Sustainable City Logistics through Shared Resource Concepts

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Abstract

The global trend of urbanization has important consequences on society and the environment in urban areas. Growing population, scarcity of resources and rising freight transport in urban areas result in completely overloaded infrastructures. The "last-mile" delivery in the city is considered to be particularly complex and occurs in most cases not comprehensively structured. The consequences are far-reaching environmental problems, noise pollution and a general reduction in the quality of life in the city. Therefore, in the field of urban logistics is a great potential for optimization. The subject of this article is a logistics shared-resources approach for a structured, organized and bundled supply in urban areas.

Keywords
Sustainability, sustainable logistics, supply chain management, city logistics, shared resources

1. Introduction

The problems caused by an increasing urbanization in connection with the increasing freight traffic require new models of intervention and of city logistics. Innovative and modern logistical approaches for urban logistics have to be developed in order to be able to handle the supply and disposal processes in the urban areas more efficiently. One way to do that is through bundled logistics, whereby an urban space is supplied by holistically planned delivery and disposal processes. In doing so, the widely accepted principle of small individual deliveries is to be substituted and replaced by bundling of orders by type of goods and delivery zone combined with environmentally friendly means of transport. Through the integration and development of such new structures, economic aspects for the individual as well as social characteristics have to be considered in addition to environmental benefits for society as a whole. The presented concepts are intended to contribute to possible efficiency improvements in all these areas. In order to maintain the sustainable prosperity of the urban areas, it will be important in the future to drive existing and innovative technologies together with a more intensive cooperation between the city and companies [1].
This article first describes in a short theoretical background the current trends and challenges of urban logistics in order to give an overview of the actual state of art. Further it describes the actual problems in urban supply and disposal logistics. In the main part of this paper, the concept of shared resources for city logistics is presented in order to increase sustainability of transport in urban areas. Traditional and shared resource approaches in city logistics are compared showing typically unstructured and chaotic flows of goods in the city and introducing new and innovative shared resource approaches for city logistics. After this introduction into the concept of shared resources the authors

describe four possible structural forms for a more sustainable city logistics. This includes centralized as well as decentralized hub concepts. A description, possible applications, advantages and disadvantages of all four structural forms are shown at the end of this article. Finally, the article ends with an outlook for future research and a thorough conclusion.

2. Background

2.1. Current trends and challenges of urban logistics

The relationship between increasing demand for transport services for individual supply of goods is becoming ever more acute. For the supply of urban agglomerations and inner cities, ecological, social and economic requirements must be brought into a relationship, which is justified and meaningful for all stakeholders. The individual needs of citizens are growing ever more. This is why private end users today demand fast delivery and, at the same time, high quality of life with regard to environmental issues. Because of these opposing demands on urban supply, new structures, concepts and technologies are needed. The current infrastructures of the inner cities are being overloaded in such a way by the fundamental social change, that intervention is urgently required. On the basis, of current trends, such as increasing individuality, growing variety of variants and short product life cycles, the logistic processes need to be adjusted. Innovative organizational forms are required, which are economically sensible, ecologically sustainable and adapted to the currently prevailing market conditions. One way of reacting to these trends is through decentralized production sites, which, by being close to the consumer, counteract the rising transport costs and the environmental impact [3]. In the past most of the economic cycles were carried out on a nationwide or international basis, which leads to long distances for transport. Increasing cost and environmental sensitivity, however, leads to a motivation for shorter distances and could become an important criterion for site selection in a few years [4]. In addition, current trends, such as an increasing health and environmental awareness in society, influence the development towards regional economic circuits up to on-site production [3]. The trend is therefore towards the shifting of the production sites into the urban areas. In the future, the product will no longer be solely responsible for success or failure of a company, but also sustainable and ecologically acceptable logistic processes will play an important role. However, the "Morgenstadt" concept presented by Fraunhofer Gesellschaft introduces the idea of ‘Urban Production’, which integrates production sites in a city-friendly manner and provides processes and technologies that conserve energy and resources [5]. In addition to innovative concepts for energy supply, design of buildings, information and communication, mobility and transport, urban processes and organization, safety and protection and production, also ‘Urban Logistics’ will also be subject to change. The research field ‘Logistics’ ensures smooth process flows in the transport and handling of goods, in commerce, in services and the provision of food for residents [6]. Such concepts guarantee a certain proximity to the market, as the urbanization is increasingly moving sales markets to the cities [7]. Future innovations in the area of information and communication technologies (ICT) could make a significant contribution to more efficient logistical processes in urban logistics. One example is the real-time management along the entire supply chain through RFID (radio frequency identification) technology, which enables better coordination between the partners and more efficient processes at the critical interfaces. Further innovations are to be expected in the area of traffic guidance systems, which make environmentally friendly and fast transport processes possible.

2.2. Problems in urban supply and disposal logistics

In the urban environment, particular problems arise in the logistics chain. In the urban area, in contrast to the route logistics, there are special restrictions and conditions, which must be observed in the logistics planning. A particularly delicate role is played by the "first and last mile" of delivery [8]. Complexity drivers in urban supply and disposal logistics include, among other things, roads, which can only be driven at certain times, or are even inaccessible, that are pedestrian zones, etc. Particularly private deliveries often foresee deliveries to these areas. Moreover, regulations such as the nightly extradition or restrictions due to increasing environmental pollution in cities make the supply of the last mile more difficult [9]. A set of factors and criteria must be included in the planning and be observed. In addition, the diversity and density of the recipients in the urban area is enormous, which is reflected in a considerable increase in the complexity. The spectrum of the recipients to be served ranges from private customers, shops, bars, restaurants or hotels to public facilities and urban production sites. Overall, the trend in the urban supply is to have more and more small quantities in high frequency. Due to certain constraints as well as the mentioned complexity drivers the inner city logistics becomes more and more complex in its design.

3. Shared Resources as a solution for a more sustainable city logistics

3.1. Traditional vs. shared resource approaches in city logistics

The volume of traffic in freight transport services in the cities is growing steadily. A decline is not to be seen, on the contrary. Forecasts predict that freight transport will continue to grow in the next few years due to the growing degree of individualization and the availability of variants [10]. Much of the freight traffic in the cities often involves very unorganized small-scale deliveries to private customers and the supply of the inner-city retail structures, although the utilization of the means of transport is usually very low in these cases. In some cases, chaotic traffic conditions prevail in the inner city, as individual suppliers drive into the city in order to deliver a few packages to their customers. The resulting economic and environmental efficiency of these processes is therefore very questionable.
On the basis of this development, the logistics industry - especially urban logistics - is being asked to be more efficient and sustainable. A sustainable development can be considered only if three main elements are taken into account: Sustainability should be based on ecological, economic and social aspects [11]. First and foremost, it is important to respect the environmental friendliness of urban supply and thus to act ecologically sustainable. At the same time, it is fundamental that an economic viability of the logistics processes is achieved, while at the same time social aspects are respected. These three pillars of sustainability are often not balanced and have to be brought into a suitable relationship depending on the situation, whereby the ecological component is becoming increasingly important in times of increasing environmental awareness.
One way to reduce the problems associated with urban logistics and to increase the efficiency of economic and environmental technology is given by a ‘resource sharing’ approach for city logistics. This approach, unlike past perspectives, provides holistic concepts for urban supply in conjunction with the shared use of logistics resources. To this end, the contracts for an urban area are bundled according to product class, delivery zone and recipient. By combining orders, economies of scale can be achieved. In addition, the utilization of the means of transport can be increased and a much structured, clearer and more environmentally friendly delivery can be achieved. Long distance transports end at logistics hubs near to the city, where a city logistics control center combines the incoming goods and cares about an efficient last mile transport in sustainable vehicles. The introduction of such concepts into the urban supply is therefore reflected positively on the sustainable development of the cities. Figure 1 shows the traditional and typically unstructured flow of goods in the city and compares it with the concept of shared resource in city logistics.
In the following, possible structural forms of sustainable city logistics are presented using the shared resource approach.

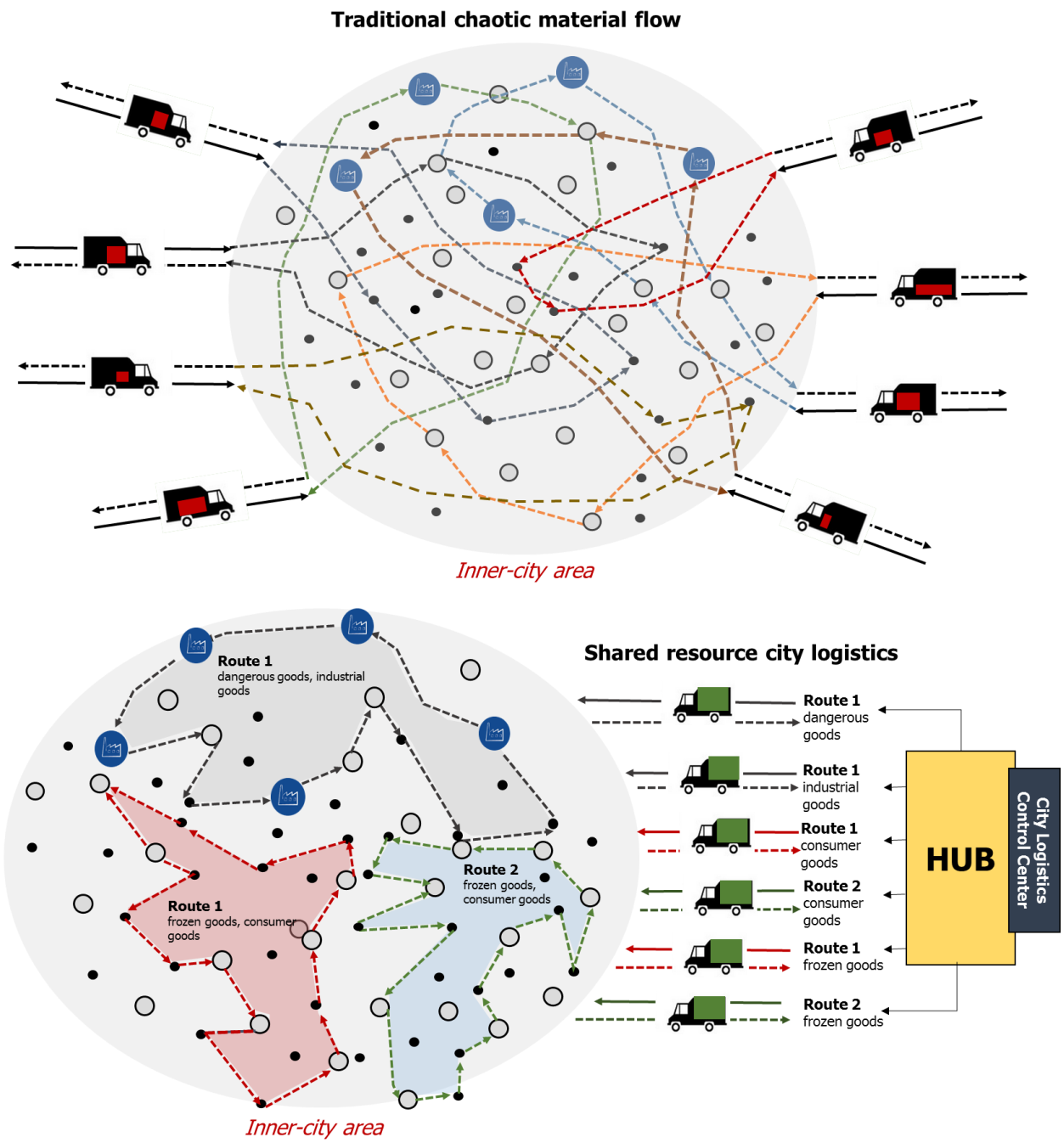

Figure 1. Typically unstructured and chaotic goods flows in the city vs. innovative shared resource approaches in city logistics

3.2. Possible structural forms for sustainable city logistics

The logistical concept, which makes the sustainable supply of urban areas possible foresees the introduction of so-called distribution centers or 'hubs' at well-connected junctions outside the urban area, from where a structured supply of the inner city is possible with shared resources. The external suppliers deliver their goods to the hub instead of delivering these goods directly to the customer in the city. From these hubs, it is possible to carry out a much better organized and bundled delivery according to planned routes using environmentally friendly means of transportation,

(see Figure 1). A very important point is the distinction of the goods into categories of goods. A possible classification is as follows:

1. Dangerous goods,
2. Consumption goods,
3. Industrial goods,
4. Refrigerated goods.

This distinction is fundamental for the selection of the appropriate logistical processes such as storage and transport, as well as the choice of means for transport. Since every urban area has different characteristics, dimensions and circumstances, it is necessary to develop different structural forms, which can be used in a flexible way depending on the situation. In this paper, four basic structural forms for a shared resource approach in city logistics are presented and described:

1. Central Hubs
2. Central Hubs for different goods
3. Decentralized Hubs
4. Decentralized Hubs for different goods.

The first form (see Figure 2) describes the use of one central hub for the concentration of all goods to be delivered in the city. In this central hub, goods are bundling according to routes and zones maximizing the efficiency and capability of means of transport.

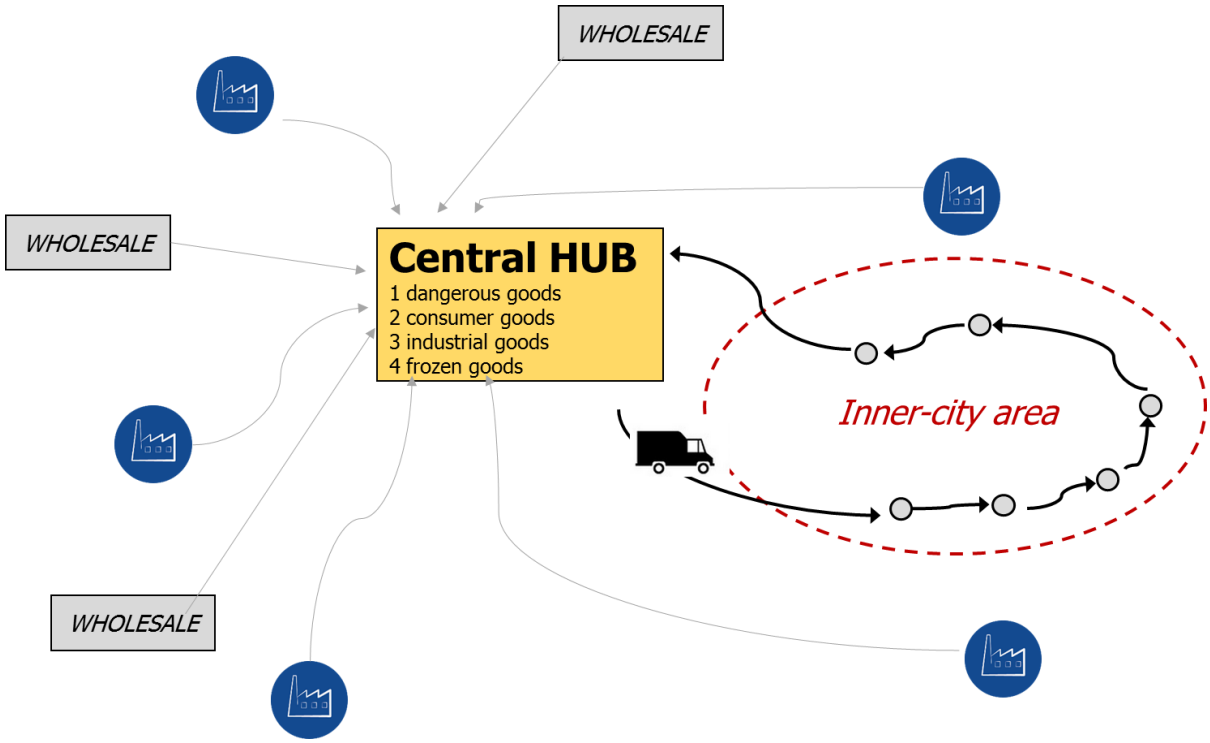

Figure 2. Central hub for city logistics

Due to different categories of goods with different needs for storage and transport it could make sense to have central hubs for different categories of goods as shown in the second form (see Figure 3). For example frozen goods have special requirements for the design of the warehouse, for the shipping process as well as the mean of transport. Thus it could make sense to establish a central warehouse/hub for several categories of goods in order to combine the advantages of building bundles and of an appropriate transport for the category of goods.

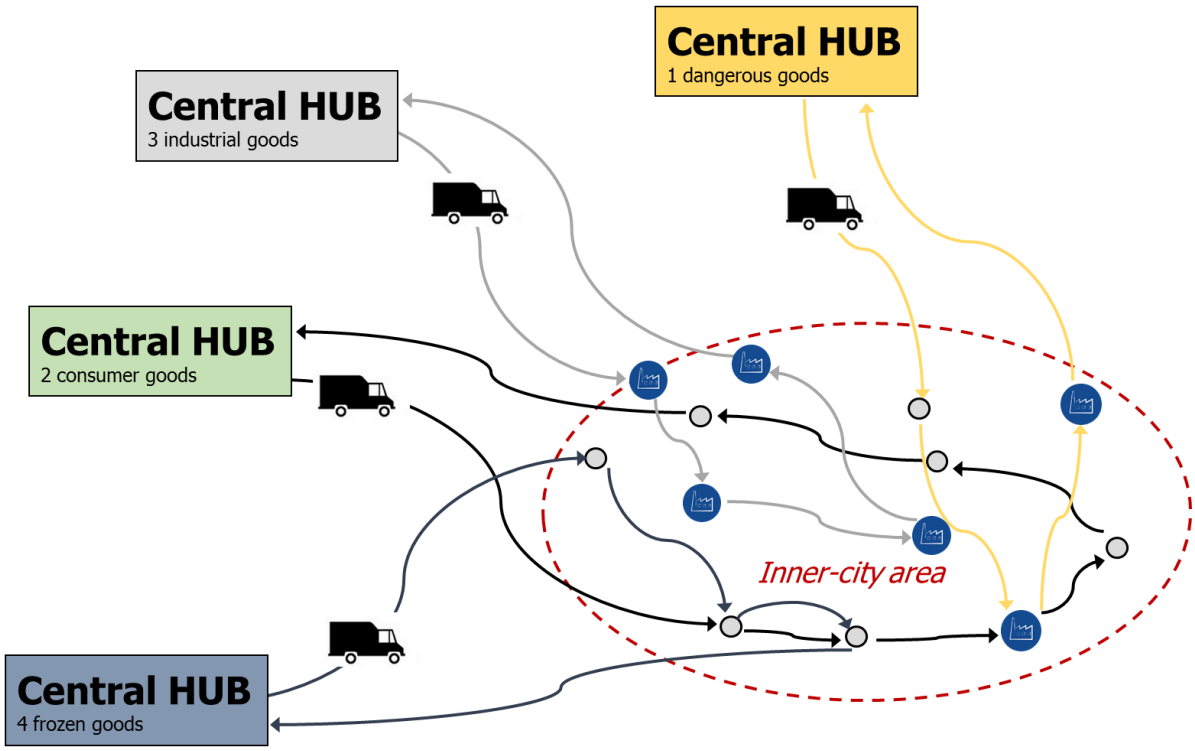

Figure 3. Central hubs for different categories of goods

In some cases, it might make sense to establish decentralized hubs in order to optimize routing in the city area (see Figure 4).

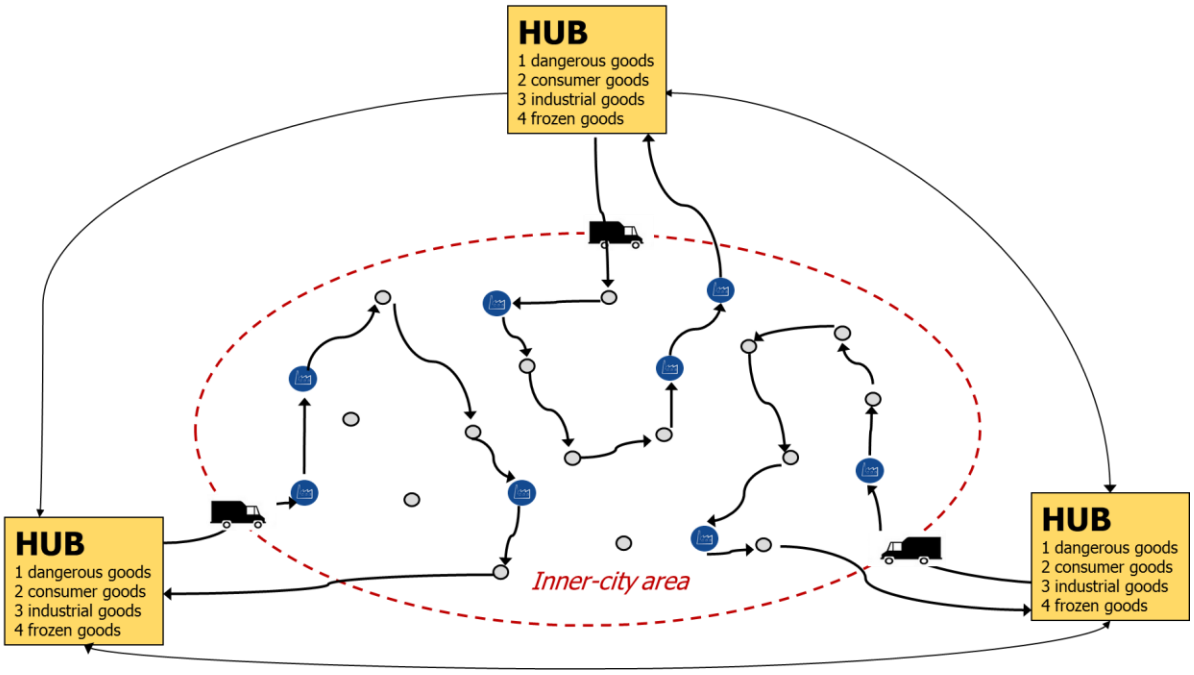

Figure 4. Decentralized hubs for city logistics

Further, it could be interesting to create decentralized hubs for different categories of goods (see Figure 5).

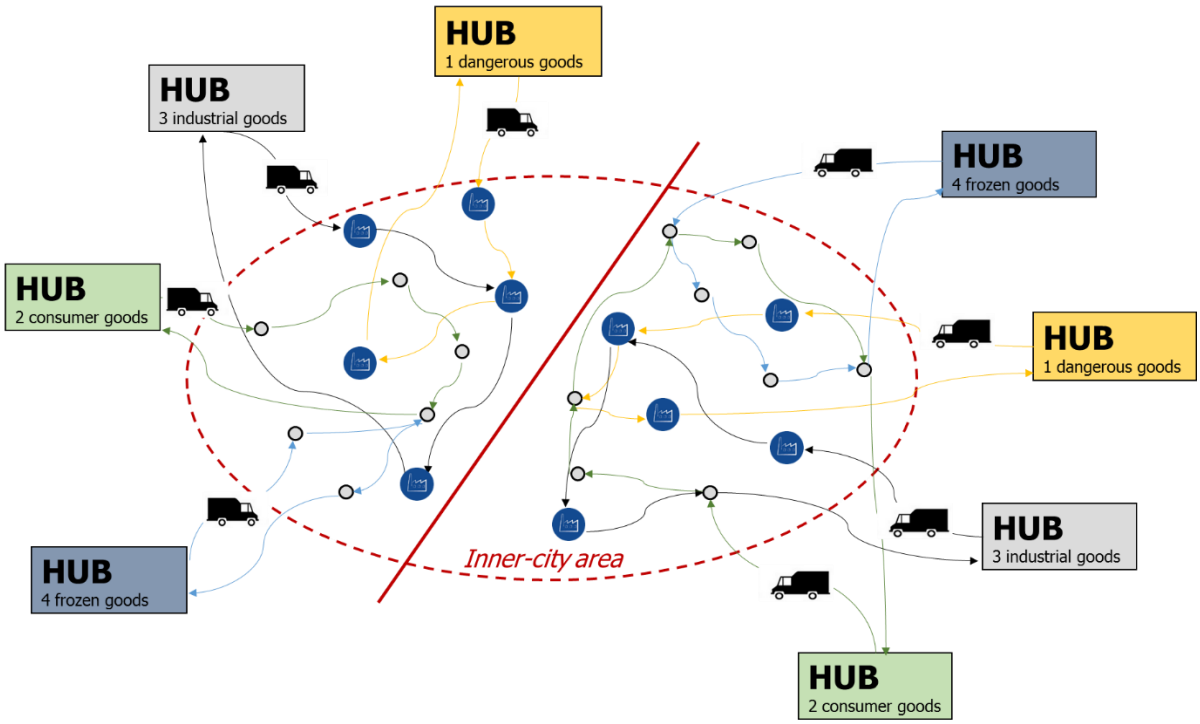

Figure 5. Decentralized hubs for different categories of goods

The basic principle of the proposed structure forms shown in Fig. 2-5 is very similar. The suppliers deliver to the hub pre-commissioned goods, which are either immediately forwarded for delivery or temporarily stored for a short period of time. The distribution of the goods is comparable to the gate system of an airport. The goods are grouped according to the location of the recipient and the category of goods and, if possible, packaged for final delivery. Depending on the density and frequency of the supply for the respective freight classes, the routes are dimensioned and fixed in order to guarantee a timely supply. The problematic of the holistic view of logistical processes and resource-saving disposition is achieved by the introduction of a central control center, which monitors and allocates the entire goods flows and means of transport as a central coordination center. The structural concepts shown in Figure 2-5 show a division into a) central or b) decentralized hubs. In addition, the hubs can be specialized in certain classes of goods, or as a multifunctional hubs for several or all classes of goods.

The hubs can be operated in various ways. In addition to typically public-sector management, the operation could also be transferred to consortia or private companies through public tenders. In addition, the possibility of private-public partnerships (PPPs) has certain advantages. While the responsibility of the private company lies on the efficient performance of the service, the public authorities will ensure that the public-oriented objectives are respected.

Table 1 shows, in addition to the properties and alternatives of operation of the aforementioned structural forms, exemplary applications as well as advantages and disadvantages.

The approach presented in this paper with the four identified structural forms aims at a sustainable design of urban logistics using shared resources. In the implementation of such concepts, it is indispensable to examine the specific characteristics of the given metropolitan area, to choose the right configuration from and, if necessary, adapt it to the situation. The presented structural forms are to be regarded as an inspiration for further research on future-oriented reorganization of urban logistics.

Table 1. Characteristics of the presented structural forms for city logistics

	Concept 1 **Central Hub**	*Concept 2* **Central Hub for different goods**	*Concept 3* ***Decentralized Hubs***	*Concept 4* ***Decentralized Hubs for different goods***
Description	- big, central hub for all classes of goods - separation of warehousing, transport of the different goods in the logistics center - bundled supply by goods and receiver structure	- specific hubs for each class of goods - spatial separation of the goods - bundled supply starting from the respective hub following the receiver structure	- more hubs (for all goods classes) - delivery to nearest hub (interaction) - zone division - separation of warehousing, transport of the different classes of goods - bundled zone supply by goods / receiver structure	- more specific hubs for each class of goods - delivery to nearest hub - establishment of zone responsibilities - interaction between hubs - bundled zone supply by receiver structure
Application	- small urban areas - a lot of space available in the periphery - one main hub outside the urban area	- small urban areas - spatial separation of receivers (e.g. industrial areas) - limited availability of space	- big cities and metropolitan areas - more main hubs - good connection between main hubs - delivery from all sides	- big cities and metropolitan areas - big urban areas with possible spatial separation of receivers - limited area for big combined hubs
Advantages	- coordination from one point - centralization - good overview - infrastructure investment	- specialization - transparent geographical separation - concentration on respective division	- coordination from central hubs - avoidance of long approach routes - simplified supply of big areas	- specialization - short distances - concentration on respective division - transparent spatial separation
Disadvantages	- long distances for delivery and supply - traffic volume concentration at one point - central coordination effort (dependency)	- high complexity and coordination effort - delivery divided by goods class, long distances	- high organizational effort - critical interaction between hubs, supply and delivery of goods more complex - cooperation between hubs fundamental	- very high complexity and difficult coordination of the overall concept - competition idea could eventually impact the overall concept negatively

4. Practical example of shared-resources in city logistics - Norwich

The following example is taken from a study from the Civitas Initiative [12], which is part of the European Union and shows the applicability in practice of the proposed approach. Norwich is a small town with around 130,000 inhabitants, located in the east of the United Kingdom. This best practice example shows the potential of an urban transshipment warehouse for the supply of goods. The aim of the project was to design an environment-friendly concept for urban transport by optimizing delivery with clean and energy-efficient means of transport. This should provide benefits such as less noise, emissions and noise.

The reduction of the number of deliveries and thus a smaller number of movements of the responsible means of transport in urban areas and especially in the city center of Norwich should be achieved through the bundling of orders

and the use of vehicles with low emissions. The privately operated transshipment warehouse did not require continuous investment from the public sector paying for itself.
The measures for the initial implementation were the following:

- Selection process (tendering) of an operator for the operation of the warehouse
- Location analysis with main criteria (i) space and (ii) connection to the city transport network
- Measures to show the attractiveness of the transshipment warehouse for customers

After a careful selection process, the project was carried out in cooperation with the logistics service provider "Foulger Transport". Goods suppliers to the urban area now have the option to supply the transshipment warehouse instead of their end customers in the city center and thereby saving not only time, but also a considerable effort for coordination for urban supply. The service provider tries to bundle deliveries to the city center and thus increases the efficiency of the last-mile traffic. Initially, it was difficult to convince suppliers of the concept, but this could be overcome through an experienced satisfaction with the service provided. The delivery process has been converted over time to smaller means of transport. A high increase of efficiency could be achieved being allowed to use the bus lane now for freight traffic. In an initial test phase, all environmentally friendly vehicles that supplied the city with goods were allowed to use the prioritized lane. Later this was limited to transport vehicles from the transshipment warehouse in order to provide the desired time savings and fluidity in traffic. Attractiveness of working with the suppliers' transshipment warehouse increased and the prioritized lane achieved significant time savings (average 4 minutes per 25 minutes of transport) and reduced fuel consumption as well as emissions in delivery due to smoother traffic.
The following table summarizes the achievements in the case study of Norwich.

Table 2. Summary best practice example Norwich [12]

Goals and incentives	Measures
reduction of environmental impact and efficiency of last-mile delivery	transshipment warehouse for the supply of urban goods
reduction of noise pollution	promotion and use of environmentally friendly transports
avoiding high traffic volumes	benefits of cooperation with the transshipment warehouse
optimizing urban supply	introduction of a separate lane for environmentally friendly vehicles

5. Conclusion and outlook

The global megatrend of urbanization is advancing persistently. The consequences of the strong increase of population in urban areas are manifold, and especially the steeply rising traffic volume is a major problem. First and foremost, the quality of life of urban residents suffers from these problems. The currently chaotic situation of urban supply and disposal should be regarded as an opportunity for the development of urban logistics. Various constraints and the enormous variety of influencing factors and actors make the logistic planning on the "last mile" a complex undertaking. The focus is usually not on the overall system "city". The prerequisite for the implementation of the presented structural forms is the fulfillment of sustainability in all its three dimensions. The efficiency of the shared resource approach is positively influenced by scale effects, better utilization of the means of transport and better coordination of the flow of goods. In addition to a reduction in the consumption of resources as well as transport costs, the quality of life for residents in the city should also increase. In the future, the planning of urban logistics will play a key role in urban development in order to combine goals such as economic growth, environmental protection and quality of life. We will look at the entire system, which requires close cooperation between the parties involved. The development of society, increased energy costs, stricter environmental conditions and the growing spread of innovative information and communication technology will contribute to the city's improvement in all areas.

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Biographies

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