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EUROPEAN UNION

LOGISTICS AND TRANSPORT

City logistics technology

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CONTENTS

1. THE ISSUES OF CITY LOGISTICS

1.1. City logistics – what is it?

The definition of the City logistics results from the definition of the term: logistics. Logistics is an interdisciplinary scientific field dealing with the coordination, harmonization, interconnection and optimization of the flow of raw materials, semi-products, products and other kind of materials and services as well as flows of information and finance in terms of customer satisfaction with the optimal resources spending.

City logistics is referring to all logistics and transport processes that are presented in the city, all services which have to be delivered, and all people whose need to move.
City logistics is the process of **optimizing overall logistics and transport operations** of private companies in the city or in a particular area. Special consideration shall be on the **environment, reducing traffic congestion and reduce fuel consumption**. City logistics compares the advantages and disadvantages of different solutions for both the public and private sectors. **Private carriers** are trying to **reduce their costs for transporting goods**, whereas the **public sector** is trying to **reduce traffic congestion, negative effects of transport on the environment**_and on city streets trying to preserve the original features of cities as centers of commerce, culture, entertainment and sport.

The principle of comprehensive transport serviceability

Comprehensive transport serviceability of the area includes satisfaction of transportation needs of the residents and business entities in the given territory, i.e. passengers and goods transportation. An unsystematically organized transport chain in the territory (city) causes the creation of problems, such as traffic congestions, environmental pollution and failures of other services. All these aspects result in reducing the quality and possibilities of using the particular territory and, last but not least, a number of social and social problems.

1.2. Interconnection of the system

Three main parties (stakeholders) are involved in solving the problems of freight transport:

End-users (private sector, enterprises and other natural or legal entities, shippers) of the system either send goods to other entities, or receive goods from other entities.

Carriers (logistics providers, transport operators) try to minimize their costs related to loading,

transportation, transshipment, unloading, warehousing, packaging and handling with the goods in order to maximize their profits and be able to meet the requirements of final customers.
Residents who live, work or shop in the city

The state administration and city government (public sector) try to ensure a higher economic development of the area or city, residents' employment and living standards. They seek to eliminate the
traffic congestions, improve the environment and increase the safety on roads.

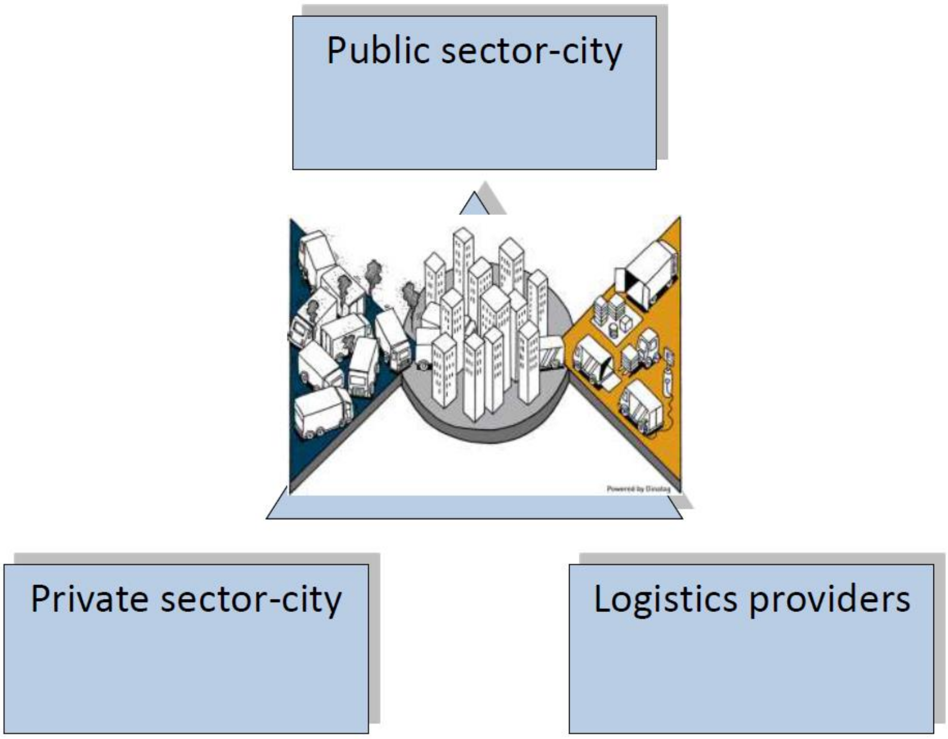


Fig. 1 Interconnection of the system within the city logistics

1.3. Environment of the city logistics

When implementing the city logistics systems, emphasis should be placed on a recent development of transport and traffic **telematics**, which provides a technical potential for effective measurement, vehicles detection, vehicles categorization, on-line communication, information delivery, traffic management and navigation. For example, Global Navigation Satellite System (**GNSS**) for positioning the trucks and Global System for Mobile Communications (**GSM**) enable vehicle operators to dynamically change the route and optimally plan the goods distribution depending on vehicle position or current traffic situation. Implementation of these telematics systems can help reduce costs, total traveled vehicle distance and environmental impacts.

E-commerce provides opportunities for fast and direct shipments in the field of **B2B** (Business to Business) and **B2C** (Business to Customer).

1.4. Basic concept of the city logistics

The concept of the city logistics has a potential to solve these complex logistics problems. City Logistics is the process of overall optimization of logistics and transportation operations of all private companies in a city or in a particular area. Specific consideration is given to the environment, reducing traffic congestions and reducing fuel consumption - by deploying economical vehicles as well as reducing amount of traveled distance.

City logistics concepts

City logistics concept usually consists of one or more combinations of the following examples:

- Advanced Information System
- Cooperation of carriers to optimize the logistics operations
- Public logistics terminal - Urban distribution center
- Controlling the capacity utilization of trucks
- Underground transport systems
- Optimization of vehicles for supply and use of environmentally friendly vehicles – CNG, LPG, electromobiles, biodiesel, hydrogen, hybrids…
- Distribution by other types of vehicles (e.g. railway vehicles, unconventional transport systems, etc.)
- Restrictions of entry of selected types of vehicles
- Charging for transport infrastructure
- Night-time deliveries
- Controlling the space utilization of the cities (Mobility Management, Logistics of the companies, etc.)
- Map for trucks drivers

ternative distribution of shipments - automatic dispensing stations

- Information technologies and telematics

These examples are mostly for higher efficiency combined with each other to meet local transport and land-use plans.

2. ROAD TRANSPORT OF WORLD CITIES

Urban freight transport has become an important issue in the field of urban planning. Due to the increasing occurrence of congestions, environmental impacts and considerable energy consumption, this problem has a growing importance.

City logistics includes solutions of **transportation of materials and goods, warehouses operation, including the business network, operation of the internal transport system, transport services for small and medium-sized enterprises and passenger transport**.

2.1. Major problem in big cities

- An absence of segregation between passenger and freight transport
- Vehicles share the same transport network
- Relationship to transport planning – policy!
- Congestion affects the transport operation,
- Problems related to transport politics,
- Problems with parking, loading and unloading,
- Problems with customers and goods delivery - unloading and collection, time of delivery and collection, etc.

This problem can be solved by various **regulatory measures** that try to separate each other from the conflicting components:

- **Spatially** – by reserving the selected roads, or at least traffic lanes only for urban passenger transport; construction of overground and underground parking garages, entry limitations for heavy trucks, parking/stopping prohibition, reserved parking, etc.

- **Timely** - some urban areas try to displace freight transport with heavy tonnage into the night and early morning hours, restrict it, or totally prohibit it, time-limited parking.

However, with higher territory utilization and higher economic activity, the need to apply individual logistics principles arises, coordinate and synchronize them with the participation of city authorities.

Examples of city logistics solutions in the field of road transport in EU cities:

2.2. Specialized Objects (Urban Distribution Center)

From the analysis of large cities such as **Berlin, Bremen, Munich**, etc., the most frequently used solution is to create the specialized logistics centers (parks), intermodal terminals and distribution centers.

A more efficient utilization of freight vehicles can be achieved by consolidation of freight in
“city distribution centers” or “urban consolidation centers”.

UCC is a logistics facility that is situated relatively close to the area that it serves, for example, a city center, an entire town, or a specific site. It collects shipments of different companies in terms of an integrated logistics system. UCCs offer storage, sorting, consolidation, and deconsolidation facilities as well as a number of related services such as accounting, legal counsel, and brokerage. Consolidation of deliveries may lead to a decrease of kilometers traveled.

Principle of the UCC - Freight arrives at an “external zone,” where it is consolidated into urban trucks. Each urban truck delivers to one or several satellite platforms (destinations). Here, freight is transshipped into environment-friendly vehicles adapted to pickup and delivery in crowded inner city areas. Satellite platforms offer no storage facilities, requiring complex real-time coordination, control, and scheduling of urban trucks and city freighters.

Above all, the most important functions of these objects are:

- relocation of goods from industrial facilities,
- packaging, weighing, application of bar codes, etc.,
- goods loading and unloading,
- goods warehousing,
- providing necessary consultations in the field of logistics, law, marketing, finance, etc.,
- handling with storage equipment,
- consignments transition in the form of intermodal transport units among railway, inland waterways, maritime and road transport.

2.3. Restriction or permission of vehicles entry to city centers

Vehicles entry to individual parts of a city may only be permitted for certain **types of vehicles, only at certain time intervals** or **on the basis of the issued license**.

Depending on the type of a vehicle - **size, weight, quantity of produced emissions**. In most cases, the weight limit related to the total vehicle weight is applied, however, for example, in city centers, it is often necessary to apply the width limitation since the narrow aisles do not allow the transit of wider vehicles. Restrictions may also be applied to vehicles meeting certain **emission limits**.

2.4. Ecological (low-emission) zones (restrictions by ecological standards)

Low-emission or ecological zone: area where only vehicles meeting certain emission criteria may enter. Zones can be specified by:

- geographical delimitation,
- time sequences,

- vehicle emission standards,
- types of vehicles.

Existing low emission zones: **Italy - Rome, Sweden - Stockholm, Gothenburg, Malmö, Lund, Great Britain - London, Spain - Madrid, France - Paris, Denmark - Copenhagen, Italy - Milan**.

2.5. Map for truck drivers

Creation of this map helps navigate and orientate in the city. The map contains information about, e.g.:

- restriction of vehicle driving by weight,
- occurrence of supply and loading ramps,
- prohibition of trucks entry,
- preferred routes, etc.

A detailed supply map allows **optimizing the individual supply routes to a particular custome**r. This map can be distributed in printed form or as a part of satellite navigation systems (electronic formats) which are capable to navigate the driver to the required route.

Fig. 2 Example of the map for truck drivers

2.6. Charging for transport infrastructure

Charging for a certain area or individual road sections allows to transfer the external costs of infrastructure construction and external costs arising from the vehicles operation (environmental pollution costs, congestion costs and car accident costs) directly to the operator or owner of vehicles. There are more types of charging, and also several technologies and methods to implement them. It can be used both manual and automated systems as well as state-of-the-art technologies for monitoring and enforcement technologies using radio and satellite connections.

3. TRANSPORT AS A SYSTEM

3.1. Transport system of the city

Depending on the position (location) of the source, i.e. activity generating transportation demands, and the location of the destination, i.e. activity accepting transportation demands, the transport can be divided into:

- **transit** (or bypass) transport – i.e. the source and destination of the transport route are located outside the given territory;
- **external transport** (target and source) – i.e. the source is located inside and destination is located outside the territory, or vice versa;
- **internal transport** – i.e. both the source and the destination are located within the territory.

The offer of roads capacity in the city does not correspond to the current demand. Due to urban roads congestion, there are collisions among individual components of surface passenger and freight transport (both dynamic and static) and pedestrian traffic. Several organizational and regulatory measures can be applied to solve this problem. **Long-term regulatory measures** for the transport organization in cities include:

- **Organization of transport** on the road network (measures to achieve the highest possible transport segregation, definition of main and side roads, creating one-way roads, Parking/stopping prohibition and restrictions regarding certain movements and maneuvers on the road, etc.),
- Organization of **transport movements at intersections** (marking shift lanes, no right turn, commanded driving direction),
- Measures **to increase the homogenity of the traffic flow** (elimination of slow vehicles permanently or temporarily, reduction of driving speed limit, people´s access to communication, etc.),
- Measures to **increase the homogeneity of the traffic** (limit interference with communications, etc.),
- Preference **tools and measures for means of transport in public passenger transport or emergency vehicles** (preferences on separate lanes at intersections).

Short-term regulatory measures on the road network include:

- Measure to the **distribute and layout the traffic peak hours** (temporal and spatial),

- Establishing **temporary bypass routes**,

- Measures to **manage the emergency short-term concentrations** of traffic,

3.2. Transport links in the city and their relation to the City logistics

During transportation of passengers, cargo and information, certain links are created. They interconnect urban, suburban, intercity, inter-regional and international modes of transport. There are basic transport links in the city, such as:

- transport links to **employers' sector**,
- transport links to **civic amenities**,
- transport links to **recreation**.

3.3. Formation of the city's transport system

The city's transport system consists of:

- transport **networks**,
- traffic **organization** (traffic management and regulation in terms of time and space aspects),
- means of **transport**.

The process of dealing with the city's transport system can be summarized in four steps:

- **optimizing** the **functional arrangement** of the city that leads to the elimination of residual transport of all levels;
- **reconstruction** of existing elements of the current transport system, design and construction of new elements of the transport system;
- **organizational measures** and **traffic management** that optimizes an utilization of transport corridors;
- **regulation** and **restriction** of certain modes of transport.

4. SYSTEM APPROACH TO URBAN TRANSPORT

The transport network within the city's transport system consists of 3 elements:

- Parking place
- Intersection
- Street

4.1. Parking place

In terms of the theory of systems, it represents the integration element. Arriving and departing vehicles represent the output value. Stock (inventory) of cars in the parking lot (place) represents the input value. According to the purpose, they are divided into:

- Parking place in residential zones,
- Company parking place for employees and clients,
- Parking place in front of public buildings,
- Park and Ride (Kiss and Ride) parking place

Basic terms:

parking - placing the vehicle at a rest state (vehicle idle) outside the traffic lanes of the road

- short-time - $t \leq 2$ h
- long-time parking - $t > 2$ h)

shutdown (pulling over) - placing the vehicle at a rest state outside the traffic lanes of the road in the place of residence / location of the vehicle operator

vehicle stall - area necessary to pull over or parking a vehicle (longitudinal, oblique and perpendicular).

4.2. Intersections

Intersections are an important element of the city's transport system. From the point of view of the Graph theory, intersections are traffic nodes (junctions) within the transport system of the city in which individual roads meet (connect). They have their capacity, input and output edges and specific properties. The most frequent are: intersections with junction roads, roundabouts and junctions controlled by traffic lights

4.3. Street

Street consists of one or more **traffic lanes** and particular number of **parking slots** (it can be 0). In the transport system, it performs the function of a buffer through which a certain number of vehicles flow and certain inventory of vehicles (vehicles at rest) is maintained. Operation is affected by the traffic lane width, especially in situations when vehicles are parked at both ends. They have their passability (transit capability) and also their capacity.

4.4. Traffic management

Traffic management on the road communications – it is part of the system solution of transport operation in the city. In **terms of time aspect**, it can be divided into:

Real-time management – the immediate traffic management – for example: by traffic lights at the intersection, traffic lights indicating the parking house capacity or manually unidirectional detour (bypass) operation,

Operative management – pre-planned regime of transport, e.g.: daily change of the traffic lanes direction, change of intervals (signal time intervals) at traffic lights in after-noon rush hours, streets closures, etc.,

Tactical management - reorganization of the transport system in a medium time peri-od (seasonal streets closures due to maintenance),

Strategic management - major reorganization of the traffic management based on the systematic management using information systems, modeling and simulation software.

5. DEFINITION OF TRANSPORT SERVICEABILITY

5.1. The impact of transport on settlements and cities development

Depending on the new phenomenon of the 1960s, when urban growth was being curtailed and stopped in terms of territorial expansion and, in addition, there is a tendency for deconcentration, geographers established (e.g. Berg, Drewett, Klaassen, Rosi, Vijveberg 1982, Cheshire and Hay 1989, M. Tosics 1989) "General Theory of Modern Urban Development". This theory is based on the assumption that urban development takes place in successive phases of urban development: **urbanization, suburbanization, desurbanization and reurbanization**. The phases are repeated in cycles in all cases of urban development, i.e. first of all, in innovative centers, and subsequently, they expand to the rest of the world. The urbanization process is influenced mainly by the country's economic maturity and the industrialization degree which results in the optimal population placement.

5.2. Transport serviceability

According to the Act on Public Services in Passenger Transportation (Czech Republic), transport accessibility represents ensuring the transport for all days of the week, especially to schools, public authorities, work (job), health facilities and to satisfy the cultural, recreational and social needs, including the transport to come back.

In relation to local residents, transport serviceability can be characterized as follows:

- **in terms of spatial perspective** - the ability to carry (transport) a person within the desired area (stops availability, destination accessibility, density of traffic network, etc.)
- **in terms of time perspective** - the ability to carry a person within the desired time (time of traffic operation on the transport line during the day, regularity - line-interval of transport, etc.)
- **in terms of transport lines capacity** - the offer of free space in vehicles on the particular line at the required time and transport direction (vehicles capacity utilization, etc.)

- **in terms of finances** - the ratio of ticket price (fare) for the individual population groups to their income (salary).

In most cities, transport serviceability is ensured by **four basic modes of passenger transport**:

- urban passenger transport,
- line regular bus transport,
- individual car transport,
- railway passenger transport.

Mostly, they are operated concurrently without greater co-ordination. However, there are exceptions; in some areas, so-called "**integrated transport systems**" already exist, where time and space coordination of the different modes of transport in the city is ensured.

Integrated Transport System (ITS) is a system of transport serviceability of a particular integrated territory by public passenger transport including multiple modes of transport or transport lines of several carriers (operators) when passengers are transported under the uniform transport and tariff conditions (transport rules and tariff system).

Transport is often provided by **various means of transport (vehicles)**. Integration may include even continuity to cycling or individual car transport in the form of **P+R, B+R or K+R (Park and Ride, Bike and Ride, Kiss and Ride)**. Different carriers may participate in ITS and timetables of individual transport lines shall be optimized, no matter which carrier operates the given line. Passengers within ITS utilize uniform tickets which can be used throughout the system regardless of the carrier and used means of transport.

6. MODELING THE OPERATION IN THE TRANSPORT SECTOR

6.1. Modeling individual passenger transport can be divided into three phases:

1. phase

In the first phase, a simulated communication network is created. The network consists of nodes and sections. Nodes represent intersections, sources and destinations of transport, and places where communication characteristics changes. Sections represent communications which interconnect the road network nodes.

2. phase

In the second phase, the particular territory is divided into areas (regions) in which transport originates and ends. For such divided regions, transport relations matrices are defined, on the basis of transport surveys, which determine how much traffic is in motion among transport areas and entries to the territory.

3. phase

In the third phase, journeys according to the transport relations matrix are assigned to the current communication network. For each relationship, one or more routes are searched according to the defined parameters.

6.2. Model possibilities (functions)

- Determining traffic intensities on newly constructed roads and specifying the decrease or increase in traffic on the existing road network;
- Construction phasing assessment;
- Road sections closure simulation;
- Impact of the traffic organization assessment - construction of unidirectional roads
- and road sections closures, forbidden turning of some directions at intersections, "Green wave";
- Determining transit, destination and initial transport to the given territory;
- Determining overall traffic and transport characteristics - total transport performance, average journey time, total time consumption, etc.

6.3. Basic terms:

Road lane - the basic part of the road section intended for one traffic flow of road vehicles or the main traffic lane of a one-way road.

Traffic lane - a reinforced part of the road section intended for one traffic flow of road vehicles or pedestrians.

Traffic flow - a sequence of all vehicles (or pedestrians) moving in the lane either in succession or in lanes side by side in one direction. It can consist of several road or pedestrian flows.

Traffic flow intensity - the number of road vehicles or pedestrians who pass through a certain road profile or its part over a selected time period in one traffic direction.

Rush (peak) hour intensity - maximum intensity of vehicles, pedestrians or cyclists which pass through an observed road profile per hour.

Traffic flow structure - it expresses the share of individual vehicle types from their total sum at a certain time period and observed road section.

Traffic flow density - the number of vehicles (pedestrians) on a particular road section at a certain time period.

Traffic flow speed - mean value of vehicles (pedestrians) speed in a selected road profile (instantaneous speed).

Unit vehicle - a theoretical vehicle indicating the conversion of all vehicles to its value. It is expressed by the characteristic features (driving mainly) of a passenger car.

7. PROGNOSIS AND MODELING TRANSPORT NEEDS

7.1. Transport-engineering instruments for transport modeling

Transport modeling does not include only traffic modeling and simulation. There are a number of transport-engineering instruments (tools) which can be used for many activities.

In summary, however, these tools can be divided into several groups:

- **planning and decision-making** tools (these cover supportive tools to help with tracing communications, designing transport areas, economic assessment of constructions, environmental impacts, and others – e.g. software AutoTURN, AeroTurn, etc.);

- tools for the **transport demand analysis** (mainly focused on the allocation of traffic load on a communication network based on the existing and proposed transport infrastructure and the relevant urban concept);

- **analytical computational tools** (these include mostly supportive software packages facilitating otherwise complicated calculations and their output consists in, for example, designs of traffic lights at intersections where some of the more sophisticated products can find optimal alignment of signal plans - Highway Capacity Manual, Edip-Ka, etc.);

- tools for **optimizing traffic devices** (most of these tools are designed to optimize signal programs of traffic lights at intersections, or to design shift lanes and width ratios at uncontrolled intersections),

- **traffic simulation tools** (the most comprehensive solutions are focused not only on the analysis and optimization of transport systems, but also provide a visual presentation of outputs – software VISSIM, Paramics, Aimsun NG, etc.).

7.2. Modeling and simulation of traffic flow

Transport (traffic) modeling and simulation is used mainly within transport engineering and transport planning. **The aim** is to create such a transport model in the given territory which can help apply transport infrastructure design (geometric and broad arrangement of the communication network), public passenger transport design (establishing new bus lines, stops locations, etc.) or environmental impact assessment.

The fundamental aspect of transport models is to model, as closely as possible, the vehicles movements and their mutual interactions. The main criteria include: the model network extent, **the degree of approximation to the real state and the details illustration**.

According to these criteria, models can be divided into:

- macrosimulation models,
- mesosimulation models,
- microsimulation models,
- nanosimulation models.

Microscopic simulation models

The principle of microscopic simulation (microsimulation) is to **model the journeys of individual vehicles over a given communication network** when taking into account all the **parameters of an infrastructure and means of transport** including the driver behavior. The basis of microscopic models is especially to model each vehicle movements moving in the traffic flow.

„Car following" model

Car following model, which describes the longitudinal movement and behavior of the vehicle in the traffic flow depending on the previous vehicle, represents the most widespread type of microscopic simulation models.

The basic principle of the car following model is to determine the **dependence of vehicle acceleration on surrounding conditions**, which means, in a simpler case, only on a condition of a vehicle in front of a followed vehicle.

8. CREATION OF THE TRANSPORT PROCESS USING SPECIFIC SOFTWARE

Nowadays, the field of transport planning, management and optimization is basically irrelevant without using the relevant computer support.

8.1. PTV Vision

The PTV Vision modeling software, more precisely some of its functional modules (VISEM, VISUM and VISSIM), is a comprehensive software package designed to support planning and management of traffic processes.

VISUM: Software for transport networks planning and analysis. It models in parallel public passenger transport networks as well as individual car transport networks which can be, subsequently, operated as one common network or separately. It helps to evaluate existing or propose a completely new level of public passenger transport from the point of view of both the provider and the passengers.
The basic functionality of the VISUM module is to allocate transport relations matrices to the model transport network (i.e. transport network loading by transport relations). The obtained output provides a comprehensive image about availability, time loss, occupancy, and so on.

VISEM: It is a model for generating transport relations matrices and calculating the transport demand. Parts of the input data for the process of defying transport relations matrices by software VISEM are represented by the distances matrix, time availability, transfers matrix, classified matrix, etc. in appropriate formats acceptable by VISEM.

VISSIM: Software module for multimodal modeling that enables to perform a microscopic traffic flow simulation by the user. It generates a realistic model of pedestrian and cyclist behavior and can accurately simulate their movement along urban roads synchronously with the motor vehicles movement.

Other components (modules) of PTV Vision: VISEVA - transport demand with simultaneous destination choice. INTERPLAN - graphic planning and optimization of timetables and theoretical graphs of transport. INTERPLAN/select - application for individual and dispatcher planning for route optimization. VISUM-online - Software for a real-time traffic management on motorways and roads. Traffic engineering workstation SITRAFFIC P2 - application for creation of signal plans of both isolated and coordinated intersections.

8.2. Options (usage) of PTV Vision:

- Research projects focused on roads capacity (motorways, roads, intersections);
- Optimization of traffic-projection intersections designs;

- Microscopic simulations on motorway networks (throughput, transport quality);
- Simulation of telematics benefits;
- Microscopic simulation of public passenger transport vehicles driving.

8.3. Course of the simulation study

The simulation process consists of **two basic stages**. In the first stage, a simulation model is to be designed and created. This process covers the creation of the certain model (transport network) and necessary data collection and evaluation. During the second stage, simulation experiments are carried out on the created and verified model. The final step is to implement the conclusions and results from the simulation study into real life.

The whole process is divided into 11 basic steps:

- Transport problem formulation
- Determining objectives and overall plan of the simulation process
- Model concept creation
- Data collection and analysis
- Simulation model creation
- Model verification
- Model validation
- Simulation process proposal
- Simulation implementation and analysis
- Need of further simulation
- Final report creation

9. LOGISTICS OF SUPPLYING THE CITY BY FREIGHT TRANSPORT

9.1. Logistics operation of the city

Basic concepts of logistics operation of cities and territories in the field of freight transport are basically two logistics technologies:

- **Hub and spoke**
- **Gateway**

Hub and Spoke - is based on the existence of a single logistics center from which the territory is operated by distribution roads (spokes). Consignments are collected by the carrier from the shipper's premises and returned to the carrier's depot for consolidation. At the carrier's depot, consignments are sorted by location (typically by destination state or depot), loaded onto road freight vehicles (usually semi-trailers), and then, transported to the destination hub.
Sorting at the origin hub can be done manually, based on a visual identification of the delivery address on a parcel, or it can be an automated process whereby the parcel travels along a conveyor belt and be identified by a machine that reads a bar code printed on the parcel.
At the destination hub, consignments are deconsolidated, either manually or via the automated conveyor belt process. At the destination hub, however, consignments are sorted into "runs" or "routes. A "run or route" is typically a cluster of suburbs in the same geographical area or a single location that has a high volume of deliveries made to it on a daily basis.
Once the consignments are sorted into the "run or route" at the destination hub, they are loaded onto smaller delivery vehicles and delivered to the consignees in that particular area.

9.2. The technology operates with two transport circuits:

- circuit of **external** transport - consolidated consignments for 1 or more recipients,

- circuit of **internal** transport - distribution of deconsolidated consignments from the hub (logistics center) on the territory.

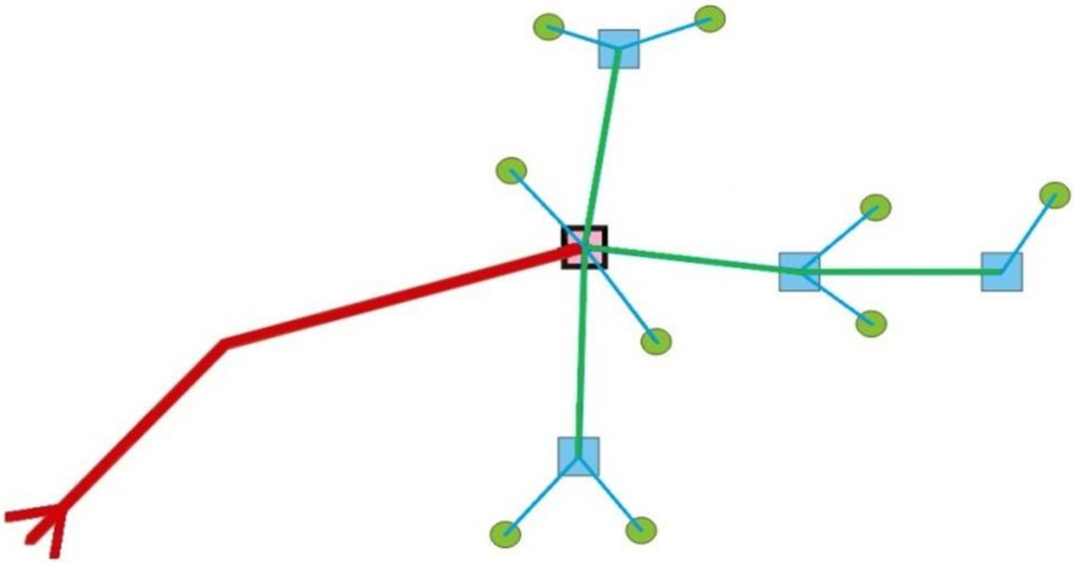


Fig. 3 Hub and Spoke logistics technology

External transport is ensured by high-capacity freight transport systems or their combinations (in multimodal transport systems).

Internal transport is constrained by the transport infrastructure condition. Mostly, it is ensured by road transport operated by trucks with their total weight 3.5 - 6 tons.

This technology is suitable for the area operation of medium-sized or small agglomerations – up to 1 million citizens.

Logistics technology Gateway is suitable for the logistics operation of large core cities (more than 1 million citizens).

At the entrances to a big city core, the "Gateways" are built – similar logistics objects as logistics centers for the **hub and spoke** technology. In these gateways, following activities are usually performed:

- handling with consignment,
- consolidation and deconsolidation, including packaging,
- collection and distribution of consignments.

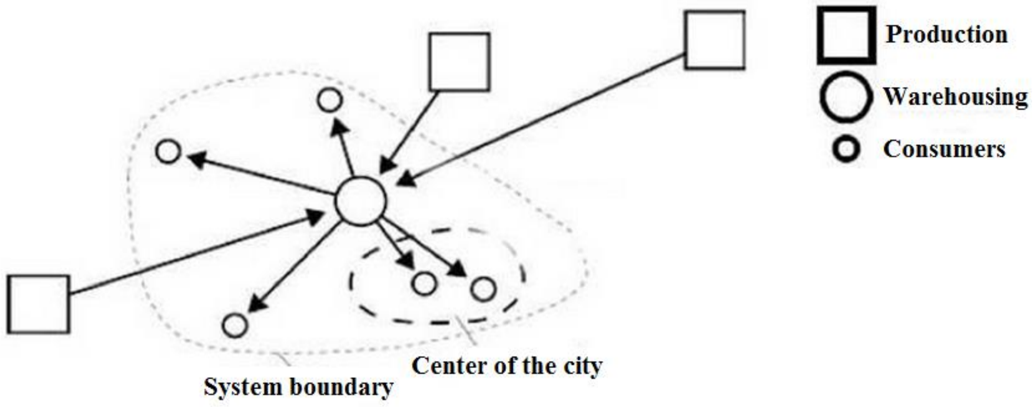


Fig. 4 Gateway logistics technology

10. TECHNOLOGY OF THE CITY OPERATION BY FREIGHT TRANSPORT

10.1. Approaches to the city logistics issues and freight transport in cities

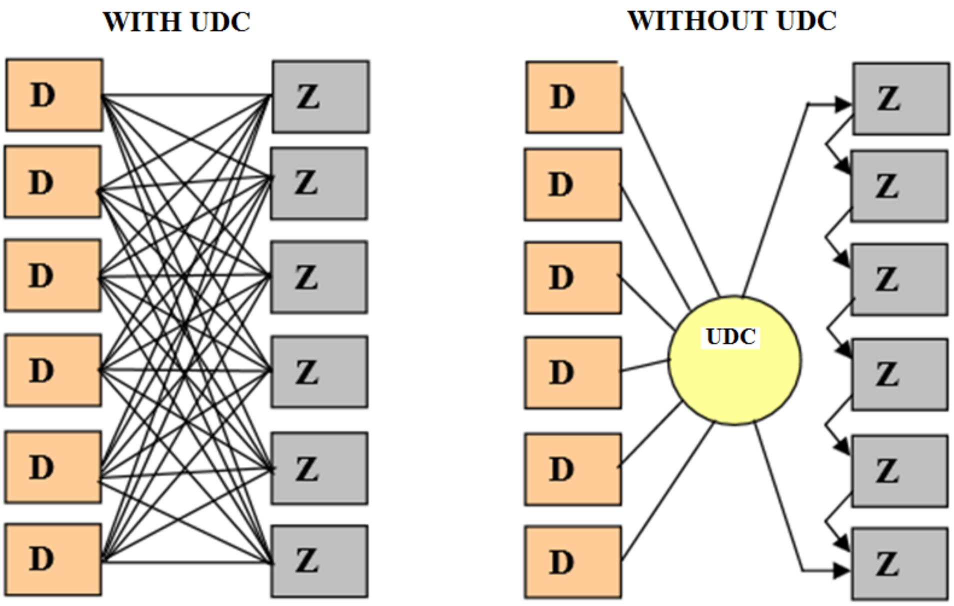
The term of "city logistics" represents the application of logistic approaches to the goods (consignments) and passengers' movement in urban conditions. It characterizes the process of optimizing logistics and transport processes in urban agglomeration involving the private and public sectors.

As already mentioned (see chapter 1), city logistics systems (technologies) in freight transport in Europe are often composed of combinations of the following city logistics approaches:

- Urban distribution center,
- Cooperation of carriers to optimize the logistics operations
- Controlling the capacity utilization of trucks
- Underground transport systems
- Optimization of vehicles for supply and use of environmentally friendly vehicles
- The distribution by other types of vehicles
- Restrictions of entry of selected types of vehicles
- Charging for transport infrastructure
- Night-time deliveries
- Controlling the space utilization of the cities
- Map for trucks drivers
- Alternative distribution of shipments
- Information technologies and telematics (Advanced Information System).

Aforementioned city logistics approaches are combined to each other to achieve higher efficiency in order to solve defined problems of cities. A suitable combination of measures can **reduce the negative impacts of freight transport on the environment**, reduce **congestions** caused by freight transport and **number of freight vehicles (trucks)** in the particular area while maintaining its **economic growth**.

Urban distribution center – see. chapter 2



Note: D – carrier; Z – customer
Fig. 5 Supply vehicles movements with and without the urban distribution center

Specific goals that can be achieved by introducing the UDC:

- reduction in the number of trucks in the particular area,
- reduction in the total number of journeys of trucks,
- reduction of congestion, emissions of air pollution and noise,
- increasing attraction to the area,
- greater supply reliability,
- improvement of provided service levels,
- overall optimization of the logistics chain

Use of alternative fuels

One of the other options to reduce the environmental impact of transport is to use the alternative fuels which are more environmentally friendly compared to conventional fossil fuels. Alternative fuels include **LPG** (propane, butane), **CNG** (compressed natural gas), **biofuels** (bioethanol, vegetable oils, biodiesel), **hydrogen**, **electric power** and **hybrid** drives.

Consignments distribution by unconventional transport systems

Cargo trams - In some cities, there is a dense network of tram lines that are not 100% utilized in night hours. Therefore, there is an opportunity to use them for the supply activities or collection of waste. In Zurich, trams are adjusted for bulk waste collection. In Dresden, specific Cargo tram is operated; it connects the distribution center and the factory in the city center.

Fig. 6 Cargo trams operated in Dresden

Bicycles - The distribution of parcels and light consignments by couriers riding a bicycle is common and used in many European cities. Using bicycles, light consignments and parcels are usually distributed in city center. Consignments are delivered directly to the addressee.

Restriction (regulation) of entry of selected types of vehicles – see. chapter 2

Fig. 7 Florence – regulation based on a license

Charging for transport infrastructure – see. chapter 2

Night-time deliveries

The aim of night-time deliveries of city centers and other areas is to avoid congestions that occur during the day, and at the same time, not to contribute to them. Night deliveries reduce vehicle driving time, emissions, fuel consumption, and allow for larger utilization of vehicles to supply.

Information and telematics technologies

- webpages,
- on-line route planners,
- driver/warehouse communication, driver/distribution center communication,
- warehouse information systems,
- fleet management,
- providing real-time information on traffic conditions and infrastructure,
- optimization of journeys, etc.

Map for truck drivers - see. chapter 2

10.2. Examples of particular City Logistics solutions regarding freight transport abroad:

- Brussels - Caddy-Home
- Aarhus – Restricted entrance into the pedestrian zone
- Copenhagen - The system of certificates, couriers on bicycles
- Bordeaux - UCC
- Lyon – Entrance charging
- Paris - Electric tricycles, night-time deliveries, etc.
- Dublin - Night-time deliveries
- Geneva - UCC
- Milan - Cityplus – consignments consolidation
- Savona - Metrocargo
- Trento - Electromobiles
- Verona – Multimodal logistics terminal Quadrante Europa, Green vehicles (environmentally friendly)
- Fukuoka - UCC
- Hungary - Fleet Management System
- Monte Carlo - UCC
- Amsterdam - Floating distribution center, Cargo tram
- Leiden - UCC
- Tilburg, Groningen – Effective supply
- Berlin - Strategy for integrated transportation of goods, Building distribution center for the construction of the Potsdamer Platz in Berlin
- Bremen – Handbook about the transport network for freight transport, City logistik
- Freiburg - The system of centralized management of supplies to the city
- Munich - UCC

lo (also Bergen a Trondheim) – Entrance charging

- Evora – Ecologus
- Graz - City logistik Graz
- Salzburg - City logistik
- Vienna – TIP
- Barcelona - night-time deliveries, Web sites
- Malmö - Food industry logistics, traffic management using the satellite navigation
- Basel - City Logistik (BCL)
- Zürich - Transport of bulk waste by tram
- London - Construction material distribution center, Congestion fee,
- Heathrow - Distribution center
- Norwich - City distribution center (CIVITAS SMILE), Project - Shop and go,
- York - Cyclone couriers

11. DATA COLLECTION AND PERMEABILITY ANALYSIS

11.1. Assessing the performance of local roadways

Local roads (roadways) are designed to **peak hour intensity** determined by conversion based on daily intensity distributions. Full-day intensities for the design period are determined on the basis of a transport model, existing data forecasting - by extrapolating the linear or non-linear function, by the method of single or average growth coefficient, or by using the nationally determined growth coefficients, or transport development.

In terms of performance assessment, local roads for motor transport are divided into four (functional) groups (classes):

- roads in the transition sections, sections between the external road network and crossroads through built up municipalities areas (functional groups A and B),
- roads of functional groups A,
- roads of functional groups B,
- roads of functional groups C.

11.2. Performance assessment principles

The determination of (design intensity - performance) local roads capacity for vehicles according to the standard is calculated on the basis of established principles and compiled into table reports for functional groups of A, B and C.

The principle of calculation consists in adjusting the basic hourly or full-day intensity (capacity) by the correction coefficients that affect the performance of the local road section.

Allowable intensities of local roads of functional groups C

Table. 1 Basic values of allowable intensities of local roads of functional group C

Functional class	Allowable intensities in both driving directions (veh./h)		Good service and complete equipment at degree of motorization		Poor service and low equipment at degree of motorization	
	Hourly	Daily	1:3.5	1:2.5	1:3.5	1:2.5
C	300	3000	1600	1400	1200	900
C serviceable	200	2000	1200	1000	800	600
C (D)	100	1000	600	400	400	300

11.3. Traffic surveys

Current traffic volumes, traffic intensities and transportation flows, traffic conditions on current transport facilities as well as understanding all the relationships and contexts which cause the traffic and its growth are detected and acquired by the traffic surveys and analyzes. Their intimate knowledge represents the starting basis for the **transport planning**.

Traffic surveys utilization:

- **Ensuring the data for designing and planning**
  - Modernization of road and urban networks
  - Improving transport on existing roads
  - Design of parking areas
  - Transport services of the territory
- **Evaluation of the existing traffic relationship**

Surveys divisions

- **Depending on the territory size and the number of habitats**
    - General survey
    - Nationwide traffic counting (it obtains data on traffic intensity and traffic flow structure)

- **Detecting the traffic characteristics**
    - directional survey
    - intensity survey,
    - speed survey

- **Depending on a monitored mode of transport**
    - Road transport survey
    - Pedestrian traffic survey
    - Cycling traffic survey
    - Urban public passenger transport survey
    - Survey on crossroads and motorways
    - Verification surveys
    - Purpose survey
    - Special surveys (intersection)

- **Forms of surveys execution**
    - observation
    - oral asking
    - inquiry
    - traffic-sociological surveys

12. ANALYSIS AND MODEL OF POPULATION MOVEMENTS AND ANALYSIS OF CONNECTIVITY AND APPROPRIATENESS OF CARTOGRAPHY METHODS

12.1. Methods of determining traffic intensity

Traffic intensity on a road is measured (detected) by following ways:

- Using the results of previous transport surveys.
- Performing and evaluating a traffic survey.

In conditions of the Czech Republic, these sources of information regarding traffic intensity are available in particular:

- long-term traffic counting (census);
- national traffic counting (census) – it is the basic information on road transport traffic intensities. It takes place over a five-year cycle on a selected roadway network covering all motorways, roads of first class and second class, selected roads of third class and selected local roadways. The national census is ordered by the Road and Motorway Directorate of the Czech Republic.
- using results of other traffic surveys - surveys of road, cycling and pedestrian traffic are regularly performed in some municipalities.

Methods of performing traffic intensity surveys

- **manual**

- survey using technical equipment - **detectors** built or fixed to the road – hoses, induction loops; radar and infrared **detectors** - located close to the roadway (some types allow to record even intensity of cycling and pedestrian traffic); **videodetection** – video-outcome recording and analysis of the system for automatic video-outcomes evaluation, **combined** (for example, video recording with subsequent manual evaluation).

Traffic intensity is usually monitored and measured separately by individual directions and time - at least by hours.

Vehicle types

To monitor traffic intensity, it is advisable to divide vehicles into these types:

- **O - Passenger cars** – Without trailer and with trailers, vans,
- **M - Motorcycles** – Two-wheeled motor vehicles without trailer and with trailers,
- **N - Trucks** – Light, medium and heavy trucks, tractors, special trucks,
- **A - Busses** – Vehicles intended for the passengers and their luggage carriage providing more than 9 seats (including articulated buses and buses with trailers),
- **K – trailers** and articulated vehicles (truck+semi-trailer).

EVALUATION OF TRAFFIC INTENSITY SURVEY

Methodology for determining the estimation of annual mean of daily traffic intensity on the basis of a short-term survey is based on the conversion of the traffic intensity measured during the short-term traffic survey using coefficients characterizing the daily, weekly and yearly variations of traffic intensities.

12.2. Geographic Information Systems

A geographic information system or geographical information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. The acronym GIS is sometimes used for geographic information science (GIScience) to refer to the academic discipline that studies geographic information systems and is a large domain within the broader academic discipline of geoinformatics. What goes beyond a GIS is a spatial data infrastructure, a concept that has no such restrictive boundaries. In a general sense, the term describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. Geographic information science is the science underlying geographic concepts, applications, and systems. GIS is a broad term that can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business. For that reason, GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis and visualization. GIS can relate unrelated information by using location as the key index variable. Locations or extents in the Earth space–time may be recorded as dates/times of occurrence, and *x, y,* and *z* coordinates representing, longitude, latitude, and elevation, respectively. All Earth-based spatial–temporal location and extent references should, ideally, be relatable to one another and ultimately to a "real" physical location or extent. This key characteristic of GIS has begun to open new avenues of scientific inquiry.

12.3. The creation of digital maps

Creating digital maps is organizationally demanding and time-consuming process. First of all, Aerial pictures of the given area must be taken. Pictures can only be taken in very clear weather by special cameras that capture images either digitally or on a large-format film. Images must always keep information about their location, exact coordinates, altitude and rotation. Subsequently, images are processed by computer, for example, they are color-aligned. It is necessary to have a digital terrain model, or accurate altitude information at all points of the entire area with certain spacing according to the terrain, resulting scale and required accuracy. Then, it is necessary to mark the boundaries
of individual images on the basis of which the resulting pictures will be composed. The matched neighboring pictures are further linked into a single large mosaic which is then "staggered" into individual map sheets.

12.4. Spatial planning

Spatial planning is a specific type of planning, sometimes referred to as environmental changes management. It focuses primarily on changes in the material components of this territory. It systematically and comprehensively solves its functional utilization, establishes the principles of its organization and coordinates materially and timely the construction and other activities influencing its development.

Three categories of spatial planning tools can be defined:

- **Spatial Planning Background Materials:** These are mainly spatial and technical data, i.e. datasets characterizing the territory conditions which are usually processed in digital form for individual cities.

- **Spatial Planning Documentation:** It results in various regulations and restrictions (for example, for what purpose the territory can be used). This usually includes the territorial plan of a large territorial unit, or municipality and the regulatory plan.

- **Spatial Decisions:** On the basis of these, it is possible to locate a construction on a certain territory, change its utilization and protect important interests in it.

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