UNECE

A Handbook on Sustainable Urban Mobility and Spatial Planning

Promoting Active Mobility

UNITED NATIONS

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

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UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE)

The United Nations Economic Commission for Europe (UNECE) is one of the five United Nations regional commissions, administered by the Economic and Social Council (ECOSOC). It was established in 1947 with the mandate to help rebuild post-war Europe, develop economic activity and strengthen economic relations among European countries, and between Europe and the rest of the world. During the Cold War, UNECE served as a unique forum for economic dialogue and cooperation between East and West. Despite the complexity of this period, significant achievements were made, with consensus reached on numerous harmonization and standardization agreements. In the post-Cold War era, UNECE acquired not only many new member States, but also new functions. Since the early 1990s the organization has focused on analyses of the transition process, using its harmonization experience to facilitate the integration of central and eastern European countries into global markets. UNECE is the forum where the countries of western, central and eastern Europe, Central Asia and North America – 56 countries in all – come together to forge the tools of their cooperation. That cooperation concerns economic cooperation and integration, statistics, environment, transport, trade, sustainable energy, forestry and timber, housing and land management and population. The Commission offers a regional framework for the elaboration and harmonization of conventions, norms and standards. The Commission's experts provide technical assistance to the countries of South-East Europe and the Commonwealth of Independent States. This assistance takes the form of advisory services, training seminars and workshops where countries can share their experiences and best practices.

TRANSPORT IN UNECE

The UNECE Sustainable Transport Division is the secretariat of the Inland Transport Committee (ITC) and the ECOSOC Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals. The ITC and its 17 working parties, as well as the ECOSOC Committee and its sub-committees are intergovernmental decision-making bodies that work to improve the daily lives of people and businesses around the world, in measurable ways and with concrete actions, to enhance traffic safety, environmental performance, energy efficiency and the competitiveness of the transport sector. The ECOSOC Committee was set up in 1953 by the Secretary-General of the United Nations at the request of the Economic and Social Council to elaborate recommendations on the transport of dangerous goods. Its mandate was extended to the global (multi-sectoral) harmonization of systems of classification and labelling of chemicals in 1999. It is composed of experts from countries which possess the relevant expertise and experience in the international trade and transport of dangerous goods and chemicals. Its membership is restricted to reflect a proper geographical balance between all regions of the world and to ensure adequate participation of developing countries. Although the Committee is a subsidiary body of ECOSOC, the Secretary-General decided in 1963 that the secretariat services would be provided by the UNECE Transport Division. ITC is a unique intergovernmental forum that was set up in 1947 to support the reconstruction of transport connections in post-war Europe. Over the years, it has specialized in facilitating the harmonized and sustainable development of inland modes of transport. The main results of this persevering and ongoing work are reflected, among other things, (i) in 58 United Nations conventions and many more technical regulations, which are updated on a regular basis and provide an international legal framework for the sustainable development of national and international road, rail, inland water and intermodal transport, including the transport of dangerous goods, as well as the construction and inspection of road motor vehicles; (ii) in the Trans-European North-south Motorway, Trans-European Railway and the Euro-Asia Transport Links projects, that facilitate multi-country coordination of transport infrastructure investment programmes; (iii) in the TIR system, which is a global customs transit facilitation solution; (iv) in the tool called For Future Inland Transport Systems (ForFITS), which can assist national and local governments to monitor carbon dioxide (CO_2) emissions coming from inland transport modes and to select and design climate change mitigation policies, based on their impact and adapted to local conditions; (v) in transport statistics – methods and data – that are internationally agreed on; (vi) in studies and reports that help transport policy development by addressing timely issues, based on cutting-edge research and analysis. ITC also devotes special attention to Intelligent Transport Services (ITS), sustainable urban mobility and city logistics, as well as to increasing the resilience of transport networks and services in response to climate change adaptation and security challenges. In addition, the UNECE Sustainable Transport and Environment Divisions, together with the World Health Organization (WHO)–Europe, co-service the Transport Health and Environment Pan- European Programme (THE PEP). Finally, as of 2015, the UNECE Sustainable Transport Division is providing the secretariat services for the Secretary General's Special Envoy for Road Safety, Mr. Jean Todt.

"Greenhouse gas (GHG) emissions from transport have increased over the last three years, while average CO_2 emissions of new passenger cars increased for the first time in 2017. The sector remains a significant source of air pollution, especially of particulate matter and nitrogen dioxide, although these emissions have been reduced in the last decade. It also is the main source of environmental noise in Europe."

Source: Transport and Environment Reporting Mechanism (TERM). ***Progress of EU transport sector towards its environment and climate objectives. 22 November 2018.***

"In 2014, the THE PEP Paris Declaration enhanced the priority goals previously adopted in Amsterdam with a new strategic direction "to integrate transport, health and environmental objectives into urban and spatial planning policies.

"In 2019-2020, the THE PEP process has to move to a next level and include sustainable urban mobility as a supporting factor the implementation of the 2030 Agenda and the Sustainable Development Goals as well as the Paris Agreement."

THE PEP Handbook Sustainable Transport and Urban Planning 2019

FOREWORD

Half of humanity—3.5 billion people—live in cities today, pushing the pressure on urban energy consumption, pollution and congestion to problematic levels. Although cities occupy just 3 per cent of the available land, they account for up to 95% of carbon emissions both through transport and energy sectors. It is forecasted that by 2050, more than 6 billion people, about 70 percent of the global population, will live in urban areas. Many of the urban population currently depend on a car or other motorised vehicles for their mobility. This results in an appalling 1 billion cars worldwide (excl. trucks) many of which are in use in (or near) urban centres. In cities, these cars are not only the main sources of air pollution (according to the WHO there are 7 million premature deaths annually) but cities are also home to more than half of the world's 1,25 million road traffic fatalities annually.

Since urbanisation and increased urban mobility needs are inevitable, an intentional push towards sustainability is crucial not only to lessen the strain on social, economic and environmental well-being but also to fast-track national and global development. The New Urban Agenda issued by the Habitat III Conference in 2016 identified metropolitan planning and management as one of the most critical needs to ensure sustainable urbanisation.

It is with these tremendous challenges in mind that member States in the Economic Commission for Europe (ECE) and the World Health Organization (WHO) in the Region have established the Transport, Health and Environment Pan European Programme (THE PEP) in 2002. By providing an intersectoral and intergovernmental policy framework, THE PEP promotes mobility and transport strategies that integrate environmental and health concerns. This Handbook on Sustainable Urban Mobility and Spatial Planning is an example of such implementation mechanism. It has been developed further to a decision of the THE PEP Steering Committee at its Fifth session in November 2017 and the UNECE Inland Transport Committee at its Eightieth session in February 2018. Indeed, these inter-governmental bodies realised that there are major knowledge gaps among ECE member States when it comes to integrating transport, health, quality of life and environmental objectives into urban and spatial planning policies and that these cross-dimensional issues are very rarely looked at from the holistic perspective they require.

The current handbook aims at addressing those remaining gaps and at offering such a multi-disciplinary approach. Designed for various levels and profiles of urban policy and decision makers (including mayors, urban planners, transport infrastructure engineers etc.) it provides access to a wealth of resource materials and references to multiple case studies, good practices and examples from cities across the Euro-Asian region and beyond. A concise set of key messages and recommendations will serve as a substantive input to the Fifth High-level Meeting on Transport, Health and Environment which is taking place in Vienna on 26-27 November 2020.

I believe that the models and approaches put forward in this publication can play a useful role in guiding urban decision makers from across the ECE region in more effectively integrating urban mobility requirements and spatial planning priorities, and in doing so making our cities more liveable and preparing them for a greener, more mobile, digital and innovative future.

Olga Algayerova

Executive Secretary
United Nations
Economic Commission for Europe

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LIST OF ACRONYMS

AEI/AVI:	Automatic identification systems
AI:	Artificial Intelligence
AM:	Active Mobility
APC:	Automatic Passenger Counting
AVLS:	Automatic Vehicle Location System
BRT:	Bus Rapid Transit
C-ITS:	Cooperative Intelligent Transport Systems
CAV:	Connected Autonomous Vehicles
CCEL:	Communauté de Communes de l'Est Lyonnais
CCTV monitoring:	Closed Circuit Television monitoring
CO:	Carbon Monoxide
DLTs:	Distributed Ledger Technologies (ex. Blockchain)
EC:	European Commission
ECOSOC:	Economic and Social Council of the United Nations
EDI:	Electronic Data Interchange
EDITS:	European Digital Traffic Infrastructure Network for Intelligent Transport Systems
ELTIs:	European Local Transport Information Service
EU:	European Union
EVs:	Electric Vehicles
ForFITS:	For Future Inland Transport Systems
GBU "MosTransProject":	State Institution (GBU) "MosTransProject"
GDP:	Goss Domestic Product
GHG:	Greenhouse Gas
GIS:	Geographic Information System
GLONASS:	Global Navigation Satelitte System (глобальная навигационная спутниковая система)
GNSS:	Global Navigation Satellite Systems
GTFS-RT:	General Transit Feed Specification -real time
GTFS:	General Transit Feed Specification
HDV:	Heavy Duty Vehicles
HEARTS:	Health Effects and Risks from Transport Systems
HEAT:	Health Economic Assessment Tool
HIA:	Health Impact Assessment
ICE vehicles:	Internal Combustion Engine vehicles
ICT:	Information and Communication Technology
IEA:	International Energy Agency
IoT:	Internet of Things
IRU:	International Road Transport Union
IT:	Information Technology
ITC:	Inland Transport Committee
ITS:	Intelligent Transport Services
KSODD:	Complex Traffic Management Scheme (in Moscow)
LNG:	Liquefied Natural Gas
LRT:	Light Rail Transit
LUTI:	land use and transport integrated models
MaaS:	Mobility as a Service
MKAD:	Moscow Ring Road

MZA:	Miejskich Zakładów Autobusowych (Warsaw municipal bus operator)
NDCs:	Nationally Determined Contributions
NFC payment:	Near Field Communication Payment (contactless payment)
NGOs:	Non-Governmental Organizations
NMVOC:	Non-Methane Volatile Organic Compounds
NOx:	Nitrogen Oxides
NUPs:	National Urban Policies
OECD:	Organization for Economic Cooperation and Development
OEM:	Original Equipment Manufacturer
PA:	Physical activity
PASTA Project:	promoting physical activity through sustainable transport
PDU:	Plan de Déplacement Urbain
PHEV:	Plug-in Hybrid Electric Vehicles
PM:	Particulate Matter
PPP projects:	Public Private Partnerships projects
PPT:	Public Passenger Transport system
PTV:	Passenger Transport Vehicle
PTV:	Passenger Transport Vehicle
RATP:	Régie Autonome des Transports Parisiens
RTPI:	Real Time Passenger Information systems
SD'AP :	Schéma Directeur d'Accessibilité
SDGs:	Sustainable Development Goals
SEA:	Strategic Environmental Assessment
SIRI:	Service Interface for Real Time Information
SOx:	Sulfur Oxydes
STIB/MIVB :	Société des Transports Intercommunaux de Bruxelles / Maatschappij voor het Intercommunaal Vervoer te Brussel
SUMP:	Sustainable Urban Mobility Plan
SYTADIN:	Synoptique du Trafic de l'Ile-de-France (paris Region road traffic control system)
SYTRAL:	Syndicat mixte des transports pour le Rhône et l'agglomération lyonnaise (Hône District and Lyon metro area public transport managing authority)
TCL:	Transports en Commun Lyonnais (Lyon public transport company)
TCM :	Transportation Management Centres
TCO:	Total Costs of Ownership
TERM:	Transport and Environment Reporting Mechanism
THE PEP:	Transport Health and Environment Pan- European Programme
TIH:	Transport Interchange Hub
TIR:	Transport International Routier (International Transport of Goods)
TMaaS :	Traffic Management as a Service
TOSA concept:	Trolleybus Optimisation Système d'Alimentation
TPG:	Transports Publics de Genève
TRB:	Transport Research Board
TRL:	Technology Readiness Level
UITP:	Union Internationale des Transports Publics
UNDP – GEF:	United Nations Development Programme - Global Environment Facility
UNECE:	United Nations Economic Commission for Europe
VNRs:	Voluntary National Reviews
VOC:	Volatile Organic Compounds
VTTS:	Value of Travel Time Savings
WHO:	World Health Organization
WIM:	Weigh-In-Motion
WP5:	Working Party on Transport Trends and Economics
WTW:	Well-to-Wheel
XML protocol:	Extensible Markup Language protocol

CHAPTER 1.

TOWARDS SUSTAINABLE URBAN MOBILITY

1.1 GLOBAL TRENDS CHALLENGES AND FORECASTS

1.1.1 The quest for hypermobility in times of rising resource limitations[1]. The big picture: climate, health, stress and mobility

FIGURE 1.1 ARTICLE "STRESS AND THE CITY" BY DANIEL P. KENNEDY & RALPH ADOLPHS

The shift towards a predominantly urban world was formally assessed around the turn of the millennium but it took over a decade to start building multilateral regulatory frameworks on climate, sustainability and biodiversity.[2]

Together with national governments – and sometimes even more actively, local and regional governments – a wide range of stakeholders and interest groups from civil society and the private sector have actively grasped change, being at the frontline of daily challenges.

Mobility, health, greener mobility and infrastructure, air quality, CO_2 and greenhouse gas (GHG) emissions are among the most pressing issues faced by communities across the globe, and cities are turning to accelerated environmental transformation and adaptation. This takes place within the larger context of global industry shifts including digitization and the rise of on-demand mobility systems, which show great potential to support the development of new sustainable mobility plans. And yet, the world still has to move from piecemeal experimental approaches to core structural changes, as highlighted throughout the present report.

"The present Handbook of the Transport Health Environment Pan-European Programme (THE PEP) is designed to foster practical solutions and to support local governments and leading stakeholders in moving towards healthier and yet affordable urban systems"

In a world with over half of the urban population living in expanding metropolitan areas, and an expected 600 million new metropolitan inhabitants by 2030, mayors gathered at the U20 Summit in Tokyo in May 2019 jointly affirmed that *"building sustainable and resilient cities is crucial to safeguard the quality of life, livelihood and health of our city dwellers"*.[3] While the necessary changes obviously include mobility and transportation, the present *Handbook* of the Transport Health Environment Pan-European Programme (THE PEP) is designed to foster practical solutions and to support local governments and leading stakeholders in moving towards healthier and yet affordable urban systems.

With over 70 million more people living in urban areas annually (World Bank, 2018) and a forecast of 6.5 billion urban dwellers by 2050, urbanization is a source a global growth – with many problems.[4] (Fig.1.1). Investment gaps are widening, inequalities are rising (OECD, 2018), territorial and social cohesion is at risk (Fleurbaey et al., 2018). Land-use policies are massively ailing (Seto et

[2] The Paris Agreement only came with the COP21 in 2015, as the adoption of the Agenda 2030 and the framework of the SDGs. The New Urban Agenda was adopted in Quito in 2016 at Habitat III. In 2020, the COP15 "Biodiversity" is expected to launch a new convention on biodiversity protection.

[3] Urban 20 Tokyo Mayors Summit Communiqué, May 2019.

[4] Real estate markets should account for more than US$ 4.3 trillion by 2025 (Grand View Research Inc, 2018). Yet the affordability gap is ceaselessly growing, estimated at more than US$ 650 billion per year (UN Habitat, 2018). The global smart cities markets should account for more than US$ 2 trillion per year (Frost & Sullivan, 2018) to US$ 3.5 trillion per year (Research and Markets, 2017) by 2025. Yet, there is little evidence that internet 3.0, IoT, industry 4.0... are self-help drivers for inclusive territorial development (Eubanks, 2018, Temin, 2017). As citizens in cities and regions across the globe struggle with congested mobility systems, social networks, design, television and cinema, literature, etc. are boiling with anticipation and science fiction about cities and their future virtual and physical infrastructures. Creative industries as a whole shape global (urban) imaginaries worldwide, with a market of more than US$ 2 trillion per year (PWC, 2015, WCCE, 2018).

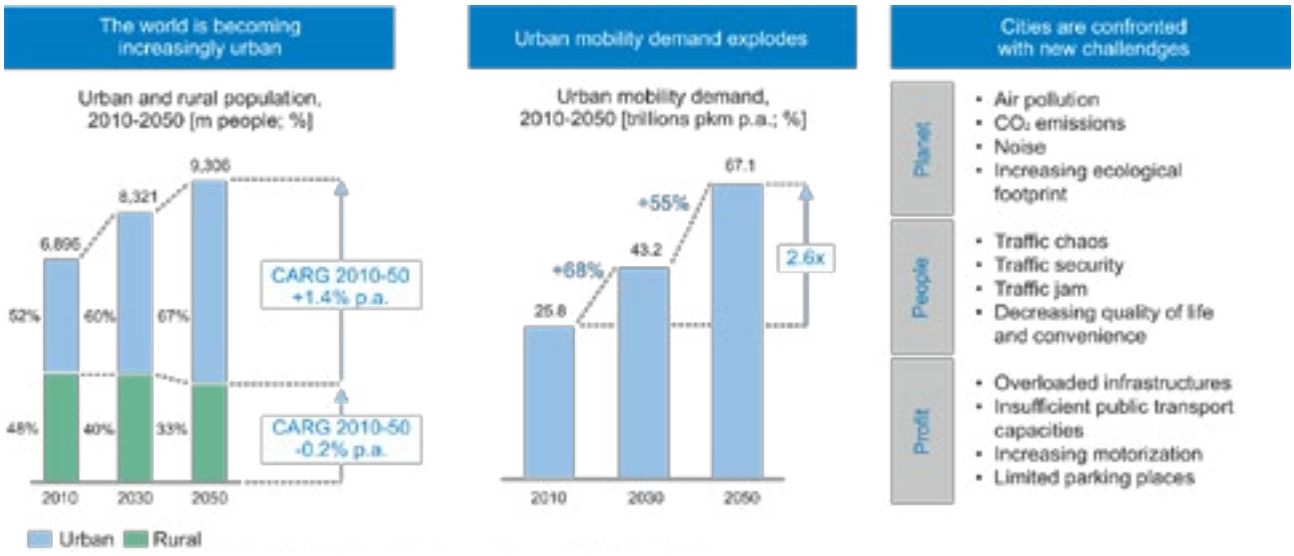
al., 2012; Angel, Galarza et al., 2016)[5] and the ecological footprint of human activities is growing faster than ever (Boulding, 1966; Meadows et al., 1972; Wackernagel, 1996; Rockström, 2009; Sachs, 2015). This is the new normal for infrastructure investments, only that solid evidence about future cities – and corresponding infrastructure and mobility systems – is still to be built up.

In the absence of a clear pathway towards optimal city shape, ensuring equality, sustainability and growth (Salat et al., 2012; Ahfeldt, 2017), communication about off-grid local experiments or investments in designated smart urban mega projects tends to be overemphasized. In developed countries, management costs of existing infrastructure are soaring and citizens' reluctance or resistance to new projects is growing, despite a growing need for mobility. In low- and middle-income countries, the lack of finance for infrastructure threatens both long-term growth (Floater et al., 2017) and the environment.

As illustrated by the Nationally Determined Contributions (NDCs) to reach the Paris Agreement and the Voluntary National Reviews of the Sustainable Development Goals, the call for a cross-sectoral approach to urbanization, mobility and infrastructure development is becoming louder on local, regional and global levels (IISD, 2017, AFD, et al., 2018). It is still, however, to be transformed into applicable policies.[6]

In the transition towards the decoupling of economic growth from carbon emissions (Snower, 2018), a new approach to infrastructure projects is emerging, connecting hard and soft infrastructure, infrastructure finance and user behaviour, civil and financial engineering, changing industry processes (WEF, 2017; Kelly, 2019) and the development of inclusive infrastructure (Mc Kinsey, 2016; IDB, 2018). Mobility is rapidly changing, with digitization offering a wealth of new opportunities to move from siloed to platform or even distributed approaches.[7]

FIGURE 1.2 OUR COMMON URBAN FUTURE[8]



The local expectations and global calls for rapid transitioning towards more sustainable urbanization models take place at a time when health and stress levels in cities are increasingly being regarded as a global problem.

[5] There is a high probability (> 75 %) that large areas of the European continent totalling approximately 77,500 km² – the equivalent of the combined total surface of Belgium and the Netherlands – will have been converted to urban areas between 2000 and 2030 (Seto et al., 2012).

[6] Proposals such as the *Planetary Boundaries* (2009) or the reinforcement of the *Anthropocene Theories* (2009 2016) offer new horizons for a more holistic approach to current global transformations but they have remained mostly conceptual.

[7] Despite the invention of Transit Oriented Development (Calthrope, 1993), the number of motorized vehicles and especially private cars in the world is expected to reach 1.5 billion in 2020, from 675 million in 1990 (Sperling and Gordon, TRB, 2009, UNECE, 2015).

[8] Arthur D. Little Lab and International Association of Public Transport (UITP), The Future of Urban Mobility 2.0, 2014.

1.1.2 UNECE region road users still love cars

FIGURE 1.3 HOW TO STOP CITY LIFE FROM STRESSING YOU OUT

Source: CNN Health, Susie East, Oct. 2016

In the Commonwealth of Independent States, the car-ownership trend has been growing over the past 10 years. However, as initial reference values were low, the current motorization level of these countries is markedly lower than that of developed countries. Many of the largest cities in these countries, however, 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) an increase in car usage measured in kilometres travelled per capita.

In other parts of Europe, the trend is the opposite, driven by local governments and civil society, which describe private car ownership and private car mobility (especially cars powered by fossil fuel) as major hurdles to sustainable livelihoods. The equation is not that simple, however, as shown by recent massive social upheaval in France, triggered by proposed additional taxation on fossil fuels, especially diesel, to help fund a more carbon neutral economy. The proposals were accompanied by measures to lower speed limits on the national road network. Around France's major urban cores, in periurban and rural areas, car ownership is not regarded purely as an issue of lifestyle that can be changed according to fashionable trends.

All across UNECE member countries, global trends are changing mobility patterns and affecting transportation systems and vehicles, be it electro mobility, shared mobility or active mobility. This has an impact on industry, society and urban governance. The rapidly rising digitization of the economy offers many opportunities to rethink urban patterns and mobility issues, which in the future will require much cross-sectoral and multi-stakeholder coordination.

1.1.3 Accessibility and development versus congestion?

"A city living on total automotive dependence becomes dysfunctional, inefficient and inconvenient for life. The goal of the transport system is to move people, not vehicles"[9]

Researchers of urban transport systems agree that with the unbridled rise in the use of privately-owned cars, traditional and mature cities are no longer comfortable to live in. Population growth and increasing urbanization create rising transport demand and population mobility and corresponding challenges related to the accessibility of certain urban areas, transport destinations and transport services. Congestion of urban road networks in large cities is due to transport demand being disproportionate to the capacity of available road infrastructure.

The annual economic damage associated with delays in passenger transport and cargo as a result of traffic congestion in Europe is estimated at around €100 billion, or more than 1 per cent of the gross domestic product (GDP) of the European Union.[10]

For many years, administrations in major cities considered ramping up the capacity of urban roads through their reconstruction and the construction of new ones as the principal measure against traffic congestion. The respective transport planning concepts adopted in the century known for "rapidly developing motorization" were premised upon the paradigm of "planning for cars in cities". As shown by practice, such attempts to tackle the issues of increasing the accessibility of urban areas and easing congestion never yielded long-term positive outcomes due to the emergence of so-called "induced" mobility.

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 expanded road infrastructure – highlighted the need for a new paradigm for urban transport development.

The concept of "sustainable urban transport" or "sustainable mobility" sought to ensure the mobility of the population by reorienting transport demand towards safer and more environmentally friendly modes of transport (i.e. "urban mobility planning").

However, despite all the positive aspects of this approach, which is already partially implemented in many major cities, it nevertheless stems from the given transport demand for which the public transport service system is designed. Planning cities and transport infrastructure around motor-vehicle traffic continues to produce major externalities associated with transport activities, in particular, leading to some 1,250,000 road accident deaths and 3,200,000 deaths from air pollution per annum.

We clearly need to shift our dominant transport paradigm towards focusing investments on creating bright, energetic and lively urban areas adapted to accommodate people's lives. The importance of this approach to urban planning is being acknowledged by a growing number of specialists.[11]

This reorientation of transport planning priorities is intended to complement the basic planning principles of sustainable urban transport systems, such as:

- Creating efficient alternatives to the use of privately owned vehicles.
- Implementing transport demand management mechanisms.
- Developing means of active mobility.
- Integrating transport and urban planning effectively.
- Engaging stakeholders through selecting a transparent and participatory approach.

1.1.4 Transport versus the environment?

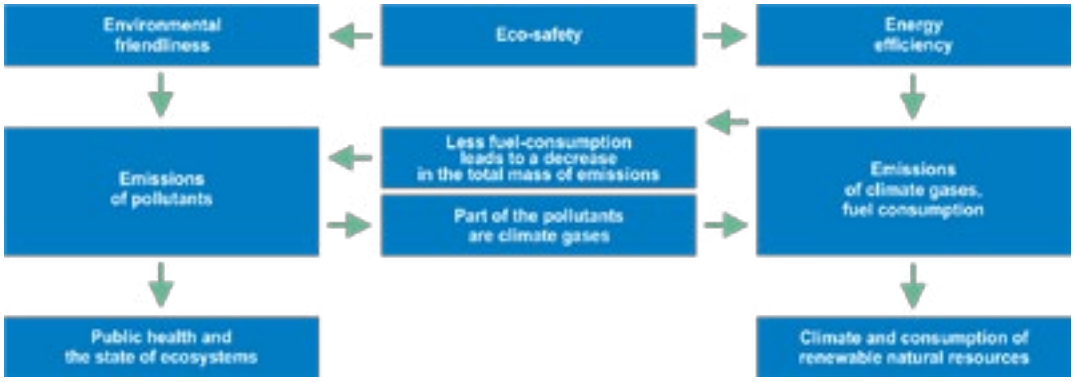
Transport activities, particularly in urban areas, remain a major source of emissions of air pollutants and noise. New data from the World Health Organization (WHO) show that, at the global level, nine out of ten people breathe air containing pollutants exceeding WHO air quality guidelines.

Exposure to ambient air pollution is estimated to cause almost half a million premature deaths per year in the WHO European region. Road transport is a major contributor to emissions of greenhouse gases, which contribute to climate change. In a business-as-usual scenario, by 2030 the share of carbon dioxide emissions arising from transport could reach 40 per cent of the global total.

The health-related effects of climate change include an increase in the frequency and severity of extreme weather events, such as heatwaves, droughts, flash floods, cold spells and changes to the patterns of vector-borne diseases, such as malaria and tick-borne encephalitis. Noise has emerged as one of the top environmental risks to physical and mental health and well-being. In spite of limitations in the availability of data across the pan-European region, it is estimated that at least 100 million people in the European Union are affected by road traffic noise levels exceeding WHO guideline values. In western Europe alone, at least 1.6 million healthy years of life are lost as a result of road traffic noise. Road traffic injuries are the leading cause of death among young people aged 5–29 years and cost governments approximately three per cent of GDP. About one in four road deaths involves a pedestrian or a cyclist.[12] Transport operations entail a series of combined negative effects, including physical inactivity, air pollution, psychosocial impacts such as from noise, impacts on nature, landscape and biodiversity of transport infrastructures, climate change and injury due to traffic hazards.

Transport and, above all, motor vehicles are the largest source of environmental pollution (Fig.1.4). 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 nitrogen oxides (NOx), hydrocarbons (VOC and NMVOC), particulate matter (PM), carbon monoxide and sulphur oxides (SOx).

FIGURE 1.4 ASPECTS OF MOTOR VEHICLE ENVIRONMENTAL SAFETY



Air pollution causes some 350,000 premature deaths per year in EU countries, while emissions from heavy trucks alone inflict health damage to the extent of between €43 billion and €46 billion per year. Moreover, vehicle emissions negatively affect the state of flora and fauna along with the condition of buildings and structures.

Motor vehicles pollute the atmospheric air and the environment not only with the toxic components of exhaust gases but also, for instance, with fuel vapours, tyre wear and road wear products, and brake lining wear.

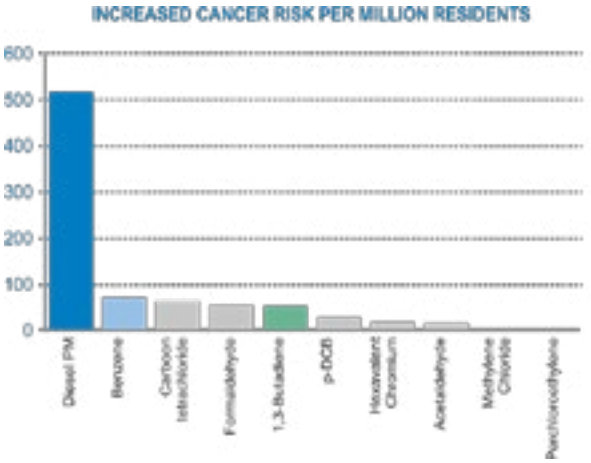
Another worrying issue is the impact of transport on global climate change. Continued urban population growth and economic development will accelerate transport demand in the coming years, which in turn will increase the rate of growth in CO_2 emissions from urban passenger transport. Constraining the global average temperature growth to 2°C will pose a challenge as urban passenger transport is projected to grow by 60 to 70 per cent by 2050 as compared with 2015 levels (ITF, 2017; IEA, 2016). Total motorized mobility in cities may increase by 94 per cent between 2015 and 2050, translating into a 26 per cent global increase in CO_2 emissions resulting from urban mobility growth alone (ITF, 2017).

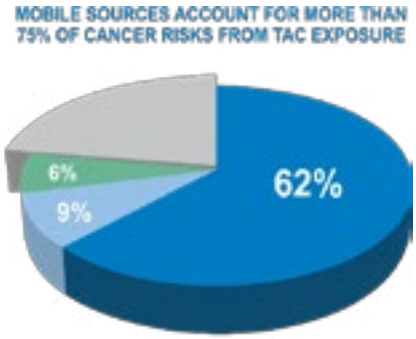
1.1.5 Mobility versus health and well-being?

The negative effects of transport activities relate mainly to the impact of transport 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 of transport on the environment and reduced physical activity due to the excessive use of private cars. Air pollution is ranked fourth in the list of global health risk factors.

The carcinogenic risks arising from particulate emissions released by diesel engines are much higher than the same risks associated with other pollutants (Figs.1.5 and 1.6).

FIGURES 1.5-1.6 CANCER RISKS ASSOCIATED WITH TOXIC AIR POLLUTANTS[13]



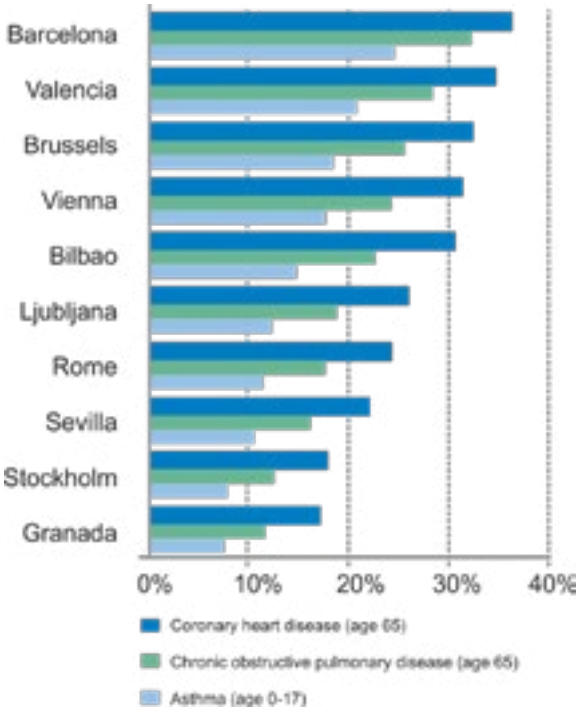


Motor vehicles stand out among other sources of pollutant emissions into the atmosphere due to the exhaust gases that they produce being released into the atmosphere at the ground level, making it difficult for them to disperse. Fig. 1.7 shows the proportion of the population with chronic non-communicative diseases living along urban motorways in 10 European cities.

Public health is also affected by climate change. According to WHO, about 250,000 additional deaths per year will be caused by climate change between 2030 and 2050. It should also be taken into account that the share of motor vehicles surpasses 35 per cent 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 CO_2 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. Well-being is sometimes viewed as an essential element of the quality of life, and an essential component of the broad and so much indefinable concept of "happiness".

FIGURE 1.7 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[14]



The increase in morbidity and mortality associated with the operation of motor vehicles leads to significant additional expenditure on public medicine as well as incurring costs for budgets at all levels. That is why many governments pay special attention to the issue of prevention, and to quality planning for urban areas where transport systems are a critical factor in urban sustainability.

Developing various kinds of active mobility is the most important activity of all in sustainable urban transport planning.

The benefits of active urban mobility are enjoyed by individuals through reduced health care costs, and by city authorities through reduced health care expenses.

Research results indicate that in relation to the costs associated with the treatment of diseases caused by pollution, accident risk assessment, etc. every kilometre travelled by car in EU countries costs society on average 0.15 € whereas every kilometre travelled cycling benefits society in the form of 0.16 € thanks to the improvement of public health and the absence of the negative effects associated with car use.[15]

The positive impacts of active mobility on the economy are numerous. They include:

- Reduced noise and pollutant emissions into the atmosphere.
- Less congested roads.
- Fewer road injuries.
- Lower expenses on road infrastructure.
- Better accessibility and quality of urban life.
- Enhanced physical activity and health of the population.
- More tourism and job creation.

[15] https://www.sciencedirect.com/science/article/pii/S0921800915000907?fbclid=IwAR39ErgnQGfMFWcme9KHmR7TuoqiMsT4bQXruuh-hRlrZEUwYFWqCTJXmTw, Transport transitions in Copenhagen: Comparing the cost of cars and bicycles, 2015.

FIGURE 1.8 THE CONTRIBUTION OF CYCLING AND WALKING TO THE ECONOMY OF LONDON

Studies point to the development of active mobility having a beneficial effect on the urban economy, with pedestrians and cyclists spending 40 per cent more time in stores than motorists!

This conclusion 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 to work take sick leave 1.3 times less often than their colleagues, thus saving the country's economy £128 million annually[16] (Fig.1.8).

Providing compact and dense urban development and diverse land-use patterns in urban areas is conducive to the emergence of active transport modes among the population, which boosts their motor activity. Table 1.1 illustrates possible strategies and key methods for sustainable urban land use and transport.

TABLE 1.1 POSSIBLE STRATEGIES AND KEY METHODS FOR SUSTAINABLE URBAN LAND USE AND TRANSPORT

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

1.2 THE PEP AND THE IMPLEMENTATION OF AGENDA 2030

The Transport Health Environment Pan-European Programme (THE PEP) was adopted in Geneva in 2001. THE PEP High-level Meetings 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 2020.

Key challenges to be addressed

- Growing transport demand and excessive reliance on the use of private vehicles.
- 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.
- Rise in non-communicable diseases due to sedentary lifestyles and general lack of physical activity.

[16] http://content.tfl.gov.uk/walking-cycling-economic-benefits-summary-pack.pdf?fbclid=IwAR2OxnxBhqfofsW5CRSWvQ_gWmTL1euoLdlxtmk9-h5E6UHWo08H3N1ViYk.

Solutions

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

Mechanisms for implementation of the programme

- Holding relay-race workshops (a series of seminars and conferences on issues related to transport, health and environment in cities of the UNECE region to disseminate best practices and knowledge).
- Developing national action plans on transport, health and environment.
- Developing THE PEP partnerships on specific issues related to the objectives of the Programme.
- Developing guidance materials and practical recommendations.
- "THE PEP Academy" (a system of courses and curricula on Transport, Health and Environment, "summer schools", etc.).

The programme established six national partnerships on the topics of eco-driving, green and healthy jobs in transport, integration of transport, health and environmental objectives into urban and spatial planning policies, the Transdanubia Partnership, and a health economic assessment tool for walking and cycling.[17]

1.2.1 THE PEP and the Sustainable Development Goals

On 25 September 2015, the Member States of the United Nations adopted the 2030 Agenda for Sustainable Development, which enshrines 17 Sustainable Development Goals[18]. To achieve these goals, all countries of the world must step up their efforts to tackle issues such as social protection, economic growth, environmental protection, ensuring well-being for all, and fighting inequality. Almost all of the SDGs are linked in one way or another to urban and transport planning and urban activities to improve the sustainability of transport systems.

Building a sustainable urban transport system involves planning all the activities in conjunction with the economy, land use, urban planning, geography, ecology, sociology and psychology. Of the 17 SDGs, the following are related to sustainable development and urban transport systems (Fig. 1.9):

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

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

FIGURE 1.9 THE SDG TARGETS MOST RELEVANT TO THE PEP PRIORITY GOALS[19]

1.2.2 The World Health Organization Healthy Cities Initiative

The WHO European Office Healthy Cities project started in 1986 in 11 European cities, quickly expanding to other cities in Europe. It was not long before the project went international as a way of implementing public health policy at the local level. The objectives of the project are being met through undertaking commitments at the political level in accordance with the principles of "Health for All" 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.

FIGURE 1.10 FACTORS AFFECTING HEALTH[20]

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

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.[21]

The air quality model developed by WHO confirms that 92 per cent 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).[22]

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

[19] 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.

[20] 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.

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

[22] 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.

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).
3. Integrative analytical assessment methods that can be quantified and that 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.

The most famous WHO integrative analytical and quantitative tool is the Health Effects 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.23 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.[24]

1.2.3 Principles of sustainable urban transport systems

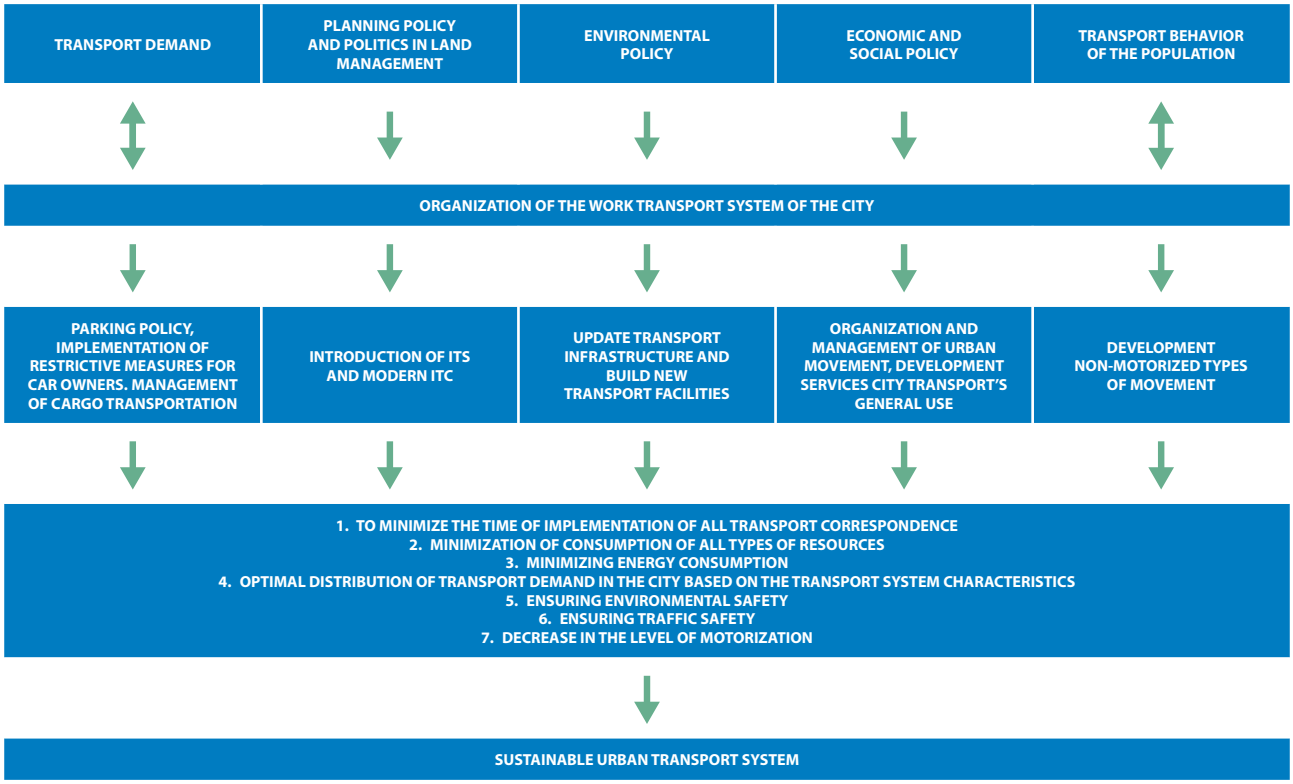
In the light of the various international initiatives, we can determine a first series of basic principles and priorities for sustainable urban transport systems:

- Place the primary focus on people and their needs.
- Improve the quality of life and meet the needs of all people by ensuring equal, safe and equitable access to places, facilities, goods, services and other people.
- Ensure a well-founded selection and alignment of all modes of urban transport and prioritize the use of the most environmentally friendly, safest and cleanest modes of transport and travel (pedestrians, cyclists, public transport, urban rail transport).
- Ensure that packages of quality measures and solutions are designed to deliver cost-effective results and promote sustained socioeconomic growth.
- Use 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.).
- Meet the needs of the economy in ensuring the timely and safe transportation of goods.
- Secure a reduction in the adverse impact of transport activities on the environment and human health.
- Engage key stakeholders, the general public and residents in transport planning.
- Ensure the protection of the rights of present and future generations.

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.[25]

[23] More detailed information on the HEARTS project is available at: http://www.who.int/cardiovascular_diseases/hearts/en/.
[24] More detailed information on HEAT can be found at: http://www.euro.who.int/HEAT.
[25] 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.

FIGURE 1.11 PRINCIPLES OF A SUSTAINABLE URBAN TRANSPORT SYSTEM



The relation between urbanization, rising motorization and the state of the environment derives from several aspects of socioeconomic development and interaction between society and nature. 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 contribute to their professional fulfilment and expand their social and cultural scope.

In the past 15 years, the concept of quality of life in urban areas has come to the fore. The notion of a liveable city brings into focus such things as a home, a district and a city as a whole –the conditions that a city provides in terms of safety, economic opportunities, well-being, health, comfort, mobility, health services, education and recreation.

Nowadays, the basic idea of urban development is beginning to transform into making all the necessary benefits available to people. Accessibility is becoming the main goal of transport systems – establishing a necessary environment for fast and comfortable travel and effective mobility through "open" design and urban planning.

1.3 TAKING ACTION: REBUILDING MODELS, PROFITING BY RAISING ENVIRONMENTAL AWARENESS

In the present report, we present case studies from across the UNECE region and beyond, showing that sustainable urban transport and planning ultimately entails the development of efficient public transport systems. Sustainable mobility plans should be backed by public and private sources of funding. New global regulations might be implemented to balance the impact of venture capital appetite for individual mobility systems.

In 2018, the total market value of the world's largest global ride-hailing companies was about US$ 100 billion, according to a calculation based upon the market value of the companies Lyft, Grab, GoJek and Uber. Uber stock-exchange market value alone was worth US$ 71 billion in 2018, which is more than the combined total investment costs for two of the world's largest metropolitan transportation infrastructure projects: the London Crossrail project and the project for the Grand Paris Express metro network serving the Greater Paris metro area by 2030.[26]

[26] Cross rail cost is about US$ 20.1 billion (source: GLA 2018) and Grand Paris Express cost is about € 38 billion or US$ 43 billion (source: Société du Grand Paris, 2018)

FIGURE 1.12 CIRCULER - QUAND NOS MOUVEMENTS FAÇONNENT LA VILLE. SOURCE: JM. DUTHILLEUL, ED., ALTERNATIVES ÉDITIONS, 2012

We strongly support the development of active mobility policies, as illustrated in chapter 4 of the current report. Such policies are even a critical part of broader public health policies. Yet, we also believe that local-level policies relating to active mobility and healthier urban lifestyles need to consider the impacts of global trends. Cities must be more closely associated with global talks about the future of infrastructure and we hope that the present report will help demonstate that global infrastructure projects must serve and support citizen-oriented, health focused mobility policies, plans and investments.

In several cities across Europe, spatial planning has become radically opposed to private motor cars, especially cars powered by fossil fuel. This trend is accompanied by intense debate and much controversy, as illustrated in June 2019 by huge demonstrations in Madrid opposing the newly elected municipal government's proposal to cancel the creation of a low emission zone in the centre of the city – a proposal which was part of its electoral programme.

Throughout Europe, we see growing convergence of real estate development and public policies featuring sustainable development. In the Russian Federation, programs such as the promotion of "comfort of living" are supporting people-centered development policies including better quality public space.

With this *Handbook*, as illustrated in chapter 7 and summarized in chapter 8, we advocate that urban masterplans across UNECE countries should be converted into integrated urban and transportation development strategies with rolling investment plans in sustainable mobility systems. We call on the UNECE Working Party on Transport Trends and Economics (WP.5) to promote such a policy change widely so as to guarantee long-term financing for public transportation systems.

Despite clear trends towards less car dependency and more integrated sustainable spatial planning and mobility policies, there is much to do, without any chance of a one-size-fits all approach. Whereas in Switzerland, for instance, civil society organizations such as the Association Transports et Environment are being joined by federal organizations to support "housing without cars" projects, growth and development priorities remain a priority in emerging economies.

"We have developed numerous case studies from across the UNECE region and even beyond, showing that sustainable urban transport and planning ultimately relies on the development of public transport systems and corresponding infrastructures."

Designated "smart city" or mega-projects are rivalling each other in size and height across Central Asia. Although such developments, being pushed by capital flows from the United Arab Emirates or Asian countries, include green features and certification, the no-car approach is yet to be advocated for. From integrated and R&D fuelled development projects such as in Amsterdam to more classical and yet rapidly changing planning norms such as in Tashkent, the UNECE region displays a wide range of nuances.

FIGURE 1.13 THE BURGUNDER ZERO CAR DEVELOPMENT IN BERN-BÜMPLIZ, SWITZERLAND (SOURCE: BLS AG).

Beyond the differences between inherited norms and planning and engineering traditions, challenges are common, starting with fighting air pollution, reducing CO_2 emissions, and reversing urban sprawl.

With society changing and technology bringing new opportunities to scale up innovations, the time is now right for action.

FIGURE 1.14 BU DHABI PLAZA PROJECT UNDER DEVELOPMENT IN NUR-SULTAN, KAZAKHSTAN (SOURCE: ADENMETAL)

CHAPTER 2.

Spatial planning for sustainable urban mobility and accessibility

2.1 SPATIAL PLANNING AND TYPOLOGIES OF URBAN DEVELOPMENT: DISRUPTIONS AND TRANSFORMATIONS

2.1.1 Spatial planning in times of change

FIGURE 2.1 THE 2016 NEW URBAN AGENDA ADOPTED BY THE UNITED NATIONS

Spatial planning – at country, region, city or neighbourhood level – is key for sustainable social, territorial and economic development. It stands at the crossroads of land use, the real estate industry and infrastructure development. In today's globalized world and growing urbanization, spatial planning, which used to be based upon long-term forecasts, is affected by systemic disruptions or transformations – climate change, natural hazards, globalized economic and capital flows, and the growth of international migration.

Spatial planning should enhance the integration of such sectors as housing, transport, energy and industry, and improve national and local systems of urban and rural development, while all the time taking into account environmental considerations.

Of all changes affecting cities across Europe and the wider UNECE region, the quest for mobility appears to be the greatest. At any moment of any given day, over 3 million people are in the air, flying. The number of cars on our streets is steadily growing. Global trade and the individualization of delivery of goods is crowding our roads and streets with an unprecedented number of delivery vehicles.

In 2016, the United Nations adopted the New Urban Agenda at the Habitat III Summit in Quito. This document promotes the implementation of national urban policies based upon integrated and mixed-use urban development. It also promotes the role of urban planning as a mean to control land and ensure a universal "right to the city", including access to basic services, housing and employment and to "the benefits and opportunities that cities can offer".

The issue of mobility features many times in the text of the New Urban Agenda, as a key to limit urban sprawl, support balanced urban and metropolitan development, and reduce the social and environmental costs of congestion and pollution.

2.1.2 Uncertainteties about models

Since the turn of the millennium, many cities have engaged in long-term visioning exercises, with infrastructure planning as key. From New York to Tokyo, Sydney to London, Moscow to Shanghai, such grand plans have led to the adoption of significant investment packages. Several cities in India, South-East Asia or Central Asia are also following suit.

FIGURE 2.2 DIFFERENT URBAN STRUCTURES, URBAN PLANNING TRADITIONS AND GLOBAL TRENDS ACROSS CITIES IN THE UNECE REGION (UTRECHT NEW CENTRAL STATION IN THE NETHERLANDS, KAZAN IN THE RUSSIAN FEDERATION)

Yet, the promotion of innovation and the development of new large-scale mobility systems have not prevented a global systemic decline in housing affordability (UN Habitat, 2018, Schumann, 2019). The governance of complex metro areas is generally weak (Lanfranchi et al., 2017) and the adverse effects of infrastructure development on spatial inequalities underestimated (Combes and Lafourcade, 2011, Fingleton and Szumilo, 2019). The connectivity between investments in large-scale infrastructure projects and the building of social capital has been neglected by neo-classical and post-Keynesian economics.

There has been failure to promote compact urban development models. Apart from questionable success stories such as the densification of downtown Vancouver, contemporary urban growth consumes three times more land per capita than in the 1990s (Angel, Galarza et al., 2016), which is true in all parts of the world. Transit Oriented Development (TOD) principles have been developed since the early 1990s (Calthorpe, 1993), but there are still no globally approved TOD standards. "Smart cities" is a concept that has been widely developed since 2005-2006, but there are still no global standards for these either. The International Organization for Standardization (ISO) has been working on sustainable community norms since 2012. The Institute of Electrical and Electronics Engineers is also working on synthetic norms, but there are still no global standards.

2.1.3 Confusion and opportunities in the spheres of mobility and transportation

Unregulated urban growth is the cradle of urban financial success stories – bringing hope, but also confusion. According to McKinsey, $110 billion United States Dollars was invested in mobility startups between 2010 and 2016, with most of it going to startups in the sharing and autonomous vehicle spaces, and the bulk of the investment coming out of Silicon Valley. The global venture capitalist community has been looking for the next big opportunity and believed it to be mobility (not infrastructure), causing systemic disruptions in urban governance, infrastructure finance and planning models. The stock exchange value of ride-hailing companies now often exceeds some of the largest infrastructure investment packages across the globe.

Subsidized public transit has long been the preferred way to move large flows of people at low levels of pollution and congestion per capita. Many promising mobility models now reflect an individualization of travel (Schwanen, 2016) with apps and fleets of cheap light electric vehicles and devices to move people effectively and at much lower costs than regular taxis.

In the United States, public transit ridership figures are already declining. Should cities forego massive infrastructure spending and repurpose roads and parking bays for new free-floating fleets? To what extent new technologies can replace complex transport infrastructures is unknown as no city has been able to reduce car ownership significantly enough to test the hypothesis.

Many changes in infrastructure development and management are under way, from integrated multimodal infrastructures to multirole infrastructures combining mobility and energy systems. Intelligent Transport Systems (ITS) are promising ways to review infrastructure pricing and favor clean transport. Yet, the upscaling of such sets of solutions requires multi-level urban governance systems, which are missing. As of today, divided urban systems are commonplace, in lieu of harmoniously networked urban mangroves.

According to the United Nations Settlements Programme (UN-Habitat), 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 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 five principles that support the three key features of sustainable neighbourhoods and cities: compact, integrated, connected. UN-Habitat supports countries in developing 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:[27]

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 km.
2. High density. At least 15,000 people per km (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; with 20 to 50 per cent of the residential floor area dedicated to low-cost housing. 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 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 concept of the "compact city". Key characteristics of a compact urban environment are shown in Figure 2.3. A compact urban environment is characterized 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.

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 essential for successful spatial planning. Management comprises organization and coordination, policy and planning, and monitoring of projects. Its goals extend to giving a hearing to opinions, analysis, decision-making and clarifying any ideas that may have been misinterpreted.

FIGURE 2.3 KEY CHARACTERISTICS OF A COMPACT URBAN ENVIRONMENT AND A TYPOLOGY OF THEORETICAL BENEFITS OF COMPACT CITIES FROM THE PERSPECTIVE OF SOCIAL LIFE, ECONOMY, GOVERNANCE AND ECOLOGY [28]

[27] https://unhabitat.org/wp-content/uploads/2014/05/5-Principles_web.pdf.
[28] Dileman F., Wegener M. Compact City and Urban Sprawl // Built Environment. 2004. Vol. 30, No. 4. P. 308 — 323.

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 secure private rights in land.

High population density implies great transport demand and a major load on transport infrastructure. The most effective solution is the provision of efficient public passenger transport. The more users there are and the more diverse their requirements are for the quality of the transport service, the more diverse the transport supply and the types of mobility should be. In a compact urban environment with a highly dense street and road network, every mode of transport is given due consideration, including walking and cycling.

As urban residents prefer to live, work, rest and shop in a single particular area without wasting time, money and effort on lengthy trips from one part of the city to another, a new trend in urban development has sprung up within the compact city concept, which is supposed to meet the diverse needs of citizens – "mixed-use development".

Mixed or multifunctional use is a concept of territorial development that implies a variety of functions, social strata and ages. The reach of potential places of attraction is substantially wider, with a balance established between compactly placed facilities and the travelling speed of citizens.[29]

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. The commercial part of the building should be limited to a few grocery stores but should make up a large retail space that would accommodate clothes 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 in close proximity.

Nowadays, the mixed-use concept is a popular trend among urbanists.

The objective of the land-use and development regulations is to minimize 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.

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 property owners.

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

Compact blocks also save time on trips, This way, the city capitalizes on savings on environmental protection measures while the residents enjoy health benefits.

The number and scale of urban agglomerations have been growing in Europe in recent decades. Currently, there are approximately 100 agglomerations with about 60 per cent of Europe's population inhabiting them.

Agglomeration development is associated with high demand for transport capacity, high infrastructure deterioration, environmental issues, and the need for legal regulation of relations with municipalities. Agglomeration areas are also characterized by functional zoning (to include housing construction, production, recreation areas or areas with recreational potential).

[29] 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.

2.2 INCLUSIVE URBAN AND TRANSPORT PLANNING, DECISION-MAKING AND STRATEGY FORMULATION

2.2.1 Principles

The quality of urban management depends largely on the quality of spatial planning, which 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 environmental and health impact of the transport system.

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

Access to transport services – a critical factor in ensuring an inclusive urban environment – includes:

- Physical accessibility and barrier-free transport infrastructure, including, in particular, public passenger transport and non-motorized 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, car sharing services).
- Temporal accessibility of urban areas when using public passenger services.

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. 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.).

Planning for inclusive urban transport systems involves building barrier-free multimodal transport chains for all categories of users.

FIGURE 2.4 A PARK-AND-RIDE NEAR THE CENTRE OF MUNICH (GERMANY). AREA VÉRDA NEW PARKING SYSTEM IN BARCELONA (CATALUNYA, SPAIN), A REGULATED PARKING SYSTEM DIVIDED INTO SEVERAL AREAS. A CHECKPOINT OF THE ROAD TOLL SYSTEM TO ACCESS THE CENTRAL PART OF STOCKHOLM. A MAP OF THE PARIS NEW BICYLE PLAN

To ensure inclusiveness of decision-making in urban transport, there should be wide involvement of different categories of users in all the discussions.

It is also important to learn from the many errors made at different times in different countries and avoid making them again. The worst error among all others was maybe the failure to adopt the principles of sustainable transport and urban planning and the lack of a systematic approach to intermodal transport planning.

Cities that endorsed the principles of sustainable urban and transport planning generally succeeded in becoming more liveable thanks to a combined package of measures, such as:

- Developing and implementing information and telecommunication technologies.
- Developing "electromobility", "smart mobility", shared mobility.
- Implementing automated driving systems.
- Increasing the public's environmental awareness.
- Sharpening the focus on healthy lifestyles.
- Promoting changes in the transport behaviour of the population.
- Implementing step-by-step the concepts *"Cities Are For People, Not For Cars", "Smart City", "Healthy Streets", "Smart Mobility"* by city administrations.

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

The establishment of a visionary and well-grounded urban mobility strategy requires careful consideration of several dimensions (Table 2.1).

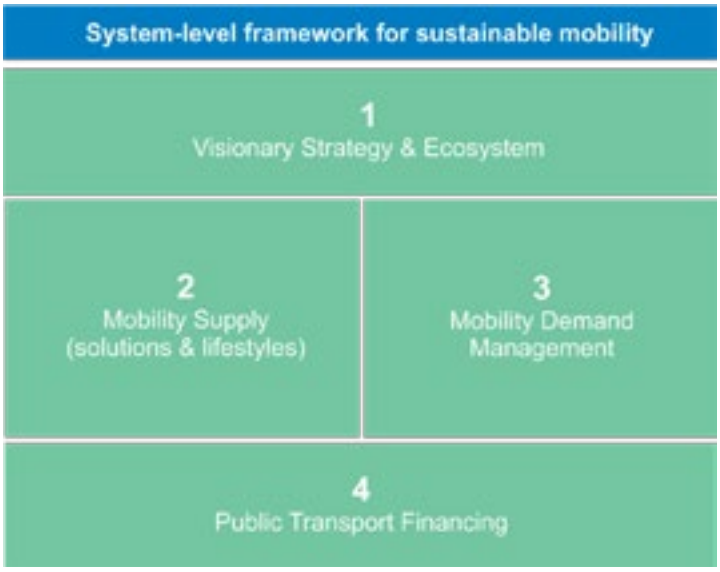
TABLE 2.1 DIMENSIONS TO BE CONSIDERED WHEN DEFINING A SUSTAINABLE URBAN MOBILITY STRATEGY[30]

1 Sense of urgency	■ Understand patterns to reach shared understanding of mobility issues ■ Objectivize current mobility performance & gaps with best practices	Setting the scene
2 Accountabilities	■ Identify key stakeholders and clarify "green zone" of accountabilities ■ Understand current (public and private) mobility initiatives	
3 Stakeholders view	■ 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) & model scope (persons, goods)	Vision and 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 mobility strategy, PR work with other stakeholder groups	

UITP has identified the system-level framework for sustainable urban mobility system (Table 2.2) which includes four elements.

[30] 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.

TABLE 2.2 SYSTEM-LEVEL FRAMEWORK FOR SUSTAINABLE URBAN MOBILITY SYSTEM[31]



For an urban-mobility policy to be successful, all four elements must be improved simultaneously, as the overall results will be influenced by the performance of the weakest link.

Described below is the world's practice of successfully combining 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, with due regard to its particular constraints and resources.

A spatial strategy provides an overview of the proposed pattern of spatial development of the territory and adds value by coordinating the territorial impacts of industrial policies. The critical issue 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 formulating a strategy should take into account the alternative spatial development options which are open to consultation and subject to strategic environmental assessment.

[31] 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.

TABLE 2.3 TENTATIVE LIST OF 25 IMPERATIVES TO BE CONSIDERED BY CITIES AS A BASIS FOR DEFINING SUSTAINABLE URBAN MOBILITY POLICIES[32]

		Cities in emerging countries with partly underdeveloped mobility systems: "Develop Sustainable Core"	Cities with high maturity and low share of public transport, walking, cycling: "Rethink the System"	Cities with high maturity and high share of PT, walking cycling: "Network the System"
Visionary Strategy and Ecosystem	Vision and objectives	Establish a transparent, viable and stable regulatory framework for PT, integrating national and regional mobility prerogatives and ensuring clear allocation of roles and responsibilities		
		Professionalize PTO and formalize public transport	Develop a political vision and urban mobility objectives based on strategic alignment between all key stakeholders	
	Strategy and master plan	Develop a visionary urban mobility strategy and master plan ensuring the right balance between stretch and achievability and shift focus from "supply oriented" to "demand oriented" measures		
	Integration of urban policies	Ensure coordination of transport planning with other policies	Develop an integrated approach for transport planning and other urban policies to shift from isolated decision-making toward integrated urban management	
	Level playing field			Initiate fair competition between modes and business models
Mobility Supply (solutions & lifestyle)	Core PT offering	Invest to establish a sustainable mobility offering and do not replicate mistakes of developed cities	Develop competitive position of public transport by evolving from "transport provider" to "solution provider" via introduction of innovative business models and partnerships	
	Offering Characteristics		Shift PTO culture from "fleet manager" mindset toward customer-centric culture and progressively enhance quality of public transport offering and customer experience	
	Value-Added Services		Further improve customer experience via service offering extension through partnerships and alliances with third parties	
	Integrated mobility		Encourage interoperability and develop multi-modal packages	Integrate the travel value chain via development of integrated mobility platforms
Mobility Demand Management	Awareness creation		Engage with citizens and business community to encourage pragmatic, well-informed and sustainable travel and location choices	
	MDM measures to influence behavior of individuals		Introduce traffic calming measures to optimize streets usage conditions and increase quality of life for residents and businesses	
			Introduce pricing measures to steer mobility demand through financial incentives and better synchronize supply and demand	
		Introduce and enforce parking policy as a critical instrument to steer mobility choices, while gradually increasing sophistication of fee and regulation structure		
	MDM measures to influence behavior of businesses	Define appropriate land-use policies to influence long-term mobility patterns and encourage transit-oriented development		
			Encourage businesses to develop active corporate mobility strategy to improve mobility of individuals and goods while minimizing costs	
Public Transport Financing	Fare revenue	Drive demand for public transport to maximize fare revenue by focusing on gradual increase of service offering quality and ensure transparency of fare adjustment		
			Further individualize mobility offering by providing bundles of services targeting different customer groups at different prices	
	Additional revenues		Assess opportunities to exploit PT assets to derive additional revenues through aggregation of third party services	
	Public funding	Prioritize public funding for capital investments into projects with sound business cases demonstrating policy benefits and long term viability		
	Earmarked charges		Explore opportunities to perceive charges from indirect beneficiaries of PT and earmark them for PT financing	
	Private funding	Further stimulate partnerships with private investors while focusing on preserving business model solidity over short term funding opportunities		

[32] 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

2.2.2 Sustainable Urban Mobility Plans and other strategic transport planning documents

A Sustainable Urban Mobility Plan (SUMP) is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life. Developing and implementing such a plan is fundamentally different from traditional transport planning (Table 2.4).

TABLE 2.4 DIFFERENCES BETWEEN TRADITIONAL TRANSPORT PLANNING AND SUSTAINABLE URBAN MOBILITY PLANNING

Traditional transport planning	**Development and implementation of aSustainable 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

The full planning cycle encompasses four primary phases (Fig. 2.5):

- Meticulous preparation of the planning process ("Preparing").
- Transparent and rational goal-setting ("Goal-setting").
- Development of the plan ("Elaborating").
- Fulfilment of the plan ("Implementing").

Future of Urban Mobility 2.0, 2014.

FIGURE 2.5 DESIGNING SUSTAINABLE URBAN MOBILITY PLANS (SUMP)[33]

The SUMP principles developed by ELTISplus incorporate 11 steps and 31 actions. The steps and actions form a logical sequence. The process is a cycle of actions that take place partly in parallel. The cycle serves as the basic structure for developing and harmonizing the SUMPs. The final actions involve evaluating the process and the result so as to find the best solutions for the next SUMP.[34]

The main problems in implementing a SUMP include:

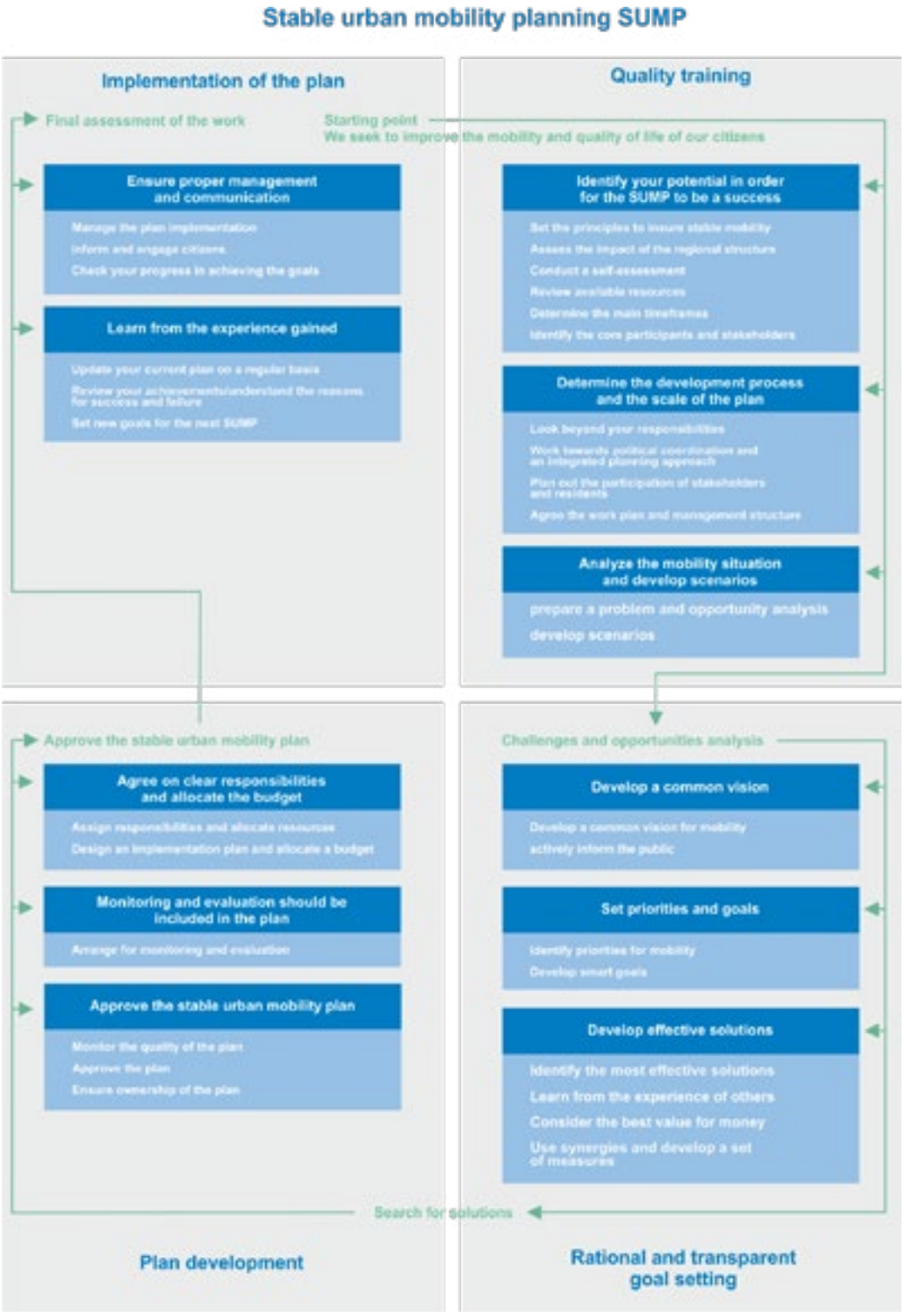
- Difficulties in the collaboration between different authorities and a lack of political consciousness.
- Weak collaboration between the areas of activity: transport, urban development and land-use.
- Insufficient funding and limited budget.
- Lack of experience in developing options.
- Insufficient public support.
- Inexperience in attracting investors.
- Lack of information and data on the application of new programmes and technologies.

The algorithm of action to develop a sustainable urban mobility plan is presented in Figure 2.6.

[33] 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.

[34] 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

FIGURE 2.6 ALGORITHM OF ACTION TO DEVELOP A SUSTAINABLE URBAN MOBILITY PLAN



In 2007, the EU adopted a Green Paper *Towards a new culture for urban mobility*, alongside the *Leipzig Charter on Sustainable European Cities*. In 2015, it adopted an *Urban Agenda* based upon 12 priorities, including mobility. And on the basis of a *White Paper Roadmap to a Single European Transport Area* in 2011, the European Commission adopted a series of 40 concrete initiatives to increase mobility and build competitive transport systems. In 2013, the *Urban Mobility Package* was adopted, recognizing the responsibility of local level stakeholders to promote sustainable urban mobility.[35] SUMPs were introduced

[35] *European Urban Mobility. Policy Context*. European Commission, March 2017.

as part of the implementation of the package, which highlights the connected responsibilities of the EU, and national and local governments in fostering innovation and change. The package also exemplifies how urban mobility relates to other major policies, such as energy, air quality, economy, social equity and accessibility.

A SUMP has as its central goal improving accessibility of urban areas and providing high quality and sustainable mobility and transport to, through and within the urban area. It looks at the needs of the "functioning city" and its hinterland rather than a municipal administrative region.

The European Commission supports the promotion and further development of the SUMP concept, as well as providing the necessary tools and guidance to help cities across Europe implement their mobility plan. The core SUMP principles are presented in Table 2.5.

SUMPs are more than just a technical tool. They can serve as common platforms for policy makers, local authorities, urban transport planners, academics, NGOs and other mobility professionals.

Since their launch in 2013 and according to the European urban mobility observatory Eltis, the SUMP guidelines have become the main reference for the development of sustainable urban mobility plans and have been adopted widely across Europe.

As of 2019, the SUMP Guidelines are being updated to reflect recent trends in mobility, technology and society. This is the right time to actively encourage a triple helix kind of approach to sustainable urban mobility and transport, connecting multilevel governance, urban and transportation policies, and industry.

TABLE 2.5 CORE SUMP PRINCIPLES

Meeting the basic mobility needs of all users
Balancing and responding to the diverse demands for mobility and transport services by citizens, businesses and industry
Guiding a balanced development and better integration of the different transport modes
Meeting the requirements of sustainability, balancing the need for economic viability, social equity, health and environmental quality
Optimizing efficiency and cost effectiveness
Making better use of urban space and of existing transport infrastructure and services
Enhancing the attractiveness of the urban environment, quality of life and public health
Improving traffic safety and security
Reducing air and noise pollution, greenhouse gas emissions and energy consumption
Contributing to a better overall performance of the trans-European transport network and Europe's transport system as a whole

The Guidelines on "Developing and Implementing a Sustainable Urban Mobility Plan" developed by the European Platform on Sustainable Urban Mobility Plans[36] are intended to foster a balanced development of all transport modes, while encouraging a shift towards more sustainable modes.

[36] http://www.eltis.org/sites/default/files/sump_guidelines_en.pdf, Guidelines "Developing and Implementing a Sustainable Urban Mobility Plan", European Platform on Sustainable Urban Mobility Plans, 2014.

A Sustainable Urban Mobility Plan addresses the following issues:

Public transport. The plan should provide a strategy to enhance the quality, security, integration and accessibility of public transport services, covering infrastructure, rolling stock, and services.

Non-motorized transport. The plan should raise the attractiveness, safety and security of walking and cycling. Existing infrastructure should be assessed and improved where necessary. The development of new infrastructure should be envisaged not only along the itineraries of motorized transport. Dedicated infrastructure should be considered for cyclists and pedestrians to separate them from heavy motorized traffic and to reduce travel distances, where appropriate. Infrastructure measures should be complemented by other technical, as well as policy-based, and soft measures.

Inter-modality. The plan should contribute to better integration of the different modes and should identify measures aimed specifically at facilitating seamless and multi-modal mobility and transport.

Urban road safety. The plan should include actions to improve road safety based on an analysis of the main problems and risk areas.

Road transport (flowing and stationary). For the road network and motorized transport, the plan should address moving and stationary traffic. Measures should aim at optimizing the use of existing road infrastructure and improving the situation in the identified "hot-spots" and overall. The potential should be explored for reallocating road space to other modes of transport or other public functions and use which are not related to transport.

Urban logistics. The plan should include measures to improve the efficiency of urban logistics, including urban freight delivery, while reducing emissions of GHG, pollutants and noise.

Mobility management. The plan should include actions to foster a change towards more sustainable mobility patterns. Citizens, employers, schools, etc. should be engaged in its preparation.

Intelligent Transport Systems. ITS being applicable to all transport modes and mobility services, both for passengers and freight can support strategy formulation, policy implementation and monitoring of each of the measures included in the plan.

Basel (Switzerland) drafted and approved a SUMP in 2015. It finished among the three finalists of the 7th SUMP Awards which were announced in March 2019, ranking second behind Manchester, which was praised for its multimodality approach.The Basel SUMP (*Verkehrspolitisches Leitbild*) includes fundamental measures for the next 10 to 15 years. It 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:

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

For each of these strategic areas, the SUMP documented specific goals, strategies and measures. In 2018, the implemented measures were checked for efficiency, progress was monitored and the original measures adapted and extended as necessary. At the same time, new measures and projects were defined for the next three years.

FIGURE 2.7 INNER-CITY AND REGIONAL CONNECTIVITY ARE AT THE HEART OF THE BASEL SUSTAINABLE URBAN MOBILITY PLAN (SUMP)

The Basel SUMP is therefore in different phases at the same time: measures are being implemented and monitored and new ones are being planned and drawn up, while the targets are, in some cases, being adapted.

Many positive results were already seen in the first three years. Some examples include a 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 to public transport.

A significant increase in the number of cyclists, and the noticeable improvement of road safety and air quality are further proof that the plan has been effective. And the possibility to adapt and define specific goals every three years allows new technological developments and trends to be considered and incorporated into the plan. 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 with the French city of Saint-Louis and the German city of Lörrachand. The Basel SUMP is therefore also an example of regional and cross-border cooperation for more sustainability.[37]

The expected effects/impacts of sustainable urban and transport planning strategies can be both local (reduction in air pollution as well as in the accident rate and transport noise) and global (reduction in greenhouse gas emissions) and benefit the population (improved health, lower premature mortality, better quality of life).

It is also important that city administrations draw up programmes for the integrated development of transport infrastructure, which should cover all modes of transport.

The main principles of such programmes are as follows:

- Safety, quality and efficiency of transport services for the population, as well as legal entities and individual entrepreneurs, engaged in economic activities in the territory of a settlement or urban district.
- Availability of transport infrastructure facilities for the population and subjects of economic activity in accordance with the standards of urban planning of a settlement or the standards of urban planning of a city district.
- Development of transport infrastructure in accordance with the needs of the population in the mobility or legal entities and individual entrepreneurs, engaged in economic activities – in the transportation of passengers and cargo.
- Development of transport infrastructure balanced with urban development.

[37] Based on the answers given by Basel to the UNECE questionnaire.

- Management of transport demand.
- Priority conditions for ensuring the safety of life and health of road users in relation to the economic imperatives of business activities.
- Priority conditions for the movement of public transport.
- Development and promotion of walking and cycling.
- Efficient functioning of the existing transport infrastructure.

Various types of transport planning documents (including Master Plans, Integrated Road Traffic Management Schemes, Programmes of Transport Infrastructure Development) are called for to solve the following tasks:

- Ensure transport and pedestrian connectivity of territories including proposals for the development of a regional and municipal network, aimed at reducing the off-target load on federal roads, needed for maintaining local communications.
- Organize rational distribution of transport flows, including transit, along the network of roads with the use of reverse and one-way traffic, if necessary, as well as by improving information support for drivers.
- Regulate traffic lights and implement an automated traffic control system.
- Organize the movement of public transport, especially in dedicated lanes.
- Form a single parking space and, if necessary, paid parking space.
- Develop bicycle and pedestrian traffic and related safe infrastructure so as to relieve a significant load from the road network.
- Ensure road safety.

FIGURE 2.8 COMPREHENSIVE PLAN FOR SUSTAINABLE MOBILITY AND TRANSPORT IN ALMATY

In Kazakhstan, the city of Almaty has engaged since 2013 in a strategy of sustainable transport with technical support from the United Nations Development Programme - Global Environment Facility. Among the main drivers of change were the development of high-speed corridors for public transport as well as the infrastructure for non-motorized traffic.

A new street format was proposed and designed. It 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 Bus Rapid Transit (BRT) line designed in 2015–2016 builds on transport modelling and passenger-flow estimates. A pilot area of pedestrian space reconstruction with a segregated bicycle arrangement was completed in 2016.

FIGURE 2.9 COMPREHENSIVE PLAN FOR SUSTAINABLE MOBILITY AND TRANSPORT IN ALMATY: DEVELOPMENT OF A BRT NETWORK

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 and now services 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 a clear advantage over private vehicles.

The experience of Almaty is unique, as the city has managed to avoid the need for construction of overpasses for stations owing to the open-type BRT.

The advantages are as follows: saved surrounding space, minimum station-to-sidewalk distance, accessibility for people with reduced mobility; and passengers can 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 per cent. In December 2018, new articulated 18-metre buses came 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 progressing towards eliminating private-car traffic with a view to curbing emissions from motor vehicles.[38]

In the Russian Federation, a legal and regulatory framework has been created, establishing requirements for project documentation on transport planning[39]

The Town Planning Code of the Russian Federation provides for the obligation of city administrations to develop programmes of integrated development of transport infrastructure. The requirements for these programmes are set out in Resolution No. 1440 of the Government of the Russian Federation.

In the framework of these programmes, existing and long-term distribution of passenger flows by mode of transport is provided, considering issues of accessibility and quality of transport services, and the environmental and health impacts of transport.

Federal Law No. 443 "On Traffic Management in the Russian Federation" establishes the legal procedures and order for development of documentation on traffic management at local (Traffic Management Projects) and network (Complex Schemes of Traffic Management) levels to ensure quality and safety of traffic. Priority for public transport is a key requirement in traffic management schemes.

Federal Law No. 220 "On the Organization of Regular Passenger and Luggage Transportation by Road and Electric Public Transport in the Russian Federation and on Amendments to the Certain Legislative Acts of the Russian Federation" provides the basis for public transport systems planning.

These documents generally make it possible to create the legal basis for ensuring a sustainable transport system.

One element of transport planning in the Russian Federation is the implementation of restrictions on access of vehicles with low environmental performances on some urban territories. The legal base for such solutions was created[40] according to Article 30 of Federal Law No. 257 of 8 November 2007 "On Roads and Road Activities in the Russian Federation and on Amendments to the certain legislative acts of the Russian Federation", and Article 6 of Federal Law No. 96 of 4 May 1999 "On protection of ambient air". In accordance with these documents, State authorities can ensure the protection of air quality in residential areas. and restrict the access of motor vehicles.

In 2017, the new terms "electric car" and "hybrid car" were defined and relevant traffic signs and markings introduced in the Traffic Code (by Resolution No. 832 of the Government of the Russian Federation of 12 July 2017). The same resolution introduced the new road sign "Zone with restriction of truck traffic by ecological class" and additional information signs "Ecological class of vehicle".

These solutions provide an opportunity for public authorities and local governments as well as for road owners to ban transit of vehicles with low environmental performance through the territory of settlements to reduce the negative environmental and health impact, and to give preference to "clean" transport modes and vehicles.

Advanced and efficient modelling techniques are required to forecast the outcomes of urban and urban transport developments. Different types of models may be used:

- Traditional network and transport planning models that disregard the effects of land use.
- Policy research models that furnish a simplified view of a city and help users grasp the kind of outcomes that a policy can achieve.
- Sketch planning models, which give a representation of the key relations between demand, supply and land use at the strategic level in a city without detailing transport networks or the nature of land use.

[38] Based on information provided by the Mayor's Office of Almaty and the UNDP-GEF Project "Sustainable Transport of Almaty", 2018, https://alatransit.kz/ru.
[39] Provided by the Ministry of Transport of the Russian Federation, 2019.
[40] Provided by the Ministry of Transport of the Russian Federation, 2019.

- Transport and urban planning models are land use and transport integrated models (LUTI), which help get a clear understanding of transport networks and land-use patterns and their interrelation with the focus on strategic issues. This model has the most complex structure.

The land-use and transport model can help understand how people's transport behaviour will shift in response to changes in the transport system; the way in which the efficiency of the system will respond to changes in the nature of its use; how the situation with traffic congestion, pollution, accidents, public mobility will change; how shifts in land use will affect the use of the transport system and how changes in the cost of using the transport system will affect land use.

In practice, it is well advised to combine mathematical modelling for predicting quantitative indicators with qualitative approaches to estimate those indicators that cannot be quantified (e.g. "quality of life").

Use of these complex models, however, requires a considerable amount of resources and expertise.

When developing and implementing an effective urban planning system, the following three key aspects must also be focused on:

- Communities and local organizations engaged in specific urban development activities.
- Stakeholders whose activities, interests, needs and values are directly dependent on urban development issues.
- Platforms for stakeholders and partner organizations to engage with each other.

The involvement of all stakeholders requires mutual efforts to be made in a harmonious and constructive manner. These activities should involve national and local authorities, transport and health sectors, environmental protection and urban planning authorities, business structures and civil society. There should be both vertical and horizontal integration: vertical, from the top level of ministries to grass-roots structures and communities, civil society organizations that play a pivotal part in sustainable development policies, ensuring access to environmental information and awareness-raising; and horizontal, entailing a coordinated strategic approach across all four sectors — transport, health, environment and urban development.

Horizontal integration can be achieved institutionally through combining the functions of the respective authorities (e.g. by creating a single authority for land use, transport and environmental protection), or through establishing special interdepartmental administrative bodies such as commissions or committees, led by the heads of city administrations.

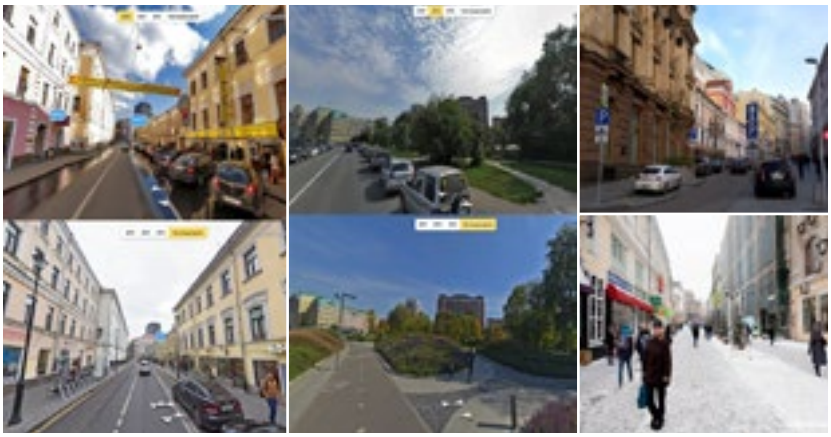
The objectives and goals related to environmental protection and health are vital to decision-making mechanisms in the transport and land-use sectors and therefore should be integrated into these mechanisms. Quantitative indicators to measure the progress of these goals and associated tasks must also be defined, along with the necessary monitoring and evaluation mechanisms and mechanisms to present claims in environmental protection and public health (expertise, monitoring, etc.).

As far as the population is concerned, people need to understand and assimilate the objectives of urban policies if their transport behaviour is to change. Therefore, information and awareness-raising campaigns, especially in relation to aspects of transport demand regulation and mobility implementation models, are strategically important for building public support. Significant success can be achieved through:

- Continuously communicating with local and municipal authorities with surveys and policy evaluations published to ensure transparency in decision-making.
- Making full use of local and national health systems to highlight the health impacts and other beneficial aspects of transport policies.
- Launching mass public information campaigns to tout the benefits of active mobility as a practical, healthy and safe alternative to the use of private vehicles. Raising awareness among parents and children *about the benefits of* walking and cycling, urging them to practise active mobility through offering them demonstration activities.
- Collaborating with the media and NGOs to promote walking, cycling and public transport use, and to generate a favourable image of public transport; to promote car-sharing, car-pooling, park-&-ride spaces (P+R), bike sharing through public events and wide coverage of all propitious environmental, economic and social effects. Popularizing physically active modes of travel brings down the injury rate as motorists gradually adapt to the presence of pedestrians and cyclists on the road as traffic users with equal rights.

2.2.3 Sustainability, mobility, accessibility

FIGURE 2.10 EXAMPLES OF STREET SPACE TRANSFORMATION IN CENTRAL MOSCOW: MAROSEIKA STREET (LEFT) AND CRIMEAN EMBANKMENT (CENTRE), KUZNETZKY BRIDGE (RIGHT)



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 while improving the environment and the state of the urban economy and enhancing the physical activity of citizens. However, planning practices remain too often an obstacle for accessibility policies, especially due to indirect incentives for urban sprawl.

TABLE 2.6 SUMMARIZING ACCESSIBILITY ISSUES

Challenges		
Lack of implementation	Conceptual ambiguity	
	What accessibility?	How much accessibility?
Usability limitations of accessibility measures	Ill conception	Identifying accessibility needs
Usefulness limitations of accessibility measures	Lack of appropriation	Defining sufficient accessibility
Insubstantial role of accessibility in the policy agenda	Low adherence to real-life concerns	Standardisation
	Partial implementation	Loss of meaning of accessibility
		Appropriateness to context of use

It is therefore of vital importance to act and take measures in order to plan and manage accessibility in the context of ensuring sustainable urban development.

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

This target was 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 considering growth effects: the quantitative goal states that the number of cars has to be reduced by 10 per cent in spite of 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 a dense city with narrow streets.[41]

Lyon (France): putting accessibility at the heart of city life[42]

Many European cities are working hard to create liveable cities that are accessible to all – regardless of age, mobility or ability. In France, Lyon has chosen to address accessibility as a cross-cutting issue and to invest substantially in creating a barrier-free and inclusive environment.

[41] Based on the answers given by Basel to the UNECE questionnaire.
[42] http://www.eltis.org/discover/case-studies/lyon-putting-accessibility-heart-city-life, Michiel Modijefsky, 2019.

Promoting independent mobility is an important part of Lyon's overall strategy to become more accessible. This is particularly important considering that around one third of the people who use Lyon's public transport network have mobility issues. This includes people with "permanently reduced" mobility (e.g. wheelchair users, people with visual impairments and those who are deaf or hard-of-hearing) and "temporarily reduced" mobility (pregnant women, and people with pushchairs, shopping or luggage).

Urban mobility and public transport are important focal points in the city's Accessibility Programme. The programme was developed by a Communal Accessibility Commission, consisting of elected representatives of the city and its nine boroughs, and representatives of 62 civil society organizations and institutional partners. Besides mobility, the programme targets the accessibility of public space and municipal institutions, and overall accessibility of life in the city (e.g. culture, education, employment and information).

Specific improvements in urban mobility are planned and guided at the level of the Métropole de Lyon (also known as Greater Lyon). Metropolitan Lyon was created in 2015 as the territorial authority to coordinate the development and implementation of policies in the 59 municipalities that make up Greater Lyon. On behalf of Metropolitan Lyon, SYTRAL is the sole organizing authority of urban and intercity transport in the Greater Lyon area and in the larger department of Rhône.

The extensive and accessible transport network covering Lyon and the greater Metropolitan area is the result of 30 years of continuous planning by SYTRAL, by the public authorities, and by transport operators and other partners. In 1997, Lyon was the first city in France to adopt a Sustainable Urban Mobility Plan (in French, *Plans de déplacements urbains*, abbreviated to PDU) after 2 years of analysis and consultation. The 1997 PDU was revised and updated in 2005 and in 2015 work began on the current PDU (2017 to 2030), which was established in 2017.

With each version, the geographical scope of the PDU was adapted in order to respond to the dynamics of the Lyon agglomeration and the mobility patterns of the population. As such, the 2017 PDU covers 73 municipalities: the Métropole de Lyon, the 8 communes of the Community of Communes Est Lyonnais (CCEL) and the 6 communes of west Lyon for which SYTRAL acts as the transport authority.

The PDUs are considered examples of a well-integrated planning approach, where the various objectives and measures identified are synergetic. For example, the current PDU (2017 to 2030) includes 122 actions along eight strategic axes. One of these is promoting access to mobility for all. At the same time, actions under other strategic axes also contribute to improving access to mobility, for example by promoting:

- The organization of public space around soft/active modes (e.g. walking).
- High quality and service levels for public transport throughout the metropolitan Lyon.
- Integrated land-use planning, with mixed land use to keep distances to services acceptable and maintain appropriate population density to support public transport services.

In addition to the PDU, actions to improve access to mobility and the transport network have been guided by the Accessibility Master Plan (in French, *Schéma Directeur d'Accessibilité*, abbreviated SDA) and the Programmed Accessibility Agenda (in French, *Schéma Directeur d'Accessibilité – Agenda d'Accessibilité Programmée*, abbreviated SD'AP). These voluntary policy instruments were introduced in France in 2005 and 2015 respectively, specifically to improve the accessibility of the roads and public spaces as well as the public transport network.

A budget of EUR 60 million was allocated to carry out all operations to meet this objective. This ambitious programme for the TCL network – which consists of metro, tram, bus, trolleybus and two funiculars – was implemented by SYTRAL between 2008 and 2015.

The public transport network is extensive, including four metro lines, two funicular lines, five tram lines, 1,000 buses and 6,555 stops. All of the vehicles used for public transport are equipped with a low floor, retractable ramps and wider entrance doors, and each has four seats reserved for people with reduced mobility.

All metro stations (except Croix-Paquet, where the configuration does not allow its redevelopment) are now accessible. They are equipped with sound-system lifts and embossed buttons and braille to enable easy access for people with low or no vision, as well as people in wheelchairs. Seven out of 10 bus stops are equipped for people with reduced mobility. Lyon's approach is in many ways an example of an integrated planning and needs-based approach.

Both principles are captured in the underlying objectives of the PDUs:

- The organization of travel must be in line with the development of the agglomeration, including the economy and its companies, with the aim of facilitating the use of the right mode of travel in the right place.
- Users and their needs should be at the heart of planning process.
- Mobility planning should promote social equity and improve access to different mobility services.
- Mobility planning should improve air quality and the quality of the overall environment.

The development of an Accessibility Master Plan also reflects both the high level of user participation and the horizontal and vertical integration of mobility and accessibility planning into wider policy. Even with smaller investment budgets to promote accessibility, the integrated and participatory way in which accessibility has been addressed in Lyon provides a useful example of how to promote accessibility effectively.

2.3 REVIEWING PLANNING STRATEGIES IN "HYPERMOBILE" SOCIETIES

2.3.1 Towards the end of car-centric urban models?

Nowadays, it is clear that the policy of adapting cities to cars is no effective remedy for congestion, because sooner or later there will be no room to move. With mass motorization, the failings of inadequate urban transport planning can no longer be ignored.

The analysis of the situation dominant in most cities in developed and developing countries indicates a number of causes:

1. In most cities, urban transport is not seen as a whole – either functionally or spatially.
2. 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. Financial resources allocated in cities for urban transport are often inadequate, erratic in nature and do not undergo strategic planning.
4. The 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. Weak institutional and technical potential in various functional areas, such as:
   - Traffic management in many cities is narrowly defined and poorly technically implemented:
     - There are no strategic plans with a special focus on these issues. Consequently, cities rarely take road engineering measures to improve pedestrian safety and prioritize public transport
     - Intelligent Transport Systems (ITS) lack wide implementation in traffic organisation and monitoring, as well as in passenger information
     - Traffic light systems are obsolete.
   - 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; and operating costs account for the lion's share of cities' budgets.
   - Inadequate management of the demand for privately owned vehicles by pursuing alternative measures (development of public transport, park and rides, car sharing, carpooling, non - motorized types of travel) along with implementing various transport policies to restrict trips by privately owned vehicles in congested parts of cities.
   - Tram tracks and lines being dismantled, transferred and closed, urban electric transport providers closing and going bankrupt.

6. 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 capitalized upon.
7. Only limited investments are made 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 from now

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-motorized travel. By contrast, separate land use and the prevalence of high-speed motorways increase the number and length of road trips.

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 this. 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 close link between urban planning and mobility, much more attention should be paid to analysing 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-motorized 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.[43] In other words, "demand creates supply, and supply creates demand".

2.3.2 Fighting induced transport demand

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).

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. Owing 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 overcome congestion. However, experience has shown that such measures do not reduce the level of congestion in the long term.

Generally, it takes induced transport demand a few years to offset the effect of expanding transport infrastructure. In most 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 other hand, the deployment of a public passenger transport system (PPT) is gradually gaining in efficiency by attracting more users.

In this regard, measures to contain "hypermobility" need to be taken – covering a wide range of administrative, economic and information measures, directed in the first instance at minimizing the negative effects of "hypermotorization".

The following are some solutions to limit "hypermobility" or "mobility sprawl":

(a) Organizational: 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.

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

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.
- Organization of one-way traffic on all sections of the network which will enhance the capacity.
- Introduction of strict parking rules, especially in the streets.
- Placing public transport at an advantage in traffic, including by 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.
- Introduction of fees for using certain sections of the street and road network, such as a fee to drive into the city centre.

In Basel, the forecast for urban public transport demand is made with a high-resolution multimodal transportation model, which considers public transport, motorized individual transport, bicycle and pedestrians. Park & Ride and Bike & Ride are also displayed in the model. The model perimeter includes the Swiss, German and French part of the Basel metropolitan area.[44]

2.3.3 Case studies and good practices

The Green Mobility initiative, supported between 2013 and 2017 by the Nordic Council of Ministers (Copenhagen) which is being carried out by the International Centre for Social and Economic Research "Leontief Centre" (based in St. Petersburg) represents a unique strategic platform aiming to achieve 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.

FIGURE 2.11 KAZAN (RUSSIAN FEDERATION) IS MOVING TOWARDS AN INTEGRATED APPROACH OF TRANSPORT AND MOBILITY

In Kazan (Republic of Tatarstan, Russian Federation), the city seeks to curb down congestion with measures to optimize traffic (traffic signalization, re-marking roadways), to address the demand-side management of trips by private motorized transport (paid parking, calm traffic zones), to redistribute traffic flows (one-way traffic) and to create new transport links (construction of new roads, overpasses, junctions).

The shaping of a sustainable urban transport system in Kazan rests on 10 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.

[44] Based on the answers given by Basel to the UNECE questionnaire.

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. Prioritizing 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.[45]

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 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 forecasted 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 utilizes 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.[46]

FIGURE 2.12 A TRANSPORTATION PLAN FOR 2040 IN TYUMEN (RUSSIAN FEDERATION)

In Tyumen, the city administration approved a transport infrastructure integrated development programme for Tyumen for the period from 2018 to 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.

[45] Based on the answers given by Kazan to the UNECE questionnaire.
[46] Based on the answers given by Kazan to the UNECE questionnaire.

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 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 contained in the Master Plan provide for a functional saturation of the public city centre, strengthening its representational and socio-cultural functions. It is this part of the city 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.[47]

FIGURE 2.13 DEDICATED LANES FOR PUBLIC TRANSPORT AND CYCLING IN MOSCOW

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.

The main components of a new Moscow transport system, which is currently under development are based on the following: Improved convenience: modernization of the rolling stock, development of passenger information systems, implementation of intermodal ticket and tariff solutions, increase of urban transport capacities, development of barrier free 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; organization 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, optimized 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 organization in charge of determining whether routes should be altered and the financial and operational indicators of operating routes re-calculated. Whenever required, changes in the route network are introduced in the shortest time possible, with the necessary time taken to properly inform the public.

[47] Based on the answers given by Tyumen to the UNECE questionnaire.

Demand forecasting is carried out by macro modelling. 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.

Essentially, 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 activities.[48]

FIGURE 2.14 SUSTAINABLE MOBILITY IN THE INNOVATION DISTRICT OF SKOLKOVO (MOSCOW)

Skolkovo is 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 transport 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.

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 the Russian Federation 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.[49]

[48] According to the response of Moscow to the UNECE questionnaire.

[49] According to the Green Mobility initiative, supported between 2013-2017 by the Nordic Council of Ministers (Copenhagen) which is being carried into effect by the Leontief Centre, www.mobility.leontief-centre.ru.

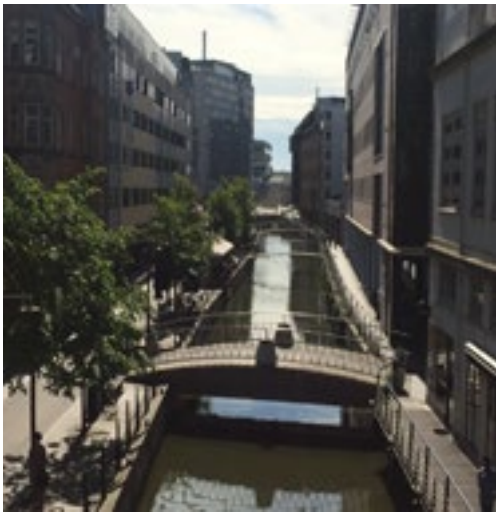
FIGURE 2.15 AN INTEGRATED URBAN TRANSPORT PLAN IN STRASBOURG (FRANCE)

In Strasbourg (France), a 5-year Urban Transport Plan was adopted after a participatory process 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 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.
- Building new, and improving existing, cycle paths.
- Increasing awareness of the health benefits of active mobility.[50]

FIGURE 2.16 A LONG HISTORY OF DEVELOPING A LIVEABLE CITY OF AARHUS (DENMARK)



Aarhus (Denmark) should be CO_2-neutral by 2030. 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. Rundown industrial estates are disappearing to be replaced by housing and knowledge-intensive businesses. Several 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 be in the future house Aarhus School of Architecture and other educational institutions together with youth-/student housing. Today Godsbanen is the driver of the area, a 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 proved it. Aarhus had been preparing for this for at least 25 years. Investing in the university with its 60,000 students makes Aarhus the youngest city in Denmark, and as a result of investments in social centres, like Godsbanen, and music halls and theatres in the restructured port area more and more people choose Aarhus as a place to live.

[50] Based on the answers given by Strasbourg to the UNECE questionnaire.

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

To prevent such consequences and solve the challenges ahead, the city of Aarhus has developed a policy vision focusing on growth, liveability, health, sustainability and densification. Here are these policies 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 liveable city.

Main initiatives:

- A road network leading to central parking facilities.
- Improved 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 Downtown Mobility Plan (2017) for the City of Aarhus replaced the existing Downtown Traffic Plan from 2005. The main objective of the Downtown Traffic Plan had 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 met through a focus on active and public travel modes as well as reduced commuting distances.

The 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 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 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 free up surface area for a more liveable public realm.[51]

[51] According to 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), www.mobility.leontief-centre.ru.

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 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.[52]

2.4 URBAN TRAFFIC MANAGEMENT: PREVENTING CONGESTION

2.4.1 Passenger traffic

A growing urban population leads to an increased demand for urban routes but their extensive development no longer meets all the mobility needs of societies and economies.

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 consider the environmental and social factors of decision-making.

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 recognize the collision that occurs between cars and cities as an objective reality.

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

- Growing public motorization.
- 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 motorization and the pace of road construction.
- Several objective urban planning problems related to urban spatial development inherited from the past.[53]

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

The experience of many countries 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:

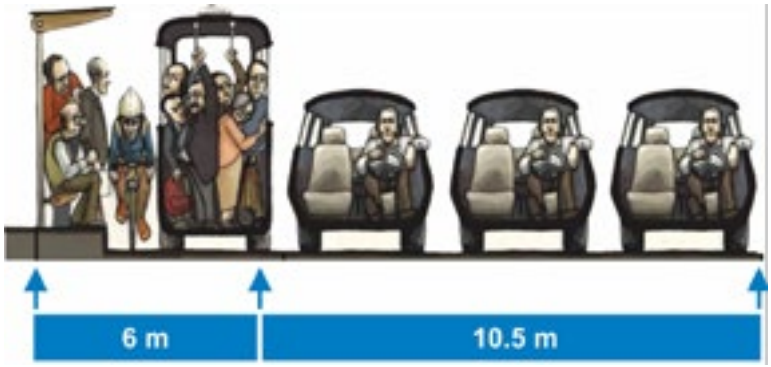
- Knowledge of the characteristics and effects of different modes of transport on the urban environment.
- Viewing transport as a functional system comprised of many different elements elements integrated for optimal use.
- Concerted efforts to strike a balance between the behaviour of individuals and 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 considered: 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 human-oriented urban environment.
- A phased plan must be drafted to implement activities aimed at creating a liveable city.[54]

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

[53] 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.

[54] 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.

FIGURE 2.17 DISTRIBUTION OF STREET SPACE BETWEEN TRAFFIC USERS



Specific measures should influence the transport behaviour of citizens by shifting the "point of balance of individual preferences towards a social optimum"

Priority passage (or *high-level right of way*) 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.

Implementing priority passage includes a variety of engineering and organizational 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 ensure a rational transport policy encompass fiscal and organizational measures that make daily car trips to the city centre more expensive and inconvenient. What also merits mention is "Internalization of externalities", bringing user costs on urban road trips into line with the full amount of actual costs including social and environmental ones.[55]

1. **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.
2. **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 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.
3. **Principle No. 3.** Each section of urban space, that is streets, passages, sidewalks, yards, has its owner. Parking unauthorised by the owner is deemed an offense. Paid parking is a tool used to limit excess transport demand where it is 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.[56]

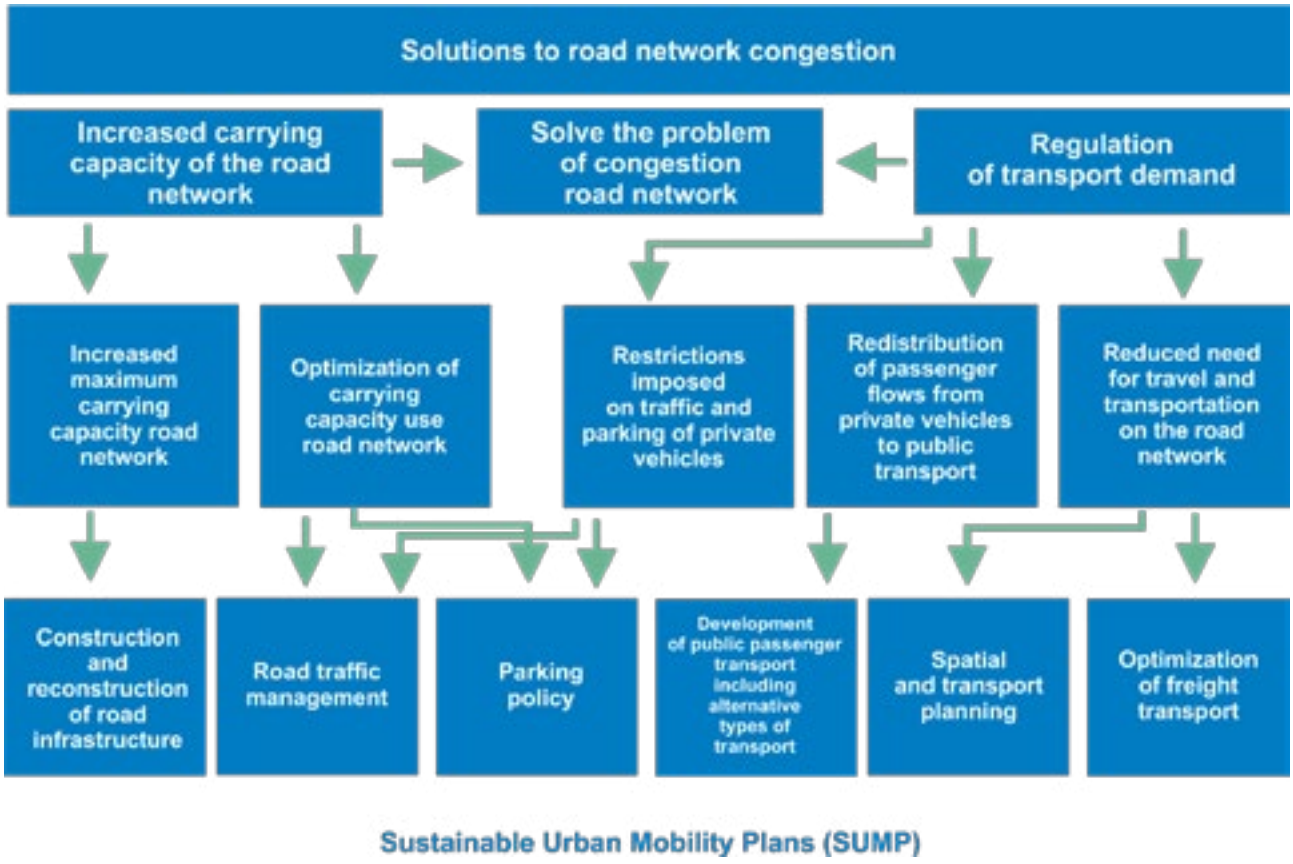
The principles listed above lead to the following common practices:

- 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 city centres, cars are banned from parking on the street and only allowed to stop to drop off passengers. Parking on sidewalks is limited by engineering means or administrative prohibitions. The idea is to impose on users 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, shall 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.

55 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.

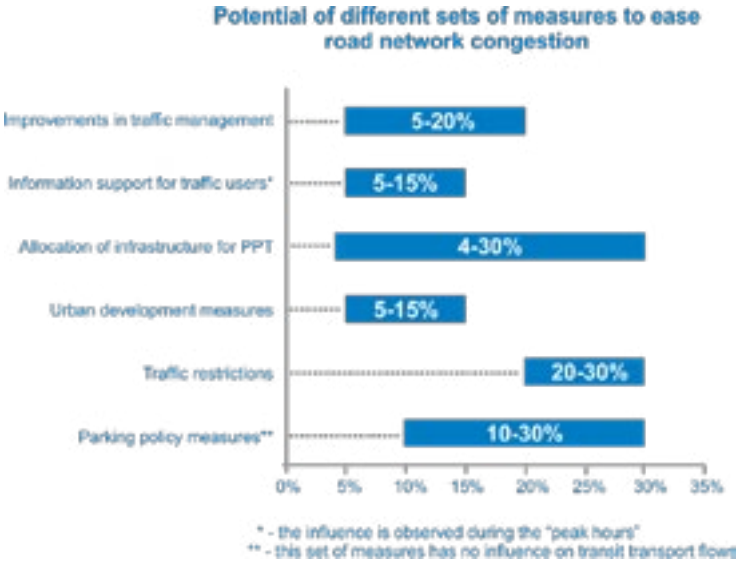
56 http://www.litres.ru/pages/biblio_book/?art=2874155 Vukan R. Vuchik, Transportation for Livable Cities / translated from English by A. Kalinin under scientific editorship of M. Blinkin.: Territory of the future; Moscow; 2011, ISBN 978-5-91129-058-0.

FIGURE 2.18 SOLUTIONS TO ROAD NETWORK CONGESTION



2.4.2 Urban freight traffic and city logistics

FIGURE 2.19 POTENTIAL OF DIFFERENT SETS OF MEASURES TO EASE ROAD NETWORK CONGESTION



Urban logistics should be seen as the practical organization of the 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 exchanges among economic entities.

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 harmonized in carrying out works which affect the capacity of highways and 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 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 optimized; 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.[57]

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

Despite freight transportation making up 10 to 15 per cent 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).[58]

Given the large scale of distribution of goods flows, cities are faced with the challenge of managing them properly. Developing measures to optimize 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 per cent of the vehicles on the road in the European Union, they are responsible for 22 per cent of road transport CO_2 emissions and this is only expected to grow. Road freight transport is projected to increase by 56 per cent between 2010 and 2050. At the same time 4,000 EU citizens die in truck accidents every year.

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 means 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 several 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. 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.

[57] Filimonov V. Gorodskaya/munitsipal'naya logistika (City/municipal logistics) http://www.fill2001.narod.ru/GorodskayaLog.htm.
[58] Rodrigue J.-P., Dablanc L. City Logistics, http://people.hofstra.edu/geotrans/eng/ch6en/appl6en/ch6a2en.html.

An 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. CO_2/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.

TABLE 2.7 KEY STATISTICS - TRUCKS, BUSES AND COACHES IN THE EU REGION[59]

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 decarbonized	T&E study shows how to decarbonize 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
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

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

2.4.3 Case studies and good practices

TABLE 2.8 LEVERS TO CONSIDER WHEN DEFINING APPROPRIATE URBAN LOGISTIC SCHEMES[60]

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	

In all cities throughout Europe, urban freight and last-mile logistics are a growing concern, linked with the exponential development of on-demand shipping.

Italy's Largest Low Emission Zone "Area B" is launched in Milan[61]

To try to combat congestion and air pollution, Milan has limited city access further for petrol and diesel vehicles. With an area covering approximately 72 per cent of the entire municipal territory, "Area B" is now Italy's largest low emission zone.

"Area B" is a region of 97.6 per cent of the city's resident population (almost 1.4 million inhabitants). It impacts all those who enter the city by motor vehicle every day, steadily and progressively restricting the most polluting ones in a bid to enhance air quality.

Euro 0 petrol vehicles and Euro 0, 1, 2 and 3 diesel vehicles are now banned within this area from Monday to Friday between 7:30 and 19:30 (excluding holidays). On 1 October 2019, Euro 4 diesel vehicles will also be banned (these have been banned from the central "Area C" since 2017). Gradual bans for other classes of passenger and freight vehicles will follow until 2030, the point which all diesel vehicles will be banned in Milan.

The introduction of "Area B" has been described by the municipality as "part of a definite, progressive and gradual set of rules to reduce particulate matter and improve urban quality in Milan". They predict air pollution to decrease dramatically in the next few years: it is expected that atmospheric traffic emissions will reduce by roughly 25 tonnes of PM10 and between 900 and 1,500 tonnes of NOx by 2026.

This news comes just weeks before the Ultra Low Emission Zone (ULEZ) comes into force in London, where drivers of older, more polluting vehicles (up to Euro 4 for petrol and Euro 6 for diesel) are now being charged to enter the congestion zone area at any time.

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[60] 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.

[61] http://www.eltis.org/discover/news/italys-largest-low-emission-zone-area-b-launched-milan, Hannah Figg, April 2019, United Kingdom.

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.

These measures have led to the number of transit trucks in Moscow diminishing by 25 per cent with the average daily traffic speed on the Moscow Automobile Ring Road climbing by 4 per cent. 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 several environmental aspects, achieve reduced noise levels in residential areas and overall improvement of the road transport situation.[62]

In Minsk (Belarus), the government has introduced restrictive measures on the passage of trucks with a total weight of more than 1.5 tonnes on some 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.[63]

FIGURE 2.20 "LA CHAPELLE INTERNATIONAL" INTEGRATED LOGISTIC HUB IN PARIS, CONNECTING RAILWAY, ROAD AND URBAN STREET NETWORK, WAS OPENED IN JUNE 2018 (SOURCE: SOGARIS)

2.5 ORGANIZING URBAN PARKING SPACE AND PARKING POLICY

2.5.1 Basic principles

One of the cornerstones of the State policy in traffic management is "organization of the urban parking space and parking policy".

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.).

[62] 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.

[63] Based on the answers given by Belarus to the UNECE questionnaire.

In creating a single parking policy 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.
- Empowerment of the organization 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 operate the facilities, or attract a private partner on a competitive basis under PPP projects.

The organizational 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: improved traffic conditions; 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.

The experience of European countries demonstrates that introducing single parking space systems, including paid parking lots in the street and near the road, and 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 per cent and improved transport accessibility to major places of attraction.

2.5.2 Case studies and good practices

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

In London, when a vehicle is registered to enter to city's toll system, 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. In 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. This policy has gone with a comprehensive approach to public space transformation, a trend that many European cities are following.

FIGURE 2.21 PARKING INSPECTOR ON DUTY IN WESTMINSTER, LONDON, PARKING AREAS RESERVED FOR TWO-WHEEL VEHICLES IN GROSVENOR SQUARE, LONDON, CAR PARKING SPACE IN ONE OF THE CENTRAL STREETS OF MUNICH COMBINED WITH A BICYCLE PARKING LOT, DEDICATED PARKING AREA FOR TWO WHEEL VEHICLES IN ZURICH (SWITZERLAND)

The competition for innovation between European cities is intensive. Barcelona prides itself to be the first city to use 100 per cent of the proceeds from parking to fund a public bike rental programme. Paris (France), has one of the densest network of bike-sharing systems in the world and the municipal government has launched several initiatives to expand public spaces at the expense of cars. In Copenhagen too, thousands of metres of street space have been transformed into a pedestrian zone while hundreds of parking spaces have been removed.

The peculiarities of specific cities and 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. In that context, new issues are arising, such as the management of the enforcement of new regulation systems. In many cities, law enforcement is now being outsourced to private companies who developed sophisticated digital monitoring systems to control parking. This trend goes with other technological innovations of parking metering (electronic database of private vehicles, scanning cars).

FIGURE 2.22 "MOSCOW PARKING SPACE" PROJECT

Since the 1990s, the situation of street parking in Moscow was notoriously chaotic. In 2012, the municipal government launched the project "Moscow Parking Space" designed to enable comfortable traffic of pedestrians, public transport vehicles and motor vehicles.

Since it was launched, 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 billion rubbles (€260 million). The most popular mode of payment among drivers is the "Parking of Moscow" mobile application (it is used by 84 per cent of drivers). The outcomes are very positive, with an increase in the traffic speed by 12 per cent, a decrease in the number of parking violations by 64 per cent, a decrease in the number of private vehicles entering the Garden Ring Road by 25 per cent, an increase in the turnover of car space by a factor of 4.[64]

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

FIGURE 2.23 TBILISI COMPREHENSIVE NEW TRANSPORT AND PARKING POLICY

Tbilisi City Hall Transport Policy is focused on 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. The system will be gradually implemented in the city infrastructure and will contribute significantly 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, etc. The City Hall has also introduced bus lane arrangement on Pekini and Shartava streets. It is also planned to include bus lanes on every major street.[65]

FIGURE 2.24 PARK-AND-RIDE ON RADIALNAYA STREET IN MINSK (BELARUS) AND IN ST. PETERSBURG (RUSSIAN FEDERATION)

In 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. Minsk currently has two such parking lots. There are four ways to pay the parking fee: via a parking card, by sending a text message or used i.e. a request to a common short number, through a parking meter or a payment terminal, as well as via mobile or internet banking (United Payment and Information Space).[66]

In St. Petersburg (Russian Federation), 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 the city. Putting them to use will help citizens reduce travel time and avoid traffic jams[67].

2.5.3 The key towards successful parking space management strategies

Pricing

Street parking tariffs

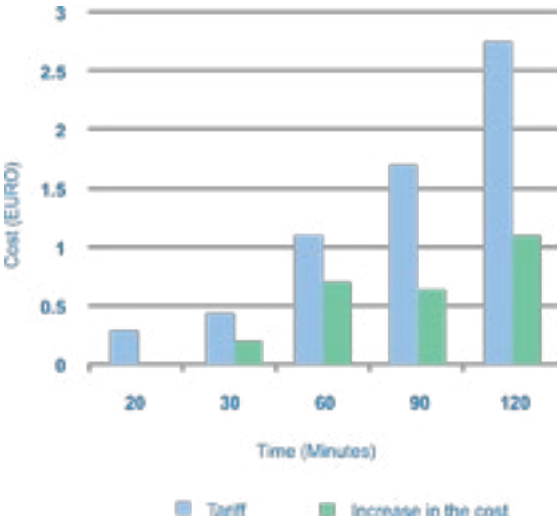
A fee for using street space is usually introduced in order to optimize the use of the roadway (motorway). It influences the extent to which space is used minimizing the number of cars which slow down traffic in search of parking space. The fee is set based on the demand sensitivity (that is, depending 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.[68]

[65] Based on the answers given by Tbilisi to the UNECE questionnaire.
[66] Based on the answers given by Belarus to the UNECE questionnaire.
[67] https://www.gov.spb.ru, the official website of the Administration of St. Petersburg.
[68] Simon Anderson and André de Palma (2004). "The economics of pricing parking," *Journal of Urban Economics*. University of Virginia. Volume 55, Issue 1.

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 harmonization of fees charged for street and off-street parking. The fees should be aimed at encouraging drivers to opt for off-street parking.

Several European cities have established "Controlled Parking Areas", 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, preference is given to visitors who come for a short time to do shopping, and to 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 the day.

FIGURE 2.25 THE PROGRESSIVE SCALE FOR PARKING SPACE FEE IN THE BLUE ZONE, MADRID, SPAIN



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 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.

Parking regulations at the place of residence

Trips between the city's central business district 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.

FIGURE 2.26 BIKING STATIONS IN LYON (FRANCE) AND BARCELONA (SPAIN)

Taxation for companies that reserve street parking spaces

There is a practice of imposing additional taxes on companies and enterprises that provide parking space for their employees.

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.

Regulations

Limiting the number of parking spaces for cars

Hamburg, Zurich[69] 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. Thus, each off-street parking space within a limited area should result in the same number of street parking spaces eliminated

Introduction of a parking maximum limit

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, 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.

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.

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 their pollution levels exceed the established standards. This strategy is used in the following cities, for example: Berlin, London and Milan. In addition, cars with high exhaust emissions are also prohibited from parking in the city.

Coping with a new generation of challenges

FIGURE 2.27 UNREGULATED FREE-FLOATING MOBILITY DEVICES THREATEN THE ENVIRONMENT AND RAISE CONCERNS REGARDING SAFETY AND COHABITATION WITH PEDESTRIANS IN DENSE URBAN CENTRES

While cars are the main target of new parking regulations, it should be noted that public space is affected by a new generation of mobility devices, especially free-floating bikes or electric scooters, resulting in overcrowded pavements at the expense of pedestrians.

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

Design

Physical barriers against cars

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.

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.

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.[70] The development of the tram network in Strasbourg 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 reorganizing the space in a way that meets the approved security requirements. In Zurich, 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, there are so-called "residential street" zones ("woonerfs"), where cars left parked by residents make up winding roads, forcing cars to move slower near cyclists and pedestrians. In Paris and Copenhagen, 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 in Antwerp (Belgium), there are streets with children's playgrounds organized 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 and technology

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 per cent 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.

[70] 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.

"Smart" meters

Smart parking meters 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 meters 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.

FIGURE 2.28 EXAMPLE OF AUTOMATED FINING SYSTEM IN PARIS (FRANCE)

Parkon cars equipped with a scanning device

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.

To achieve effective management of parking space, the main four mechanisms are used: economic impact mechanisms, regulatory influence mechanisms, organization of design works and contractual relationships.

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.

CHAPTER 3.

PUBLIC TRANSPORT PLANNING, THE CORNERSTONE OF SUSTAINABLE URBAN MOBILITY

3.1. PUBLIC TRANSPORT AS A KEY ELEMENT OF A "LIVEABLE CITY". INTEGRATED URBAN DEVELOPMENT POLICIES ACROSS THE UNECE REGION

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 choose a good workplace, where we can manage to realize 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 organizations.

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, Figure 3.1) 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, Figure 3.2).

FIGURE 3.1 MADRID, SPAIN. THIS DISTRICT PERFECTLY ILLUSTRATES BOTH APPROACHES TO RAISE THE ACCESSIBILITY IN A CITY: THE OCCUPATION DENSITY HAS RISEN WITH 5-6-STOREY APARTMENTS, WHILE THE INCREASED TRAVEL SPEED IS PROVIDED WITH LIGHT RAIL LINE ON A SEPARATED TRACK

FIGURE 3.2 KRASNODAR, RUSSIAN FEDERATION. THIS LIGHT RAIL LINE DEPLOYED IN THE CENTRE OF THE AVENUE IN ORDER TO REDUCE CROSSINGS AND RAISE THE SPEED OF TRAM TRAINS. THE LINE IS SURROUNDED BY THE TREES FOR ECOLOGICAL AND AESTHETICAL REASONS. THE BUSHES PROVIDE THE GREEN FENCE FOR SAFETY AND HIGH-SPEED MOTION

A massive transition of commuters from public transport to private vehicles led to a growth of total costs (extending to direct costs and externalities) for transport system operation. 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 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.

FIGURE 3.3 LACK OF TRANSPORT GOVERNANCE AND CAR DEMAND MANAGEMENT, WEAK PUBLIC TRANSIT PLANNING LEAD TO POOR CONDITIONS FOR ALL USERS OF TRANSPORT SYSTEMS, REDUCE QUALITY OF LIFE AND AFFECT THE CITY'S ECONOMY

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).

The purpose of public transport was transformed from "transport for the poor" at the end of the 19th century to "transport for sustainable development" at the turn of the 21st century. As of today, mobility and transportation plans are still largely being developed in parallel or with too narrow connectivity with urban plans (master plans). Yet, the convergence of land use and mobility is a key for territorial sustainability.

3.2 WHY PUBLIC TRANSPORT SHOULD BE THE BACKBONE OF SPATIAL PLANS

3.2.1 Comparative assets of mass transit and individual mobility

As individual mobility is not declining, and urban sprawl is a reality, it makes sense to review a series of comparative assets of mass transit and individual mobility, be it about environment, budgets, safety and quality of service.

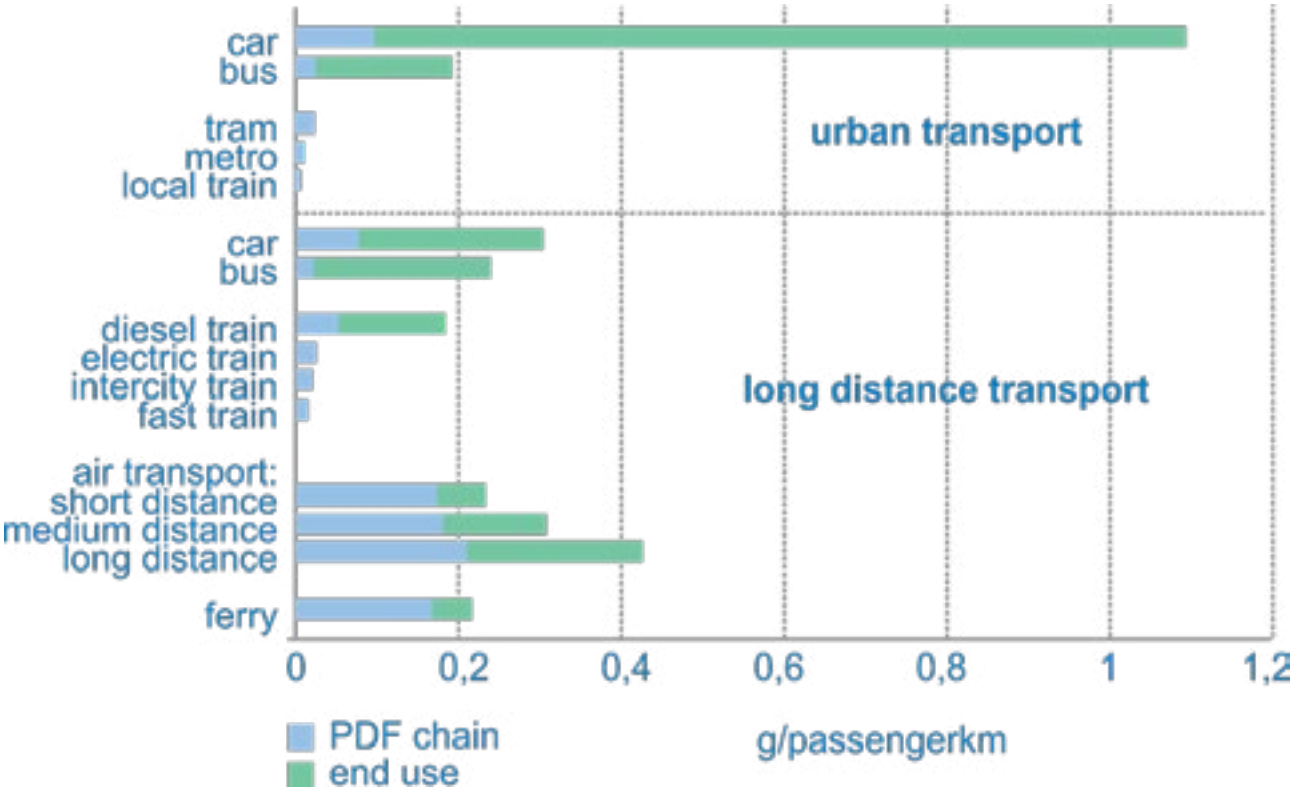
Environmental impact. Studies show that emissions of pollutants can be reduced by 1.3-5 times owing to transportation by bus as compared with private vehicle transportation, and by 4-1,000 times by using rail transport (including energy production, Figures 3.4 and Table 3.9).[71]

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 per cent of the electricity that feeds the tram system is generated by wind farms causing zero environmental damage.[72]

In addition to fuel pollution, urban air pollution with micro particles 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.[73] As city buses transport 10-20 times more passengers than cars per kilometre (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.

FIGURE 3.4 EMISSIONS BY MODE OF TRANSPORT, INCLUDING FUEL PRODUCTION AND DELIVERY, AS WELL AS IN TRAFFIC, G/PASS-KM



[71] http://www.trafikdage.dk/td/papers/papers96/tr_og_em/kaleno/kaleno.pdf
[72] https://www.tfgm.com/environment/public-transport.
[73] 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

TABLE 3.9 EMISSIONS BY MODE OF TRANSPORT, INCLUDING FUEL PRODUCTION AND DELIVERY, AS WELL AS IN TRAFFIC, G/PASS-KM.

	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	0.010	0.019	0.029	0.028	0.027	9.2	0.0011
Tram	0.004	0.008	0.012	0.012	0.011	3.9	0.0005
Metro	0.003	0.006	0.008	0.008	0.008	2.7	0.0003
Local train							
Long distance transport							
Road transport	2.659	0.308	1.034	0.066	0.079	119	0.0391
Car(**	0.360	0.245	1.460	0.029	0.163	82	0.0301
Bus							
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	0.574	0.234	0.741	0.204	0.007*	217	0.0012*
Short distance (200km)	0.605	0.309	1.055	0.210	0.008*	230	0.0012*
Medium distance (300 kt)	0.717	0.429	1.799	0.245	0.009*	268	0.0014*
Long distance (> 500 km)							
Ferry transport	0.344	0.218	4.536	1.610	0.137	220	0.0011*

***includes only the emissions during the production and distribution of the fuel**
{passenger car fleet at year 1994**

Distribution of space. 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 can 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, and also cycling as an addition to public transport, see examples at Figures 3.5-3.7).

FIGURE 3.5 GENEVA, SWITZERLAND. THE ROAD SPACE IS DIVIDED BETWEEN ALL THE MODES – RAIL TRANSIT, PEDESTRIANS, BIKES AND CARS. ONLY SINGLE LINE IS PROVIDED FOR CARS

FIGURE 3.6 MOSCOW. THE NARROW STREET SPACE IS DIVIDED REASONABLY BETWEEN PEDESTRIANS, CYCLISTS AND BUS/CAR TRAFFIC

FIGURE 3.7 DÜSSELDORF, GERMANY. SEPARATED CYCLING LANE PASSES BULB TRAMWAY STOP

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 (Table 3.11).

Road safety. 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 (Table 3.10). 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 whereas when transported by tram, the numbers will go down by 55 times in comparison to car transportation.

TABLE 3.10 NUMBER OF ROAD ACCIDENTS CAUSED BY MOTORISTS PER ONE PASSENGER TRANSPORTED IN THE RUSSIAN FEDERATION

№	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, several sources show a rise in traffic safety in urban areas due to a growing share of public transportation. For example, according to UITP,[74] 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. Pedestrian crossing barriers – «labyrinths» - can improve safety (Figure 3.8).

FIGURE 3.8 DÜSSELDORF, GERMANY. PEDESTRIAN CROSSING BARRIERS PROVIDES SAFE TRAM LINE CROSSING, FORCING A PEDESTRIAN TO LOOK AT COMING TRAMWAY BEFORE THE LINE CROSSING

[74] https://www.uitp.org/news/knowledge-brief-LRT

FIGURE 3.9 DÜSSELDORF, GERMANY. RAMP FOR GRADE-SEPARATED CROSSING OF BIKE LANE WITH RAILROAD PROVIDES SAFE AND CONVENIENT SEAMLESS TRAVEL FOR CYCLISTS

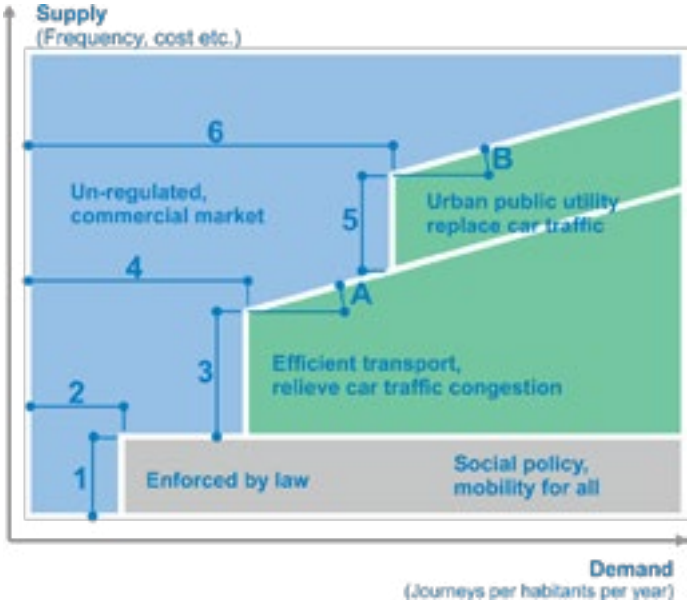
Quality of service: accessibility, safety, security, travel time, punctuality, affordability, etc.

Public transport, in its essence, is 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 subsidization 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 3.10. 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.

FIGURE 3.10 POSSIBLE LEVEL OF QUALITY STANDARDS FOR TRANSPORT SERVICE GIVEN DIFFERENT LEVELS OF DEMAND[75]



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.

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 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. Level 4 shows the 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.

As shown in Figure 3.13, 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.

[75] Gustav Nielsen. Public transport — Planning the networks. HiTrans Best practice guide 2 / Guidelines. Skytta, Norway. 2005 — 176 p.

FIGURE 3.11 COMPARISON OF OPERATING COSTS AT DIFFERENT LEVELS OF SERVICE QUALITY STANDARDS FOR THE SAME VOLUME OF TRANSPORTATION

Transfer of 300 passengers per hour – two solutions, expensive and cheap:

1. High standard:
   Headway: ≤ *10 min*
   Load: ≤ *1 passenger/m²*

Expensive: 6 buses on a route

2. Low standard:
   Headway: ≤ *30 min*
   Load: ≤ *6 passenger/m²*

Cheap: 2 buses on a route

In the Russian Federation, the Federal Social Standard was adopted in order to provide methodical support for 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. 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.

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.

FIGURE 3.12 PARIS, FRANCE. BUS STOP PAVILION HAS AN ATTRACTIVE AND PRACTICAL DESIGN, CONVENIENT FOR MAINTENANCE. GLASS WALLS PROVIDE COMFORTABLE WAITING AREA FOR PASSENGERS

FIGURE 3.13 MOSCOW. THE BUS STOP IS EQUIPPED WITH TICKET MACHINE AND A DISPLAY BOARD WITH ACTUAL ARRIVAL TIME

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. 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. In justifying expenditures, a fair balance of incomes and an attainable level of expenses must be ensured which allows for adequate financing of transportation for the sake of compliance with technological requirements.

Also, in 2017 the Russian Traffic Regulations were updated with the two new signs restricting entry of motor vehicles according to their environmental class: the "Low emissions zone for freight vehicles" sign, and the "allowed vehicle environmental classes" additional information sign. These will allow to ensure priority of the more environmentally clean vehicles, including working on gas engine fuel. Besides, some measures were taken to subsidize production of the high environmental class vehicles, including working on gas engine fuel. During implementation of the National project "Safe and High-quality Roads" (2020 - 2024), a bus fleet renovation is planned for the 20 biggest urban agglomerations. The allocated funds for the fleet renovations amount to 20 billion RUR, and the new buses working on compressed natural gas will be prioritized.

FIGURE 3.14 THE NEW BUSES OF VOLGABUS COMPANY WORKING ON COMPRESSED NATURAL GAS IN THE RUSSIAN FEDERATION

3.2.2 Principles of public transport routes network planning

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 free-of-charge transfers at several stops across the agglomeration.
- 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.

- 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.
- 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 (structure of tariffs, fare payment systems, information systems and marketing) in coordination with restrictive measures for private vehicles.

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 the necessary success either.

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

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.

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 enough 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 is an even more ambitious goal.

Definition of the transport network structure

The idea of public transport is to serve several persons per vehicle for less generalized cost (direct expenses and externalities like pollution, accidents, time spent, etc). The larger amount of people per vehicle – the closer is the goal (reduction of generalized costs). The basic principle of public transport is the concentration of passenger flows along a small number of routes, so as to achieve larger loads per vehicles, while keeping the reasonable headways (about 10 minutes or less). Transfers are an integral feature of a large share of routes. 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 begin 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 divided by 60 minutes) on routes with low traffic should be ensured.

Understanding the role of planning in different institutional environments

Successful planning requires studying the organizational structure of transport management, stakeholder interaction, demand for public transport services and changes in the sector.

First, 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 centralized planning over a city.

Second, 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".

Third, 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.

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.
- Various patterns of regional transport management 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.
- Organizational 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 important.

Capitalizing on the synergy of the network effect

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.

In order to compete with the private vehicle sector in an urban environment in a 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. 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.

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

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.

The influence of rail infrastructure on the development of adjacent territories can be well traced in world practice. 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 memorize 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 preferences. LRT has excellent adaptive ability: the capacity of the rolling stock and carrying capacity can be incrementally increased from 1,000 up to between 15,000 and 18,000 passengers per hour without having to restructure the infrastructure. In particular, the 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 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).

Network effect[76]

Regardless of demand elasticity and service frequency being interdependent in an intricate way, doubling the traffic frequency along the route will lead to traffic growth by only 20 – 50 per cent, 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 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.

3.2.3 Principles of PT mode choice and organization 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.

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 high-capacity buses and 11 articulated trams (27 m) 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 (Table 3.11). The high frequency of bus traffic requires a dedicated lane whose costs must also be considered.

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 per cent more expensive than transportation by tram, transportation by medium-capacity buses will be 89 per cent 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 manifold 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 close to standard load. The task of the transport planner is to select the rolling stock and intervals in such a way that all vehicles are filled as close as possible to the permissible load density during peak hours but without exceeding it.

[76] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005

TABLE 3.11 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[77]

№	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

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 3,900-4,000 passengers per hour, the frequency of extra-large capacity buses will exceed 30 vehicles 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 vehicle-built-in 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 (Figure 3.15).

[77] According to data obtained by IEC (Infrastructure Economics Centre) in the Russian Federation, http://infraeconomy.com/en/.

FIGURE 3.15 PARIS. ALL THE TRAMWAY STOPS ARE EQUIPPED WITH PLATFORMS, LEVEL WITH THE VEHICLE FLOOR, ALLOWING NOT ONLY CONVENIENT ACCESS FOR EVERYBODY, BUT ALSO REDUCING BOARDING TIME. EVERY PLATFORM HAS A SPECIAL WAITING AREA WITH ENOUGH WIDTH AND SEATS. THE TYPICAL STOP IS EQUIPPED WITH AN INFORMATIONAL TABLE ON WAITING TIME FOR THE ROUTES SERVED

Environmental requirements encourage the gradual transition to electric transport, that is the tram, trolleybus, electric bus, and urban electric railway.

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 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 in German, Swiss, Austrian or some other countries' cities have no more than 1-2 routes per street, which consequently helps ensure that large and extra-large capacity vehicles are filled in conformity with the applicable passenger density standard while also saving costs for transport services.

3.2.4 The interactions between different 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 maximize 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.

FIGURE 3.16 DÜSSELDORF, GERMANY. CROSS-PLATFORM TRANSFER BETWEEN BUS AND TRAMWAY PROVIDES MOST SAFE AND FAST TRANSFER, ALLOWS TO REMOVE EXCESSIVE ROUTES AND RAISES THE ROUTE NETWORK EFFICIENCY

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 (from vehicle door to vehicle door), as well as, if possible, arrivals of transport vehicles common stopping station at intersections (Figure 3.19).

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.

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.

At rail/bus crossings over the bridges, the upper level bus/tramway/rail stop should be provided exactly on the bridge above the crossing, and the below level stop – just below the bridge, so as to provide the shortest walking distance possible, with the lifts (and escalators – upstairs, und downstairs on busy stations) connecting the levels in all possible transfer directions. Use of stairs should be minimized and replaced with lifts and escalators (Figures 3.17 - 3.20). Transfer shortest paths are usually more important, then shortest connection to surrounding area, due to increased amounts of people wishing to transfer then to start/end their journey here (Figures 3.21, 3.22, 3.25).

The best type of interchange is cross-platform interchange, when the vehicles stop at both sides of the same platform (Figure 3.23). In order to achieve this, some ground transit routes in Toronto, Boston, Valencia and other cities routed underground, to provide cross-platform interchange with subway. The other means to make an interchange convenient is to concentrate all the routes under the same shelter, e.g. routing tramway line into the station building (Figures 3.23 - 3.28).

FIGURE 3.17 DÜSSELDORF, GERMANY. ESCALATORS ARE CONNECTING STREET LEVEL WITH UNDERGROUND PEDESTRIAN SPACE TO PROVIDE THE MOST CONVENIENT PEDESTRIAN ROUTE

FIGURE 3.18 ST. PETERSBURG. THE NEW TRANSIT HUBS ARE EQUIPPED WITH ESCALATORS GOING TO STREET LEVEL, PROVIDING ATTRACTIVENESS FOR PASSENGERS

FIGURE 3.19 GENEVA. TRANSIT HUB AT RAIL TERMINAL PROVIDES THE SHORTEST WALKING DISTANCE BETWEEN ALL MEANS OF TRANSPORT (RAIL, TRAMWAY, TROLLEYBUS, BUS, TAXI). THE TRAMWAY AND TROLLEYBUS STOPS ARE LOCATED JUST INSIDE THE RAIL CROSSING TUNNEL

FIGURE 3.20 ST. PETERSBURG. LADOZHSKY RAIL TERMINAL IS A GOOD EXAMPLE OF TRANSIT HUB, INTEGRATING INTERCITY RAIL, SUBWAY, TRAM AND GROUND TRANSIT IN THE SAME HUB BUILDING. WALKING DISTANCES BETWEEN THE MODES ARE THE SHORTEST POSSIBLE

FIGURE 3.21 ST. PETERSBURG. PASSENGERS CAN TRANSFER BETWEEN ALL MODES IN THE SAME TERMINAL BUILDING. THIS IS COMFORTABLE ON RAINY AND SNOWY DAYS

FIGURE 3.22 GENEVA AIRPORT PROVIDES CONVENIENT AND SHORT WALKING DISTANCES BETWEEN THE TERMINAL AND ALL THE OTHER MODES (INTERCITY RAIL, TROLLEYBUS AND BUS LINES)

FIGURE 3.23 TORONTO. TRAMWAY LINES ARE INTEGRATED WITH UNDERGROUND SUBWAY STATIONS SO AS TO PROVIDE THE SHORTEST AND MOST COMFORTABLE TRANSFER TIME BETWEEN TWO RAIL MODES

FIGURE 3.24 TORONTO. TRAMWAY LINE RAMP FOR THE UNDERGROUND STATION IN ORDER TO PROVIDE THE MOST DIRECT CONNECTION WITH THE SUBWAY STATION

FIGURE 3.25 TORONTO. TRAMWAY LINE BUILT TO THE SUBWAY STATION BUILDING, SO AS TO PROVIDE THE SHORTEST AND MOST CONVENIENT TRANSFER TIME

FIGURE 3.26 MOSCOW. TRANSIT HUB AT KUTUZOVSKAYA INTEGRATES SUBWAY, URBAN RAIL, BUS AND TROLLEYBUS ROUTES WITH THE SHORTEST WALKING DISTANCES POSSIBLE. THE BUS STOP IS PLACED DIRECTLY AT THE BRIDGE OVER THE RAIL LINE IN FRONT OF THE STATION ENTRANCE

FIGURE 3.27 DÜSSELDORF. TRAMWAY STOP IS PLACED ON THE RAILWAY BRIDGE IN ORDER TO MINIMIZE WALKING DISTANCE AT TRANSFER

FIGURE 3.28 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

For larger cities and metropolitan areas there is usually need for higher capacity public transportation service. With a rich 20th century rail heritage, urban rail services are here to help. One of the best examples – Moscow Central Circle was opened in 2016 in Moscow using an existing 54 km railway loop which was used exclusively for freight operations. Payment modes are the same as on other types of city public transportation. Although considered as a Central Line it is a fine example of "classic" urban heavy rail service.

Tram-train is a light rail mode of transportation that has its own separate rail infrastructure inside several cities of an agglomeration which share heavy rail infrastructure among them. This mode of transportation shares the advantages of both heavy and light rail systems: capacity, safety, accessibility to the cities' very centres, but without the need to construct seperate tracks among the cities of an agglomeration.

Usage of tram-train systems is quite popular in Germany and Switzerland with vast urbanized areas of high- and mid-density development. Such "hybrid" modes would be in demand in polycentric agglomerations with distance between cities no more than 30-50 km. Implementing such systems might require some changes in national technical standards, as it might be forbidden for light rail rolling stock to use heavy rail infrastructure even if compatible with heavy rail signalling systems.

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 provide 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 of relevance:

- 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 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.

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 are dependent on 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.

3.2.5 Specific issues of urban public electric transport development

Urban public electric transport in many countries 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 they were gradually divided, generating a disintegration and causing unnecessary transfers.

Nowadays, 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 unified ticket for all the modes for 90-minute journey with unlimited transfers (with prohibition of tickets and tariffs "by transport mode" or "by vehicle entrance") as well as delivering high-frequency service on all the rail modes, 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 (with free transfers between both modes). The system operates during the day and integrates rail transport into citywide transport to serve as an interchange hub to facilitate transfers.

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 traction (electric, diesel, etc) operated takes a backseat to the track structure, i.e. the extent to which the public transport line is segregated from the road traffic. Surveys[78] 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 road network.

The conventional bus - trolleybus division is effaced with the introduction of an electric bus, that is a trolleybus with autonomous capabilities. For the electric bus to run, it needs to pass approximately 20-25 per cent of the route under the contact wire to have enough 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 without any additional cost.

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.

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).

[78] 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".

FIGURE 3.29 SCHAFFHAUSEN, SWITZERLAND. THE PARLIAMENT VOTED TO PRESERVE TROLLEYBUS OPERATION IN THIS SMALL TOWN DUE TO ECOLOGICAL REASONS

In cities where passenger traffic is under 500 passengers per hour, building a trolleybus line is not economically viable, so the largest number of urban and agglomeration routes remain covered by buses – mainly electric buses, powered by contact wire, but able to come out of the wire to serve the surroundings. 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).[79] As compared to road transport, rail transport has several advantages:[80]

- higher carrying capacity
- reduced amount of land required to transfer passengers
- 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 tyres and pavement
- no other vehicles on the dedicated line (owing to the railway-design track)
- higher traffic safety (less manoeuvres, no other vehicles on the road, ~ 4 time fewer accidents per passenger).

Throughout the UNECE region, tramway face a rebirth, which is not new but now becoming common again. In the west of Europe, the development of tramways was relaunched in the 1980s in cities such as the French cities Nantes, Grenoble or Strasbourg. The eastern part of Europe is also witnessing similar changes and cities which still operate old trams such as Bucharest are actively looking for modern replacement solutions. Meanwhile in the Russian Federation starting with Moscow which plans to renovate over 60 km

[79] 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".
[80] http://mapget.ru/strategy/rol-get/

of tram line by 2020,[81] many large cities have engaged in tram redevelopment and modernization. In Azerbaijan, Baku is likely to also develop a new tram network.

In some cases, trams can have a similar impact on urban development than railways and serve as a catalyst for transit-oriented development or in such case, we could say tram-oriented development. In Basel (Switzerland) a new neighbourhood with around 5,000 workplaces was developed on the former factory site of Klybeck. Additionally, 10,000 people will live there in the future. The neighbourhood was developed thanks to a new tram connection known as Tram Klybeck, something that was integrated in early stage urban planning.[82] This goes with the development of a comprehensive tram-based MRT system at city, canton and tri-nation wide scale led by the Tram Network Region Basel 2020. In less than a decade, this integrated mobility and development policy, connected to the large-scale urban innovation project IBA Basel connecting Switzerland, Germany and France has proven to be an efficient catalyst of sustainable urban development.

Several thousands of kilometres away from Basel, in Central Asia, Uzbekistan is considering redeveloping trams, such as in Samarkand, the country's second largest city which follows a plan to develop intermodality and transit-oriented development.

Kazan (Russian Federation):[83] 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 help establishing transport links between the residential areas and the city centre and the streets with access to external roadways.

FIGURE 3.30 THE CITY OF KAZAN IS CONTRIBUTING TO THE DEVELOPMENT OF A MODERN TRAMWAY TO A NEW RESIDENTIAL AREA

[81] Based on the answers given by Moscow to the UNECE questionnaire.
[82] Based on the answers given by Basel to the UNECE questionnaire.
[83] Based on the answers given by Kazan to the UNECE questionnaire.

While the use of electric transport may have been earlier constrained by the need to develop a 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) 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 several 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.

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 largest 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. This 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.

Electric buses

The impressive deployment of electric buses in China has recently been at the centre of attention. While globally, the 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 accounted for more than 99 per cent of mobile vehicles in these two segments. This is because state subsidies in China, make electric bus purchases more attractive than diesel, despite the significantly higher production cost of electric buses. Also, UNECE member States along with India have demonstrated an increase in the fleet of electric buses.

Statistics show that 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). In the coming years, manufacturers are expected to continue scale up their production and diversify their products. In 2018, the market share of electric buses was estimated at around 9 per cent, marking the transition from niche to a more mainstream and the beginning of a steep and necessary upward curve.

In principle, 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 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.

FIGURE 3.31 PROMOTION OF ELECTRIC BUS IN MOSCOW AND DEMONSTRATION OF AUTONOMOUS BUS PARKING IN PARIS

In practice, the situation is different. Replacing huge bus fleets with electric vehicles will take time and costs money, an investment that transportation companies and local governments alone might not be able to support without national and international additional funding. The pace of development of electric busfleets depends on operators' investments plans. Although the issue is more complex than technological change, the competition between transportation companies is intense. Electric buses in Moscow are equipped 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.[84] In Paris, RATP, the company operating public transportation, has recently (April 2019) introduced experimental autonomous parking systems in buses depots while developing a fleet of hybrid vehicles.

The most efficient and recommended charging option for electric bus is the contact wire lane ("dynamic charging"). The problem with charging in electric buses which charge statically is the electrical contact area which limits the current and battery charging speed: the energy transferred to the battery per unit of time is currently about 100 times lower 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 per cent.

The figure below 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.

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 (Czechia) 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).

Electric buses in Warsaw (Poland):[85] purchase of bus stock (130 low-floor, low-emission buses) with associated infrastructure: The Warsaw electric buses project includes: replacement of 10 per cent of the vehicle stock of Warsaw MZA municipal bus operator with 18m articulated electric buses; and creating associated infrastructure, including the construction of aerial chargers at the ends of selected bus lines, and the adaptation of bus depots. In the long run the project will assist the Poland-wide trend towards electric mobility, limiting risks related to CO_2 emissions generated by fossil fuels consumed in the transportation sector worldwide. The project is supported by co-financing from the Polish Operational Programme "Infrastructure and Environment", which distributes EU assistance funds. The total cost of the project will amount to US$ 89.5 million, including external financing of US$ 47.5 million. The remaining US$ 42 million will be covered by the applicant – MZA bus operator, which is a municipal company 100 per cent controlled by the City of Warsaw. Public opinion in Poland is still mostly wary of electric mobility, considering expensive electric vehicles to be something of a waste of money. However, passengers were positive about the electric buses that went into operation in Warsaw even before the current project began. They appreciated the noise reduction provided by such vehicles and the lack of pollutants generated by their propulsion systems. Key impact: within the duration of the project, the avoided emissions of non-methane volatile organic compound will amount to 20,987t/year. The avoided emissions of NOx will equal 124,133t/year, while of SO2 – 49,407t/year and of PM2.5 – 0.139 t/year.

[84] According to the response of Moscow (Russia) to the UNECE questionnaire.
[85] https://www.c40.org/case_studies/warsaw-electric-buses-2017, C40 CITIES, 2018.

Cities implementing some of the largest electric bus fleets in Europe[86]

Brussels: The public transport operator in Brussels (STIB/MIVB) operates 7 'midi-bus', 5 standard and 25 articulated busses, using overnight depot charging and opportunity charging at depots and in the city centre. Currently these buses (of 2 different bus makers) are running in commercial service on 4 lines.

Geneva: Geneva's public transport operator (TPG) operates a fully electric bus line using the TOSA concept (Trolleybus optimisation système alimentation) which is composed of opportunity and flash-charging infrastructure installed at line ends and along the line corridor. It allows an efficient electric bus operation without the constraints of long depot charging. Furthermore, the existence of a large trolleybus and tramway network makes it an interesting synergy example from the point of view of electrical infrastructure.

Paris: The public transport operator in Paris (RATP) currently operates a fleet of 85 electric buses with 77 more e-buses to be operational by October 2019. Particularly interesting is the reorganization of the workshops and depots necessary to a smooth integration of this new fleet. Furthermore, with an order of more than 800 more electric buses, Paris will be a leading city in Europe in scaling up the electrification of the city's bus fleet.

Namur (Belgium): The public transport operator in Wallonia (TEC) runs a large fleet of 46 plug-in hybrid electric standard buses (PHEV) in the city of Namur. The buses are operating in a zero-emission mode in urban environments and switch to diesel for regional and inter-urban operations, making it an interesting use case for small and medium sized cities.

3.2.6 Case studies and good practices

Case studies and good practices in public transport planning, financing and management are given below.

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 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.

A comparison of service density shows that the service area of Zurich is about 3 times bigger than that of Bochum.

TABLE 3.12 COMPARISON OF SERVICE DENSITY INDICATORS OF PUBLIC TRANSPORT IN ZURICH AND BOCHUM[87]

Indicator	Units of measure	Zurich	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	2 440	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

[86] https://www.uitp.org/events/training-and-study-tour-electric-buses, UITP (Union Internationale des Transports Publics), 2019.
[87] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005.

In addition, Zurich has its routes going not only towards the city centre and back but 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 are put in operation at specific intervals.

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.

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.

Experience of Jönköping (Sweden) in route network modernization. In 1996, Jönköping (a city with a population of more than 80,000 people) completed the upgrading of its bus route network. The entire network is built around three diametrical 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. This was achieved by implementing a number of necessary measures, namely, traffic management and traffic light cycles introduced with priority given to public transport, dedicated lanes and road sections for public transport traffic only, optimised location of stopping points, informing passengers on the location of buses en route by electronic displays in real time.

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, which is why 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 per cent in a five-year period, while prior to that it had been steadily decreasing by 1-2 per cent per year. Similar cities in Sweden, which have not yet carried out such reforms still have the passenger flow decreasing by 1-2 per cent per year. The proportion of public transport in Jönköping rose from 19 per cent to 22 per cent. 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 the ticket was 68 per cent up from 32 per cent.

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 optimize 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.

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.

Experience 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. In the late evening, buses are replaced by taxis to match the level of demand.

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.

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 for shopping. Bus passengers visit the city centre more often and spend more money in shops than motorists.

Cambridge (United Kingdom) — 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 per cent within 4 years was achieved in 3 years with the flow having climbed by 30 per cent.

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.

City central area revitalization. Several cities replaced car traffic in the city centres with tramway lines, in order to create safer, cleaner, more liveable areas. Special attention is paid to old-style vehicles, which become tourist attractions and even more support and even more support the attractiveness of cities (Figures 3.32-3.38).

FIGURE 3.32 PARLA, SPAIN. IN ORDER TO REACH THE HIGH QUALITY OF LIFE CITIES CLOSE THEIR CENTRAL AREAS FOR CARS AND PROVIDE THE ATTRACTIVE PEDESTRIAN SPACE AND RAIL PUBLIC TRANSPORT

FIGURE 3.33 ANTALYA, TURKEY. THE NEW LINE WITH OLD-STYLE VEHICLES WAS BUILD IN THE CITY CENTRE TO ATTRACT TOURISTS AND PROVIDE THE TOURIST AREA TRANSPORTATION

FIGURE 3.34 ISTANBUL. NARROW HISTORICAL STREETS CAN BE ADOPTED FOR EVERY MEANS OF TRANSPORTATION – PUBLIC TRANSPORT, PEDESTRIANS AND PRIVATE CARS

FIGURE 3.35 ISTANBUL. CURVED RAIL LINES MAKE PEDESTRIAN AREAS EVEN MORE ATTRACTIVE

FIGURE 3.36 ISTANBUL. HISTORICAL AREAS WITH NARROW STREETS ARE BEST SERVED WITH TRAMWAY LINES DUE TO ABILITY TO EASILY ADOPT. OLD-STYLE TRAMWAYS ARE APPRECIATED BY TOURISTS

FIGURE 3.37 MOSCOW. TRAMWAY LINE SERVES PEDESTRIAN BAUMANSKAYA STREET

FIGURE 3.38 TORONTO. TRAMWAY LINES ARE PRESERVED IN DOWNTOWN AS THE MOST EFFICIENT MEANS OF TRANSIT, PROVIDING THE CHEAPEST, SAFEST AND MOST ECOLOGICAL TRANSPORT

Edinburgh, Scotland, United Kingdom: 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 (Table 3.13).

TABLE 3.13 AN EXAMPLE OF EVALUATING URBAN TRANSPORT POLICY MEASURES FOR DECISION-MAKING IN THE CITY OF EDINBURGH (UNITED KINGDOM)[88]

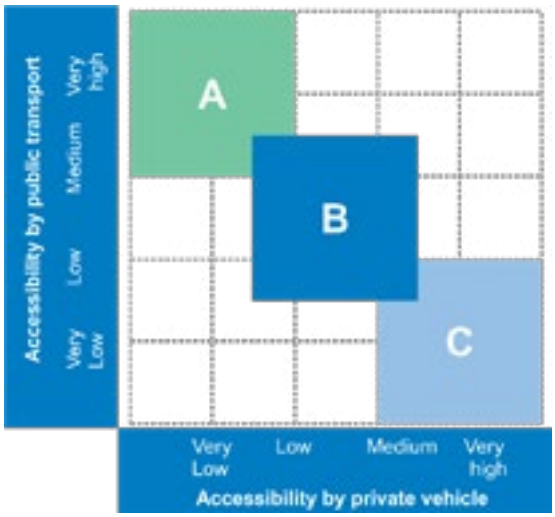
Objective	Measures	Data
Cost-effectiveness	Reduced travel time Transportation reliability Operating costs Capital expenditure Payments Taxes and budget efficiency	Transport modelling Transport modelling Analogue objects Analogue objects Transport modelling Financial and transport modelling
Local economy	Increase in employment level Economic impact	Economic model Economic model

[88] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005.

Objective	Measures	Data
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

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 (Figure 3.39).

FIGURE 3.39 THE METHODOLOGY USED TO EVALUATE TERRITORIAL ACCESSIBILITY BY PUBLIC AND PRIVATE TRANSPORT WITH THE AIM TO LINK LAND USE AND TRANSPORT DEVELOPMENT IN NORWAY



Stockholm, the experience of modelling and developing a tram-line Project Feasibility Study.

The tram line was built and went on to become a great success for the Stockholm region. This experience serves to illustrate the importance of devoting adequate attention to detail and setting aside enough time for transport models to be drawn up in a quality manner.

FIGURE 3.40 IN STOCKHOLM, 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 on 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. 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.

Separation of tramway tracks from the road, providing platforms for seamless boarding.

In several Russian cities and worldwide, 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 passengers with prams, passengers carrying luggage, elderly people and disabled passengers (Figures 3.41-3.48).

FIGURE 3.41 SEPARATION OF TRAM TRACKS IN LENIN STREET IN PERM, RUSSIAN FEDERATION (LEFT) AND CONSTRUCTION OF A NEW TRAM LINE IN THE CENTRE OF YEKATERINBURG IN 2016 (RIGHT)

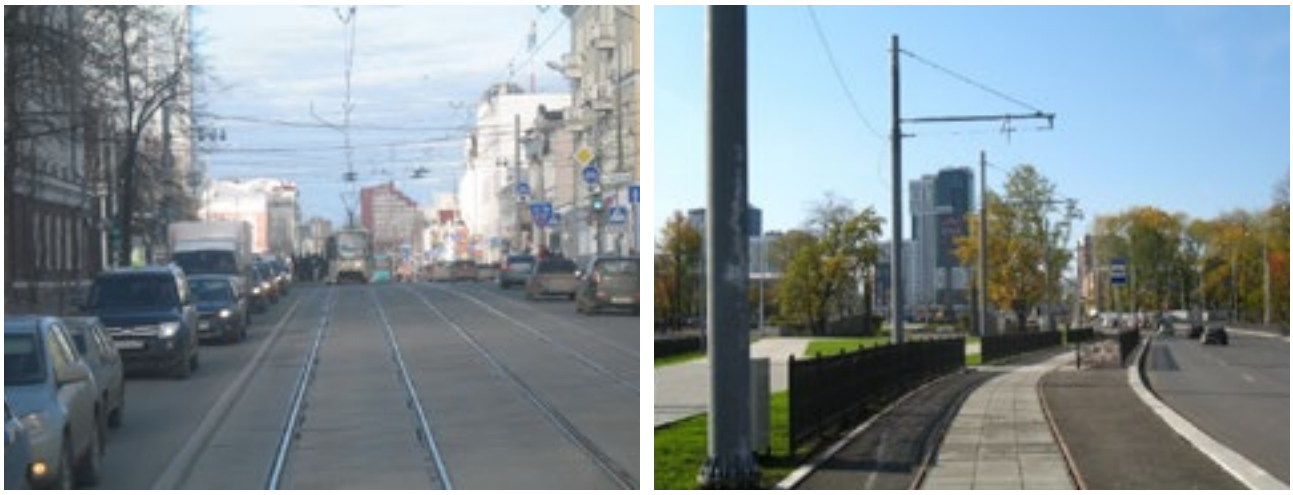


FIGURE 3.42 PERM. TRAMWAY STOP OUTSIDE OF THE CITY CENTRE IS EQUIPPED WITH ISLE PLATFORMS, PROVIDING SAFE BOARDING TO THE TRAM EVEN ON THE NARROW STREET. NOTE THE PLATFORM LEVEL ON THE EXTERNAL CURVED PART OF THE TRACK

FIGURE 3.43 MOSCOW. TRAMWAY LINE IS SEPARATED FROM CAR LANES WITH DELINEATORS

FIGURE 3.44 DÜSSELDORF. INDIVIDUAL SOLUTION TO SEPARATE ONLY ONE WAY OF TRAM TRACK IN NARROW STREET CONDITIONS

FIGURE 3.45 ULYANOVSK, RUSSIAN FEDERATION. THE ROAD LINES ARE REDUCED TO PROVIDE THE SPACE FOR ISLE PLATFORMS. THIS SOLUTION PROVIDES NOT ONLY FOR SAFE BOARDING, BUT ALSO ALLOWS CARS TO MOVE WITHOUT STOPPING ON TRAMWAY BOARDING

FIGURE 3.46 GENEVA. THE ROAD PAVEMENT IS RAISED AT STOP AREA TO THE PLATFORM LEVEL, PROVIDING NOT ONLY CONVENIENT BOARDING FOR THE PASSENGERS, BUT ALSO SAFETY ON BOARDING AND PRIORITY FOR TRAM MOVEMENT. THIS TYPE OF TRAM PLATFORM IS CALLED "WIEN PLATFORM"

FIGURE 3.47 MOSCOW. SEPARATION OF TRAMWAY LINE AND BIKE LANE FROM CAR TRAFFIC, WIDENING OF THE SIDEWALKS IN MOSCOW CENTRE IN 2017 DEMONSTRATE THE NEW PRIORITIES OF THE MOSCOW GOVERNMENT IN TRANSPORT POLICY

FIGURE 3.48 PARIS. GREEN TRACK IS A TECHNOLOGY, ALLOWING THE EXPANSION OF GREEN SPACE IN THE CITIES

Priority for public transport. In order to provide better travel speeds, cities organize bus lanes, or reduce car traffic on the streets by means of traffic management.

FIGURE 3.49 MOSCOW. BUS LANES, IMPLEMENTED IN 2018, IN BOTH DIRECTIONS ON A ONE-WAY STREET PROVIDE TWO-WAY PASSENGER SERVICE

FIGURE 3.50 MOSCOW. IMPLEMENTATION OF PUBLIC TRANSPORT PRIORITY AT THE INTERSECTION: ONLY PUBLIC TRANSPORT ALLOWED TO CROSS THE STREET IN A DIRECT WAY. THE SAME METHOD WAS APPLIED EFFECTIVELY IN TORONTO

Elimination of back-up routes and creation of a main route network in the Russian Federation. 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 (Figure 3.51). 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 3.51 MOSCOW. THE SCHEME OF THE MAGISTRAL ROUTE NETWORK IN THE MOSCOW CENTRE IS SIMPLE, UNDERSTANDABLE AND CONVENIENT FOR PASSENGERS

How Dutch railway stations encourage multimodality.[89] The Dutch experience shows that providing accessible and numerous bicycle parking facilities at public transport hubs, such as railway stations, is crucial in fostering multimodality. Combining different transport modes can make journeys faster, more convenient, more reliable and more predictable. Plentiful and secure bicycle parking facilities at public transport hubs can increase the overall efficiency of the transport network. As it enables longer distances to be travelled in less time, cycling dramatically increases the catchment area of public transport, allowing more people to travel in a sustainable way.

The Dutch approach to cycling infrastructure investment is an excellent example of strong national support for multimodal transport, despite the implementation of the infrastructure being a local issue. In the Netherlands, more than 40 per cent of train passengers travel to railway stations by bicycle, whereas only 11 per cent of bus passengers travel to bus stops by bicycle.

Dealing with the increasing demand for parking places in public transport hubs is a challenge for local authorities. Dutch municipalities and provinces that are responsible for constructing bicycle tracks and encouraging the use of bicycles have made headlines for building some of the world's largest bicycle parking facilities. The city of Utrecht has recently opened a three-storey underground bicycle parking facility at its central station (Utrecht Centraal) with room for 12 500 bicycles.

The Action Plan for Bicycle Parking at Stations partially succeeded in reducing the anticipated deficit in bicycle parking spaces, especially at smaller stations. The subsequent actions built extensively on the results of the Action Plan and strengthened the dialogue between all of the stakeholders involved.

Data reveals that cycling in combination with public transport is on the rise. Some 40 per cent of the 1.2 million daily rail passengers ride their bicycles to train stations. The initiatives presented above have all contributed to helping to meet the increasing demand for more and better parking facilities at stations, thereby encouraging multimodal transport behaviour.

Municipalities and provinces have been encouraged to invest significantly in bicycle parking, resulting in a total of 96 000 parking spaces being added since 2012, when the Action Plan for Bicycle Parking at Stations was launched. The overall deficit of parking spaces has been reduced, but not completely, although more people are now able to cycle to public transport hubs and continue their trip by train or bus. Moreover, the improvement of cycling infrastructure has also led to significant environmental, social and economic gains.

The model of multi-stakeholder cooperation is the main strength of the Dutch example. Although the levels of ambition and investment are due to the Netherlands being the country with the highest number of bicycle trips per year, the model of multi-stakeholder cooperation can be a source of inspiration for other countries seeking to improve the efficiency of cycling infrastructure with a special focus on bicycle parking facilities. The Dutch experience offers a strong case for greater cooperation between municipalities, service providers, civil society and research institutions to make multimodality a reality in cities.

City of Dundee, Scotland, United Kingdom. Transport Systems & Services: the measures taken.[90] Dundee scored maximum points for PT coverage, which is reflective of the extensive bus network operation within the city boundaries. For other bus related indicators (speed, affordability and ease of use) they scored relatively lower, particularly in relation to cost, although this is likely to be due to the fact that fares are typically higher in the United Kingdom by EU standards and wages are typically lower in Dundee than the United Kingdom average. The usability of Dundee buses was let down due to the lack of integrated fares (two companies operate buses within the city) and lack of fare information and ticketing purchasing options. They also scored highly on 'Accessibility to services' and 'Planning of new areas' (both 80 per cent). This was due to Dundee's efforts on Eco mobile-oriented and accessible land use planning. They also scored highly on information systems due to the high levels invested by the city (RTPI at bus stops) as well as the quality of information provided by the local bus operators. Similarly, for both accessibility for people with reduced mobility and walking conditions, Dundee scored highly, both 80 per cent. This again is due to the high levels of investment made by the city in improving walking areas and public transport facilities, the latter in conjunction with the local public transport operators. They did score relatively less on mobility management services, parking policy, car free/low speed zones and cycling conditions, all

[89] http://www.eltis.org/discover/case-studies/how-dutch-railway-stations-encourage-multimodality, Francesco Ripa, Brussels Region, Belgium, Polis, Polis Network, 2019.

[90] https://ecomobility.org/ecomobility-shift/, City of Dundee, United Kingdom, EcoMobility SHIFT Case Study.EcoMobility SHIFT is a total quality management scheme for cities, with an assessment and an external audit. During the assessment stage, 13 criteria are assessed using 28 indicators. A municipal stakeholder group evaluates the effectiveness of a city's sustainable transport policies and actions in terms of environment, accessibility, safety and equity. It is the first scheme of its kind to include all of the following three elements: the policy environment (Enablers), the actual measures (Transport Systems & Services) and the effects of these on the transport system (Results & Impacts).

of which pulled down the overall score for this indicator grouping, although, highlighted the need for improvement in these areas. The lowest score related to green vehicles, although, this was in part due to the city been unable to find evidence related to public ownership of low emission vehicles, as such data are not currently available.

City of Burgas, Bulgaria. Transport Systems & Services: the measures taken.[91] Burgas has a lot of work to do to reduce the need of travel. Planning and construction of the central city areas in the last few years increase the options of non-car traveling, but still 58 per cent of the trips of people living in Burgas are made by car. There is an increasing share of public transport by 5 per cent, compared to the previous year, but the car remains the dominant mode of transport, with bicycle transport still taking an insignificant share. The City Council has approved some strategies for sustainable urban development, currently implemented by the municipal administration.

There are some restrictive measures and some supporting measures to encourage citizens to leave their private cars. Burgas Municipality has introduced paid parking – Blue Zones in the central areas of the city. This restricts the access of cars to the main administrative and market area, turning it into a pedestrian zone. The local PT company is owned by the Municipality, has its own budget and receives donation from the state authorities. With the current implementation of an integrated public transport project, the Municipality is introducing an improved, optimized, more attractive and accessible public transport scheme and service to the local community, guests and tourists visiting the city.

The project will introduce a bus rapid transit lane that will give priority to public transport, making it faster, attractive, and affordable, and thus increasing its popularity. A special service available to disadvantaged people is "Ring and Ride".

3.3 FINANCING PUBLIC TRANSPORT

Public Transport projects are often constrained by high upfront capital costs, low returns and long development and payback periods. In addition, direct user fares are often set too low to cover operational costs, due to social affordability concerns. Several financial tools and risk-sharing mechanisms are available to improve the relative risk-return profile of sustainable transport infrastructure projects:

- Public-private partnerships (PPPs) are procurement methods that allow for private sector participation and risk sharing. PPP projects must offer sufficient "value for money" compared to traditional public procurement. PPPs are particularly suited for BRTs, rail links, and shared-use vehicle systems.
- Loans, grants and loan guarantees are traditional financial tools frequently used to leverage private investment in large-scale transport projects (rail or metro) that otherwise would be fully owned and operated by public stakeholders.
- Green bonds have the potential to attract institutional investors such as pension funds and insurance companies by tapping into the debt capital markets, which are currently underexploited for green infrastructure investment.
- Short-run subsidies can be used to provide transitional support to sustainable transport options and technologies. They notably can be used to foster innovation, ramp-up production, offset upfront capital costs, and compensate for network infrastructure bias towards fossil fuel-based road transport. Examples include support to charging infrastructure for electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs).

[91] https://ecomobility.org/ecomobility-shift/, City of Burgas, Bulgaria, EcoMobility SHIFT Case Study.

FIGURE 3.52 ST. PETERSBURG. THE PUBLIC-PRIVATE PARTNERSHIP ALLOWS THE REBUILDING OF A TRAMWAY LINE IN KRASNOGVARDEISKY DISTRICT ACCORDING TO LIGHT RAIL STANDARDS

FIGURE 3.53 USOLYE-SIBIRSKOYE, RUSSIAN FEDERATION. TO PROVIDE INTERCONNECTIVITY BETWEEN INTERCITY RAIL AND URBAN TRANSPORT SYSTEMS, THE TRAM LINE WAS PROLONGED TO THE RAILWAY STATION. THIS PROJECT DEMONSTRATED EFFICIENCY EVEN FOR A RELATIVELY SMALL TOWN

3.3.1. Different 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 of 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 (Table 3.14).

TABLE 3.14 AN ANALYSIS OF DIFFERENCES IN TERMS OF THE TRANSPORT POLICY BETWEEN THE UNITED KINGDOM AND FRANCE[92]

	United Kingdom **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 planning and building development.	The revival of cities through high-quality public transport management is a source of political status and pride for cities
	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 organizational unity between the central government (infrastructure financing) and regional transport administrations responsible for transport planning and operation.	Separation of organizational objectives between urban and regional public transport. Integration of regional and city tariffs (among several modes of transport) is rare.
Characteristics of LRT projects	Provide regional transportation along commuter "suburb - agglomeration centre" routes.	Improve 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 per cent of the overall LRT construction expenses
	Minimizing 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

[92] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005.

The authors' analysis has revealed significant differences in approaches to the development of urban transport systems in the United Kingdom and France; the differences being caused by different social and political backgrounds of the two countries.

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 without at least requirements established for transport safety.

Regular bus transportation is deregulated in the United Kingdom (except in London). 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.

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 exposing 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 further by 12-15 per cent, which in turn will destabilise local bus operators, while the performance of the LRT will also remain insufficient. Such competition turned out to be detrimental to all the operators in the region and the transport system as a whole.

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). Local Transport Plan (LTP) is developed through consultations with interested organizations, 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.
- Contain a description of the strategic transport policy and measures for its implementation .
- Be 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 public transport (owing to its appeal) which leads to less externalities in the transport system.

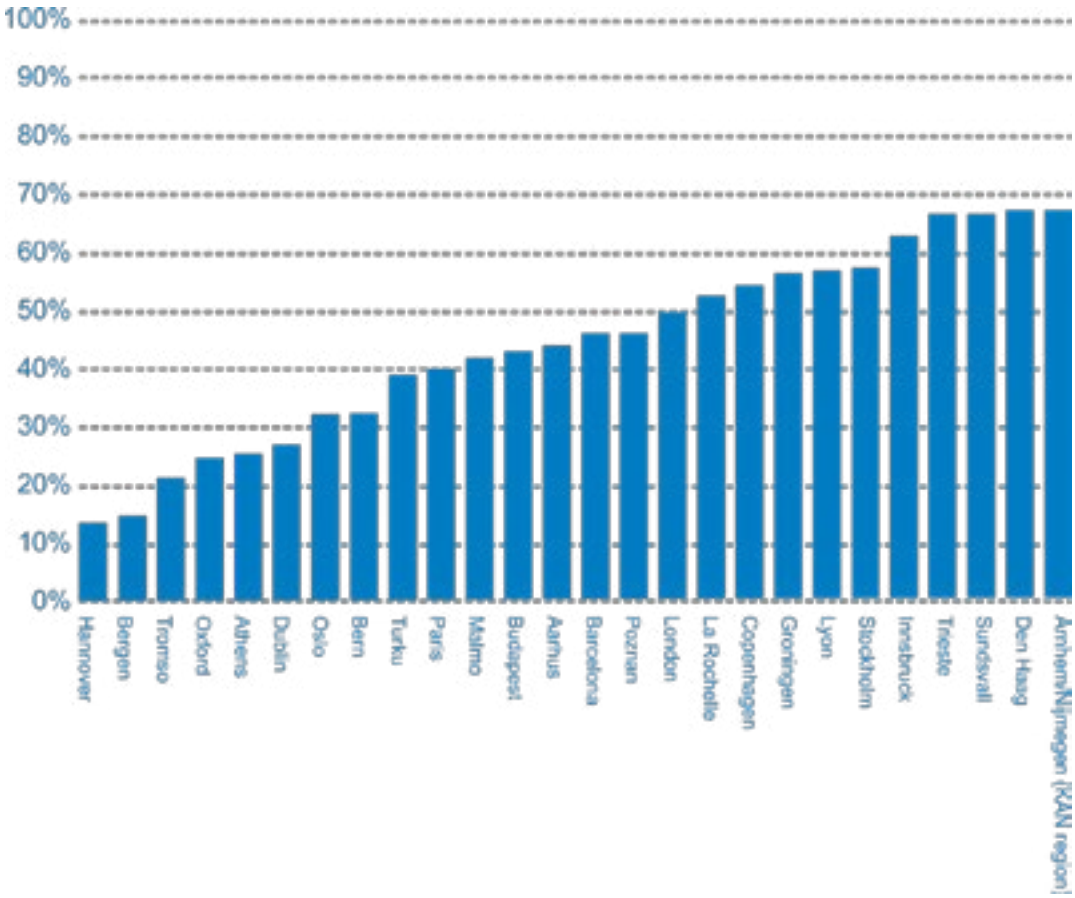
Among experts of 20 cities (including: Madrid, Barcelona, Berlin, Copenhagen, Helsinki, London, Munich, Zurich and Vancouver), a survey was conducted in order to identify the factors that determine the successful transport system: the most instrumental factors were assigned 3 points, the moderately instrumental ones had 2 points, and insignificant ones had 1 point, while negative factors were given minus 2 points.

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. Select data are shown below.[93]

[93] HiTrans Best Practice Guide. 2. Public transport — planning the networks. Gustav Nielsen, et al. HiTrans, 2005.

FIGURE 3.54 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 (the city or region), whereas the net cost contract implies that all revenues are collected by the fleet operator (carrier) 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).

Gross cost contract means the full control and responsibility of the customer (city) on the public transport quality of service. Passengers pay their fare to the city; the city organizes the public transport according to the quality standard, approved and monitored by the city. Public transport operators paid according to the quality they get by the contract – so they are responsible to the city operators were paid according to the quality standards agreed upon in the contract - so they were responsible to the city .

Precise responsibility of a city for the service quality as a whole system, provided by the gross cost contract – leads to the most efficient solutions on public transport, financial sustainability of the transport system, better quality for lower fares, closer reach of the public transport goals – reduction of externalities and social equality.

CHAPTER 4.

PROMOTING ACTIVE MOBILITY FOR HEALTHIER URBAN LIFE

The 1.5° report published in October 2018 by the United Nations found that addressing air pollution could save Europe up to $775 billion by 2025, by saving on health costs and the economic damage of premature deaths, but also by increasing tourism and real estate values in places currently devalued due to air pollution.

The average person in Europe loses two years of their life due to air pollution. The report also estimates about 800,000 people die prematurely in Europe per year due to air pollution, or roughly 17 per cent of the 5 million deaths in Europe annually.[94]

FIGURE 4.1 ELECTRIC VEHICLE CHARGING POINT IN RURAL AND TOURISTIC MOUNTAIN AREA IN AUSTRIA. SOURCE: RENAISSANCE URBAINE

[94] Source: WEF, 2019.

4.1 A SYNTHETIC REVIEW OF THE LINKS BETWEEN URBAN TRANSPORT AND HEALTH

4.1.1 Time spent in transport and factors influencing consumer choices: speed, reliability, service chain

Speed

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; the 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 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.[95]

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.

An increase in the transport correspondence speed is achieved by solving the following transport planning tasks:

1. Improving route traffic conditions, including through the physical allocation of necessary lanes and traffic routes.
2. Optimizing distances between stops.
3. Achieving reduced waiting time, including at interchange hubs, through coordination of traffic schedules.
4. Ensuring reduced walking distance at interchange hubs.
5. Introducing improvements into road traffic regulation, including by allowing priority passage for passenger transport vehicles at intersections.
6. Reduced on-foot door-to-vehicle distances.

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.

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.

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.

[95] In Moscow, transportation contracts include a zero tolerance policy 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 Based on the answers given by the Republic of Belarus to the UNECE questionnaire.

Reliability

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 mainly by demand management methods — price demand management (paid parking, paid travel through congested road areas) with a quality alternative provided by 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 based on 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:

- Separating tram tracks and providing dedicated lanes for road transport to exclude the influence of traffic factors and road accidents.
- Creating 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 carriers are financially sound to provide for timely repairs and to avoid breakdowns of vehicles and tracks.

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 daily, then transportation "strips" him or her of 20 per cent of free time. With a growing urban population, the daily time in travel rises reaching 2 hours or more in large cities.

The time-money-service chain

The buffer time represents the additional (absolute and specific) time expenditures on the trip due to transport connections lacking in reliability. Buffer time is estimated as time expenditures required to achieve the goal of the travel with a given reliability, such as 90 per cent.The time buffer 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.[96]

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.

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 these conditions and to measure the strength and duration of their effects.

[96] In Moscow, Prague and several 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).

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.

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 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 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.

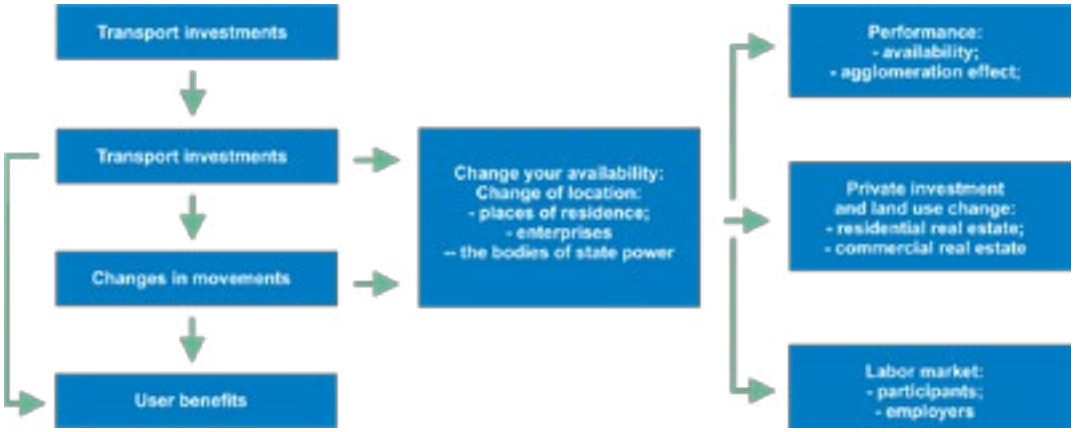
The value of reduced travel time of a passenger expresses three aspects.

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.

FIGURE 4.2 RELATIONSHIP BETWEEN DIRECT PASSENGER BENEFITS, IMPROVEMENTS IN ROAD TRAFFIC CONDITIONS AND WIDER ECONOMIC IMPACTS



4.1.2 Pollution and health

Motorized 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, CO_2 in addition to emissions of other polutants. The volume and composition of pollutant emissions discharged by motor vehicles depend not only on the environmental performance of rolling stock but also on the quality of the motor fuels used (most importantly, sulphur content), as well as the technical condition of vehicles in operation.

TABLE 4.15 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

TABLE 4.16 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.[97] The transport pollutants emitted cause both local exposures (CO, hydrocarbons) and local and more global (regional, interregional) effects (NOx, SOx, PM).

An assessment of air pollution impact on health

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 anaemia and cardiovascular diseases, headaches, a feeling of weakness and impaired productivity. Sulphur dioxide (SO2), 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 anaemia and heart disease. Lead causes a long-term adverse impact on human health resulting in haematopoiesis 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. "Particulate matter" is 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.

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.

[97] 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.

Another transport factor leading to a negative impact on public health is traffic-induced noise. Being the main source of noise in cities, motorized transport causes various negative impacts on 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 per cent 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.

The noise level is influenced by several factors:

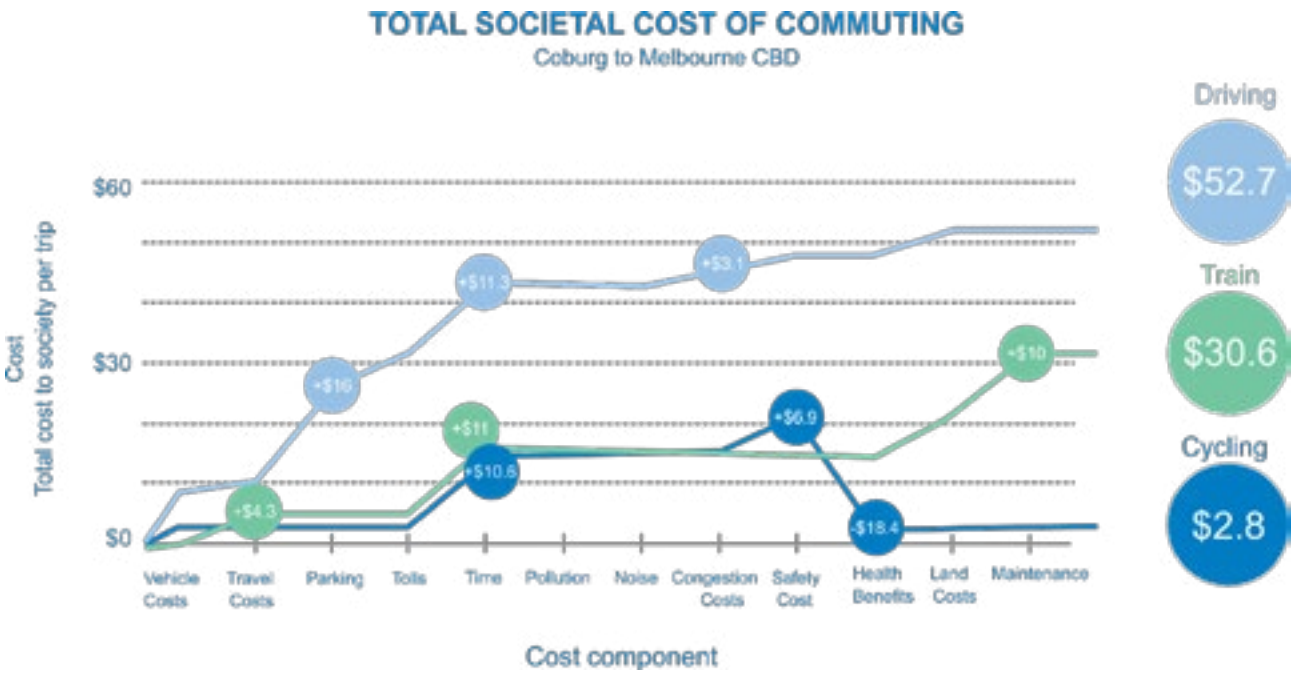
- Traffic flow intensity (the highest noise levels are recorded in the main streets of major cities at a traffic intensity of 2,000–3,000 cars per hour).
- Traffic flow speed (a gain in the speed of vehicles is followed by increased engine noise, the noise of wheels rolling on the road and air resistance).
- Traffic flow composition (freight vehicles produce more noise than passenger traffic).
- Engine type (diesel, petrol, electric).
- Type and quality of road surface.
- Spatial planning decisions.
- Green spaces available (there should be sanitary protection areas with trees and bushes along highways 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 several 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. Hypodynamia is one of the causes of obesity, diabetes and depression.[98] With Melbourne used as an example, researchers from Australia showed that travelling by car costs society 19 times more than cycling. [99]

FIGURE 4.3 STUDY CONDUCTED IN AUSTRALIA USED MELBOURNE AS THE PREMISE FOR A COMPARISON OF CYCLING COSTS AGAINST MOTOR VEHICLE USE COSTS



98 https://www.newsru.com/world/13may2008/hypodinam.html

99 http://blog.deloitte.com.au/divorcing-growth-car/?fbclid=IwAR059hS_5eSGJ-IUi9KkV57QGkS9hpy_nV56R6NXt_THK80eCmQzqQAhvlw

4.2 ACTIVE MOBILITY AS AN INSTRUMENT OF PUBLIC HEALTH

4.2.1 Physical activity and health

The World Health Organization (WHO) recommends a minimum of 150 minutes of moderate intensity, aerobic physical activity for adults per week. Statistics suggest that almost half of European citizens over 18 do not partake in this type of activity at all. In 13 out of 26 EU member States, the percentage of individuals who did not spend any leisure time exercising exceeded 50 per cent. Countries such as Denmark and Finland fair slightly better with 19.3 per cent and 23.3 per cent respectively while Greece, Bulgaria and Romania report numbers well over 50 per cent.

Physical activity (PA) levels in the EU are affected by factors such as age, gender, education and income. Generally, men are more physically active than women, and the same can be observed for those with higher levels of education and income. Even a moderate amount of PA can be hugely beneficial one's health over a lifetime. More specifically, physical inactivity has been linked to cardiovascular disease, strokes, obesity, type 2 diabetes, cancer and poor musculoskeletal and mental health. PA has been shown to contribute to the prevention of these non-communicable diseases as well as promote weight loss, thus decreasing the risk of obesity.

The importance of PA in relation to human health has been long recognized by planners and policy makers alike. For example, the EU Platform for Action on Diet, Physical Activity and health was launched in March 2005 with intention of tackling rising obesity levels in Europe. Aside from addressing nutrition, the initiative specifically focuses on the promotion of physical activity as a measure to promote healthy lifestyles.

HEPA Europe (European Network for the Promotion of Health-Enhancing Physical Activity) is a network which works for better health and wellbeing in the European region through the promotion of PA. All the activities of HEPA are based on WHO policy statements such as: the European Strategy on Physical Activity, the Global Strategy for Diet, Physical Activity and Health and the NCD Action Plan. Corresponding documents from the European Commission were also utilized.

FIGURE 4.4 THE WORLD HEALTH ORGANIZATION EUROPE'S HEALTHY CITIES NETWORK, A REGIONAL-LOCAL APPROACH

- The WHO Europe's Healthy Cities programme which started in 1998 fosters health and well-being by improving urban planning to create better urban areas to live, by increasing community empowerment and participation to improve social cohesion, and by investing in people for a peaceful planet. The European network operates in 30 countries via 1300 Healthy cities covering approximately an urban population of 250 million people. A key feature of a Healthy Cities approach is to try to integrate health into all local policies, including transport.
- The aim of the WHO French Network of Healthy Cities is to promote exchange between municipalities and agglomerations who wish to develop healthy public policies. It has nearly 100 cities-members covering a population of 14 million people.
- In order to develop active mobility with health, transport or even tourism objectives, the local authorities have many strategies available, such as environment, education, planning, etc. This will involve several local city councillors and services cooperating.
- As physical activity is a major determining factor in of health, active mobility can be included in local health policy frameworkj128
- s, such as Local Health Contracts.

4.2.2 Physical activity and active mobility

Regarding Active Mobility, 78.4 per cent of Europeans spend at least 10 minutes of continuous walking to get to and from places in a typical week. This encouraging number demonstrates the Importance of this activity as a means of promoting health and reducing sedentary behaviour. The WHO along with health professionals have led the way in terms of tackling physical inactivity and health problems through the promotion of Active Mobility.

Global trends in urban planning and policy have seen more efforts directed toward the development of sustainable urban mobility plans and more liveable cities. One of the central components of Sustainable Urban Mobility Plans (SUMPs) is a balanced and integrated development of all transport modes. Increasing Active Mobility which includes walking, cycling and the use of public transport, frees up urban space which would normally be occupied by motorized transport infrastructure. Aside from this, it also reduces energy use as well as air and noise pollution. Perhaps most importantly, Active Mobility provides an opportunity to tackle and reduce illnesses and other negative side effects of sedentary behavior and general physical inactivity.

The promotion of walking and cycling individually or in combination with public transport present an excellent opportunity to incorporate PA into daily life. This is because mobile Europeans spend on average 70–80 minutes per day travelling. In addition to this, 50 per cent of all car trips are shorter than 5 km. This contrasts with sport and exercise which requires more time, effort and motivation. The convenience and affordability of Active Mobility give it the potential to reach sectors of the population less receptive to appeals to take part in sports and exercise. This is particularly true in the case of sedentary, obese or elderly people.

FIGURE 4.5 CITIZENS OF COPENHAGEN (DENMARK) RIDE THE BICYCLE NOT FOR ENTERTAINMENT, BUT FOR PERSONAL AND WORK/SCHOOL TRIPS, ALL YEAR ROUND

Copenhagen 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 per cent, with cycling traffic going up by 20 per cent. Approximately 41 per cent 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.

"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 per cent of them violate traffic regulations to some extent with only 1 per cent 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 per cent of the population, not just for those who cycle around wearing fancy 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.[100]

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.

4.2.3 Enabling factors, barriers and challenges for active mobility (AM)

The primary enabling factors for the successful promotion of active mobility are strategies, visions and policies driven by political buy in at governmental level. A setting of environmental targets, increased road safety and a general awareness of the benefits of active mobility for health are also strong success factors. In addition to this, Urban mobility plans, cycling concepts and additional Active Mobility measures and interventions further promote successful uptake.

On the other hand, the promotion of Active Mobility involves numerous challenges and barriers. A lack of political will driven by a fear of losing car driver votes has thwarted previous Active Mobility schemes. Lack of available budget and limited space as a result of the prioritization of motorized transport present further hurdles. Limited collaboration between local and national government departments, planning sectors and stakeholders combine to add conditional constraints to initiatives, while a lack of pedestrian and cycling infrastructure and an underdeveloped cycling culture provide obvious roadblocks to AM promotion.

Transport and health policy have a very clear connection as they both aim to create environments and settings where human behaviour can be influenced. Transport and urban planning have an impact on peoples travel behaviour while health policy aims to promote physical activity as a means of preventing non-communicable diseases. Active Mobility serves as the interface between these two sectors. Aside from health benefits, AM reduces congestion, pollution and emission levels and contributes to healthier and more social urban environment.

[100] **http://letsbikeit.ru/2015/02/copenhagen-cycling-innovation/**

The WHO understands and addresses the link between AM and health in their 'Health in all Policies' approach. This is a framework based on the acknowledgement of the fact that a healthy population can only be achieved through combined effort and consideration across all fields of policy. Although this important connection is understood by stakeholders and policy makers, the health benefits of PA and AM are often not prioritized in planning. They are often viewed as a welcome side effect of efforts to tackle other issues such as congestion.

The Health Economic Assessment Tool (HEAT) online tool was developed by the WHO in collaboration with experts to estimate the economic value of reduced mortality rates as a result of increased AM. The tool is intended to be incorporated into a comprehensive cost-benefit analysis of transport interventions or infrastructure projects. This includes assessing the current status of transport and previous investments. HEAT is also complementary to existing economic valuation methods for transport interventions aimed emissions or congestion. The default parameters for this assessment are based on the European context however they can be adapted to fit specific situations.

HEAT[1] calculates the impact of transport related variables on the economic value of mortality rate improvements. For example: if x people cycle or walk y distance on most days, what is the economic value relative to mortality rate? It can be applied within multiple contexts such as for the planning of new cycling or pedestrian infrastructure or the value of cycling promotion schemes for a specific workplace.

Case study. The PASTA Project: promoting physical activity through sustainable transport

The PASTA (Physical Activity Through Sustainable Transport Approach) project was a 4-year EU co-funded initiative which aimed to bridge the gap between transport and health by encouraging active mobility in cities. This innovative approach attempted to circumvent resistance to exercise through the incorporation of physical activity into daily life. The main objective of the project was to develop a Health Impact Model (HIM) for Active Transport (AT) which builds on and contributes to already established models. Other objectives include identifying the key determinants of AT behaviour, understanding how AT relates to Physical Activity (PA) and, measuring the effectiveness of efforts to promote AT. 7 European cities were selected as case studies for the project including: Antwerp, Barcelona, London, Örebro, Rome, Vienna and Zurich. The PASTA project followed the TAPAS (Transportation, Air Pollution and Physical Activities project which ended in 2013). The TAPAS research programme was designed to help decision makers design urban policies that address climate change and promote other health-related outcomes.

The PASTA project involved developing a set of qualitative and quantitative indicators to asses and measure the state of active mobility in European cities. This was achieved through extensive interviews and workshops with practitioners from the 7 selected case study cities. The selected indicators include the following: modal share of cycling and walking, cycled or walked kilometres per year, current awareness of active mobility, land use and topography, policies for active mobility and political support. The development of an indicator set such as this one assists planners and decision makers with understanding active mobility as well as the conditions which constrain and support it within an urban context.

A series of workshops and interviews with practitioners from the transport and health sector were then carried out in the case study cities. The intention of this process was to examine the link between the promotion of active mobility and the overall health levels in towns and cities. In addition, the cooperation between diverse sectors and city departments covering health, urban planning and transport was also explored.

The outcome of the project was an updated version of HEAT. Which is a tool designed to assist urban planners as well as transport and health practitioners with garnering support for greater investment in active mobility. A further outcome was the documentation of good practice case studies from across Europe.

FIGURE 4.6 THE SWITCH PROJECT: EMBRACING ACTIVE TRAVEL FOR HEALTH

The EU funded SWITCH project aimed to increase AM, reduce GHG-emissions and primary energy consumption as well as generally contribute to higher quality of life in cities. This was achieved by assisting planning and transport practitioners to conduct professionally organized campaigns to encourage people to "switch" from cars to active modes when making short trips. This change was beneficial to public health as well as to public transport operators as AM is easily combined with bus or rail trips.

SWITCH campaigns have been implemented in Antwerp, Donostia / San Sebastian, London Hounslow, Gdansk and Vienna involving 11,000 participants, for an overall budget of €1.63 million (€1.27 million from EU funds).

The focus of a SWITCH campaign is to get people to exchange short car journeys for active modes. Therefore, the primary beneficiaries of the program were car users. The primary target audience of the campaign guide were practitioners in the field of urban transport planning as well as public health. Well established behavioural change approaches were used to develop the four core elements of the initiative:

- Personalized Travel Planning
- Arguments from Public Health
- ICT applications
- Actions applied to people in a period of life change, e.g.: new home or new job.

These four elements were tailored to tailored for the varying and unique contexts in which they were applied. Personalized travel planning (PTP) involved a form of communication called 'dialogue marketing' based on close, tailor-made contact with targeted individuals in order to promote a change in travel behaviour.

Information and Communication Technology tools can be valuable for a SWITCH campaign for the collection of travel and activity data as well as to support behavioural change. 'Life change moments' present opportunities for behavioural change as they are instances where individuals are often forced to reflect about their routines and behaviour. Examples of 'Life change moments' include moving homes or to a new school or even getting a poor health diagnosis. When this happens, people are more susceptible to targeted campaigns.

The SWITCH campaign consisted of several phases:

- Recruitment: Defining the target group and obtaining contact data.
- Contact: Face-to-face or indirect contact.
- Baseline Survey: Learn about current mobility behaviour through face-to-face, online or telephone surveys.
- Segmentation: Filter out people who do not match target group specifications.
- Motivation: motivate people to participate through incentives. Offer information/advice on "service sheet".
- Advice: provide individualized advice along with continued support and encouragement.
- First After-Engagement Survey: measure short term behavioural change.
- Second After-Engagement Survey: 4-6 months after the campaign, measure long-term behavioural change.

TABLE 4.17 THE SWITCH PROJECT IN DONOSTIA / SAN SEBASTIAN, BASQUE COUNTRY, SPAIN

Results	Before the campaign	Shortly after the campaign	3 months after the campaign
Number of participants	532	490	471
Car use	21.6%	21.1%	9%
Cycling	9%	10.1%	6.5%
Awareness of health benefits of active travel	99%	99.6%	99.6%
Participants having access to a car and who reduced car trips		107	5
Participants walking (at least once a day)	54.9%	54.2%	68.8%

Donostia/San Sebastian is an example of a city that successfully implemented the SWITCH program. The city is the capital of the Gipuzkoa province in the Basque country. Its wider metropolitan area is home to 485,000 inhabitants. The main economic activity of the city is tourism. The city has adopted an urban mobility strategy that prioritizes active travel modes. It boasts 65 km of cycle lanes and connections between the urban regional network which provides access to the rest of the province.

There is a well-developed public transport service with a high usage rate and regular upgrades to its bus fleet which includes some electric and hybrid vehicles. In response to increasing car usage in previous decades the city implemented an urban conversion programme to thwart this trend an maintain a people friendly environment. As a result of these efforts, pedestrian modal share has remained high followed by public transport and cycling.

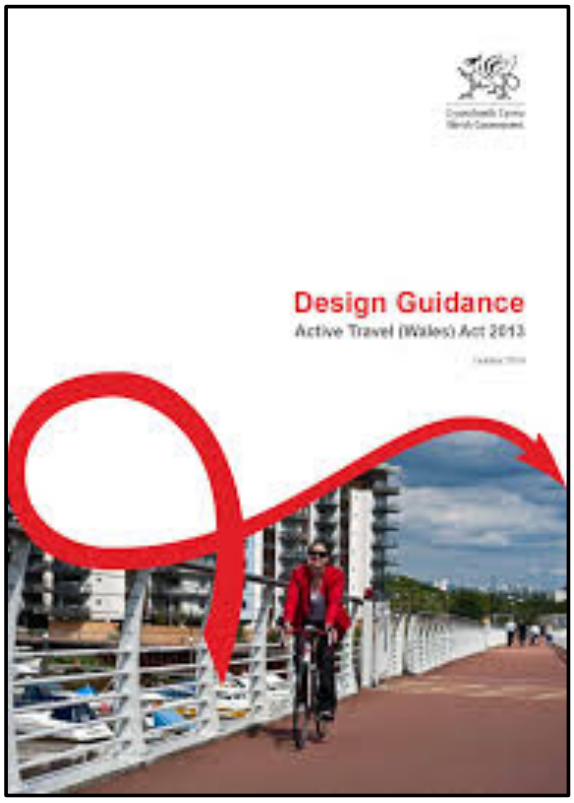
The selected target groups for the implementation of the SWITCH campaign in this context were: people who had recently moved homes, changed their educational status or been advised to increase their physical activity for medical reasons. Some of these groups, including individuals who had recently moved home were recruited by way of the municipal census department.

These attempts were further supported by the Culture and Diversity department which was already running a welcome campaign for all new residents in Donostia. Gaining access to people who had changed their educational status was facilitated by the chancellor of Gipuzkoa's campus. Reaching individuals who had previously received medical advice proved more difficult as medical staff tasked with conveying information about SWITCH often did not have enough time to do so during consultations. An alternative recruitment approach was developed which involved info days at various medical centres.

Campaign participants were provided with incentives which included one out of four gift options: step counter, cycle torch, cycle bell or drink bottle. At the end of the campaign a raffle was organized in which all participants had the opportunity to win folding bicycles, "smart" wristbands and annual tickets for the city's e-bike sharing system.

A mobile app was developed to track participants travel behaviour. This application was based on the already existing "Moves" app with some minor language adjustments. Most participants requested specific assurance that the app was only able to measure distances and not record locational data. People who were more familiar with mobile applications appreciated the new source of information and provided positive feedback. In general, most participants reported that they preferred paper-based trip documentation. It is therefore recommended that ICT tools be considered as complementary rather than primary data collection methods.

FIGURE 4.7 THE WALES ACTIVE TRAVEL ACT (2016)



To increase AM and reap its numerous health and societal benefits, the Government of Wales implemented the Active Travel Act (2013). The act focuses on walking and cycling as transport modes and does not cover recreational or competitive walking and cycling. This piece of legislation makes it a legal requirement for local authorities in Wales to map and plan for suitable routes for active travel. In addition to this, they are obliged to upgrade their pedestrian and cycling infrastructure on a yearly basis. Public health dimension of AM is the primary driver for the Act and wider objectives related to well-being, physical activity, behaviour change and road safety. The act highlights the important role played by good quality infrastructure networks as well as the need to incorporate the health dimension into transport planning and legislation.

The act was implemented in September 2014 after being submitted for public consultation. The Minister for Economy, Science and Transport played an instrumental role in the deliverance of the Act into legislation. Under the Act authorities were required to prepare and publish maps of existing travel routes as well as maps of integrated networks for specified settlements linking services and residential areas. The new proposed plans would have the purpose of encouraging active travel as an option for short journeys. The mapping process was supported by £ 300 000 of funding from local authorities.

The integrated network map lays out the plans of the local authority over a 15-year period. All practitioners involved in the planning, design, approval, construction and maintenance of the active travel networks and infrastructure are tasked with providing design and delivery guidance for local authorities. The funding of the new routes was secured by redirecting spending previously allocated to cycling and walking as well as through sponsorships from the private sector.

The Active Travel Action Plan was published in February 2016 to complement the implementation of the Active Travel Act. This was done through setting out wider actions across a broad range of government departments to increase AM levels across Wales. It includes 28 actions under 6 themes which are summarized below (see Annex to Chapter 5)

Infrastructure grants to local authorities totalling over £11 million have been awarded for active travel schemes for 2016-2017 by the Cabinet Secretary for Economy and Infrastructure's budgets. This includes £5 million for the Safe Routes in Communities Grant. Thirty schemes across Wales have benefited from funding to make improvements to local active travel infrastructure focused around schools. In addition, nineteen local authorities have received a Road Safety Capital Grant of over £2 million for schemes making improvements for walkers and/ or cyclists.

The Welsh Government's Rural Development Programme is providing funding for a "Development of the Walking and Cycling Network in Rural Wales" project. The project has already identified eight schemes across Wales to fill key gaps in the national walking and cycling network. These developments open new opportunities for local people to access jobs, services and tourist destinations using active transport.

TABLE 4.18 KEY INDICATORS OF THE IMPACT OF THE WALES ACTIVE TRAVEL ACT MEASURED IN 2016

Indicator	2016	2018
Proportion of the population (aged 16 and over) who use a bicycle for active travel at least once or twice a week	5%	6%
Proportion of the population (aged 16 and over) who walk for active travel purposes at least once or twice a week	61%	58%
Proportion of the population (aged 16 and over) who use a bicycle for active travel purposes at least three times a week	3%	2%
Proportion of the population (aged 16 and over) who walk for active travel purposes at least three times a week	47%	-
Proportion of primary school children who typically walk or cycle to school	43%	-
Proportion of secondary school children who typically walk or cycle to school	35%	-
Number of seriously injured road pedal cyclists admitted to hospital	236	225

The key requirement of the approach adopted by the Wales Travel Act (2013) is the continuity of walking and cycling route networks. Integration with public transport is necessary in order to generate additional movement and enable multi-modal mobility. A wide range of policy areas including public health benefited from AM. In conclusion, coordination across government and local authorities is required to support and promote active travel.

The Utrecht Healthy Urban Lab, the Barcelona superblocks, the sets of measures and initiatives in Vienna to encourage walking show that the promotion of active mobility and the connectivity between *active mobility* and *public health* is now a widespread concern in cities among many UNECE member States.[101]

FIGURE 4.8 THE HEALTHY VISION GREEN STRUCTURE UTRECHT 2030 (MARCH 2018)[102]

[101] Utrecht: http://www.polisnetwork.eu/publicdocuments/download/1364/document/linssen_healthy-urbanization-utrecht_eandh-wg-08042014.pdf. Barcelona: http://www.bcnecologia.net/en/conceptual-model/superblocks; https://www.c40.org/case_studies/barcelona-superblocks. Vienna: http://newsletter.wienzufuss.at/l1jGm0GuqDg7R2uXOZ.

[102] Utrecht Green Structure Plan actions aim at sustainable urbanization: less and slower traffic, climate- and energy-neutral construction, efficient water management and green areas for pleasant and healthy urban living.

4.3 HOW CAN CYCLING (AND WALKING) PAY OFF?

"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."[103]

4.3.1 Cycling in a co-modality perspective

"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."[104]

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 considered 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 transport policies 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 mass transit implies the construction of urban transport systems combining 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.

FIGURE 4.9 ENCOURAGING CYCLING AND WALKING IN CITIES[105]

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 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 connect 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.

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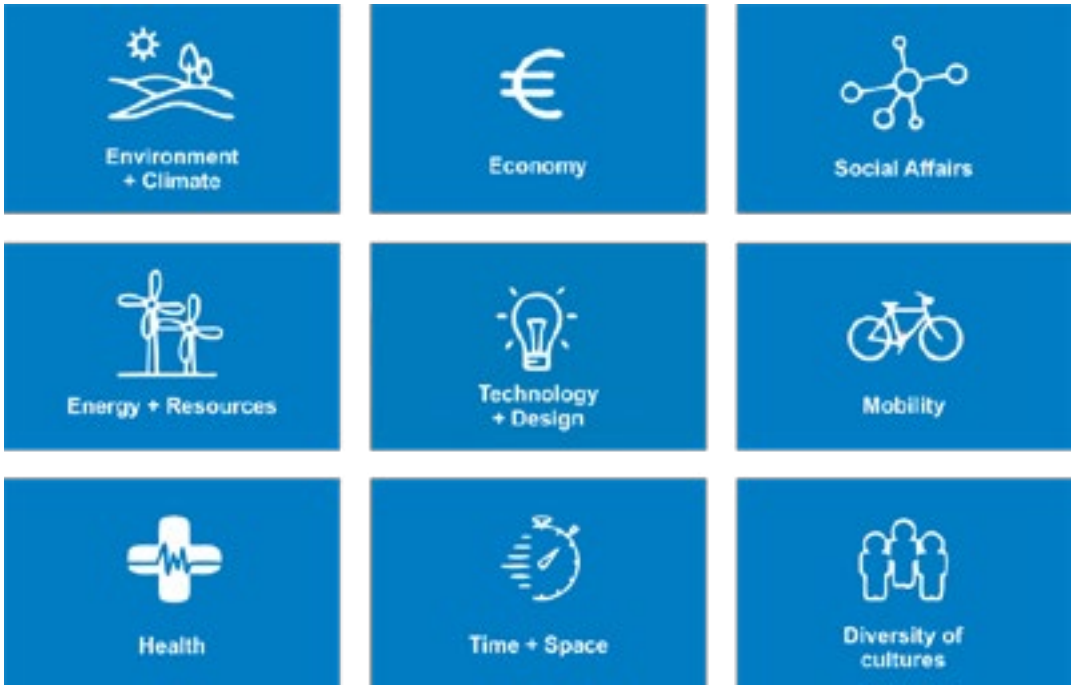
[103] https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2015.302724?journalCode=ajph&fbclid=IwAR3RJeLUt6op0piF9Ih4LzyBzu8NwKgp063UkXn2Ar85Z3T7JNJQTXtKSjg, American Public Health Association — Dutch Cycling: Quantifying the Health and Related Economic Benefits

[104] *Copenhagenize*. Mikael Colville-Andersen

[105] https://sutp.org/files/contents/documents/resources/J_Others/GIZ_SUTP_Infographic-10-Principles-for-Sustainable-Urban-Transport_ru.pdf

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 lack of physical exercise.

FIGURE 4.10 COMPREHENSIVE 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-motorized 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.

FIGURE 4.11 WINTER BIKE PARADE IN MOSCOW

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 twice as many people cycling than in California; and in hilly San Francisco, there are twice as many cyclists than in relatively flat Denver. Climate, terrain and other factors cannot be viewed as insurmountable obstacles to increasing the number of cyclists, as the facts bear out.

In the Netherlands, 36 per cent of the population choose the bicycle as their main mode of transport, and in cities the percentage is even higher. In Amsterdam, nearly 60 per cent of journeys are made using cycling or walking. Copenhagen, another role-model city for cycling, also boasts a low level of car ownership, especially for a city with a per capita GDP of over $25,000. Total cycle ridership is over 2 million km / day and the city also has the second highest penetration of share-cars in the world. In Copenhagen, which has invested $150 million in cycling in the past decade alone, 62 per cent of the population go to work or school by bicycle — 7 times more often than by car. Copenhagen is known for the fact that during snowfalls municipal vehicles first clean the cycle lanes, and only then the roads.

FIGURE 4.12 THE LOGO OF THE VELOCITY 2019 CONFERENCE IN DUBLIN (IRELAND), NOW A SIGNIFICANT INTERNATIONAL EVENT, ORGANIZED BY THE EUROPEAN CYCLISTS' FEDERATION

There are many reasons why Copenhagen has such a high share of bicycle trips. The city has a long cycling tradition, which is recognized and accepted as a part of the daily life-style and routine of many citizens. Cycling is well incorporated in the traffic planning, having taken this into account and reacted accordingly over the years to cater to the increasing number of cycle users by initiating relevant infrastructure developments.

Today, the cycle network stretches over 410 km in an area of about 90 km^2. Furthermore, the city is improving its cycling conditions using innovative transport planning instruments and the constant optimization of demand-oriented measures, such as the following:

- Constant appraisal of the current cycle situation by surveying and counting.
- Frequent optimization and extension of the cycle network by establishing of missing cycle tracks and maintenance of existing (sub-)urban cycle tracks.
- Widening of cycle tracks as a reaction to existing and future bicycle traffic demands.
- Measures to accelerate the cyclists to minimize their average journey time (e.g.: making them part of "green routes", prioritization on intersections, green waves for cycles, Bicycle Commuter Superhighways).
- Establishing infrastructure for cycle parking: bicycle-parking houses (Commercial: 0.5 bicycle parking spaces per employee / Residential: 2.5 bicycle parking spaces per 100 m^2).
- Easier intermodal transfers between bicycles and public transport.
- Additional services and innovations, to aid cycle usage in general (e.g. LED warning sensors on special intersections, footboards in front of traffic lights, air pump stations).

4.3.2 Integrated cycling and walking friendly infrastructures at city and metropolitan-region levels

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 is a key feature for cycling as a system.

FIGURE 4.13 THE PROJECT OF BICYCLE SUPERHIGHWAY IN THE RUHR REGION (GERMANY)

In 2015, the German Federal Ministry of transport launched a plan to create a «bicycle superhighway» of over 100 km to connect 10 cities and 4 universities in the densely urbanized and otherwise car-centred Ruhr region. The idea sparked in 2010 after more than 3 million people went down a portion of road between the cities of Duisburg and Dortmund closed for a cultural event. *«Coupled with Europe's blossoming affection for electric bikes and Germany's limited proximity between cities, the Radschnellweg stand to attract a new wave of pedal-powered commuters. Frankfurt, Hamburg, Berlin, Munich and Nuremberg are also undertaking bike-related feasibility studies in order to curb traffic and pollution in those urban areas».*[106] This project is targeting getting some 50,000 cars off the roads.

[106] Kelly McCartney, Ecowatch, July 2016

Similar initiatives are also under way in other parts of Germany, be it Munich in Bavaria or Berlin, where Berlin's Senate Department for Environment, Transport, and Climate Change estimates that currently half of the journeys taken in Berlin are under 3.1 miles, but a third of these journeys are undertaken by car. While Denmark has focused most of its efforts on Copenhagen, the Netherlands have started building a network of over 20 bikeways in the beginning of the 2000s. Besides, Norway has also announced its will to create bikeways connecting 9 cities. The theme of cycle highways is gaining traction, it was for instance one of the main topics of VeloCity 2019 in Dublin.

FIGURE 4.14 DEVELOPMENT OF INTERCITY CYCLING ROUTES TO SUPPORT SUSTAINABLE TOURISM. THE EXAMPLE OF POETRY ROUTES IN BADEN WÜRTTEMBERG, GERMANY

Case study. Münster intermodal policy

Bicycle stations are a crucial part of long-term attractivity of new cycle infrastructures. In the city of Münster (Germany), more than 2,000 people switched from other modes to cycling after a brand new and convenient bicycle station was created near the central railway station, meeting a high demand from commuters for quality bicycle parking spaces. The bicycle station provides parking space for 3,300 bicycles and it is divided in different sections referring to daily, monthly, and long-term parkers. Today almost all available spaces for parking situated outside the bicycle station are occupied with around 3,000 bicycles. The underground bicycle station itself can be reached by a big ramp and by two steps, one leading directly into the central station and the other one into the adjacent pedestrian area.

The Münster case is a good example of the need to develop quality *mobility points* to give uncomplicated and fast access to low-emission mobility around the clock. It can be a central facility in a new urban development area or strengthen structures in existing neighbourhoods. A variety of vehicles and services can be booked and used. This way, mobility services can be bundled in a well-structured way in one place, which is particularly important in new urban development areas. These are the potential services offered at a mobility point:

- Bike sharing (station of the city system or local initiative).
- Car sharing (parking spaces for various providers and local initiatives).
- Single-track vehicle sharing stations (e.g. e-scooters, motorcycles) and stations for other, emission-free means of transport (freight bicycles, e-bikes).
- Delivery service infrastructure (community mailboxes, lock boxes for interim storage, cooling boxes).
- IT infrastructure (computer terminal or the like) for vehicle hire, enabling of use, lock box allocation, delivery notes etc.
- Bicycle repair and service workshops - charging stations (e.g. for electric bikes and scooters or mobile hand-held devices which can e.g. be used for accessing dynamic real-time transport information).

Case study. Promoting pedestrian trips in French cities

France is implementing several initiatives to promote walk, such as the walking buses to school or the pedestrian's signs including walking time.

FIGURE 4.15 SIGNAGE FOR PEDESTRIANS SHOWING DISTANCES IN MINUTES IN GRENOBLE (FRANCE). PHOTO: ENVIRO2B.COM

Inspired by the experiences of the Nordic and some English-speaking countries, around 350 French 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, well marked routes. There is a "timetable" where the bus leaves the neighbourhood and there are several "stops" at a set time in the morning. It leaves the school after the last class when all "passengers" are ready.

As well as improving children's health and reducing motorized 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.

The city centres tend to be more and more pedestrian and yet many urban dwellers still choose to get about using individual motorized transport. The main criteria when choosing a mode of transport for daily journeys are time and the ease of getting 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 has piloted an experiment in nine cites. An evaluation of the signage showed that 91 per cent of inhabitants appreciated the new pedestrian signs and 86 per cent 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 kilometres of streets, and it plans to further expand the scheme.[107]

Case study. "My street" project in Moscow

In Moscow, the implementation of the project "my street" includes the promotion of alternative mobility ways including walk and cycling. 327 squares, highways and public spaces have been undergone improvement and reconstruction, including:

- 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.
- Quality public space.[108]

[107] Based on the answers given by France to the UNECE questionnaire.

[108] According to the response of Moscow to the UNECE questionnaire. More information about the urban improvement projects carried out in Moscow can be found at: https://www.mos.ru/city/projects/mystreet

FIGURE 4.16 A BIKE FESTIVAL IN A STREET IN ALMETYEVSK (RUSSIAN FEDERATION)

In Almetyevsk (Republic of Tatarstan, Russian Federation), the municipal government is implementing a special 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 and 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.[109]

Similarly, The Tyumen city administration has also designed a concept to develop a network of cycling paths in the city and took measures to build bicycle infrastructure, now totalling 56.27 km (out of a total of 195.30 km planned new cycling routes).[110] This cycling programme is part of a wider "smart transport" policy, with 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.[111]

A Centre for Operational Monitoring of Transport Vehicles on the Line has been created. Automated reporting systems have been installed on vehicles, as well as an Automatic Fare Payment System and contactless payment, including NFC payment, that is, payment by phone.[112]

4.4 SAFE CITY APPROACHES FOR PEOPLE-CENTRED CITIES

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 per cent of GDP. 90 per cent of road deaths occur in low- and middle-income countries despite them accounting for only about 54 per cent 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 per cent 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.

[109] Based on the answers given by Almetyevsk to the UNECE questionnaire.
[110] Based on the answers given by Tyumen to the UNECE questionnaire.
[111] Glonass is a Russian equivalent to Galileo (Europe) and GPS (United States) satellite positioning systems.
[112] Based on the answers given by Almetyevsk to the UNECE questionnaire.

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.

While speed may reduce the travel time of drivers and passengers it often happens to be the source of a large number of road safety risks. Nonetheless, many countries still prioritise traffic speed of movement over safety. Statistics on speed limitation in different countries are shown in Figure 5.11, which illustrates the need for speed control measures.

FIGURE 4.17 URBAN SPEED LAWS[113]

While the number of road accidents is on the decline, some 26,000 people a year are still killed on the road in Europe, 38 per cent of them in cities. Pedestrians and cyclists are at the highest risk. Roads are 8 times more dangerous than other settings.[114]

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.

Cyclists dislike riding among cars, while pedestrians are stressed out by cyclists riding near them and so on. 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 car lanes, the more difficult it is to stay within the speed limit as even responsible drivers are tempted to the urge to step on the gas while driving along a wide road. Narrowing 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.

The 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.

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 results from the geometry of streets which provokes high speeding, crossings put in place improperly, and scarce and dangerous cycling paths. Such places cannot be fixed all at once but they need to be made safer.

[113] http://www.sum4all.org/publications/global-mobility-report-2017, The Global Mobility Report, 2017: Tracking Sector Performance. Washington DC., Creative Commons Attribution.

[114] From a presentation by Anthony D. May, Professor of Transport Engineering, University of Leeds, UK.

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 behaviour 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.[115]

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.

TABLE 4.19 PRINCIPLES, CORE ELEMENTS, AND ACTION AREAS OF THE "SAFE SYSTEM" APPROACH[116]

PRINCIPLES	CORE ELEMENTS	ACTION AREAS	
Humans Make Errors	Economic Analysis J	Land Use Planning	Street Design and Engineering
Humans Are Vulnerable to Injury	Priorities and Planning	Improved Mobility Options	Speed Management
Responsility Is Shared	Monitoring and Evaluation	Enforcement Laws and Regulation	Education and Capacity Building
No Death or Serious Injury is Acceptable	Comprehensive Governance and Management	Vehicle Design and Technology	Post-crash Emergency Response and Care
Proactive vs. Reactive	Strong Targets and Data		

Case study. The new Road and Traffic Act in Finland

The purpose of the new Road Traffic Act adopted in Finland 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 recognized 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 will enter 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. The national guidelines for planning the pedestrian and bicycle traffic will be maintained by the Finnish Transport Agency. They include the systematic lowering of speed limits in housing areas to 30 km/h and promote different measures to improve pedestrian safety (e.g. new pedestrian crossings, elevated pedestrian crossings, improved lighting), as well as the use of structurally separated bicycle lanes when possible (city of Tampere).[117]

[115] 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

[116] 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

[117] According to Finland's response to the UNECE questionnaire.

Case study. The *Vision Zero* policy in Sweden

While Vision Zero has delivered good results by reducing many on-the-road kills and major injuries, the results have not been positive for all groups of road users, including for motorists. [118]

Vulnerable road users, such as pedestrians, cyclists and drivers of two-wheeled motor vehicles are particularly at risk. There is a potential to improve safety for cyclists through the use of good equipment, such as tyres, brakes, lights as well as helmets. Currently the Government of Sweden is drafting a national strategy for increased and safe cycling.

Several factors and measures have indirect impact on transport safety. For example, traffic volume and composition is affected by traffic regulations, the economy, demographic trends and weather conditions. For example, studies conducted by the government of Sweden illustrate that a strong connection to the labour market, i.e. education, employment and income implies a lower risk of a road traffic accident. Likewise, a strong connection to family is related to longer distances travelled in road traffic environments, but also less likelihood of being involved in an accident.

Vision Zero calls for roads to be designed so that accidents do not lead to serious or fatal injuries. Examples of measures in the road design that have contributed to reducing serious and fatal injuries for pedestrians and cyclists include adaptation of speed limits and establishment of traffic calming measures such as roundabouts, speed humps and three lane roads.

[118] The Government of Sweden runs the Transport Agency's Traffic Accident Data Acquisition system to ensure good accident and incident reporting takes place because it creates the conditions for taking effective actions that improve road safety. The main feature of the system is that it collects data from both the Swedish Police and hospitals. According to the Green Mobility initiative, supported between 2013-2017 by the Nordic Council of Ministers (Copenhagen) which is being carried into effect by the Leontief Centre, www.mobility.leontief-centre.ru.

CHAPTER 5.

Reaping the benefits of societal changes and energy transitions

5.1 MANAGING SYSTEMIC TRANSITIONS

5.1.1 Empowering local governments

The UNECE region covers more than 47 million km^2 and is home to 17 per cent of the world's population – over 1.3 billion people as of 2019. It includes some of the world's richest countries, as well as countries with a relatively low level of development. This diversity in the levels of development represents *"a challenge to UNECE, as it must respond to the expectations of its different members. However, it is also an advantage, as it encourages the sharing of experience and knowledge, as well as a guarantee of financial and technical aid to countries in need."*[119]

However, all regions, all countries, all cities, all stakeholders, are confronted to converging challenges and in particular, societal changes and energy transitioning. Across the globe, the civil society is showing signs of great awareness regarding environmental preservation and the promotion of healthier and more liveable urban environments.

FIGURE 5.1 THOUSANDS OF MADRID CITIZENS PROTEST AGAINST THE SUSPENSION OF THE "MADRID CENTRAL" ANTI-POLLUTION PLAN INTRODUCED BY MADRID'S NEW MUNICIPAL GOVERNMENT. PHOTO: REUTERS, 20 JUNE 2019

5.1.2 Managing multiple transitions

The transition is about environmental and societal changes

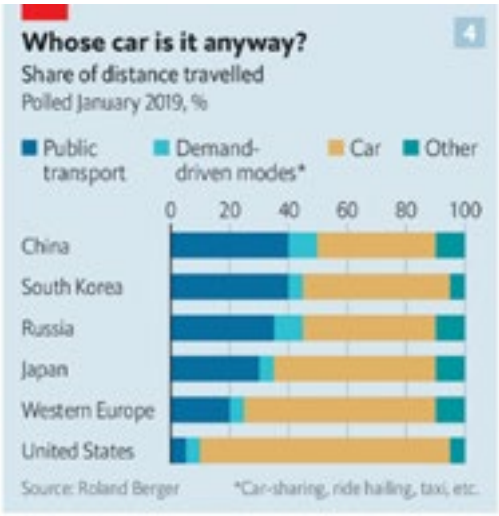
Aspirations for healthier lifestyles and healthier livelihoods are growing. The notion of happiness used to be the cornerstone of development policies in the aftermath of World War II. It is back again, only that it is not promoted by governments, but by the people and especially the younger generations. In the next two decades, urbanization will continue to grow. In the absence of universally tested solutions to tame down quickly car and combustion engine dependency, the shift towards pedestrian, cycling, in other words active mobility oriented urban development models will go with frictions and tensions. It is not just a question of changing the modal split. Promoting sustainable urban mobility requires committed but also well trained and skilful political leadership, as well as an effective engagement from within the civil society and the business sector. The sheer complexity and the costs of the ongoing multifold transition cannot be underestimated.

[119] Source: UNECE.

The transition is about energy and industry

All around the world we are witnessing rising concerns about GHG emissions and dependency on car, internal combustion engines, and fossil fuels. Yet, despite countless local initiatives, urban mobility – when including logistics – still massively relies on fossil fuel and transitioning to other modes can be economically and socially very challenging. Cities can be a role-model, but long-term gains will come from shared benefits. What would be the point of developing zero CO_2 urban cores if this meant longer commuting times and more urban sprawl for many?

FIGURE 5.2 URBAN TRANSPORT MODAL SPLIT IN THE WORLD
SOURCE: ROLAND BERGER / THE ECONOMIST, MAY 2019



Case study of EV buses in China

The case of electrification of public bus and taxi fleets in China best exemplifies the interconnection between industry shits and sustainable mobility. It is also exemplary of how globally public transportation is being shaped.

Since the end of 2018, reports and articles are piling up about an interesting and unanticipated phenomenon, which is questioning the whole mobility approach globally.In May 2019, a report went as far as to declare that *"The bus wars are over. Electricity – and China – won"*, comparing the 421,000 electric busses of China as of 2019 with the much smaller amount of 300 units in the US. [120] In reality, if electrics are now racing past a 50 per cent share of new bus sales worldwide, according to Bloomberg New Energy Finance[121], this is not only due to China. Across Europe as well as in the Russian Federation, for example, electric bus fleets are developing rapidly. Besides, other alternative sources of energy are also emerging at a fast pace, such as hydrogen power vehicles.

The Chinese case, however, is striking. Out of a situation of serious congestion and air pollution in cities and especially the largest urban regions, subsidies and stringent pollution regulations have pushed more and more cities to switch over to electrics entirely. Shenzhen switched to all electric buses, in 2017 and the 13 million people metropolis now has 16,000 electric buses.

The Guardian reported in December 2018 that *"more than 30 Chinese cities have made plans to achieve 100 per cent electrified public transit by 2020"* and the impact of such large changes is massive. Calculations show that the deployment of EV city buses in Chinese cities will help spare nearly 250,000 barrels of gasoline and diesel in 2019, according to Bloomberg New Energy Finance.

To stimulate demand, electric vehicles are strongly subsidized and exempt from purchase taxes. In six of the largest Chinese cities, they are also exempt from the restrictions placed on the purchase of cars with internal-combustion engines. The country's charging infrastructure is rapidly developing, with Beijing having more public charging points than Germany, according to a research from *The Economist* from April 2019.

Together, these stimuli have created an electric-vehicle boom, so strong that some analysts say that sales of cars powered by internal-combustion engines in China have already peaked. According to McKinsey, China only lags two or three years behind the United States of America in autonomous driving but there is more, as China is creating a comprehensive ecosystem for mobility, including cars and other vehicles, apps, data, standards, communications… aiming to create new standards and deploy them globally.

The combination of *electrification* and *autonomy* is at the heart of the ongoing profound disruption which is taking place in China at a much faster pace than anywhere else. The tech sector is interested in batteries, in autonomous mobility, in artificial intelligence, in deploying 5G, and investors originating from the tech sector have also made large investments in bike sharing systems. According to *The Economist* whether such businesses can persist when their rental incomes fall far short of the capital costs remains unclear. *"If they*

[120] Source: Think Progress. 2019. ThinkProgress is an editorially independent project of the Center for American Progress Action Fund
[121] Bloomberg NEF. *Electric Vehicle Outlook 2019*

can, it will be because of the value that tech firms capture from the data they provide. Providing the best advice on when to get on a bike, when to wait a minute for a bus and when to hail a Didi would bring with it an impressive flow of cash."

The interesting point about China is that public transportation is completely part of the game and is even partly driving it: the future mobility ecosystem connects tech companies, car and other motorized vehicle making companies, cities, governments…and transportation users.

In the case of China, the high proportion of internet users and the quasi-ubiquity of digital payment systems is driving a growing middle-class into rapidly changing behaviours. China is the world's largest market for rides ordered from a smart phone. The Didi ride hailing system has over 550 million registered users (which would correspond to nearly half of the total population of the whole UNECE region). According to *Roland Berger* consultancy, China might well be leading the way towards less car ownership not only in China, but globally. In 2017, car-sharing in China was ten times more developed than in the West, according to Roland Berger.

The case of Poland's National Urban Policy

In the assessment of the 2007 Leipzig Charter on sustainable European cities that was conducted in 2017, the development and successful implementation of *"strategies to further the use of sustainable (and soft) mobility and intelligent city logistic systems"* is described as *" a major task for cities and city regions today".* Improved connectivity is a leverage for sustainable urbanization not only from an environmental but also from a social standpoint as it helps bring together all parts of a given city.

Although there are already many EU initiatives and funding possibilities in this area, the report calls for *"more extensive coordination"* to maximize the results of these initiatives and to improve mutual learning. The objectives are to achieve *"sustainable and efficient urban mobility, focusing on public transport, reduction of motorized private transport and the promotion of so-called soft mobility (walking, cycling), accessibility (design of the public space for the disabled, elderly, young children, etc.), and efficient transport with good internal (local) and external (regional) connectivity."*

A detailed assessment of the situation in the 28 EU member States shows very different situations.

Yet, if there can be no "one size fits all" approach to develop smarter and more sustainable mobility plans and strategies, the combination of regional approaches, local initiatives and national urban policies is an interesting way to build a coherent, low carbon, way forward in the field of mobility and transportation.

Poland's national-level policy is increasingly focusing on actions aimed at cities in all their variety. In 2015, Poland created a National Urban Policy 2023 (NUP; *Krajowa Polityka Miejska*). This policy sets out the Government's urban policy-related activities within the context of the 2017 national Strategy for Responsible Development (*Strategia na Rzecz Odpowiedzialnego Rozwoju*), the National Strategy of Regional Development 2010-2020: regions, cities, rural areas (*Krajowa Strategia Rozwoju Regionalnego 2010-2020: region, miasta, obszary wiejskie*), and the National Spatial Development Concept 2030 (*Koncepcja Przestrzennego Zagospodarowania Kraju 2030*).

The Polish case exemplifies the rising global call for the creation and implementation of National Urban Policies as a strategic tool to frame urbanization and promote sustainability through city development.

In 2017, a global research in the 35 OECD countries concluded that while most OECD countries are actively engaged in developing and advancing at least some types of urban policies at the national level *"much work remains to be done to increase the scope of NUP and in making it an explicit strategy, such progress (being) a cornerstone for implementing the New Urban Agenda over the next 20 years as well as being crucial to the achievement of the SDGs and other global agreements such as those relating to climate change."*[122]

On-going initiatives such as the OECD working group on the territorialisation of the SDGs are relevant ways to explore how to move from principles to implementation of multilevel urban governance and policies, including sustainable mobility as a priority area. Interestingly, after hosting COP24 in 2018, Katowice, in Poland, has been officially selected as the host city of the 2022 World Urban Forum.

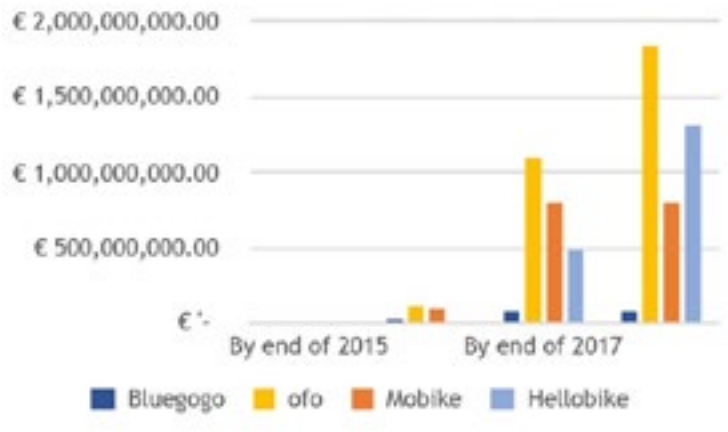
[122] *National Urban Policy in OECD Countries*, OECD, 2017, 140p

5.2 ENVIRONMENTAL AND SOCIETAL CHANGES IMPACT ON MOBILITY BEHAVIOUR: THE SHARING ECONOMY

5.2.1 The development of bicycle-sharing systems

As of 2016, there were 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.[123] The latest trend in bike-sharing is large scale free floating, a new market led by Asian companies which became global in less than five years although Germany, for example, introduced the concept of free-floating bike-sharing in 2000. Bike-sharing is no longer a local or a municipal issue. It has become a global mobility and transit issue, notwithstanding complex environmental consequences.

FIGURE 5.3 TOTAL FUNDING RAISED BY SELECTED FREE-FLOATING BIKE-SHARING COMPANIES (AS OF JULY 2018)[124]



Mobike, a Hong Kong based company which successfully started operations in nine major Chinese cities (Beijing, Shanghai, Shenzhen, Guangzhou…) as of 2015 has 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. Although the company, now a world leader, claims it has contributed to save that 4.4 million tonnes of CO_2 equivalent emissions of ridership of its bicycles, free floating bike systems have developed very fast and the market is highly volatile. By the end of 2017, about 16 million bikes "floated" on China's streets to transport about 130 million registered users. The growth came to a sudden halt in 2017 with the bankruptcy of *Bluegogo*, the third largest operator, with many more following the same fate. Meanwhile, the rest of the world follows the roller-coaster fate of Chinese free-floating bikes.

FIGURE 5.4 INTRODUCTION OF THE GOBIKE FREE-FLOATING SYSTEM IN ALMETYEVSK IN 2017 (RUSSIAN FEDERATION)[125]

Owing to the colossal rate of development of free-floating bikes, sustainability issues arose such as the clogging of public spaces and the massive destruction of bikes. Europe's largest bicycle dealers cooperative, ZEG, a German company, renounced its membership of the United Nations Global Compact pointing out to the negative environmental consequences of massive quantities of aluminium required to produce massive quantities of cheap bikes without any recycling policy. Though the rapid development of biking allowed by free floating systems should have positive environmental impacts, such as reduced congestion, improved air quality, increased accessibility of public transit by complementing public transport services[126] this service cannot go without proper regulation and without transparent and accountable policies regarding bikes production and recycling.

[123] 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/.
[124] Source of graph and figures: *The evolution of free floating bike-sharing in China.* S. Ibold, dr C. Nedopil, In *Sustainable Transport in China*, August 2018.
[125] Based on the answers given by Almetyevsk (Russia, the Republic of Tatarstan) to the UNECE questionnaire.
[126] The Bike-share Planning Guide, ITDP, https://www.itdp.org/wp-content/uploads/2014/07/ITDP_Bike_Share_Planning_Guide.pdf

The fact that free-floating bike systems have become so widespread so quickly illustrates 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.[127]

Apart from free floating, docked bike-sharing systems have been developed the world-over in the last decade.

In China, the city of Hangzhou initiated a public station-based bike-sharing (PBS) scheme in 2008 for its 4.8 million inhabitants. The number of public bikes in the city grew from only 2,000 in 2008 to about 84,100 in 2016, with a total of 3,572 stations. In comparison, the biggest public bike-sharing scheme outside of China, Vélib' in Paris, operates a total of 1,751 stations and 23,900 bicycles.

Today, a lot of cities around the globe have their own bike-sharing systems, and more programmes 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.

FIGURE 5.5 THE MAYOR OF PARIS AND THE PRESIDENT OF PARIS METROPOLITAN AUTHORITY IN A SHOW TO PUBLICIZE THE NEW VELIB' BIKES IN 2018[128]

Case study. The Gdańsk - Gdynia - Sopot Metropolitan Area bike sharing system in Poland[129]

The system, called MEVO, launched as a single public bike sharing scheme in the 14 cities and communes of the Gdańsk - Gdynia - Sopot Metropolitan Area in Pomeranian Voivodeship, Poland. The electric bike can be used by residents and tourists visiting Gdańsk, Gdynia, Sopot, Tczew, Puck, Reda, Kartuzy, Sierakowice, Somonino, Stężyca, Władysławowo, Żukowo, Pruszcz Gdański and Rumia.

The bikes can be collected from any of 660 bicycle stations spread across 6 cities and municipalities in the Metropolitan Area. Renting and returning bicycles to any of these stations is at no extra charge. Bicycles can also be returned outside the designated parking stations; for an additional fee of PLN 3, bicycles can be returned anywhere within the area of use (the boundaries of individual cities), as long as they are left in a public place and do not hinder other users of public space.

Cyclists that rent a bicycle from any location outside the 660 stations and who return it back to one of the stations, earn a bonus in the form of a 2 Zlotys (0.47 euro) top-up. Rental fee without subscription is 0.10 Zloty per minute. Monthly subscription and annual subscriptions are also available at respectively 10 Zlotys (per month) and 100 Zlotys (per year). Subscribers are able to use a bicycle for 90 minutes per day and pay a fee of 0.05 Zloty per minute once the 90 minutes have been exceeded. MEVO is one of the first bicycle systems in Poland available all year round. Starting with 1,224 bicycles, it is planned that the number of bicycles in the Gdańsk - Gdynia - Sopot Metropolitan Area will ultimately be increased to 4,080. During the winter season, part of the fleet will be kept in storage, as demand will be lower. The project is co-financed

[127] https://www.itf-oecd.org/sites/default/files/docs/policy-priorities-decarbonising-urban-passenger-transport_0.pdf, Policy priorities for decarbonizing urban passenger transport. OECD/ITF, 2018

[128] After it was introduced, the deployment of the new Paris bike sharing system faces many drawbacks including months long delays to create new docking stations and problems with the new bikes, quoted as expensive and fragile, 2018. France.

[129] http://www.eltis.org/discover/news/one-eus-largest-electric-bike-sharing-systems-launched-gdansk-gdynia-sopot, Michiel Modijefsky, 2019.

by the European Regional Development Fund under the Regional Operational Program of the Pomeranian Voivodeship for the years 2014-2020.

FIGURE 5.6 MEVO BIKE-SHARING SYSTEM (ONE OF EU'S LARGEST ELECTRIC BIKE-SHARING SYSTEMS) LAUNCHED IN GDAŃSK - GDYNIA - SOPOT METROPOLITAN AREA (POLAND)[130]

The development of bike-sharing systems can also include several types of bikes, including cargo-bikes, as currently experienced in the new mixed-use development project of Aspern near Vienna in Austria.

FIGURE 5.7 CARGO E-BIKE SHARING SYSTEM IN ASPERN. SOURCE: RENAISSANCE URBAINE, 2016

Successful bike-sharing systems across the globe share 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.

[130] More information: Mevo bike sharing system: https://rowermevo.pl/en/.

Case study. More cycling through shared e-bike systems in London[131]

Shared e-bikes, implemented at scale, could double the number of bicycle trips in London, increasing their modal share and reducing congestion and pollution. A recent report by Steer suggests that 813, 000 daily trips in Greater London could switch to shared e-bikes. This would lead to 21,000 fewer hours spent in traffic and 184 fewer metric tons of CO_2 emissions every day. Based on current trip patterns, the study assessed how many daily trips could potentially switch to shared e-bikes. The study uses a 'switchable trips' methodology that is also applied in Transport for London's (TfL) – Analysis of Cycling Potential. It considers both complete (door-to-door) trips as well as the first/last mile station access/egress portion of public transport trips. However, it excludes trips by children, people over 80 years of age, and trips that are too long, too short, or that involve accompanying children or carrying luggage.

On this basis, the study finds that out of the 17.4 million daily trips made across Greater London, about 8.2 million trips are potentially 'switchable' to shared e-bikes. It is suggested that large-scale deployment of e-bikes would result in a switch of 813,000 daily trips to shared e-bikes. This corresponds to a modal share of 4.7 per cent, roughly twice the current share. The largest part of the modal shift to e-bikes comes from public transport (325,000 trips), followed by vehicles (279,000 trips), while changes in walking (116,000 trips) and first/last mile (95,000 trips), trips account for the remainder of the modal shift.

An important assumption underlying the calculations in the report is that the positive trend in cycling use seen in recent years continuous. London Mayor's Transport Strategy aims to ensure that by 2041, 80 per cent of journeys in London will be made by cycling, walking and public transport. To reach this objective continued investment cycle infrastructure is required which normalizes cycling for a wider range of people and for more trips. The introduction of shared bike schemes has been a strong force in popularizing cycling. The Steer report estimates that development of a shared "dockless" e-bike system(s) at scale would require between 81,000 to 163,000 new e-bikes in London, along with the necessary bike lane and charging infrastructure, to meet the identified demand.

In order to ensure the benefits of such schemes are maximized – and that London avoids the problems they have caused in other cities – a strategic approach is required, a report by the London Assembly Transport Committee concluded earlier this year. The report calls the implementation of a London-wide licensing scheme involving a small number of operators being licensed to lend bikes across the city. In addition, Supplementary Planning Guidance for cycling should instruct boroughs to require that new developments have parking space for dockless bikes and TfL should provide space in appropriate places on the TfL Road Network.

Currently, TfL does not have the powers to regulate dockless bike operators at a London wide level as this falls within the remit of the local highway authorities. TfL is working with London Councils to explore the possibility of establishing a new bye-law to enable a pan-London approach to be taken. TfL is also considering the best approach to dockless parking as more bikes are deployed and, based on operational feedback from boroughs, is planning to update its code of practice for operators.

5.2.2 Car-sharing systems are now part of the urban mobility portfolio

Sharing economy an issue popularized a decade ago, is a game changer in the field of mobility,[132] based on the collective use of goods and services, barter and lease instead of ownership. 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 US$ 335 billion by 2025.

In less than a decade, transport services have become a major sector for 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.

[131] http://www.eltis.org/discover/news/cycling-could-double-london-shared-e-bike-systems, Michiel Modijefsky, 2018.
[132] *What's Mine Is Yours: The Rise of Collaborative Consumption.* Rachel Botsman and Roo Rogers, 2010

By contrast, users moving away from car ownership by switching to car sharing services can bring about major social effects such as growing financial well-being of the population achieved through saving on car purchases; reducing the space taken up by parked cars; lower consumption of resources used for the manufacturing 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).

As applied to the transport system, shared use mechanisms are represented by ride-hailing Uber, Gett, Yandex, etc.), short-term car rental (car sharing), fellow travellers search (car-pooling or ridesharing) although in practice, the generic term of car sharing is widely acknowledged to designate individual and platform-based car sharing. 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 a trip regardless of the location.
- Social networks that make the service transparent while also bolstering the level of driver - passenger trust.

In 2014, car sharing 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.[133]

There are two car-sharing 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.

Implementing car sharing models can create negative effects. Congestion is a challenge for car sharing 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 car sharing, 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 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 to car sharing. Furthermore, car sharing operators entering new markets are often faced with fierce competition from similar modes of transport, such as taxis and conventional car rental.

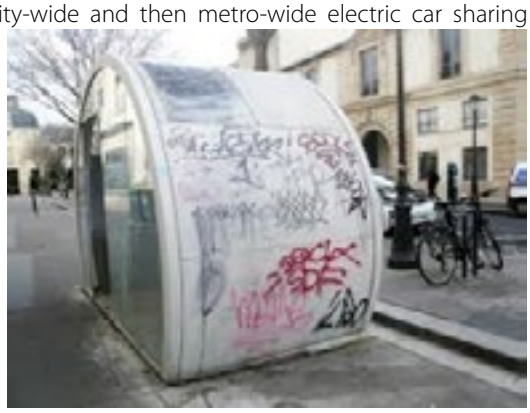
Usual problems that still need to be addressed by car sharing systems are the potentially poor condition of the car, as some customers tend to take less care of car sharing cars than others, so the fleet inevitably deteriorates in appearance, both externally and internally and the lack of cars in crowded 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. Last but not least, there is no unified way to measure car sharing across the globe, making it quite difficult to conduct precise comprehensive assessments apart from analysing case studies.

[133] 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.

FIGURE 5.8 CAR SHARING BUSINESS MODELS[134] AND A GLOBAL MAPPING OF B2C CAR SHARING PLATFORMS IN THE WORLD IN 2015/2016[135]

FIGURE 5.9 THE AUTOLIB' EXPERIENCE IN PARIS AND PARIS METRO AREA: A COMPLEX PUBLIC-PRIVATE ORGANIZATION[136]

Paris municipal government launched "Autolib" a city-wide and then metro-wide electric car sharing



system in 2011. As of 2017, the service used over 3,900 vehicles and 1,100 charging stations in Paris and surrounding municipalities. A dedicated legal entity, *Syndicat Mixte Autolib'* was formed in 2008/9 to oversee the development of car-sharing as a public service. Autolib', a dedicated private company and a subsidiary of Bolloré group, a multinational French company, started to operate the system after winning a public tender in 2008, in principle at no cost for municipal finance. Although Autolib' was a success with more than 300,000 rentals/month, the system was never profitable with a total debt of nearly 300 million euros, according to the operator. In 2016, *Syndicat Mixte Autolib'* was merged with the entity managing the municipal and metropolitan bike sharing system *Velib'*, forming a new entity known as *Syndicat Autolib' et Velib' Métropole*. Yet in 2018, the bankrupt Autolib' had to stop operation in the midst of a controversy between Bolloré Group and Syndicat *Autolib' et Velib' Métropole*. The service met many problems during a short decade of operation. Cars and stations often served as shelters for homeless people, while also stirring

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

[135] Source: TSRC Shaheen 2015, ACEA 2014, 6t) bureau de recherché 2013, German Car Sharing association 2015, Boston Consulting Group, 2016. In ADEME, *Enquête nationale sur l'autopartage. Edition 2016, état des lieux technique et méthodologique.*

[136] Illustration source: L'Express.fr / vivrelemarais.typepad.fr

discontent about an overuse of public space in the centre of Paris. Several companies such as Moov'in Paris (Renault), Free2Move (PSA group), Car2go (Daimler group) are now using the electric charging points of the former Autolib' system.

Case study. Car sharing in Moscow

FIGURE 5.10 CAR SHARING IN MOSCOW

Car sharing 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 car sharing trips and over 27,000 bicycle trips per day in Moscow.

In early autumn, 2018, there were 15 car sharing 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, companies that provide car sharing services need 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.[137]

5.2.3 Carpooling and ridesharing

Car-pooling and ride sharing, a C-to-C (consumer to consumer) way of car sharing have also followed an accelerated development in the last decade, linked with the use of smart phone and web-based tools to connect users. Although car-pooling mainly depends on private initiative, this is becoming an integrated part of multi-mode mobility strategies. In France rural and periurban areas for instance, the development of dedicated car-pooling parking is being pushed by local, district and regional governments altogether, as illustrated below.

The first carpooling projects emerged in the 1990s and initially met many obstacles such as the need to build up a user community and a convenient way of interaction with each other. This kind of service has proven particularly attractive in areas poorly covered by public transport.[138] Also, carpooling is more popular among those who travel in the same direction every day (by 30 per cent) than those who travel on casual trips.

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.

[137] http://voditeliauto.ru/poleznaya-informaciya/online/carsharing.html as well as based on the answers given by Moscow (Russia) to the UNECE questionnaire.

[138] Elizabeth Deakin, Karen Trapenberg Frick, Kevin Shively. Dynamic Ridesharing // Access. — 2012. — № 40. — С. 23—28. A study conducted at the University of California Berkeley in 2010 showed that about 20 per cent of respondents are willing to do ridesharing at least once a week.

TABLE 5.20 TYPICAL CAR-POOLING BENEFITS AND WEAKNESSES

Typical carpooling benefits	Typical carpooling weaknesses
• Savings on fuel, repair, parking and fees	• The driver is responsible for any delay and financially liable should his/her vehicle be involved in a car accident
• Reduced traffic congestion thanks to car enthusiasts and fellow travellers riding together in one car	• Drivers sometimes have to come and pick up their passengers which extends their travel time
• Reduction of emissions of pollutants and climate gases	• It is hard for municipal authorities to organize and support the operation of carpooling
• Avoiding stress and driving load. Taking turns day-by-day allows carpooling users to alternate in driving	• Risk of riding with a fellow traveller with criminal intent.
• 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	

FIGURE 5.11 THE OFFICIAL INAUGURATION OF CAR-POOLING PARKING LOTS IN MANOSQUE AND PEYRUIS (HAUTE PROVENCE, FRANCE)[139]

5.3 THE ENERGY TRANSITION: URBAN MOBILITY WITHOUT FOSSIL FUEL?

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. According to the International Organization of Motor Vehicle *Manufacturers,* fossil fuel motorized vehicles only account for less than 20 per cent of GHG in the world, making it a secondary issue. However, the number of vehicles in circulation is expected to double by 2050 as compared to the beginning of the century, especially in urban areas, already plagued by air pollution.

Transport accounts in average for more than 50 per cent to local and regional air pollution with more accurate proportions depending on both the pollutant and location.[140] 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.

[139] Source: Haute Provence info, April 2013
[140] http://eco-madi.ru, Ecotransport: textbook / S.V. Shelmakov — M.: MADI, 2018.

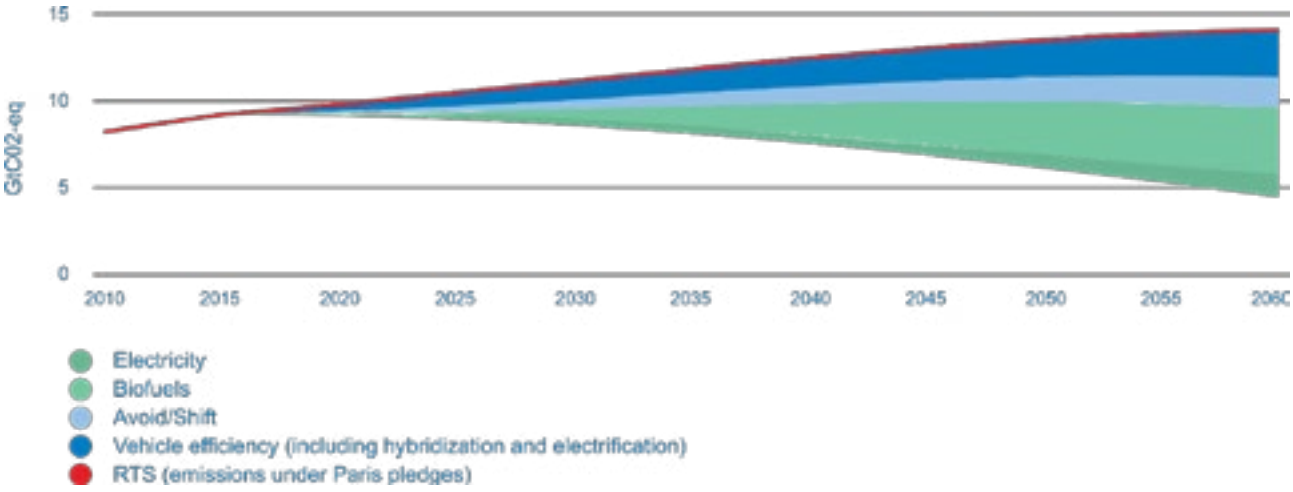
EV technology (i.e. plug-in hybrid and battery EVs) presents a promising option for technological advancement in urban travel, offering the potential for efficiency improvements of up to 100 per cent relative to ICE vehicles. Direct-charging electric battery vehicles, in particular, present the most 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 per cent, versus 22 per cent and 13 per cent 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 use.[141]

FIGURE 5.12 THE WELL-TO-WHEEL GHG EMISSIONS IN THE RTS AND 2DS SCENARIOS OF ETP 2017, 2015-2060[142]



5.3.1 The rapid growth of electric cars, a catalyst for cleaner mobility

The development of electric cars is a major change in mobility trends. As for bikes and even to some extent trams, this is not a phenomenon specific to the UNECE region but a global issue. 2016 was acknowledged as an excellent year for electric vehicle sales across the globe. 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 per cent of the total car market.[143]

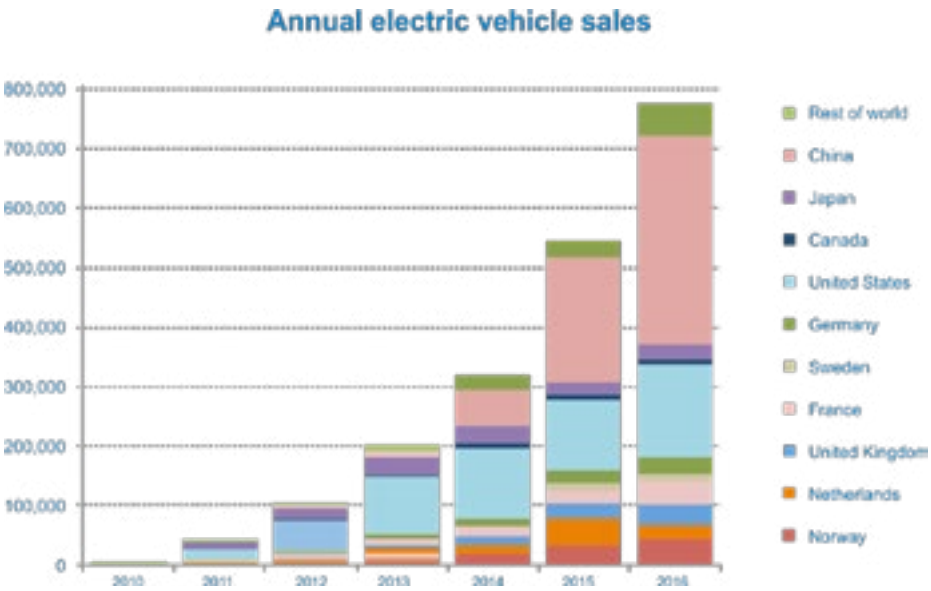
[141] https://www.itf-oecd.org/sites/default/files/docs/policy-priorities-decarbonising-urban-passenger-transport_0.pdf, POLICY PRIORITIES FOR DECARBONISING URBAN PASSENGER TRANSPORT © OECD/ITF 2018

[142] https://www.iea.org/topics/transport/, International Energy Agency.

[143] http://www.forbes.ru/biznes/338511-elektromobili-budushchee-uzhe-zdes.

A 2018 study by the International Energy Agency shows that 2017 has been even better with a total of more than 3,000,000 electric and hybrid vehicles sold.[144] In the course of 2017, the number of these vehicles went up by 56 per cent compared with 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 5.13 THE GLOBAL RISE OF ELECTRIC VEHICLE SALES[145]



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 per cent as compared to 2016. The United States has come in second with 280,000 in 2017 (up from 160,000 in 2016).

Within the UNECE region, Northern Europe is a hub for electric transport development. The share of electric cars last year accounted for 39 per cent 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 per cent of all car sales in Iceland, and 6 per cent in Sweden. Among developed countries, Germany and Japan are also worth mentioning, as both countries witness a significant uptick in the EV fleet. Sales in Germany and Japan more than doubled in 2017 as compared to 2016.

FIGURE 5.14 A PROTOTYPE OF ELECTRIC CAR DESIGNED BY KALASHNIKOV COMPANY UNVEILED IN 2018 ECHOING THE IZH-COMBI SOVIET MODEL FROM THE 1970S

The image of EVs has been profoundly changing. Premium German car brands are being challenged by Tesla at present the largest and by far the trendiest electric car maker in the world. In parallel, several new companies have been created in in recent years in China. European car makers have started to formulate a response. Electric cars are definitely the new trend.

FIGURE 5.15 ELECTRIC CHARGING STATION IN RURAL AREAS (HERE IN SANKT MICHAEL IM LUNGAU, AUSTRIA) ARE BECOMING COMMONPLACE THROUGHOUT EUROPE

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.

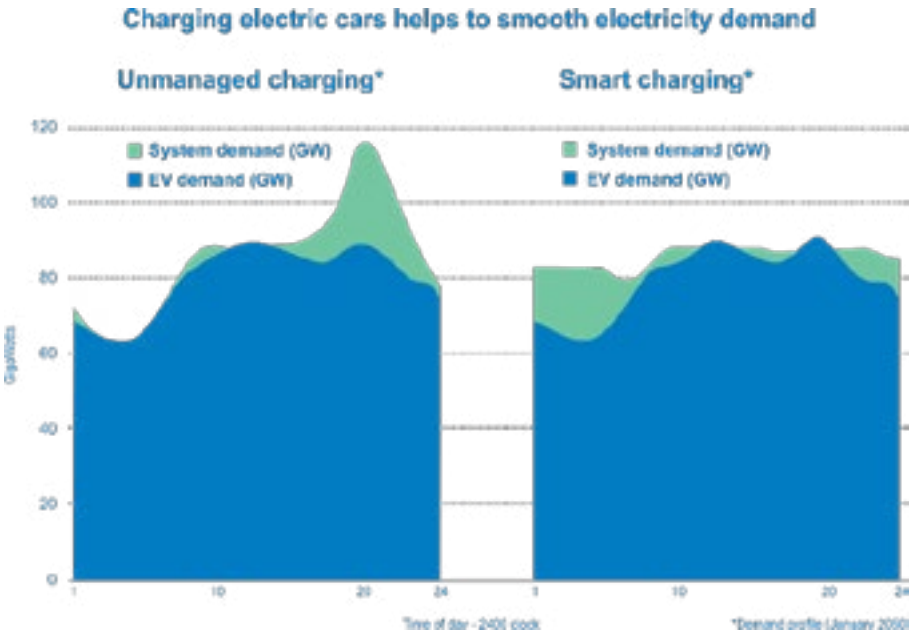
The expected environmental outcomes of more electric cars on the roads are huge, although complete lifecycle assessments of electric vehicles as compared with fossil fuel vehicles need to be refined. According to *Eurelectric* association, an electric car would reject 66g of CO_2/ km of mileage whereas a traditional car running on gasoline would reject 124g. Promoters of electric

[144] https://webstore.iea.org/global-ev-outlook-2018, Global EV Outlook 2018, International Energy Agency, France, 2018.
[145] Presentation by Michael P. Walsh, International Consultant, Founding Chairman Board of Directors, International Council on Clean Transportation, Moscow, Russia, May 19, 2017.

vehicles point out several other positive factors for the European economy linked with EV development, encouraging electric cars to become the new normal:[146]

- Creation of 200,000 new jobs by 2030.
- Sufficient recharging points in western and northern Europe today for the early market, and that just 5 per cent of charging happens at public recharging points.
- Are lower CO_2 today even when compared on a full life-cycle basis and even in countries with the least green electricity.
- Battery cells will be manufactured in the EU and there are enough raw materials available.
- 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.

FIGURE 5.16 IMPACT OF EV CHARGING ON POWER GRID MANAGEMENT

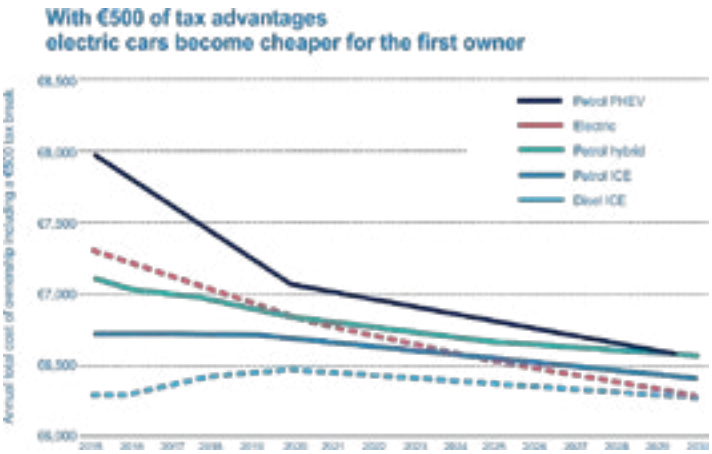


Fears that charging of EVs will cause widespread blackouts are probably exaggerated but the widespread electrification of mobility will have a lasting impact on power grid management. A recent study[147] shows that the expected ramp up of electric vehicles by 2030 should not cause significant increases in power demand, provided that smart grids are further developed.

FIGURE 5.17 ELECTRIC CARS COMPETITIVE TOTAL COST OF OWNERSHIP[148]

While purchase prices for most EV models remain higher than comparable diesel and petrol cars, the total costs of ownership (TCO) appear to be lower, considering how much it costs to fuel, maintain and insure the car. A study by the EU Consumer Organization (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.

The impact of the conversion of the car making industry to electric vehicles is being intensively debated. According to the European Commission, CO_2 emissions reduction targets should benefit the industry and could even help create 86-88,000 net new jobs by 2030.



[146] https://www.transportenvironment.org/what-we-do/cars-and-co2/publications, Transport & Environment, Brussels, Belgium, 2018.
[147] https://www.transportenvironment.org/what-we-do/cars-and-co2/publications, Transport & Environment, Brussels, Belgium, 2018.
[148] https://www.transportenvironment.org/what-we-do/cars-and-co2/publications, Transport & Environment, Brussels, Belgium, 2018.

A recent study by Cambridge Econometrics, endorsed by BMW, VW, Daimler, Renault-Nissan and Toyota advocates that a shift to plug-in vehicles should create 206,000 net additional jobs in Europe by 2030, including in construction, electricity, hydrogen, services and most manufacturing sectors. The downward trend in job creation in the automotive manufacturing industry would then stop after 2030.

Such figures are challenged by unions and others pointing to unemployment risks in many car-manufacturing regions, especially among subcontractors.

From spring 2018 to spring 2019, 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 CO_2 standard is urgently needed to accelerate investment and transition to e-mobility in Europe, which will secure the continent`s automobile industry long-term competitiveness and manufacturing jobs.

FIGURE 5.18 ELECTRIC VEHICLE DEMONSTRATION MODELS AND EXPERIMENTAL CHARGING STATIONS IN THE RUSSIAN FEDERATION AND BELARUS[149]

5.3.2 The exponential rise of electric micro-mobility: temptation without regulation?

Cities across the world experience a rapid growth in the use of "small" electro mobility devices of all sorts, such as electric scooters, electric bicycles, Segways, gyroscooters, etc. While it is difficult to estimate the long-term impact of such mobility devices on the environment and to evaluate the consequences on modal splits, individual electro mobility has become a global symbol of quality of urban living. We have tried to list some of the main devices, although this market changes vary rapidly and is also prone to numerous other sorts of experimental vehicles, which cities try to regulate to save pedestrians.

TABLE 5.21 TENTATIVE LIST OF COMMON INDIVIDUAL E-MOBILITY VEHICLES AND DEVICES

Device	Definition	Use	Notes
Electro bikes	Electric powered motorbikes	Same as a regular motorbike	Range: 50–100 km Maximum speed: same as a motorbike km/h
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 licence-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

[149] In 2018 Belarus approved a programme to create a State charging network for electric vehicles in compliance with global standards. The programme targets the deployment of 1,304 EV charging stations by 2030, the 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) and over 25,000 cars by 2030.

Device	Definition	Use	Notes
Monowheel (unicycle)	Electric self-balancing scooter with a single wheel and two stands	Used as daily urban transport and for walking in several 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: 10–35 km/h Travel range: 10–130 km Riding requires protective equipment Powerful monowheels are the safest
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
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 manoeuvrable	Fairly expensive Weight: approx. 40 kg. Mileage: up to 39 km Maximum speed: up to 50 km/h
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 motorized (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

FIGURE 5.19 INTERNATIONAL CARGO BIKE FESTIVAL, GRONINGEN, JUNE 2019[150]

[150] Source: https://www.stichtingmilieunet.nl/andersbekekenblog/agenda/international-cargo-bike-festival-en-sump-congres-in-groningen-delivering-happiness.html

5.3.3 Electric mobility: EV and drone passenger transportation?

Drone market forecasts vary considerably as they define the market boundaries differently e.g. military versus civil or commercial versus leisure use, but all agree that drones will be a multi billion-dollar market within the next five to ten years. [151]

A 2016 PwC global report on the commercial applications of drone technology estimated a volume of USD 127 billion for a civil-drone powered solutions market for addressable industries (measured by cost of labour and services that have a high potential for replacement by drones) (PwC, 2016). Goldman Sachs projected a global market size of US$ 100 billion for the period from 2016-2020, which included a US$ 13 billion forecast for commercial/civil operations and an estimated total spending on drones (both military and civil) of US$ 17.5 billion in the United States, US$ 4.5 billion in China and about US$ 3.5 billion in the United Kingdom (Goldman Sachs, 2016). A 2018 global survey by Blyenburgh, (2018) identified an expected a three-fold increase in missions for the transport of goods between 2017 and 2018 (albeit starting from a very low base). It also identified passenger drones as a growing, but miniscule market and projected the outlook for the use of drones for market sectors such as construction, maintenance and remote sensing as stable.

Regarding the number of drones, a 2016 report by Gartner projected that there will be ten times more commercial drones than manned aircraft by 2020. This would mean about 230, 480 commercially operated drones around the globe in 2020, when compared with the statistics for Boeing for 2016. These numbers are dwarfed by the projected global leisure drone fleet, which Gartner calculated at three million operative units in 2017. The firm also projected that the personal and commercial drone markets will increasingly overlap as technological breakthroughs allow the use of cheaper leisure drones for commercial applications.[152]

FIGURE 5.20 AIRBUS ELECTRIC DRONE PROTOTYPE AT LE BOURGET PARIS AIR SHOW 2019. SOURCE: AIR JOURNAL / AIRBUS

[151] Source. *(Un)certain Skies? Drones in the world of tomorrow.* ITF – CPB, 2018
[152] Source. *(Un)certain Skies? Drones in the world of tomorrow.* ITF – CPB, 2018

CHAPTER 6.

PROMOTING A NEW GENERATION OF INTELLIGENT TRANSPORT SYSTEMS (ITS)

6.1 CONTINUOUS DIGITAL DISRUPTIONS: WHERE ARE WE NOW WITH MOBILITY AND TRANSPORTATION?

6.1.1 Integrating plans and technologies is a priority

The future of urban mobility depends on a nexus of infrastructures, mobility devices (collective, individual vehicles with very short or longer range) and IT systems. This nexus is being shaped by global trends and global players. The market of urban mobility has gone global and the most visible transformations are currently data driven. In practice, few cities have enough skills and resources to build their own way forward: the future of urban mobility is no longer a local issue.

The management of those combined transitions call for more integrated policy-making connecting urban and transport policies, such as through National Urban Policies (NUPs), combined with Sustainable Urban Mobility Plans (SUMPs), as defined by the European Commission since 2013 and with a new generation of SUMPs 2.0 coming up in 2019.

In a video message shared at the Universal Assembly of UN-Habitat which took place in the end of May 2019 in Nairobi, the United Nations Special Envoy for Road Safety Jean Todt pointed out that 1.5 million people die on the roads annually, and recommended *"regulating ride hailing services, advancement in transport technology and promoting infrastructure updates that prioritize non-motorized transport"* as priorities for the implementation of SDG11 on *Sustainable, safe and resilient cities.*

The UN-Habitat Assembly also endorsed the 2023 strategic plan of UN-Habitat and its four priority areas:

1. Reduced spatial inequality and poverty in communities across the urban-rural continuum.
2. Enhanced shared prosperity of cities and regions.
3. Strengthened climate action and improved urban environment.
4. Effective urban crisis prevention and response.

In that context, transportation and mobility systems are seen as a tool to reach more important goals. However, the Nairobi discussion does not account and a crucial point: the future of mobility depends on two superseding factors, the future of infrastructures and the future of the technology related to mobility and transportation.

At a special event *"innovative urban mobility for sustainable cities in Africa"* on 31 May 2019, participants discussed a huge diversity of possible solutions the meet the demand for more sustainable transportation in cities, from biometric data to measure cyclists stress levels in Nairobi to the connectivity between different mapping initiatives for high quality, transport related data generation and the development of behavioral measures aimed at reducing the carbon from the transport sector by encouraging people to rethink transport choices, delivered through digital technologies, etc.

Yet, the session never tackled the new industry/ technology and spatial planning nexus that is emerging from accelerated technological disruptions in the field of mobility. It did not address the effects of infrastructure planning on the future of mobility and transportation in cities.

The timeframe of future transportation systems is mid-term and long-term, which is also the time frame to measure the consequences of major industry and technology shifts. The challenge for public and private decision makers in cities, as well as for citizens and related organizations is to confront 10 to 15 years' orientations with a mounting pressure from daily issues.

The dependency of plans and policies on energy and industry change is impacting the future of sustainable urban transport and planning in an unprecedented way. Addressing the issue of sustainable transport and urban planning in 2019 and for the years to come means empowering local governments so that they can deal with technology and digital transformations and use them to reduce CO_2 and GHG emissions, to manage urban growth.

6.1.2 Between sustainable transportation and sustainable planning, the key role of infrastructures

Out of the bulk of existing frameworks and recent studies and reports on infrastructures, the G7 Ise-Shima five principles promoting quality infrastructure investment adopted in 2016 is being increasingly acknowledged by governments, research groups, financial institutions, multilateral bodies.

This is illustrated by the *T20 Communiqué* of May 2019 ahead of the Osaka June 2019 G20 summit. Moreover, the final communiqué of the G20 Osaka Summit held 28 and 29 June 2019 underlines in its paragraph 13 the key role of quality infrastructures.

According to the T20 Communiqué adopted in Tokyo in May 2019, there is an urgent need for G20 countries (and beyond) to develop high quality infrastructure that is cost efficient over the life cycle, and maximizes the contributions to economic growth, the Sustainable Development Goals and environmental outcomes including impact on and resilience to climate. High-quality infrastructure should encompass all benefits and costs including spillover effects and externalities, with equal consideration to economic, social and environmental dimensions. The positive "spillover effects" of infrastructure, if well-managed, can boost GDP and tax revenue at the municipal, regional and national levels and in turn be utilized to address the gap between infrastructure demand and availability of finance.[153]

The *Ise-Shima principles* could well illustrate the way forward to further connect urban mobility policies and plans and build and manage the corresponding infrastructures, all the more if infrastructure development spill-over effects are well thought over and managed.

The principles of Quality Infrastructures

Principle 1: Ensuring effective governance, reliable operation and economic efficiency in view of life-cycle cost as well as safety and resilience against natural disaster, terrorism and cyber-attack risks

Principle 2: Ensuring job creation, capacity building and transfer of expertise and know-how for local communities

Principle 3: Addressing social and environmental impacts

Principle 4: Ensuring alignment with economic and development strategies including aspect of climate change and environment at the national and regional levels

Principle 5: Enhancing effective resource mobilization including through PPP

6.2 FROM ITS TO SUSTAINABLE ITS

6.2.1 The new face of ICT

In 2012, UNECE edited a special report exploring the role of Intelligent Transport System (ITS) in sustainable mobility. The then Secretary-General of the United Nations Ban Ki Moon wrote in the foreword to the report that "Technology has been fundamental to transport throughout human history, but recent rapid advances in information technology promise to transform transport management in ways that would have been inconceivable until recently." He also quoted Information and communication technology (ICT) as crucial for sustainable development, underlining the role of the transport sector in the global economy. According to this milestone report, ICT applied to transport are therefore based upon a series of supporting communication systems, which can be considered as the foundations developing any piece of technological equipment or ITS service. These systems include:

- Telecommunication Networks (TLC).
- Automatic identification systems (AEI/AVI).
- Systems for automatically locating vehicles (AVLS).
- Protocols for the electronic exchange of data (EDI).
- Cartographic databases and information systems providing geographical data (GIS).

[153] Yoshino, N., Bhattacharya A., Buchoud, N., Kovarik, J.B et al. *The economic effects of infrastrucutre investment and its financing.* T20 Japan Communiqué, May 2019

- Systems for the collection of traffic data, including Weigh-In-Motion (WIM) and systems for the automatic classification of vehicles.
- Systems for counting the number of users of a public transport system (APC).

Since the edition of the report, though, digitalization of the economy and the industry has move forward quickly, not only in UNECE countries but globally. Several breakthroughs can be noted, such as:

- Convergence of CCTV monitoring systems and Artificial Intelligence (AI).
- Development of open data standards.
- Emergence of new digital technologies such as blockchain.
- Development of the Internet of Things (IoT) or "connected objects".
- Rapid move from 3G to 4G to 4G+ to 5G standards in mobile phones, with a debit of 1,9 Mb/sec for 3G, 150 Mb/sec for 4G, up to 1 Gb/sec for G5.
- Development of autonomous vehicles, on land, on water (roboats), in the air (drones).
- Development of industry 4.0.

6.2.2 Dealing with mobility start-ups: *"let us fix your urban mobility problems"*

When dealing with ITC/ITS another factor needs to be taken in to account. After disruptions in retail, in the press, in the advertising industry and many others, the globalised venture capitalist community has been looking in recent years for the next big opportunity and it believed it to be mobility. According to McKinsey, $110 billion has been invested in mobility start-ups between 2010 and 2016, with the most money going to start-ups in the sharing and autonomous vehicle spaces.

Not surprisingly the bulk of the investment has come out of Silicon Valley but the balance is shifting to South-East Asia and China. Building on contemporary technological and financial breakthroughs, Uber has raised a total of $24 billion in over 22 rounds and hopes to go public in the summer of 2019. But Uber has challenges. It is burning through cash (in the second quarter of 2018, it lost $891 million) and has increasing competition due to low barriers to entry.

Cities are also starting to question their offer of "let us fix your urban mobility problems". New York was the first major city to limit the number of vehicle licenses after a study reported that Uber was contributing to traffic. In Germany, Uber was briefly banned in 2014, and currently only operates in Berlin, Munich, Düsseldorf and Frankfurt. Uber's vision is to be the world's first private multi-modal operator moving commuters by bike, car, air taxi and autonomous vehicle in the future. Whether this is a vision shared by the public and cities alike, only time will tell, but it is a relevant illustration of the profound changes in mobility and transportation systems, which go way beyond the mere addition of a series of new technologies.

6.2.3 Assessing the complex effects of technological changes on urban mobility

The impacts of the on-going digital transformations in the field of mobility and transportation are systemic and huge, within a wider social context of a growingly digitalized society in all regions of the world. Until recently, there were two main mobility solutions – private car ownership and public transport. Subsidized public transport has been the only way to move large amounts of people with low pollution and congestion. Now there is the promise that the private sector, using apps and fleets of cheap light electric vehicles, can move people as effectively but without the cost to the city. Should cities forego the massive infrastructure spending and repurpose roads and parking bays for the new free-floating fleets?

Urbanites like to move at street level where they can see life on the street as they move. Despite underground metros being highly effective mobility solutions, they are used to save time or money compared to the preferred use of a car or taxi. Bikes, scooters and other light electric vehicles are giving urbanites effective low-cost time saving mobility solutions, but they face numerous limiting factors, such as the lack of dedicated infrastructures and the need to share the road with car users.

Though public transportation is widely acknowledged as an instrument to move large volumes of people while limiting CO_2 emissions, especially with the development of electric, gas, and now hydrogen powered vehicles, cities are facing a huge challenge as societal expectations and behaviours are changing. In North America for instance, the demand for public transport continues to decrease as Americans prefer to spend

time in their car alone than use mass transport: according to the *Washington Post*, Transit ridership fell in 31 of 35 major metropolitan areas in the United States in 2017.

The only way to change this behaviour is for cities to limit single user + single car ownership and/or driving while promoting attractive and accessible public transport and developing user-centric intermodal splits.

Cities can also implement more constraining regulations, such as high congestion charges, the elimination of on street public parking bays, and even reduce the size of streets and roads, etc. In principle, less cars in cities should free up valuable road surface to be repurposed for fleets of two-wheeled light electric vehicles that are able to move large amounts of people to an endless number of destinations.

To what extent these new technologies can replace expensive public transport infrastructure is unknown as no city has been able to reduce car ownership significantly enough to test the hypothesis. Moreover, solutions that might work in urban cores and in the centre of metro areas might not easily address mobility needs at wider metropolitan and regional scales, be it for passengers, or for freight and logistics, where the use of individual car is still very much prevailing.

6.3 TRANSPORT IN THE ERA OF (BIG) DATA

The availability of digital expertise and know-how does not rely only in multinational companies or existing public transit companies. Transport users increasingly demand cities to provide digital information, particularly real-time updates on their journeys. In the context of transport, the concept of smart cities revolves around a more integrated approach of data and urban transport provision, which raises the question of available norms and standards.

FIGURE 6.1 CYCLING AS PART OF MOBILITY SYSTEMS. THE "FIETS TELWEEK" IN THE NETHERLANDS AND FLANDERS (BELGIUM) AND CYCLING ACTIVISM IN KIEV (UKRAINE)

A growing source of data comes from the platforms that provide free and anonymized data from their own information, which can be used to understand travel patterns and complement other qualitative approaches as described here. The World Bank has recently launched an Open Data Platform (World Bank, 2016) which increases the availability of data from various sources. GIZ has also published a module on Open Data in the transport sector (GIZ, 2015).

Various activities are described with the term "travel smart", which initially was featured in Australia as an initiative to understand citizen's mobility patterns and provide them with personalized improvements to their weekly trips. This normally implies a weekly travel log (people indicate the different trips, times and purposes during every day of the week) and travel smart experts provide them with alternatives in other modes (e.g. public transport, cycling, walking) that they could have used to do the same trips. This aims to provide users with an understanding of multimodality and that they can use other modes of transport for certain trips (not the same mode always, nor do they have to change to another mode forever). Research on this topic has shown that there are concrete and positive impacts in terms of mode shift (18 per cent in cars in Japanese initiatives), CO_2 emissions (19 per cent reduction) and especially when linked to participants' written plans (Fujii & Taniguchi, 2006; Zhang, Stopher, & Halling, 2013).

Many cities have developed an activity that is very clear and straightforward to demonstrate the actual effectiveness of transport modes, called the "commuter challenge". It consists of assigning a typical origin and destination and having people ride different modes of transport as they would in any day of the week – during rush hour – and demonstrate "live" who would arrive quickest. The trip must include also walking time to the vehicle, waiting time in platforms and parking and walking to the destination. Typically bicycles win these challenges, but in some cases motorbikes have won as well. Depending on the case, public transport and automobiles arrive latest. This is a great way to gather media attention as well, especially if it takes place during morning peak hour.

Various Dutch companies, NGOs and government allied to create a week where they could gather as much information as possible about bicycle use through the use of an app called *Fiets Telweek* (National Bike counting week). This gave all stakeholders a very thorough understanding of how cyclists used their bicycle network and the times they did so, their speeds and other characteristics of their trip. This enabled them to create policy proposals based on data, and also understand the needs of cyclists better.

A similar exercise is now being held in Flanders (Belgium). A similar initiative was held in Kiev organized by a cyclists association, which was directly led by civil society and supported by other groups, and citizens were invited to participate.

6.3.1 The development of open-data standards

The General Transit Feed Specification (GTFS) has emerged as a major standard to release public transit data around the world. As of 2016, approximately 1,050 transit operators released official GTFS feeds, while in 2015, Google, the historic co-founder of the system, listed about 5,900 agencies across the globe using Google Transit coverage tool. Most of the feeds are from operators in the United States, Canada, Europe, Australia, New Zealand and Japan, but some are from developing countries. GTFS was initially co-developed by Google and TriMet, the transit agency in Portland, Oregon. GTFS feeds allow public transit agencies to publish their transit data in a format that is accessible to developers to access and write applications that consume the data. GTFS data can be used for trip planners, timetable publishers and a slew of other applications that use public transit information in some way.

Because GTFS is an open standard, applications that are designed for one city's GTFS data can be used with any other set of GTFS data. This means that applications or analyses performed for one city's data can easily be performed and adapted for another city. It can be used not only to manage static transit information such as routes, stops and schedules, but GTFS-real time (GTFS-RT) data feed specifications can provide live updates on transit fleets using Automated Vehicle Location (AVL) systems and static GTFS feeds. Apart from GFTS, SIRI, or Service Interface for Real Time Information is another XML protocol to allow distributed computers to exchange real time information about public transport services and vehicles. It was originally developed as a technical standard with participation form France, Germany, Scandinavia and the United Kingdom, making it a European standard, though GTFS is also largely used across Europe.

The development of open data in the field of transport management is questioning data management, opposing "open-transport methods" to quoted "traditional methods", as summarized in the table below.

TABLE 6.22 PRINCIPLES OF COLLECTING OPEN DATA ON MOBILITY[154]

Transport instrument	Traditional method	Open transport method
GIS route and station/stop locations	Collect data using dedicated GPS device Manually upload data to desktop computer Use specialised GIS software to relate collected data to city's road network, enter details about the route Manually enter route meta-data Can only be updated by a GIS specialist	Staff ride transit route using mobile app Enter route and stop details using the app as they ride Data and meta-data automatically uploaded to accessible, central server Can be updated via a web-based graphical user interface
Passenger volumes by location and time of day	Stop locations manually marked on map, as well as alightings and boardings Stop locations plotted in GIS platform Passenger counts manually updated in GIS for each surveyed location	Survey staff can record boardings and alightings along entire route using mobile app. Data are saved with route information and automatically updated
Average travel and dwell times	Staff ride transit routes and measure travel time between pre-determined points on route map Travel time data manually entered on each route segment	Travel time automatically recorded and linked to route

Regardless of the standard, open data can save both time and money in collecting such information about routes. Real-time service information including route and stop locations, passenger volumes by location and time of day, planned schedules, service disruptions, pricing and fare products, and average travel and dwell times can all be collected automatically or manually by staff. This information can then be automatically uploaded to an accessible, central server. In comparison, traditional methods require far more staff hours, manual work to record and upload information and advanced computer knowledge of programs such as TransCAD or GIS.

Opening data can empower resource-constrained transport agencies both to collect high-quality transport data with limited effort and cost, and to conduct robust data analyses with minimal formal training in transport engineering and planning.

For data to be considered open, the data must be:

- Complete – all public data are made available, and are not subject to valid privacy, security or privilege limitations.
- Primary – data are collected at the source, with the highest possible level of granularity.
- Timely – data are made available as quickly as necessary to preserve their value.
- Accessible – data are available to the widest range of users for the widest range of purposes. The data must be available on the Internet.
- Machine processable – the data are structured to allow automated processing.
- Non-discriminatory – the data must be available to anyone, with no registration requirement.
- Non-proprietary – the data are available in a format over which no entity has exclusive control.
- Licence-free – the data are not subject to any copyright, patent, trademark or trade secret regulation.

[154] Source: World Bank Open Transport Team

6.3.2 MaaS Principles

In the past two decades, there has been considerable progress in the area of integrated information, access and payment systems of public transport with regard to "shared mobility". This is due, on the one hand, to new technical possibilities. Features such as electronic and contactless smart cards and increasingly digital solutions in conjunction with smart phones are now enabling some of the following applications:

- Real-time information processing and networking (e.g. via app).
- Paperless verification (using check-in/check-out procedures).
- Situation-specific pricing (such as prepaid and post-paid processes according to best price methods, peak pricing).
- Cashless billing of user authorizations (by way of e-ticketing/mobile phone ticketing, for example).

These services offer something of a "countermodel" to the non-networked private vehicle. Notably in Asian metropolitan areas, electronic access systems have been intensively developed. In Europe, the concept of *Mobility as a Service (MaaS*), that is *"the integration of various forms of transport services into a single mobility service accessible on demand"* (MaaS Alliance 2017) is gaining traction, with a number of cities experiencing comprehensive data-based multi-mode mobility systems.[155]

In municipalities, MaaS creates a wide range of services for users and thus offer an alternative to the own car. The model contains and integrates components of concepts that already exist such as integration, interconnectivity and optimization of transport services as well as smart and seamless mobility. New concepts that have emerged through the Internet of Things and the sharing economy, such as the term "as a service" and personal modification of travel are also added.

FIGURE 6.2 THE MAAS ECOSYSTEM[156]

The diverse means of transport options in the locally offered MaaS can be a variation of e.g. public transport, ride-car- or bike-sharing, taxi, car rental or lease. By providing a single payment channel instead of numerous ticket and payment operations, this comprehensive approach makes it possible to transform an existing inflexible transport system into a more versatile structure. Ultimately, MaaS is a digital platform for end-to-end route planning, booking, electronic ticketing and payment services involving all means of transport regardless of whether public or private. The concept is based on a user-centric model that puts the demand first.

Customer contract and travel data - The aim is to configure a single interface with provision of services from all partners. The platform operator will have access to the customer's travel data, which is important in order to be able to respond to the customer's requirements and provide a flexible system. One of the biggest security issues is data protection. Therefore, it's important for municipalities to set ground rules and regulations that address the equal access of all providers to travel data.

[155] There are some online resources available to help cities by implementing a MaaS ecosystem: *MaaS Alliance: White Paper, Guidelines & Recommendations to create the foundation for a thriving MaaS ecosystem* www.maas-alliance.eu, Deloitte Review: *The rise of mobility as a service, Issue 20 Reshaping how urbanities get around* www.deloitte.com, *MaaS Lab* The research team is part of the Urban Transport and Energy Group at University College London, www.maaslab.org, *WRI: Connected Urban Growth. Public-Private Collaborations for Transforming Urban Mobility,* www.wri.org, UITP: *Public transport at the heart of the integrated urban mobility solution A policy brief on new mobility solutions and public transport.* www.uitp.org

[156] Source: Blockchain and beyond. Encoding 21st century transport OECD / ITF-CBP, 2018 https://www.itf-oecd.org/sites/default/files/docs/blockchain-and-beyond-encoding-21st-century-transport.pdf

Technical Infrastructure. The Information and Communication Technology (ICT) is the backbone of the whole MaaS system. By creating an open technology architecture municipalities provide access to a dynamic mobility system. In this way, private partners can integrate into the system easily and new members can be added later on as well. For the municipal authorities, this entails the establishment of regulations. It's necessary to authorize standardized technical infrastructure to ensure that subsystems like parking management can be implemented easily as well.

Ensure a diverse MaaS service operator. Implementing a MaaS system includes the requirement of precise coordination (fare integration, minimum service standards and service area coordination of demand responsive transport services).

It is important to find a balance between public and private companies. Decision makers are therefore obliged to make all necessary adjustments to the existing and future services in order to achieve economic and ecological success (e.g. exclusive market access vs. allowance of competition). In this phase, the role of the MaaS operator should be determined, who sets everything in place and handles further communication between all parties.

In the final phase the MaaS system is in place and needs to be operated on a constant level. Public authorities and government can now lessen control of public transport and let commercial partners take over more control. These enterprises often have widespread knowledge and understanding about user needs and travel behaviour. However, transport authorities need to retain a market overview and provide operational support for the involved parties.

MaaS in practice. It should not necessarily be the objective to create a MaaS ecosystem from scratch. Often a city does not yet have sufficient infrastructure or private mobility operators to create a system that offers a wide range of options. But an important step forward can be taken by enabling companies to settle down and prepare the necessary infrastructure. That way it becomes easy to take the final steps towards a dynamic and reliable MaaS model. To understand the possibilities MaaS could provide a municipality with, it is beneficial to have a look at good examples of cities that have implemented such an ecosystem. Although most of the examples to date can be found in Europe, the topic is growing worldwide immensely. Intelligent mobility solutions are also becoming increasingly important at a global level and thus in emerging economies. In this sense, it can be seen as a stepping stone to a well-functioning city.

FIGURE 6.3 DUTCH MOBILITY INNOVATIONS: OVERVIEW OF THE INNOVATIVE CONCEPTS PARTICIPATING IN THE ANNUAL ACCENTURE INNOVATION AWARDS 2018. SOURCE: BUSINESSMAAS, SEPT. 2018

Case study. The "Whim" MaaS platform in Helsinki (Finland): a forerunner

FIGURE 6.4 MAAS PLATFORM IN HELSINKI (FINLAND)

In Helsinki, Finland's capital, an efficient and diverse public transport system already existed when the MaaS concept was intended to be integrated into the city. The city offers a wide range of alternatives to get from one place to another. MaaS Global, a start-up company founded in 2015, wanted to use MaaS to reduce the importance of owning a car by 2025 even more. The concept of Whim is a single integrated mobility app that can access different means of transport by purchasing a subscription and can also handle ticketing if needed. As with the ownership of a car, users obtain the spontaneity to be able to travel easily. The overall effect of this concept is changing the way people move.

Within the app users can choose between three options. The first option is free of charge and single rides can be paid for in advance. The second choice is an offer including an unlimited public transport ticket and several rides on a car-sharing vehicle or a taxi. The last alternative provides an unlimited use of all vehicles. Those include public transport, taxi, car sharing and shared bikes.

The company made its breakthrough when the local transport authority provided its open data as interface services and data packages. This case shows that an openly shared API (Application Programming Interface) is an important success factor to initiate the process in a city. Another big success driver that MaaS Global benefited from is the cooperation between private and public companies.

Case Study. TMaaS, an award-winning project with global ambitions from Ghent (Belgium)

Traffic Management as a Service (TMaaS.eu) is an awarded urban mobility project driven by the "Mobiliteitsbedrijf" of the City of Ghent, has been selected by the EU initiative Urban Innovative Actions (UIA) to receive financing. The Traffic Management as a Service-platform is a new and revolutionary traffic centre-concept for small and medium-sized cities. The European Commission will financially support the development of the Traffic Management as a Service-project by way of the UIA for a three-year period.

Setting up a traffic centre is an important part of the City of Ghent's latest mobility plan (Strategic Mobility Vision 2015). The Ghent Mobiliteitsbedrijf developed 'Traffic Management as a Service', which is radically different from previous traffic centres: the Traffic Management as a Service-concept is based on a fully digital and virtual platform that processes traffic data and provides real-time information to the residents of Ghent. To achieve this up-to-date flow of information the data are dealt with and distributed to the users automatically, so operators are no longer required to continuously monitor screens.

The project aims to develop the Traffic Management as a Service-concept for the City of Ghent, and to operationalise a virtual and digital traffic centre. Current urban mobility centres are notoriously expensive and focus on installing costly hardware in order to monitor traffic. Moreover, those systems are unable to provide personalised information to the city's residents. The Traffic Management as a Service-system on the other hand uses data that are readily available from various partners and companies and works multimodally.

To achieve this, the system automatically checks all data coming in on journeys by bike, bus, tram, train, or on foot. Based on those data the platform will send all information necessary to each commuter by way of social media, while considering each individual's personal preferences. Citizens are also able to provide Traffic Management as a Service-platform with feedback. As soon as a problem arises, the platform will automatically take action.

Commuters will not only be informed about their journeys, they will also be notified of alternatives where necessary, enabling residents to travel in the most efficient, safe, sustainable and enjoyable way possible. Furthermore, designated city of Ghent traffic employees will be able to monitor all mobility data, and use it to adjust traffic lights, inform residents, and evaluate and prepare mobility measures, among other tasks.

Current urban mobility centres are unable to provide residents with personalised information. The Traffic Management as a Service system uses readily-available data from various partners and companies and is multimodal. In other words, it takes different means of transport into account, which will all be integrated

into the user dashboard. To achieve this, the system automatically checks all incoming data about journeys by bike, bus, tram, train, or on foot, and based on this, sends the necessary information based on everyone's personal preference to each commuter via social media. What is also quite *revolutionary*, according to their promoters, is the fact that TMaaS is a unique collaboration between the government, industrial partners and universities.

Case study. Istanbul, towards metropolitan scale MaaS?

Istanbul Metropolitan Municipality runs an online ITS system informing on the traffic situation and congestions. Data of traffic sensors at the principal and other main roads are real-time published by a traffic control centre via Internet. [157]

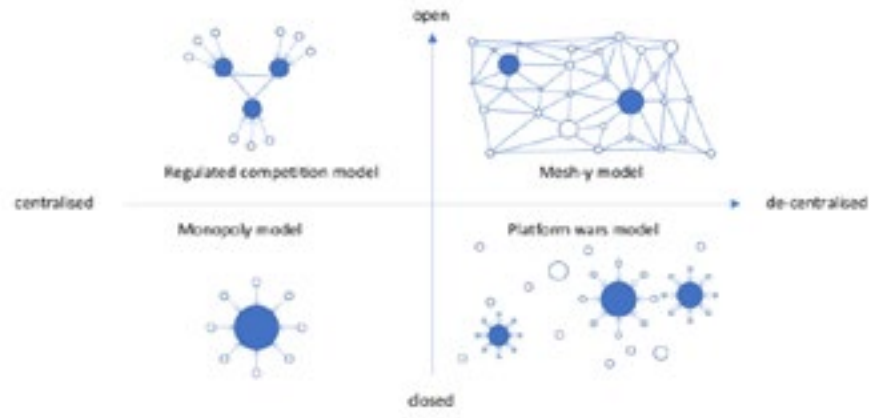
In all PT means, payments are done by either cash, by smartcards or by smart tickets. An easy-to-use smart ticket called '*Akbil*' is a plastic key with a refillable battery, valid on all buses, ships, sea buses, metro and tunnel systems and provides discounts from 10–25 per cent. Contactless smartcards are available with discounts for subscribers, students, retired, or disabled people. A 'Citizen Card' is being developed with the aim of handling more applications as car parking, e-health or event ticketing.

The smart ticketing features are of high value for PT and help to secure its success. Intended add-ons to the *Akbil* as e-ticketing will further enhance the popularity of this ITS. However, an easy handling must be kept and full applicability to all users including those not using Internet must be ensured. As an accompanying measure, every citizen should be provided with a free *Akbil* (nowadays a deposit of 6 TRL is to be paid).

6.3.2 The next digital frontiers of mobility: blockchain etc.

Digital technology continues to reshape the transport industry. Recently, much discussion has focused on blockchain and other distributed ledger technologies (DLTs). Like other economic sectors, transport could be profoundly transformed by blockchain, and other novel DLTs that allow decentralised applications to run in peer-to-peer networks. [158]

FIGURE 6.5 STATES OF THE MARKET VALUE SYSTEMS OF MOBILITY AS A SERVICE[159]



Source: Adapted from (Casey & Valovirta, 2016)

DLTs allow agents to enter into direct relationships with each other according to a commonly agreed set of rules and a high degree of trust without having to go through a central authority. Combined with a common language and syntax for the "internet of mobility" and new means of deriving insight from previously siloed data, these applications may help redefine how people access, pay for and use transport in their everyday lives.

Urban mobility today is a siloed world of separate and independently regulated services. The application of distributed ledger technologies, such as blockchain, to urban mobility may lead to a future more aligned with other "as-a-service" models where actors engage directly with each other based on commonly agreed protocols.

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[157] Source of the photo. Signature of Istanbul official statement by Instanbul Metropolitan Municipality (IMM) of joining R4E, the European funded Roadlmaps for Eenergy, with Smart public transportation and Smart traffic management as priorities? March 2017

[158] Source: Blockchain and beyond. Encoding 21st century transport OECD / ITF-CBP, 2018 https://www.itf-oecd.org/sites/default/files/docs/blockchain-and-beyond-encoding-21st-century-transport.pdf

[159] Source: Blockchain and beyond. Encoding 21st century transport OECD / ITF-CBP, 2018 https://www.itf-oecd.org/sites/default/files/docs/blockchain-and-beyond-encoding-21st-century-transport.pdf

These changes will also challenge public authorities. They must keep abreast of developments in data science and DLTs to adapt current regulations where they hinder beneficial outcomes. They must also explore new regulatory responses where these are necessary to deliver the outcomes the public wants.

The deployment of DLTs is still very much in its infancy, especially in support of Mobility as a Service (MaaS) and yet the OECD International Transport Forum has recently issued a series of recommendations to manage the way forward, show-casing the importance of a sound regulatory framework and calling upon high level government policy-making standards in the field of transportation and mobility to:

- Consider changes in data science and technology when developing Mobility as a Service.
- Look beyond initial cryptocurrency applications of distributed ledger technologies.
- Governments should help deploy the building blocks that enable wider uptake of distributed ledgers.
- Apply blockchain technology now for slow and (relatively) small transport use cases; anticipate next generation distributed ledger technologies for "big and fast" applications to be deployed later.
- Governments should develop algorithmic code-based regulation to accompany the uptake of distributed ledger technologies.

6.4 A REVIEW OF COMMON DIGITALIZATION OF MOBILITY AND TRANSPORTATION SYSTEMS

6.4.1 Common ITS regulation in UNECE member States?

Intelligent Transport Systems can give cities a new approach to the use of available resources and infrastructure. 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.

Intelligent Transport Systems can help solve issues related to improving road traffic efficiency in a prompt manner enabling newer technologies that use big data analytics, automated and connected vehicles. With a growing number of national and local initiatives, the demand for intelligent transport systems development in the UNECE region is mounting.

A sound regulatory framework is crucial 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:

1. Only few UNECE Member States 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 update existing regulations to address issues related to Intelligent Transport Systems in order to support faster and more coherent development.
2. 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 prioritization of services provided within the scope of Intelligent Transport Systems and the planned allocation of funds for technological projects.
3. Recent improvements in the technology of Intelligent Transport Systems herald significant 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 to produce autonomous vehicles due to the diversity of autonomous vehicle systems. Given the widespread proliferation of autonomous vehicles soon, 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.

Such inter-governmental discussions are taking place in the framework of designated UNECE Working Parties, incl. the Global Forum for Road Traffic Safety (WP.1) and the World Forum for Harmonization of Vehicle Regulations (WP.29).

Across the UNECE region, regions and cities are testing and implementing smart transportation projects, ranging from smart public transportation to seamless multi-modal mobility. Although there can be great differences in the size and duration of investments, the trend is towards the generalization of e-ticketing and large-scale comprehensive approaches to mobility systems.

In the case of Istanbul or Moscow, long-term transport and mobility policies include not only expanded public transit networks but also the development of new road infrastructures. In the Paris region, the masterplan approved in 2014 has ruled against the expansion of the road network to prevent sprawl. In all cases, traffic congestion is a major challenge and municipal and metropolitan authorities tend to reject traffic out of the urban cores.

Soon, automated ground mobility vehicles, including private cars and public vehicles, might be a durable game changer, even if in the next 5-10 years, it might just add another level of complexity to transportation and mobility networks driven by consumers choices and public budget constraints.

Case study. Moscow "Innovative Mobility" project

ITS in Moscow include: road user information subsystem, automated traffic management system, photo and video recording and tele-viewing system. ITS are designed to harmonize the traffic flow, as well as to ensure a rapid response to emergency situations. Currently, 100 per cent of the territory of Moscow is covered by Intelligent Transport Systems.

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). 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)[160].

The Moscow "Innovative Mobility" project displays an "all mode" approach with the development of a new road network, the development of car-sharing and autonomous vehicles, the development of cycling, and reform in the taxi sector. The quality of life and comfort of the urban commuter is at the heart of these new policies.[161]

The Moscow Central Circle (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 modern transport system of the city distributing passenger traffic in the capital of Russia.

The Moscow Central Circle 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.[162]

Passenger traffic was launched on the Moscow Central Circle in 2016. Until 2020, it is planned to develop the areas adjacent to the transport interchange hub Moscow Central Circle. Thus, abandoned industrial areas are to be redeveloped, including economic activities and housing. At last, the MCC project is part of a larger Smart Moscow 2030 comprehensive project addressing the digital transformation of the metropolis in all sectors, not just mobility.

Other large-scale projects are being implemented throughout Europe, such as in London, Paris or Amsterdam. Meanwhile in the Randstad metropolitan region (as well as throughout the whole of the Netherlands), railway connections are gradually shifting from timetables to regular intervals.

[160] According to the response of Moscow to the UNECE questionnaire.

[161] http://transport.mos.ru, Unified Transport Portal of Moscow.

[162] http://mosmetro.ru/mcc/ps/ In total, the Moscow Central Circle 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

Case study. Smart transport in Minsk (Belarus) and in cities of the Republic of Tatarstan (Russian Federation)

FIGURE 6.6 SMART TRANSPORT IN MINSK (BELARUS) AND IN CITIES OF THE REPUBLIC OF TATARSTAN (RUSSIAN FEDERATION)

In 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 introduced 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.

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.[163]

FIGURE 6.7 THE MOSCOW CENTRAL CIRCLE (MCC) (LAUNCHED IN 2016, SCHEDULED TO BE COMPLETED IN 2020)

FIGURE 6.8 GRAND PARIS EXPRESS NEW NETWORK (SCHEDULED IN DIFFERENT PHASES, WITH THE FIRST SEGMENT TO OPERATE BY 2024/2025)

[163] Based on the answers given by Belarus to the UNECE questionnaire.

FIGURE 6.9 AMSTERDAM METRO AREA SMART MOBILITY SYSTEM INCLUDES TRAIN, BUS, ROADS

FIGURE 6.10 LONDON CROSSRAIL "ELIZABETH LINE" (SCHEDULED TO OPERATE BY 2020)

6.4.2 CCTV can be used to regulate traffic

A most striking feature in traffic management is the development of CCTV, which goes much beyond that sector to include safety, security and social control aspects and it is not the UNECE region which leads the way.

As of 2017, there were 170 million CCTV across China, with an expected rise to more than 400 million by 2020. In 2015 in Beijing, the police claimed a coverage of 100 per cent of the city, as part of SDkynet, the designated nation-wide system. Though the situation in China is rather unique, it summarizes a global trend in major and even mid-sized cities across the globe, such as in Europe or in Central Asia. In France, the city of Nice has unveiled in 2018 a comprehensive CCTV system managing not only traffic, but also public-space, a system mobilizing local, national and European funds as well as a wide array of private companies in the field of road safety but also biometry etc. In 2019, the city of Dijon has unveiled an integrated smart city command centre including traffic management, energy management and other factors. Examples outside the UNECE region of limitations of such integrated command centres, such as in the city of Bandung in Indonesia, show that the management of political and social factors are as important as the initial technological inputs.

In practice, it is difficult to imagine managing metropolitan areas and complex urban systems without CCTV monitoring. In the Paris region, a network of over 1,000 CCTV cameras provide the basic infrastructure of SYTADIN, the regional traffic management system. In Istanbul, the Intelligent City System started with 6 cameras on the Taksim Square and now counts over 300 units across the metropolis, managing 3,5 million vehicles in the traffic, pedestrian flow, public transport buses, minibuses, taxis, school services, earth moving trucks, and everything else involved. With CCTV, it is much more than numbers. Additional features are being added to the systems, including face recognition in the public realm. Regarding traffic management, experiments are going on in several cities and regions. In the Paris region, new cameras have been installed in 2018 to monitor car-sharing, following an experiment at the French-Swiss border in 2015 in the border city of Jougne.

In Istanbul, the traffic management system also works with sensors on the road, allowing to inform citizens and drivers of situations such as snow, rain, storms, or ice. According to Istanbul metropolitan government, the smart traffic management system has brought about a decrease in traffic congestion by 17 per cent in 2018 as compared with previous years, despite an annual increase of vehicles per capita of 4.5 per cent. As illustrated by the Paris or Istanbul cases, CCTV systems come with many other features, such as the control of parking violations, the control of passengers etc. Centralized and integrated Transportation Management Centres (TCM) are the only visible part of such complex management systems involving several public authorities and public and private technology providers.

FIGURE 6.11 CCTV MONITORED TRAFFIC IS NOW COMMON IN CITIES

The development of CCTV comprehensive traffic monitoring systems allows for more sophisticated toll systems, including toll systems in free traffic flow, satellite-based area-wide toll systems, lane-based toll systems, city toll zones based on video, DSRC or GPS/GSM technology.

Until recently, the deployment of a toll system was anything but a simple project. And for every new route section added to the tolled zone at a later point of time, recording stations, kilometres of cable, and rows of video cameras had to be added. Technology providers now tend to value other sets of solutions such as through global navigation satellite systems (GNSS). Thanks to such technology, *"the position of every vehicle can be determined accurately, so any road or street on earth can be included in a road pricing system without the need for local infrastructure",* according to Siemens. Such new electronic toll solutions offer the operators opportunities to develop new services. In principle, they also offer more flexibility such as flexible toll fee definition depending on the time of day, the vehicle's emissions standard, the distance travelled or the road category. The system can also be used for enforcing compliance with environmental requirements.

FIGURE 6.12 CCTV MONITORED TRAFFIC IS BEING DEVELOPED IN CITIES WHERE TRAFFIC IS QUICKLY GROWING SUCH AS TASHKENT (UZBEKISTAN)

In Central Asia's largest city, Tashkent, which count over 2,5 million inhabitants, a combination of factors is pushing towards a rapid increase of the number of cars in the streets, without corresponding traffic control measures. The United Nations Development Programme is currently (starting in 2018) supporting the deployment of CCTV at the city's major crossroads, to measure and manage traffic. Up until recently, there were no traffic monitoring cameras at all in the city.

6.4.3 Smart traffic-lights: from controlling flows to supporting eco-mobility

Traffic light phasing has a significant impact on the flow and safety of traffic. In the past few years, traffic light programming has been pushed towards more benefits for eco-mobility but there is more potential to be tapped into.

Maximum waits for those who are walking, cycling or using public transport should be as brief as possible. A register of intersections, serving as a basis for the programming of traffic lights by way of weighting e.g. modes of transport as well as their capacities and frequencies, is an important instrument. The intersection register is an internal guideline for planning, standardizing planning principles for traffic light phasing and supporting the idea of giving priority of eco-mobility. The intersection register is closely connected with the classification of transport networks

Case study. Smart traffic-light in Vienna, a role model city in smart traffic lights

FIGURE 6.13 SMART TRAFFIC-LIGHT IN VIENNA (AUSTRIA)

Vienna, Austria, has about 1,300 traffic light installations. This large number stems from the wish to "get a grip" on traffic by control, an issue which prevails in most cities across Europe and the UNECE region. Traffic lights often only provide a subjectively perceived level of safety, and they induce people to rely fully on them on the one hand, or to break the rules on the other, e.g. by crossing against a red light, thus causing conflicts between traffic participants.

Organizing intersections at spots with low traffic density without traffic lights fosters coexistence in traffic. Based on the *Rules of the Road*, the flow of traffic can be improved by responsible self-organization. In this way, unnecessary waits and rule-breaking are reduced.

The safety of all traffic participants can be ensured by structural and/or organizational measures. Structural measures may include "pavement crossings" or the elevation of intersection centres. Since roundabouts need much space, it is not often possible to build them in inner-city areas. Usually, simpler, cheaper and more space-efficient measures are entirely sufficient; they create more direct routes for pedestrians and are thus more purposeful. Intersections crossed by public transport can be equipped with amber/red traffic lights for needs-based control of traffic.

The intersection register in the pipeline is to provide information about the locations where traffic lights are not necessary (in respect of existing and planned new installations) or where operating times could be reduced. Traffic lights are to be removed in selected locations under pilot projects.

Using traffic lights to support eco-mobility

Traffic lights and signs are essential for traffic regulation. The shortest possible maximum waits for pedestrians and cyclists become a growingly important target in the programming of traffic lights. To this end, the cycle times of traffic lights are to be shortened as a matter of principle; long cycle times should be limited to rush hours. Traffic light cycle times can also be reduced by a minimization of distances covered by pedestrians when they cross streets. In this context, safety is enhanced, and it is ensured that slower

pedestrians have enough time to cross. Distances can be shortened by e.g. removing less used turning lanes. Lead times for pedestrians are to be recorded and taken into consideration in calculations to improve on criteria such as subjective safety in respect of crossing time.

At present, the smooth flow of motor-vehicle traffic has high priority in the programming and coordination of traffic lights ("phased traffic lights"). In the future, intelligent traffic light programming is to support eco-mobility in that it takes the needs of all traffic participants into consideration. Existing measures are to be expanded, including more lead time for pedestrians before motorized traffic turns, special phases in which public transport means can pass intersections without having to stop at all or with fewer waits and longer green light phases for cyclists.

Case study. Münster adaptive signal control system, a benchmark in Germany[164]

FIGURE 6.14 MÜNSTER ADAPTIVE SIGNAL CONTROL SYSTEM, A BENCHMARK IN GERMANY

To control the high proportion of cyclists, special traffic lights and signs are required. In Münster (Germany), bicycle traffic is managed by three different types of traffic lights at all major intersections. The first of regulation is a separate traffic light for cyclists. At some intersections, this is complemented by an arrow within the light that assigns the direction of turn. The second the third types are usually combined with traffic lights for motorized traffic.

In addition to the regulation by traffic lights, there are special traffic signs. Every facility or preference given to the cyclists, e.g. at dead ends, pseudo one-way streets or pedestrian areas, need to be clearly indicated by signs. Furthermore, there are signs for "Dead angles", special regulations at bus lanes or indicating bi-directional cycle ways, etc.

Cyclists have an intersection clearing time like that of motorized traffic. Separate signalling for pedestrians and cyclists contributes to make cycling more attractive. In addition, the "clearing time traffic lights" which have stood the test of the pilot project should increasingly be used at focal intersections. Pelican crossings should be used as sparsely as possible. If needed, the traffic light must respond quickly to pedestrians wishing to cross to keep waits as short as possible and keep pedestrians from crossing before the light has turned green. In advanced cities such as Copenhagen or Vienna, traffic light phasing gives right of way to public transportation and cyclists. In Copenhagen, it is now possible to cross the city-centre by bicycle at peak hours without a single stop.

Phasing traffic lights to privilege public transportation

Traffic lights phasing is also becoming an integrated part of transport master plans to privilege public transportation under the principle *"no stopping unless it's a stop – systematic right of way to trams and buses."* In this context, various flows of traffic are prioritised according to the classification of transport networks.

Beyond the technological complexity of managing phased traffic lights at large scales, what is most important is the impact on user's choices. The acceleration and priority to public transport must result in an actual perceived shortening of door-to-door transit times for passengers in the future. In this regard, the comfortable and safe use of public transport is also closely linked with the design of accessways to and exits from stops. Smart traffic light phasing may contribute to this, especially when stops are located on traffic islands or at intersections.

Apart from the actual acceleration of public transport, in inner-city areas, the regular operation of public transport lines in keeping with the timetables (e.g. reliable intervals in rush hours and adherence to times tables early in the morning and in the evening) is a crucial factor for the appeal of public transport. More advantages come with ultra-low vehicles as passengers can enter and exit quickly. Innovative technology also enables dynamic prioritization of public transport depending on the traffic situation. Trams or buses running early or late can be considered, e.g. by linking the computer-based operation management system.

In short smart traffic light management can only be successful as part of a series of upgrades in the transportation network, including the design of exits and stops, the design of the vehicles (buses, or trams), the design of intermodal stations.

[164] Source: Siemens.

Another option for the acceleration of public transport is a classification of the bus network according to lines essential for the network structure – i.e. major fast lines operating at shorter intervals and fulfilling higher quality standards – on the one hand, and standard lines on the other hand. Accordingly, high-quality bus corridors are to be planned even before construction in new urban development areas starts so that the new developments are well connected even if there is no underground or tram axis in the vicinity. These high-value bus lines essential for the network structure should then be subject to the same acceleration criteria as trams.

Traffic light phasing has a significant impact on the flow and safety of traffic. In the past few years, traffic light programming has been pushed towards more benefits for eco-mobility but there is more potential to be tapped into.

In this context, maximum waits for those who are walking, cycling or using public transport should be as brief as possible. A register of intersections, serving as a basis for the programming of traffic lights by way of weighting e.g. modes of transport as well as their capacities and frequencies, is an important instrument.

The intersection register is an internal guideline for planning, standardising planning principles for traffic light phasing and supporting the idea of giving priority of eco-mobility. The intersection register is closely connected with the classification of transport networks.

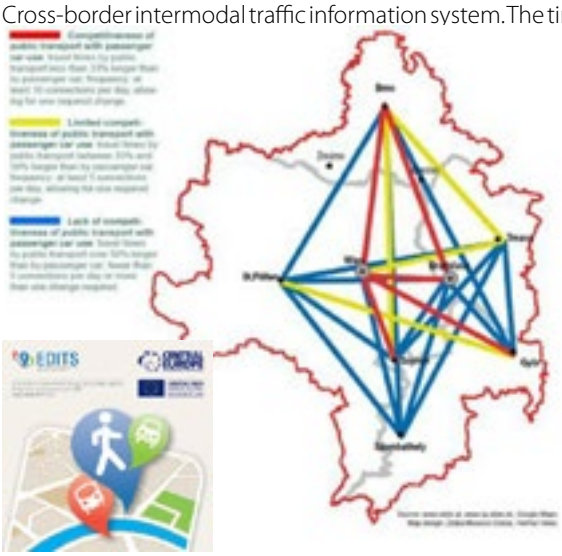
Developing cross-border traffic lights and mobility standards

In many cases, urbanization and regional development has become a cross-border issue throughout Europe, such as in the Eurodistrict Strasbourg-Ortenau across France and Germany or in the designated "centrope" region connecting Austria, Czechia, Hungary and Slovakia. The centrope region with its centres Vienna, Brno, Bratislava, Györ and Sopron, has strong potential for further economic and demographic growth.

Several processes and projects have produced a long list of proposals and ideas to shape freight and passenger mobility in the region in a sustainable and effective way. The Strategy for the Danube Region as a coordinated supraregional strategy of spatial planning and transport development forms the framework of further and more specific processes and projects. Further processes are based on this strategy. From the angle of the provinces of Vienna, Lower Austria and Burgenland, the following initiatives are particularly relevant:

FIGURE 6.15 SMART CROSS-BORDER TRAFFIC CONTROL IN THE CENTROPE REGION

Cross-border intermodal traffic information system. The time-tested regional transport and traffic information system for the eastern region, AnachB.at, which also includes a route planner, is popular throughout Austria and even Europe. Good information is of paramount importance when you have to change mode of transport during a trip. Mobility information is thus to be made more readily available to travellers in the entire centrope region step by step.



The long-term goal is to expand a service in analogy to AnachB.at across the centrope region which gave birth to another project, the "European Digital Traffic Infrastructure Network for Intelligent Transport Systems" (EDITS) funded by the European Union. EDITS prepare the ground for cross-border multi-modal traffic information systems. Based on existing platforms, specifications and systems are being created for data exchange.

To change mobility behaviour, it will not be enough to offer services; awareness-raising measures will also be required. Information about alternatives is needed for personal decisions on mobility. The three provinces intend to take joint action at various levels, including: the conduct of joint awareness-raising and information campaigns; the development of an in inter-modal information system to promote multi-modality; and the development of a new, customer-oriented, simplified system of pricing (subject to a coordinated price reform).

Overall, the trend towards personal multimodality is to be supported by a comprehensive mobility information system.

Smart traffic without smart traffic lights and without electronics

Since September 2010, the "Lindenkreuzung" intersection, one of the most important transport hubs in Dornbirn, has not been equipped with traffic lights anymore. Prior to the redesign, the intersection, which is frequented by 13,000 vehicles (including numerous buses) every day, was criticised for long waits, advanced stop areas which were too small and traffic jams. The number of pedestrians and cyclists was higher than that of cars. In the beginning, traffic light phasing was continuously optimized. However, it ended up deteriorating the situation for buses and pedestrians.

FIGURE 6.16 REDESIGNING INFRASTRUCTURES WITHOUT ELECTRONICS: THE LINDENKREUZUNG INTERSECTION IN DORNBIRN (AUSTRIA)

In the course of redesign, the intersection centre was elevated, and the traffic lights removed. Conspicuous surface markings were added. The new organization of traffic is now merely based on the "priority to the right" rule. After redesign, the flow of traffic became smoother and capacity increased because waits are shorter for all traffic participants. There are hardly any more traffic jams and peaceful coexistence can be observed. Accident statistics have shown that 2-3 accidents occurred annually in the years from 2004 to 2007. From 2009 to 2013 no accidents were registered. The removal of traffic lights has also saved money for maintenance expenses.

6.4.4 Traffic modelling through simulation and evaluation

Simulation: from users to infrastructure design

The development of digital technologies in the field of mobility and transportation allows not only to set up better traffic control procedures. It also helps build much finer grain traffic modelling and simulation. Conventional traffic simulation models generally represented only a limited part of a city's street geography and travel. For instance, car travel is fully represented in a traffic model, but travel by public transport may be incompletely represented, and pedestrian/bicycle travel is often missing altogether. This means significant groups of "users" are invisible in the assessment. Integrating motor vehicle models with models of public transport travel (bus, tramway, metro and train networks) as well as models of pedestrian and cycling networks is critical, however, for comprehensive exposure assessment. Yet, the combination of centralized data management systems with open data creates new ways to elaborate more complete mobility simulation modelling.

FIGURE 6.17 REDESIGNING INFRASTRUCTURES INCLUDING ALL MOBILITY MODES. THE R&D PROJECT OF 5TH GENERATION ROAD[165]

The impacts of user centric traffic modelling are so strong that it now has impacts on mobility and transportation infrastructure design and engineering, as exemplified by project such as the "road of 5th generation" developed by a consortium of research and industry leaders in France.

Monitoring and evaluation

While most "impact assessment", as such, is prospective, retrospective assessment can play an important role in transport and health assessment. Monitoring and evaluation tools support retrospective assessment by analysing trends in transport and correlating those with environment and health trends and outcomes. Retrospective assessment may involve processes such as health impact assessment, and a range of quantitative and qualitative tools. However, routine and rigorous monitoring and evaluation can often be performed most efficiently using standard indicators and indices (Ness *et al.,* 2007).

For example, while vehicle traffic volumes are usually recorded and reported systematically, similar data on volumes of pedestrians/cyclists using the transport system is often not routinely collected by Transport Ministries. Similarly, data on vehicle crashes may be routinely collected by police, less so data on pedestrians injured or killed by vehicles. Infrastructure ministries may report upon kilometres of road paved annually; similar indicators for sidewalks or bike paths are slim to non-existent in most developing countries and much of the developed world. Nor is data routinely collected on social well-being factors such as pedestrian traffic in correlation to crime or measures of neighbourhood cohesiveness. Consideration of health requires that essential data on transport-related human health and social factors, and not only vehicle data, be collected and monitored in a balanced transport indicator set (TRB 2008). Collecting and reporting indicator data allows public assessment of whether transport systems are moving in the right direction, whether progress is rapid enough and thus whether the right policy settings are in place.

Given the evidence that socioeconomically disadvantaged groups typically bear more of the burden of transport hazards and have poorer access to current transport systems, the social distribution of transport effects should also be monitored as part of such health-oriented analysis.

One example of a formalized transport and environment indicator set is the *Transport and Environment Reporting Mechanism (TERM)*.

Through the Transport and Environment Reporting Mechanism (TERM) report, the European Environment Agency has been monitoring progress in integrating environmental objectives in transport since 2000. The TERM report provides information to the EEA's member countries, the EU and the public and it includes several indicators used for tracking the short- and long-term environmental performance of the transport sector and for measuring progress towards meeting key transport-related policy targets. Since 2017, the indicator-based assessment component of the TERM report has been published as a separate briefing.

The most recent TERM report assesses progress towards reducing greenhouse gas emissions, and finds that although vehicle efficiency is improving, growth in travel means that total transport-related greenhouse gas emissions continue to rise. However, while TERM assesses progress on environmental outcomes including greenhouse gas emissions, air quality and noise, other important health outcomes such as road traffic injury and physical activity are still missing.

While TERM provides a promising example of transport and environment system monitoring for Europe, low- and middle-income countries require different monitoring approaches due to their differing levels of resources available for data collection. One possible solution would be to implement a standard set of surveys collecting information on a limited set of the most key factors, *e.g.* modal split, pedestrian/cycle injuries, and other health risks and outcomes, for statistically significant samples in key urban areas and/ or for different population groups. is would help monitor key transport and health links, and enrich analysis of actual and expected impacts of policy changes on public health and livability.

[165] Source of the illustration: IFSTTAR

6.5 IS AUTONOMOUS DRIVING THE NEXT BIG THING (AND WILL IT BE PRIVATE OR PUBLIC?)?

Artificial Intelligence (AI), the Internet of Things (IoT), and big data analytics are already used as tools in automating transport systems. Connected Intelligent Transport Systems, carsharing, e-ticketing systems, e-tolling, autonomous vehicles and smart mobility concepts that are discussed in many UNECE member States.

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 are put in place to capture traffic violations and send them on to enforcement bodies.
- Telematics of economic entities — management of passenger and cargo transportation (optimization of timetables, loading, etc.).

FIGURE 6.18 SWITZERLAND'S FIRST EXPERIMENTAL REAL SCALE DRIVERLESS BUS WILL RUN UNTIL 2019 IN THE CITY OF SION (VALAIS REGION)[166]

The term CAV (connected autonomous vehicles) refers to different issues. 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), with CV referring 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.

Among the most pressing issues linked with smart mobility is information control. 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. 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. Contemporary disruptions also question privacy rights, with very different policies and norms depending on national and regional legal systems.

[166] Source: *Global Geneva*, Peter Hulm, Nov. 2017. Swiss Post, the city of Sion and Valais authorities have announced that the 16-month experiment of running two Post Bus driverless buses (with yellow-teeshirted attendants) through the pedestrian quarter of the Valais capital will continue "at least until the end of 2018". The 11-seaters are free and use the livery of Swiss Post buses. So far, they have carried 60,000 passengers, and survey found over half (51%) had few qualms about travelling on the minibuses. This compares with a 2014 study that found safety concerns bothered 87% of people questioned in China, 78% in the United States, 77% in India and 75% in Japan.

TABLE 6.23 EXAMPLE OF AN AUTONOMOUS MOBILITY STRUCTURE

External machine vision	Internal machine vision	Cooperative ITS	Digital road model; V2I; I2V
■ Active emitters Radar, lidar ■ Stereoscopic devices ■ Combined	■ Transport psychology ■ Car-cabin internal status ■ Emergency situation decision-making system	Multiservice platform ■ IoT; LTE-V ■ DSRC; G5	High-precision map; Aggregated data on the transport situation; Decision-making system (macrolevel)

The development of autonomous vehicles will have an impact on responsibility and insurance policies, as it changes the organization of traffic patterns. The influence on road safety will be an important criterion to evaluate. The influence on traffic fluidity will be another. Although less traffic congestion could derive from traffic optimization, the actual size of an autonomous vehicle, whatever the source of energy it uses, is not different from a traditional one, hence the portion of road it needs to move on remains the same.

One additional innovation that is currently in test mode is the combination of autonomous driving and self-charging vehicles in energy systems integrated within road infrastructures.

FIGURE 6.19 EXPERIMENTAL ENERGY ROAD: THE VERSAILLES-SATORY CHARGING INFRASTRUCTURE FOR DYNAMIC WIRELESS POWER TRANSFER SYSTEMS TESTING[167]

In conclusion of this chapter, the perspectives of combined electro mobility and autonomous vehicles should be tackling all dimensions, be it land, air and also water. Amsterdam has been a forerunner in researching how automated boats could serve a series of purpose in cities ranging from passenger mobility to waste management and temporary public space organization (temporary bridges). As of 2019, the main practical uses though are focusing on using drone-boats to survey water and canal embankments.

FIGURE 6.20 THE PROTOTYPING OF "ROBOATS" EXPERIMENT IN AMSTERDAM, A GLOBAL COOPERATION[168]

[167] Source: Stéphane Laporte, Gérard Coquery, Virginie Deniau. *32nd Electric Vehicle Symposium (EVS32) Lyon, France, May 19 - 22, 2019. The Versailles-Satory charging infrastructure for Dynamic Wireless Power Transfer systems testing*

[168] Source: Amsterdam Institute for Metropolitan Solutions (AMS), in cooperation with MIT

CHAPTER 7.

METHODOLOGY OF SUSTAINABLE URBAN TRANSPORT PLANNING: THE CASE FOR A COMPREHENSIVE APPROACH

7.1 SUSTAINABLE TRANSPORT AND URBAN PLANNING

The diversity in the levels of development of its member countries represents a challenge to UNECE. However, "it is also an advantage, as it encourages the sharing of experience and knowledge, as well as a guarantee of financial and technical aid to countries in need".[169]

At the same time all regions, countries, cities and stakeholders are confronted with similar challenges, such as urban growth and urbanization (notwithstanding regions suffering from demographic losses), traffic congestion, a global call and subsequent commitments to reduce CO_2 emissions and tackle global warming, low physical activity due to the mass use of cars, technological changes and disruptions and so on. In spite of differences between countries and cities, there may be common methodological approaches that may be considered as a basis for decision-making at local, regional and national levels to improve the sustainability of urban transport systems.

Addressing the issue of sustainable transport and urban planning in 2020 means bridging gaps and connecting spheres of policy-making (policy development, implementation and enforcement), which have so far been largely disconnected.

Former mayor of Bogotá, Enrique Peñaloza, a well-known advocate of the New Urbanism, contends: "It is not motorways that make a city more civilised, but it is when a child can ride almost anywhere on a tricycle in an easy and safe manner that it becomes more civilised".[170] This statement, however, can be complemented by saying that such a city should be a convenient place for all citizens, including even those who cannot abandon their private cars. This "city of tomorrow" cannot be associated with high CO_2 emissions, with suffering from long-term health damage due to hours spent in congestion with poor air quality, with spending hours in transportation to get a job and keep it. All of these are key conditions to ensure "quality of life" in the city.

Practice has shown that attempts to secure sustainability and efficiency for urban transport systems without due regard to urban planning aspects, with a focus on supply of transport system`s capacity only proves to be a failure. In principle people`s mobility needs are defined by the level of objects` accessibility (working places, services, social infrastructure, other people and so on) in the urban environment.

Three levels of decisions: "avoid", "shift", "improve"

The GIZ Manual *Planning Dense and Human Scale Cities*[171] points out that ensuring the sustainability of the urban transport system is achieved through implementing the principle of three levels of decisions defined by the words "avoid", "shift" and "improve". This approach entails the following allocation of actions under existing urban policies and national authorities:

1. "avoid"

Achieve decreased generation of transport demand, reduced travel distances and vehicle mileage ("ensuring proximity"), an environment established for demand to be reallocated between different modes of transport, rationalising the traffic conditions for vehicles by implementing measures of urban planning and transport policies, mechanisms of improved land use and traffic management measures (Figure 7.1 illustrates the interaction between land use and traffic planning).

2. "shift"

Ensure that transport demand is rerouted to safer modes of urban transport and travel ("active modes") through mobility management tools and measures (transport policy)

3. "improve"

Enhance the the safety and efficiency of vehicles, fuels used, transport technologies through tools and measures of technical and transport policies.

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[169] Source: UNECE.

[170] Enrique Peñalosa. *Urban Transport and Urban Development: a Different Model.* Center for Latin American Studies, University of California, Berkeley, April 2002.

[171] Manual "Planning Dense and Human Scale Cities", Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, February, 2014.

Level 1 – "avoid" measures incorporate:

(a) Urban planning

- Achieving institutional, legislative and regulatory integration for urban and transport-planning issues (in particular, a single body must be established within the city administration to be in charge of urban planning and transport).
- Assessing the impact that the construction and reconstruction of all housing, social, cultural and industrial buildings and facilities have on the urban transport system; and ensuring that enough capacity of the transport system, required by the new housing, is reached, according to the public transport quality standards, before the new housing is placed into service.
- Support for affordable housing projects in the central parts of cities (with a view to curbing the flow of city-centre-bound trips).
- Arranging housing areas in conformity with the "mixed use" concept.
- Planning dense but limited-in-height built-up areas to meet the physical and psychological expectations of people; ensuring pedestrian accessibility to the main places of attraction and establishing an enabling environment for priority use of other active modes of travel.
- Promoting the creation of urban local (district) centres, urban public spaces and "calming areas".
- Designing traffic-free residential areas.

(b) Managing the use of urban areas from the perspective of transport service

- Ensuring that the built-up areas around the urban mass transit stations generate profits and no losses for the operation of transport facilities.
- Using this to stimulate the establishment of trade and service companies in the areas of urban transport hubs as well as providing for offices spaces near urban mass transit stations.
- Arranging socially important objects such as local authority and social service offices, medical clinics, and libraries in close vicinity of main high-frequency public transport stops so as to make them accessible for all by public transport.
- Ensuring transit-oriented development, i.e. concentration of high-capacity housing around the high-frequency route stops.
- Designing districts with a low density of buildings in such a way as to locate them within accessible cycling distance from urban mass transit systems.
- Allocating spaces and establishing the necessary environment for bicycle parking in the areas of urban mass transit systems.

(c) Improving Infrastructure

- Ensuring the connectivity of urban areas and cutting down the excess mileage resulting from necessary detours.
- Improving road traffic management including through prioritizing pedestrian, cycling and PT traffic (especially at difficult junctions and by putting in place dedicated infrastructure for the transport modes in question).

(d) Supporting solutions

- Establishing agencies within urban administrations to take charge of implementing integrated urban and transport planning policies, encouraging the establishment of associations of public transport operators, associations of PT users, etc.
- Designing and rolling out sustainable urban mobility plans, ensuring that they are extensively discussed, and their implementation monitored.
- Integrating transport into climate-change and environmental plans and programmes.
- Encouraging the use of local products, so as to mitigate the need for transportation.
- Ensuring recreational opportunities at the local level.
- Encouraging employers to introduce flexible schedules and teleworking.

Level 2 – "shift" measures incorporate:

(a) Improving the urban public passenger transport system

- Designing and implementing standards of public transport services quality; permanent monitoring of fulfilment of these standards` requirements by means of automatic sensors and electronic systems.

- Initiating transport demand and public passenger transport surveys.
- Providing multimodal optimization of the route network of urban public passenger transport, ensuring fulfilment of quality standards requirements for every citizen with less possible direct costs and externalities (accidents, pollution and noise, time spent). Using the most efficient transport modes: tramway and light rail, urban railway, dedicated bus lanes. Using a trunk-feeder network with high-frequency arterial routes and local coverage routes.
- Introducing a simple and easy-to-understand ticketing system for users, socially fair tariffs to be provided for urban transport. Implementing fare systems in line with passenger demand, promoting all the fares based on time, independently from transport modes and transfers. Providing palpable discounts for long-term (30 to 365 days) tickets to promote permanent public transport users and suppress fare evasion.
- Introducing integrated (i.e. involving all transport modes) schedules.
- Creating user-friendly websites for users of public transport.
- Ensuring an environment where developers of "smart phones apps" will have access to information on the operation of public passenger transport and traffic conditions on the road network.
- Ensuring convenient transfers: shortest possible walking distances, all stairs duplicated with micro-ramps or lifts/escalators.
- Implementing ride-sharing, car-sharing, car-pooling programmes and their integration into the urban public passenger transport system along with traditional taxi integrators.
- Initiating advertising and publicity campaigns to promote the use of public transport.
- Implementing the concept of "Mobility as a Service" (MaaS) using modern information and communication technologies.
- Introducing unified urban passenger transport management mechanisms, including tendering procedures, promotion of transport associations, establishment of urban monitoring centres, and multimodal transport management, implementation of effective mechanisms for financing municipal passenger transport, etc.
- Ensuring operator efficiency by means of gross contracts (all the fares are collected by the city; the city pays the operator for mileage and punctuality independently of the number of actual travellers). Creating conditions for investment in public transport (by public-private partnerships).

(b) Promoting walking and cycling

- Designing and adopting municipal concepts and plans to promote walking and cycling.
- Establishing a position to be filled by a person responsible for promoting cycling and walking.
- Developing and adopting recommendations to govern the design of pedestrian and bicycle infrastructure under the concept of "complete streets".
- Establishing a full-fledged urban bicycle network, including dedicated lanes for cycling traffic, cycling highways, bicycle parking, etc.
- Ensuring a "barrier-free" pedestrian environment, pedestrian areas and public pedestrian spaces.
- Introducing modern methods and means to organize and maintain a safe environment for walking and cycling, together with systems that prioritize the traffic of cyclists in road traffic.
- Initiating advertising and publicity campaigns to promote the use of bicycles and other means of active mobility.
- Encouraging companies to incentivize their employees to cycle to work.

(c) Management of the use of various modes of urban transport

- Imposing restrictions on motor vehicle traffic (e.g. bans on the traffic of certain categories of vehicles; fees to be paid to enter certain areas: "low emission zones – LEZ"; toll urban highways).
- Creating freight logistics centres.
- Concluding agreements with enterprises/companies on providing employees with monthly public transport passes; creating corporate parking spaces.
- Promoting daily work trips by bicycle or public transport.

- Promoting the economic benefits of abandoning private cars as well as the benefits of active mobility or shared use of vehicles, stimulating various solutions aimed at convincing individuals to renounce private cars voluntarily.
- Redistributing available road space and its capacity in favour of non-motorized traffic users and public passenger transport.

(d) Parking management (parking policy)

- Formulating parking rules (e.g. designation of paid parking areas, payment conditions, types of parking spaces and parking lots, enforcement measures).
- Identifying the "parking capacity" of urban areas and establishing parking fees (striking a balance in the supply of parking spaces and the parking fees, ensuring that 15 per cent of parking spaces are not occupied most of the day).
- Providing information on the availability of parking spaces and free parking spaces.
- Introducing parking time restrictions.
- Enforcing parking rules (parking police, tow trucks, fines).

Level 3 – "improve" measures incorporate:

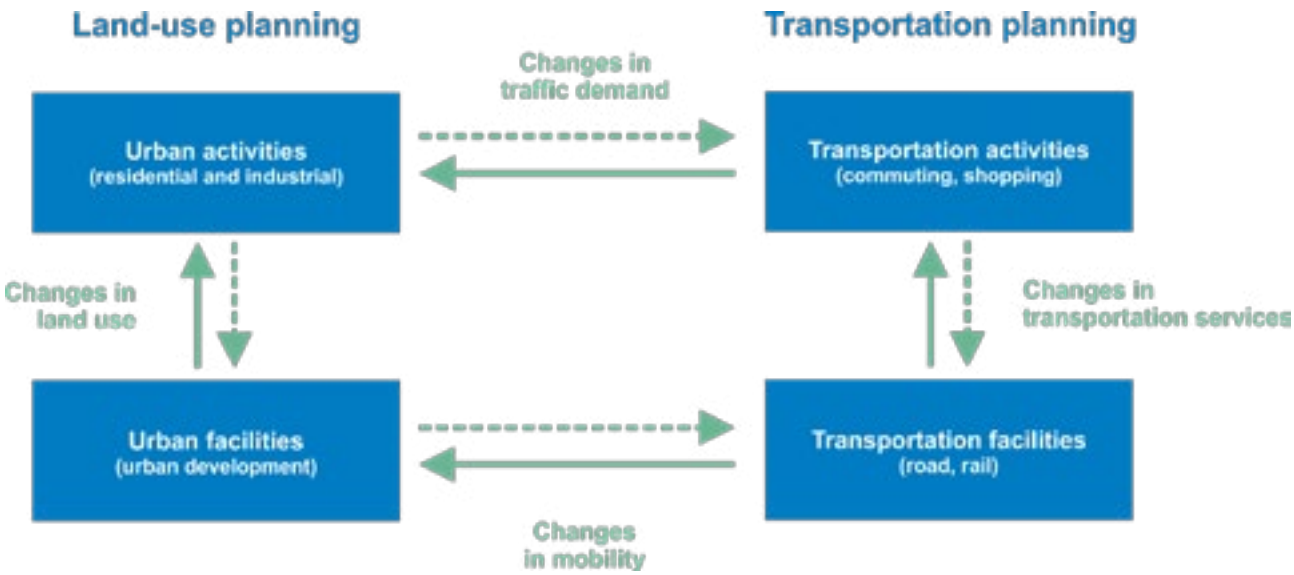
(a) Promoting the production and use of clean vehicles and motor fuels/energy sources

- Adopting modern requirements in respect of newly manufactured and imported cars that would include emission levels, energy efficiency and external noise, limiting the import of "old" cars.
- Adopting modern requirements to produced and imported motor fuels and introducing a mechanism to control the quality of motor fuels on sale and establishing liability for fuel infrastructure operators.
- Designing and introducing legal and institutional arrangements aimed at the renewal of the current fleet of vehicles through "scrappage schemes" and retrofitting certain categories of vehicles in use.
- Establishing effective procedures for maintenance of vehicles and monitoring of their technical condition.
- Introducing "low emission zones" in cities.
- Considering rebates to owners to encourage them to transition to more energy efficient and/or eco-friendly vehicles.
- Promoting "clean fuels".
- Ensuring the right infrastructure for charging infrastructure for e-vehicles.
- Introducing taxation mechanisms to encourage the purchase and use of the "cleanest" types of vehicles.
- Ensuring that environmentally friendly and economical rolling stock is procured for public needs (municipal transport).

(b) Improving the current transport technologies and traffic conditions

- Putting in place a system that would communicate operational (on-time) information to road users on traffic conditions, traffic congestion, availability of parking lots, PT timetables showing the arrival time of vehicles, etc.
- Differentiating speed limits within cities by urban road categories (with different speed limits in residential areas and general roads), better monitoring of compliance with these restrictions and imposing penalties for violations.
- Improving road traffic management including through prioritizing pedestrian, cycling and PT traffic (especially at difficult junctions and by creating a dedicated infrastructure for the transport modes in question).
- Improving traffic management on the urban road network and improving management of passenger and freight transportation via modern means of automation, telematics and transport navigation.

FIGURE 7.1 RELATION BETWEEN LAND-USE AND TRANSPORTATION PLANNING[172]



Bringing about changes in our cities calls for ideas and strategies, but of greater importance for any city is the practical experience of turning an idea into an action plan. There is no doubt that sustainable transport and urban planning can be implemented, in varying proportions, depending on the urban development situation and the prevailing land-use patterns.

Cities with an established built environment first must seek to adapt and retrofit their transport systems accordingly with a view to achieving maximum **urban-area accessibility** for public transport, non-motorized modes of transport and, last of all, private vehicles. The existing transport system should be re-designed from "car-oriented" to "mass-transit-oriented" by cutting down the growing transport demand through new construction activities or "mixed-use" construction and launching mass transit systems according to the principles listed in chapters 2 and 3, with a focus on supporting the development of electric transport. The principles of mixed use should also extend to infill projects, refurbishment of individual residential buildings, arrangement of social amenities, trade and cultural sites and the construction of business centres. Level 2 and 3 measures and decisions can be fully implemented in this context.

Implementation of the housing principles set out in chapter 2 is best-suited to **newly designed or re-designed cities and urban areas**. In this case, transport demand may be optimized through reducing excessive mobility, bringing points of generation and absorption of transport demand closer to each other and implementing the principles of "mixed-use" urban planning. Level 1, 2 and 3 measures and decisions can be fully implemented in this context.

The multifaceted nature of the task to create "liveable" cities determines the priority not only of coordination between land-use and transport policies but also development of proper strategic planning documents focused on improving people`s quality of life and ensuring the availability of various material and spiritual benefits, social services, access to workplaces and interaction with others. Development of such strategic documents must make it possible to find a balance between transport and urban planning solutions, enhance transport accessibility, ensure the desired speed and comfort of public transport, improve road safety and mitigate the adverse impact of transport on the environment and public health.

Properly defined current challenges and objectives in urban transport sustainability make it possible to select the transport policy instruments that may be used by integrated land-use and transport policy to address these challenges as well as packages of appropriate measures to be taken. Some examples of possible objectives and indicators to measure their progress (indicators to assess the process and the outcomes) which may be used to pinpoint existing problems in the area in question are given in Table 7.24.

[172] http://www.iatss.or.jp/common/pdf/en/publication/commemorative-publication/iatss40_theory_02.pdf, Traffic and Safety Sciences: Interdisciplinary Wisdom of IATSSTransportation and land use. The International Association of Traffic and Safety Sciences, Akinori Morimoto. Professor, Faculty of Science and Engineering, Waseda University, 2015.

TABLE 7.24 EXAMPLES OF POSSIBLE TARGETS AND INDICATORS USED IN THE DEVELOPMENT OF INTEGRATED URBAN AND TRANSPORT PLANNING POLICY DOCUMENTS

	Theme	Indicator
Environ-mantal indicators	Global climate change	Greenhouse gases from ransport
	Air pollution	Acidifying gases from transport Volatile organic compounds тот transport
	Consumption of natural resources	Consumption of mineral oil products, transport Land coverage Need for additional new construction
Social indicators	Heath	HeathExposure to PM from transport in the living environment Exposure to NO_2 from transport in the living environment Exposure to traffic noise Traffic deaths Traffic injuries
	Equity	Justice of distribution of economic benefits Justice of exposure to PM Justice of exposure to NO_2 Justice of exposure to noise Segregation
	Opportunities	Housing standard Vitality of city centre Vitality of surrounding region Productivty gain from land use
	Accessibility and traffic	Total time spent in traffic Level of service of public ransport and slow modes Accessibility to city centre Accessibility to services Accessibility to open space
Economic indicators	Total net benefit from transport	Transport investment costs Transport user benefits Transport operator benefits Government benefits from Transport Transport external accident costs Transport external emissions costs Transport external greenhouse gases costs Transport external noise costs

Analysis has shown that different political instruments and practical measures may be used, which can generally be grouped into six units:

- land-use activities
- infrastructure development
- transport and traffic management
- information support
- measures to change attitudes and transport behaviour
- pricing policy.

The effectiveness of different political instruments, depending on the selected objectives, is presented in Table 7.25 in regard to the central parts of cities with an established built-up environment in place and little room for reconstruction in order to change land-use patterns with construction works under way tending to be oriented at building individual commercial facilities or infill elite projects.[173]

[173] Developing sustainable urban land use and transport strategies, Anthony D. May, Professor of Transport Engineering, University of Leeds, UK, 2005.

TABLE 7.25 IMPACT OF POLICY INSTRUMENTS IN CITY CENTRES

Contribution of policy instruments in City Centres								
	Efficiency	Environment	Liveability	Safety	Health	Equity	Economy	Future generations
Land use	*	*	**		*		***	***
Infrastructure	**	**	**	**			**	*
Management	***	***	***	***	*	***	*	**
Information	**	*		*		*		*
Attitudes	*	**	*	*	**			*
Pricing	*****	***	*	**	**	**	**	*****

Key: * Minor contribution ***** Major contribution

The effectiveness of the instruments in question depending on the selected objectives is presented in Table 7.26 for "sleeping areas" where there is much greater room for changing land-use patterns, new construction works and reconstruction of existing buildings.

TABLE 7.26 IMPACT OF POLITICAL INSTRUMENTS IN "SLEEPING AREAS"

Contribution of policy instruments in Inner Suburbs								
	Efficiency	Environment	Liveability	Safety	Health	Equity	Economy	Future generations
Land use	**	**	***		**	*	****	****
Infrastructure	***	***	***	***	*	**	****	**
Management	****	***	***	****	***	***	**	**
Information	***	**	*	**	*	*		*
Attitudes	***	**	*	*	**			*
Pricing	****	**	*	*	**	**	*	****

Key: * Minor contribution ***** Major contribution

Problems associated with the rapid growth of territories are especially relevant in relation to suburbs. For that reason, the integration of transport planning and transport policy with land-use and urban development policies is of the greatest importance. The effectiveness of the instruments in question is presented in Table 7.27 for the abovementioned environment.

TABLE 7.27 IMPACT OF POLITICAL INSTRUMENTS IN OUTER SUBURBS

Contribution of policy instruments in Outer Suburbs								
	Efficiency	Environment	Liveability	Safety	Health	Equity	Economy	Future generations
Land use	****	****	****	**	***	**	***	*****
Infrastructure	**	**	**	**			***	**
Management	***	**	***	**	**	***	**	**
Information	***	**	*	**	*	*		**
Attitudes	****	***	*	*	**			**
Pricing	***	**	*	*	*	**	*	****

Key: * Minor contribution ***** Major contribution

The situation in relatively smaller urban areas is of particular interest (Table 7.28).

TABLE 7.28 IMPACT OF POLICY INSTRUMENTS IN SMALLER URBAN AREAS

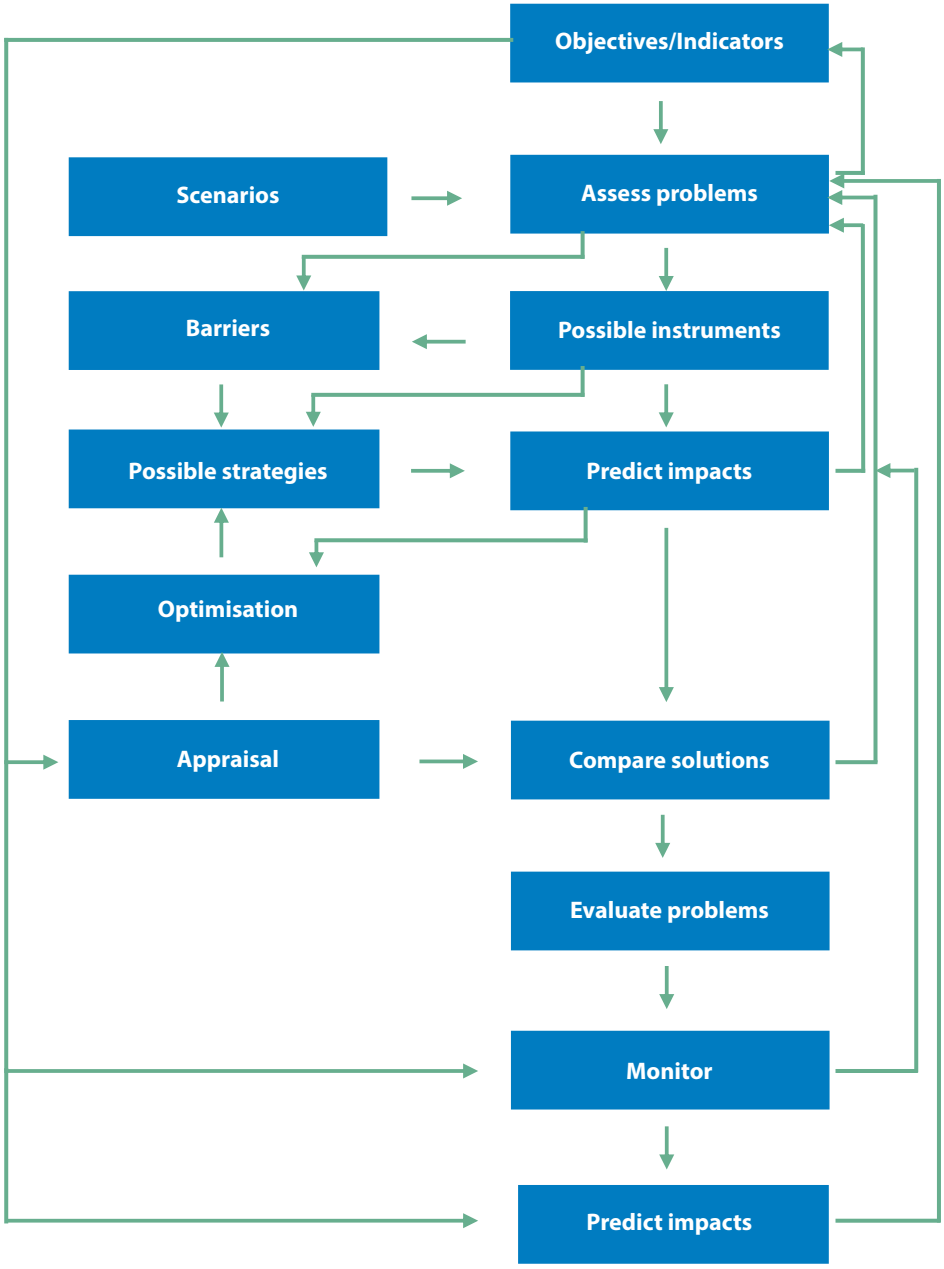
Contribution of policy instruments in Smaller Urban Areas								
	Efficiency	Environment	Liveability	Safety	Health	Equity	Economy	Future generations
Land use	****	***	***	*	**	**	***	*****
Infrastructure	*	*	*	*			**	*
Management	****	***	**	***	**	**	**	**
Information	***	**	*	**	*	*		*
Attitudes	****	***	*	*	**			*
Pricing	**	*		*		*		***

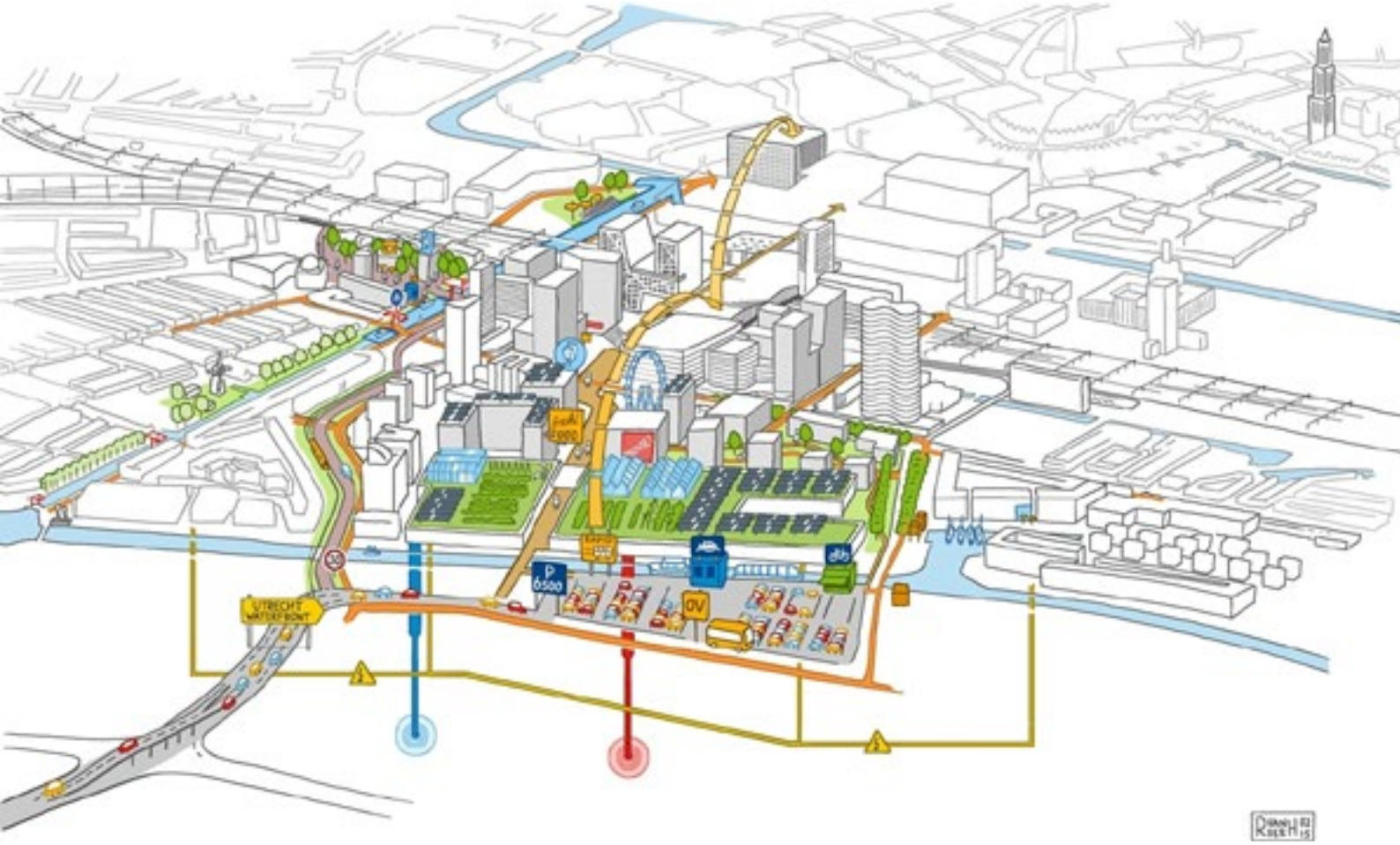
Key: * Minor contribution ***** Major contribution

About the need for a practical approach to decision-making in integrated urban and transport planning, the significance of an agreed process to implement it must be underscored. A common logical structure of such an approach should incorporate the following elements (Fig. 7.2):

- Clearly defined objectives and measures to assess the progress.
- Current problems and barriers to the achievement of the goals must be identified and assessed and potential future problems or barriers predicted.
- A strategy to achieve the goals must be designed with tools and activities selected to overcome the identified problems.
- The outcomes of the strategy must be forecasted, and tools selected by relying on land-use and transport patterns.
- Ways must be found to improve the tools, activities and the strategy itself, with the most efficient scenarios chosen.
- Implementation of the selected tools, activities and the complete strategy.
- Monitoring and evaluating the effectiveness of the progress and its results.
- Assessing whether the original goals and objectives have been achieved.
- Optimizing plans and solutions and improving forecasts.

FIGURE 7.2 LOGICAL STRUCTURE BEHIND THE PRACTICAL APPROACH TO DECISION-MAKING





CHAPTER 8.

CONCLUSIONS AND RECOMMENDATIONS

An integrated approach to urban transport can better support the achievement of the 2030 Agenda and the Paris Agreement.

Making transport systems more resilient requires adopting and implementing a comprehensive and integrated approach based on clearly defined objectives and measures in the spheres of transport, economic and urban development policies, as well as social cohesion. People and their needs are the focus of the integrated approach. The role of transport and land use planning integration is crucial. An integrated approach can prevent urban sprawl and promote inclusive eco-density.

The "avoid"-"shift"-"improve" principles must form the basis for integrating transport and urban planning, and implementing demand management:

- Developing compact, dense and public transport-oriented urban areas, combined with promoting mixed land use, reduces the need to travel ("avoid").
- Developing public transport and active mobility-oriented urban areas supports the shift to cleaner and healthier transport modes for travel ("shift").
- Developing and adapting new technologies in urban areas supports the improvement of the urban transport system ("improve").

Public transport being a key element of a "liveable city", public transport improvements have to be given priority in city strategy and have sufficient finance allocated to them.

Achieving a more sustainable transport involves: (a) the replacement of polluting bus fleets; (b) the promotion of electro-mobility; (c) the development of modern trams and intermodal hubs; and (d) the drawing up of appropriate land management policies.

Active mobility is a core element of healthy cities. Walking and cycling need to be supported not just in urban cores but on a much larger scale, in combination with other modes of transport, especially public transport. Cities need to develop user-friendly intermodal hubs and provide amenities that support cycling and walking. Initiatives such as the WHO healthy cities network should pay more attention to transportation and mobility as key factors.

Developing good quality public transport and infrastructure supporting active mobility is good practice in making cities more liveable, and in safeguarding access to markets while fostering well-being.

Cities are witnessing the rise of a new generation of Intelligent Transport Systems, which profit from financial and technological opportunities offered by digitization.

Recommendations

Urban transportation systems are growing increasingly complex. Along with existing public and private, collective and individual mobility systems, shared mobility and more recently, autonomous mobility, question the organization of public space in cities and raise the need for more transparent decision-making processes.

Decision-makers need to develop new skills, develop new approaches and make the best out of the current technological and social situation; they also need to work through partnerships to implement comprehensive, cross-sectoral mobility policies.

Along with people, attention should be given to freight in the integrated approach so that freight can access markets while urban areas liveability is not compromised.

Implementation of such an integrated approach requires development of the necessary skills by city and mobility planners and practitioners; they need to recognize risks stemming from new technologies – shared mobility, automation – and this ability needs to be enhanced through education and collaboration with academia.

Development of effective urban mobility and spatial planning policies requires participatory decision-making processes engaging multiple stakeholders ranging from municipal authorities, spatial planners, housing and transport providers over health authorities and community leaders to the urban population and commuters as main beneficiaries of the of a city's housing and transport infrastructure.

This *Handbook* addresses one of the most pressing challenges of our time – how to foster sustainable, liveable and harmonious cities.

If cities can use this guide to create their own vision and road map towards a sustainable future, the *Handbook* will have accomplished its mission.

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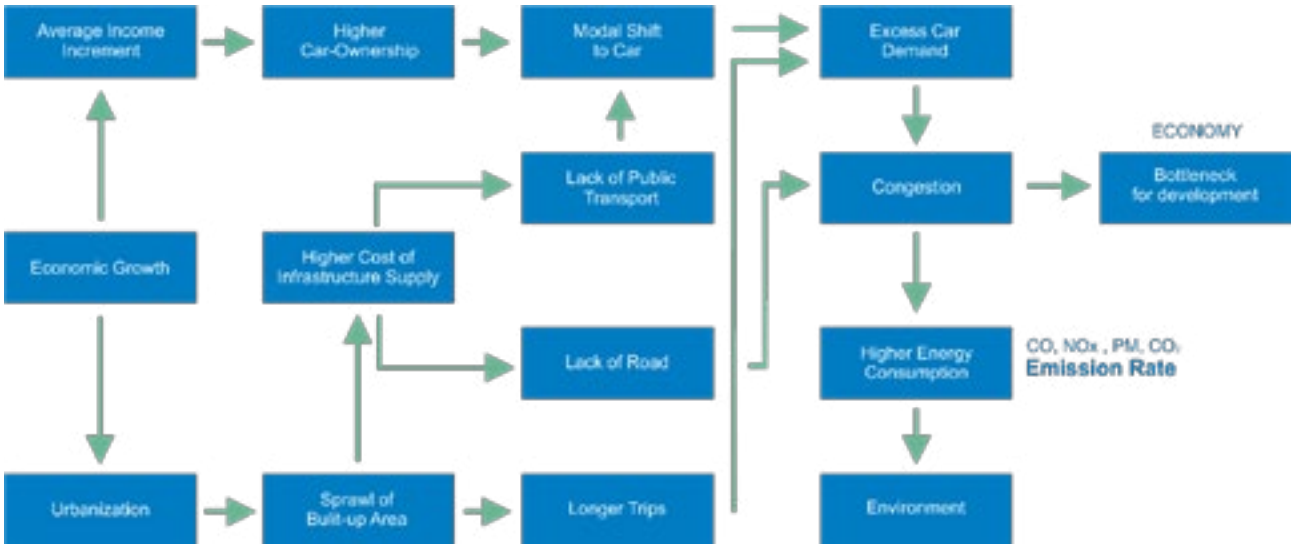
ANNEXES

ANNEX I

TO CHAPTER I

I. Principles of the distribution of street space among traffic users[174]



[174] 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), 2018.

II. THE PEP High Level Meetings and Declarations since 2001

- 2001. First High-level Meetings on Transport, Health and Environment
- 2002. Establishment of THE PEP. 2nd PEP policy framework steering committee
- 2009. Amsterdam Declaration. 3rd PEP policy framework steering committee
- 2014. Paris Declaration. 4th PEP policy framework steering committee
- 2019. 22-24 October, Vienna (Austria). 5th PEP policy framework steering committee

III. THE PEP Relay-race Workshops 2008-2018

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
Prùhonice-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, Republic of Moldova	2008	Sustainable and healthy urban transport

ANNEX II

TO CHAPTER 2
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[175]

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 planning	Availability of strategic planning and development of sustainable transport systems integrated with urban policy and urban planning. Tools to limit the demand for private car use in areas of urban development. A mechanism introduced to prioritize efficiency projects (geared at minimising costs, damage from environmental pollution and the number of accidents per passenger transported).	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.

[175] Developed by the UNECE consultant Rimma Filippova, 2019.

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
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 organizational technologies. E-Mobility development. An affordable pricing policy for all categories of citizens, convenient tariff menus, single ticket (universal fare system), informing passengers in real time, route landmarks, convenient routes and schedule.	System integration of all types of public transport. Approval of local social standards for transport service quality with high consumer quality standards set. Route networks must be designed and put in place based on quality requirements, targeted cost-saving and externalities. Targeted quality monitoring. Targeted programmes aimed at the development of high-speed passenger transport. Commercialization 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 organizational 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 development. Use of ITS, new information and organizational 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 "Liveable 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.

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
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 organizational 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.
Organizing 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 organize single urban parking space. Approval of relevant legislation. Clarify and expand the powers of cities regarding the parking policy and its enforcement.
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.).
Protecting the environment and mitigating the impact of motorized transport on the climate and on 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 withenvironmental regulations. Develop methods for assessment of environmental and public health damage. Assess the volume of pollutants discharged into the atmosphere due to motorized 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-motorized 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.

Activity area	Practice of successful cities	Measures to build and develop sustainable urban transport systems
Creating a 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.	Draw up "Cities for People" strategies with urban and transport planning expressly interlinked. Impose restrictions on the traffic of motorized 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 prioritized.
Supporting and developing non-motorized 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-motorized modes of transport and travel. Promote mobility through the mutual integration of public transport, cycling and car sharing.	View non-motorized 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 organizing 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-motorized 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.
Enhancing 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 motorized 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" motorized 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 motorized 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.
Implementing green logistics and ensure the reliability of road transport	High accessibility. Ensure "door-to-door" cargo delivery. High manoeuvrability. 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 manoeuvrability. Quick delivery. Ensure the use of different routes and delivery schemes.

ANNEX III

TO CHAPTER 5
STRUCTURE OF THE WALES TRAVEL ACT

Theme	Number	Action
Leadership	1.	Ministerial oversight to implementation of the Active Travel Act and Action Plan and champion cross-departmental co-ordination provided by Minister of Economy, Science and Transport. Examples of Ministerial cross departmental activity reported through the annual report.
	2.	National strategic oversight of delivery of the Active Travel Act and the Action Plan by The Active Travel Board.
	3.	The Welsh Government works closely with local authorities to communicate how active travel directly supports the well-being goals and benefits cross service delivery.
Legislation, Standards and Tools	4.	Subordinate active travel legislation remains under review, learning from early implementation of the Active Travel Act.
	5.	Determine best approach to improving road safety in Wales for pedestrians and cyclists. Consider legislative opportunities for strengthening active travel.
	6.	We will keep the Design Guidance under review, building on feedback from local authorities on the use of different design elements.
	7.	The Active Travel Data Management System: capture, manage and publish information on active travel infrastructure in Wales. Provide public access to key information.
	8.	Incorporate the consideration of health impacts into a revised WelTAG.
	9.	Consider further updates to TAN 18: Transport and TAN 12: Design to further promote active travel through the planning system.
	10.	Encouragement of schools to raise awareness of the importance of active travel to the health and well-being of pupils.
	11.	Explore the strengthening of the active travel elements of both the Corporate Health Standard and the Welsh Network of Healthy Schools Schemes National Quality Award.
Infrastructure	12.	Develop the strategy for funding active travel infrastructure investment.
	13.	Ensure provision for walkers and cyclists in terms of direct investments in transport infrastructure.
	14.	We will continue to make grant funding available for high quality local active travel schemes.
	15.	Require consideration of access for walkers and cyclists before supporting capital investments.

Theme	Number	Action
Promotion & Behaviour Change	16.	Development of an active travel promotion and engagement toolkit.
	17.	Development of the national communication strategy for active travel.
	18.	Work with Traveline Cymru to explore the improvement and marketing their active travel journey planner.
	19.	The promotion of Active Travel in schools including pedestrian and cycle training. Encouragement of closer links between complementary school-based programs.
	20.	Reviewal of the role of travel plan coordinators in providing support to organizations. Form partnerships in order to identify complementary programs and suitable additional behaviour change interventions.
	21.	Monitor conflict between transport user groups and identify measures to improve their interaction.
Skills & Training	22.	Offer training on the use of the Design Guidance and enable interactive learning on other aspects of active travel.
	23.	Develop mechanisms to enable practitioners to share experience and provide feedback.
	24.	Seek out opportunities to raise awareness of the Act and its aims and requirements among transport, health and education professionals, and local councillors.
Monitoring & Evaluation	25.	Develop active travel targets and work with local authorities to develop a consistent local monitoring and reporting framework.
	26.	Continue to require Welsh Government funded schemes the effective monitoring and evaluation.
	27.	Explore opportunities to enable and encourage sharing of monitoring and evaluation results.
	28.	The Action Plan will be monitored by the Active Travel Board on an on-going basis. Updates included in annual Reports.

ANNEX IV

TO CHAPTER 6
GENERAL CHARACTERISTICS OF MOSCOW RING TRANSPORTATION 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

[1] **PROMOTING ACTIVE MOBILITY – A HANDBOOK ON SUSTAINABLE URBAN MOBILITY AND SPATIAL PLANNING**
Member States in the ECE and WHO European Region established the Transport, Health and Environment Pan European Programme (THE PEP) in 2002. By providing an intersectoral and intergovernmental policy framework, THE PEP promotes mobility and transport strategies that integrate environmental and health concerns. Over the years, THE PEP has led to the development of implementation mechanisms to support the work of member States.
This publication has been designed to assist member States in integrating transport, health, quality of life and environmental objectives into urban and spatial planning policies. It provides many references to case studies, good practices and examples from cities across the Euro-Asian region (and beyond) covering a wide array of thematics areas, including: the future of sustainable urban mobility; spatial planning in function of sustainable urban mobility and accessibility; public transport planning as a cornerstone of sustainable urban mobility; active mobility and how it promotes health and the environment; and the potential of Intelligent Transport Systems in an urban context.
The publication puts forward a methodology for sustainable urban transport planning and introduces a concise set of key messages and recommendations as an input to the Fifth High-level Meeting on Transport, Health and Environment which takes place in Vienna from 26-27 November 2020.

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A Handbook on Sustainable Urban Mobility and Spatial Planning
Promoting Active Mobility

Member States in the ECE and WHO European Region established the Transport, Health and Environment Pan European Programme (THE PEP) in 2002. By providing an intersectoral and intergovernmental policy framework, THE PEP promotes mobility and transport strategies that integrate environmental and health concerns. Over the years, THE PEP has led to the development of implementation mechanisms to support the work of member States.

This publication has been designed to assist member States in integrating transport, health, quality of life and environmental objectives into urban and spatial planning policies. It provides many references to case studies, good practices and examples from cities across the Euro-Asian region (and beyond) covering a wide array of thematics areas, including: the future of sustainable urban mobility; spatial planning in function of sustainable urban mobility and accessibility; public transport planning as a cornerstone of sustainable urban mobility; active mobility and how it promotes health and the environment; and the potential of Intelligent Transport Systems in an urban context.

The publication puts forward a methodology for sustainable urban transport planning and introduces a concise set of key messages and recommendations as an input to the Fifth High-level Meeting on Transport, Health and Environment.

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