
Тверская
Театральная
Новокузнецкая
Павелецкая
Автозаводская
Технопарк
Коломенская
Каширская
Кантемировская
Царицыно
Орехово
Домодедовская
Красногвардейская
Алма-Атинская
Селигерская
Верхние Лихоборы
Окружная
Петровско-Разумовская
Фонвизинская
Бутырская
Марьина Роща
Достоевская
Трубная
Сретенский бульвар
Чкаловская
Римская
Крестьянская Застава
Дубровка
Кожуховская
Печатники
Волжская
Люблино
Братиславская
Марьино
Борисово
Шипиловская
Зябликово
Алтуфьево
Бибирево
Отрадное
Владыкино
Тимирязевская
Дмитровская
Савёловская
Менделеевская
Цветной бульвар
Чеховская
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Полянка
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Тульская
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Нахимовский проспект
Севастопольская
Чертановская
Южная
Пражская
Ул. Академика Янгеля
Аннино
Бульвар Дмитрия Донского
Медведково
Бабушкинская
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Ботанический сад
ВДНХ
Алексеевская
Рижская
Проспект Мира
Сухаревская
Тургеневская
Китай-город
Третьяковская
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Ленинский проспект
Академическая
Профсоюзная
Новые Черёмушки
Калужская
Беляево
Коньково
Тёплый Стан
Ясенево
Новоясеневская
Бульвар Рокоссовского
Черкизовская
Преображенская пл.
Сокольники
Красносельская
Комсомольская
Красные Ворота
Чистые пруды
Лубянка
Охотный Ряд
Библиотека им. Ленина
Кропоткинская
Парк культуры
Фрунзенская
Спортивная
Воробьёвы горы
Университет
Проспект Вернадского
Юго-Западная
Тропарёво
Румянцево
Саларьево
Филатов Луг
Прокшино
Ольховая
Коммунарка
Планерная
Сходненская
Тушинская
Спартак
Щукинская
Октябрьское Поле
Полежаевская
Беговая
Улица 1905 года
Баррикадная
Пушкинская
Кузнецкий Мост
Таганская
Пролетарская
Волгоградский проспект
Текстильщики
Кузьминки
Рязанский проспект
Выхино
Лермонтовский проспект
Жулебино
Котельники
Пятницкое шоссе
Митино
Волоколамская
Мякинино
Строгино
Крылатское
Молодёжная
Кунцевская
Славянский бульвар
Парк Победы
Киевская
Смоленская
Арбатская
Площадь Революции
Курская
Бауманская
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Семёновская
Партизанская
Измайловская
Первомайская
Щёлковская
Пионерская
Филёвский парк
Багратионовская
Фили
Кутузовская
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Международная
Выставочная
Деловой центр
Александровский сад
Новогиреево
Перово
Шоссе Энтузиастов
Авиамоторная
Площадь Ильича
Марксистская
Новокосино
Раменки
Ломоносовский проспект
Минская
Мичуринский проспект
Озёрная
Говорово
Солнцево
Боровское шоссе
Новопеределкино
Рассказовка
Новослободская
Краснопресненская
Белорусская
Лихоборы
Коптево
Балтийская
Стрешнево
Панфиловская
Зорге
Хорошёво
Шелепиха
Деловой центр МЦК
Кутузовская
Лужники
Площадь Гагарина
Крымская
Верхние Котлы
ЗИЛ
Автозаводская
Угрешская
Дубровка
Новохохловская
Нижегородская
Андроновка
Соколиная Гора
Измайлово
Локомотив
Белокаменная
Ростокино
ЦСКА
Петровский парк
Хорошёвская
Шелепиха
Каховская
Варшавская
Битцевский парк
Лесопарковая
Улица Старокачаловская
Бунинская аллея
Улица Горчакова
Бульвар Адмирала Ушакова
Улица Скобелевская
Аэропорт Внуково
Аэропорт Домодедово
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Линия экстренных вызовов: 8 499 787-25-86
Контакт-центр «Московский транспорт»: 8 495 539-54-54
3210
www.transport.mos.ru, vk.com/transportmos
Метро работает с 5:30 утра до 1 часа ночи

Almetyevsk (Russia, Republic of Tatarstan):

The "Smart Transport" application has been successfully integrated into the transport network of Almetyevsk. With this application, passengers can forecast the arrival of public transport at the station where they need to catch it. Information boards have been installed at public transport stations to display the passenger public transport route numbers and station names.

Buses and trolleybuses have been equipped with the GLONASS system that allows for monitoring of transport vehicles on the line, full control of transport vehicles, maintaining the interval between buses and trolleybuses and safety of operation by preventing stalemate situations.

The Centre for Operational Monitoring of Transport Vehicles on the Line has been integrated. Operating successfully, the Centre is fitted up with all the necessary modern equipment required for constant monitoring of transport traffic on the line, compliance with labour and financial discipline and enforcing observance of the rules of traffic regulations on the part of the drivers. The program "PILOT" allows generating reports for each vehicle.

In order to tackle fare evasion, systems called ASOP (Automatic Fare Payment System) and UP (Transportation Management) have been introduced; both tracking the operation of vehicles in real time helping to quickly identify errors in drivers' work and their deviations from the route chart.

The automatic toll control system helps to effectively deal with fare evasion and accurately calculate the number of travel-privilege trips (accuracy within 1%). This control system reduces the number of ticket controllers.

The modern ones include: payment by transport card, bank card, NFC payment, that is, payment by phone (leading to reduced payment time)[188].

[188] Based on the answers given by Almetyevsk (Russia, the Republic of Tatarstan) to the UNECE questionnaire.