The Impact of Redefining the Transport Network Using Micro Depots on the Economy of Postal and Logistics Companies

Author I (Stevan VELIČKOVIĆ) [a], Author II (Jelena MILUTINOVIĆ) [b], Author III (Biljana GRGUROVIĆ) [c]

[a b c] *Department School of Information and Communication Technologies, Academy of Technical and Art Applied Studies, Z. Celara 16, Belgrade11000, Serbia, stevan.velickovic@ict.edu.rs, jelena.milutiovic@ict.edu.rs, biljana.grgurovic@ict.edu.rs*

Abstract

The growth of the urban population affects the quality of life. As the population grows, so does the need for mobility. The effect of this growth is reflected in a greater number of vehicles on the city streets, greater traffic jams, increased air pollution, a large amount of noise, a lack of parking spaces, and a longer time spent on the way to and from work every day.

Also, modern life, the daily use of the Internet, the growth of electronic commerce, leads to a greater number of daily deliveries in urban areas. To achieve sustainable development and optimization of technological processes, many logistics companies are restructuring their transport and delivery networks.

Micro depots represent a logistics facility that is located near the user and which, in cooperation with micro mobile vehicles, brings numerous positive effects to logistics and postal companies as well as to the community.

The paper explains the principle of using micro depots and the impact they have on the costs of logistics and postal companies. Optimum choice of location and electric vehicles for delivery reduces the costs of both transport and delivery. The method of choosing the location of the micro depot and the assessment of the effect of cost reduction through the redefinition of the transport network, delivery vehicles and delivery routes are presented. The overall positive effects can be passed on to the end user. In addition to reducing costs, the principle of using micro depots also leads to shorter delivery times and greater satisfaction of the end user. The

effect that the use of electric cargo bikes and electric scooters in delivery has on the total costs is analyzed.

From the perspective of the local community, micro depots initiate fewer vehicles in urban areas, which means less pollution and less noise. The use of electric delivery vehicles has a positive effect on the sustainable development of urban logistics.

Keywords: urban logistics, micro depot, delivery and transport costs, sustainable development

Introduction

The main causes of human migration throughout history were the pursuit for better and safer life. With the development of technology and the beginning of the industrial era, mass migration from rural to urban areas began.

The number of cities around the world has grown rapidly in the last 100 years. In the middle of the 20th century, there were only 7 cities in the world that had over five million inhabitants. According to UN data, in 2020 there were 85 cities with over 5 million inhabitants in the world, and 494 cities had between one and five million inhabitants (Figure 1.).

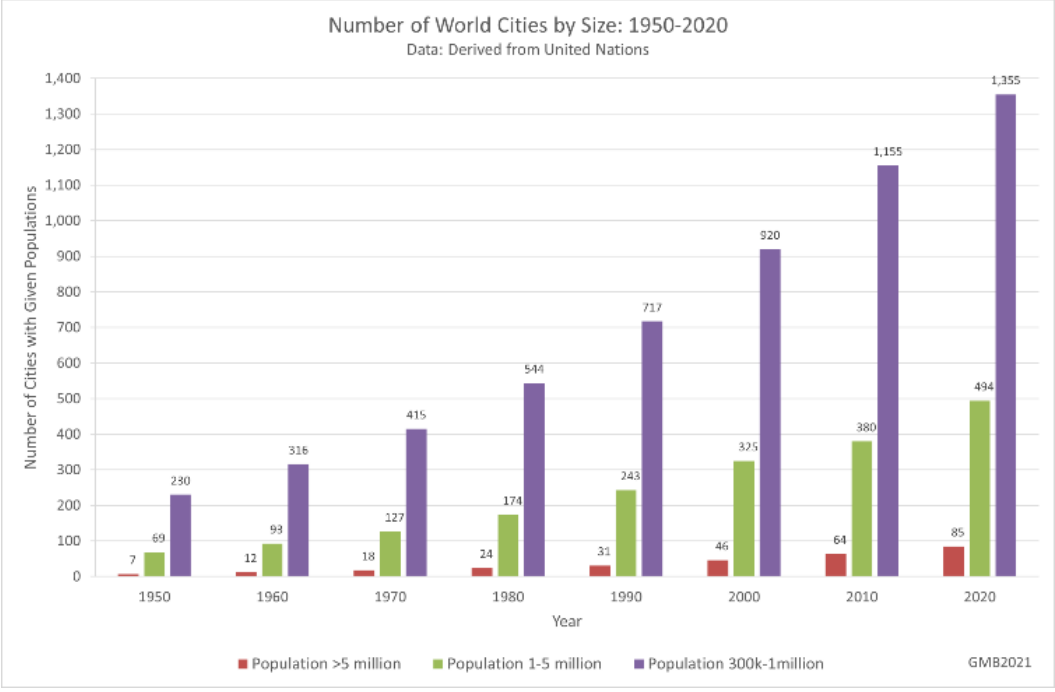


Fig. 1. Number of world cities by size
(Source: https://www.linkedin.com/pulse/brief-history-urbanization-geoffrey-batzel/)

In the middle of the last century, 30% of the world's population lived in urban areas, and already in 2007., the number of people living in rural and urban areas equalized (Figure 2.). This trend will inevitably continue. The United Nations estimates that by the year 2050., two-thirds of the world's population will live in cities, or approximately 6.5 billion people. [1]

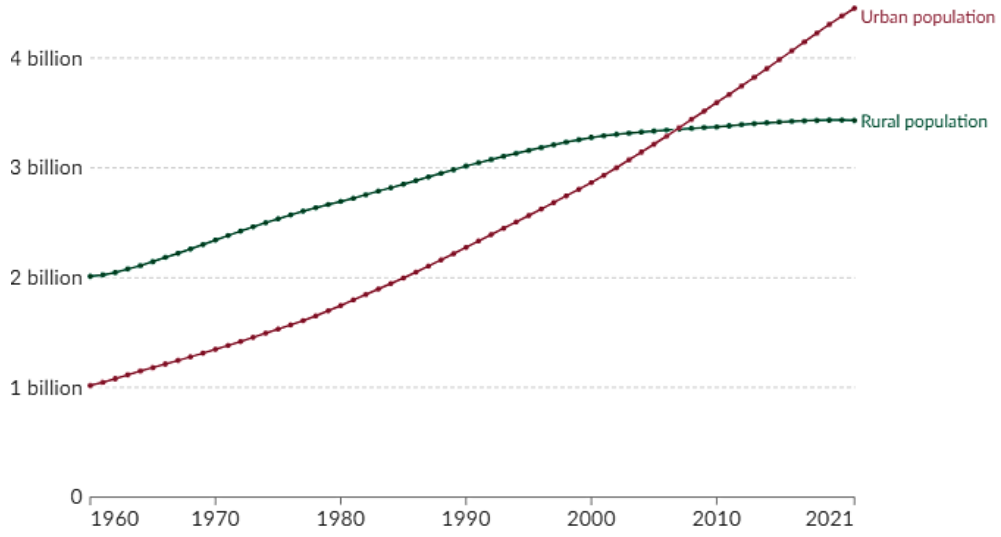


Fig. 2. Number of people living in urban and rural areas in the world
(Source: https://ourworldindata.org/urbanization#number-of-people-living-in-urban-areas, 15/09/2023)

The territorial expansion of cities led to the merging of several cities in areas that, due to their extremely large population and territory, we today call megalopolises.

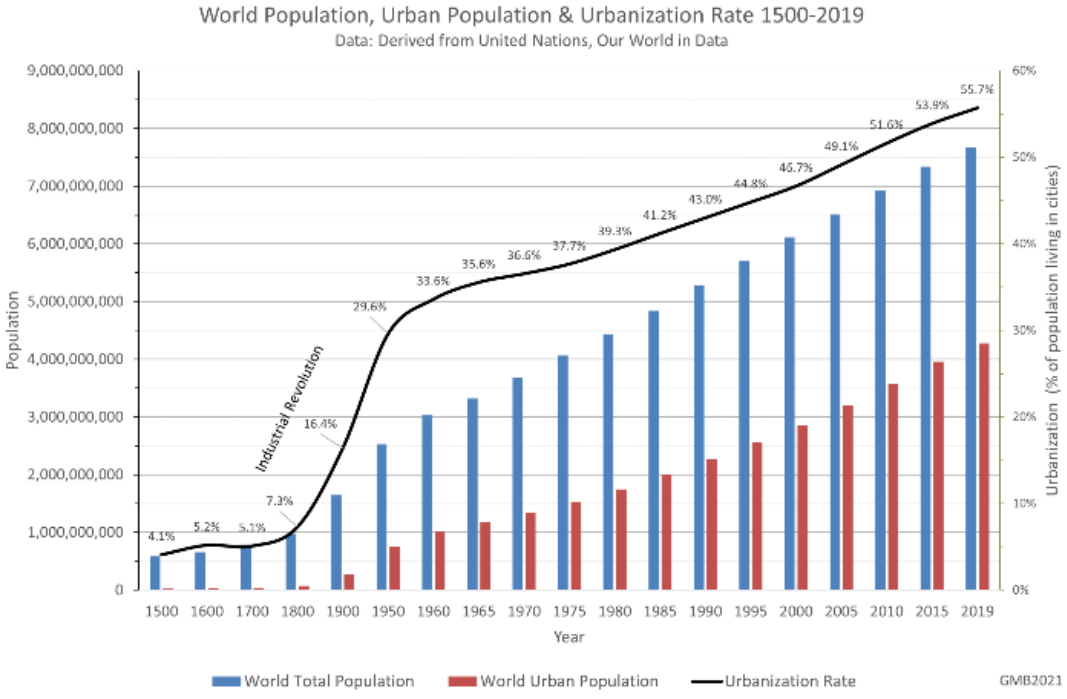


Fig. 3. World population, Urban population & Urbanization rate 1500-2019.
source (https://www.linkedin.com/pulse/brief-history-urbanization-geoffrey-batzel/)

The development of human society resulted in expansion of cities who grown both in size and in number. However, in addition to the constant progress of human society, life in cities is accompanied by numerous disadvantages. Population growth, territorial expansion of cities, diversity of human needs caused the need for greater mobility, which led to an increase in the number of vehicles in cities. The consequences are well-known: large traffic jams, large emissions of exhaust gases, increased noise levels, lack of parking spaces, longer time spent on a commuting, etc.

The emergence of the Internet has also played a major role in defining life in cities especially city logistics. As the Internet developed, so did numerous Internet services. The growth of Internet commerce has led to rapid growth of urban distribution. A large number of small mass shipments are delivered daily across cities.

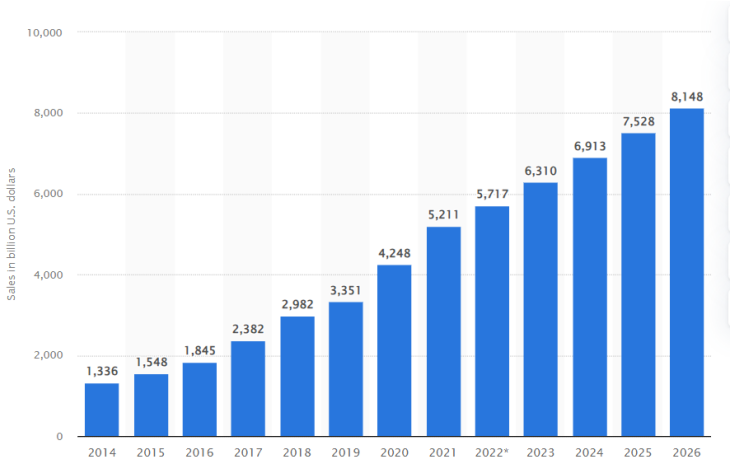


Fig. 4. Statistics of the number of e-commerce transactions in the world.
source (https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/)

As seen in Figure 4., the number of e-commerce transactions grows every year and the growth trend is expected to continue in the coming years.

Considering what has been said so far, city logistics is facing big challenges.

1. City logistics

Over time the logistics has changed and become more complex. In the beginning, logistics included processes related to transportation and storage and today logistics represents an important segment of supply chains.

In the first half of the 20th century, logistics was defined from the point of view of physical distribution. Numerous companies have found a way to differentiate their business through logistics. At the end of the 20th century, priorities in logistics changed and the focus was placed on the processes of procurement, supply, handling and management of materials and goods. With the lack of raw materials and energy, reverse logistics appeared. When we say logistics today, we mean integrated logistics that includes forward and reverse logistics.

In the business environment, logistic focuses on the needs of both users and partner companies.

Shipping companies and logistics service providers strive to generate profits with a high level of customer satisfaction through the efficient manipulation, storage and transportation of goods. The end user wants quality service at a fair price, while local authorities want safe transportation, environmental protection and consistency of urban living space.

We define city/urban logistics as the part of supply chain management that plans, implements and controls the efficient and effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customer requirements. [2]

64% of all kilometers traveled in the world today are done in urban areas, with the prediction that the number of kilometers traveled in urban areas will triple in the next 30 years. [3]

One of the biggest problems in urban areas today is the lack of space. Numerous cities around the world are faced with infrastructural problems that are reflected in reduced traffic flow in central city areas as well as a lack of parking spaces. As a result of the aforementioned restrictions, logistics facilities are being moved to the outskirts of cities. Greater distance between the service provider (the place of concentration of goods) and the end user (the place of delivery) means a longer delivery time and higher transportation costs.

The problem faced by transportation and logistics companies in cities today is how to reduce the costs of urban delivery, taking into account reliability, delivery speed and price, while fulfilling the requirements of a socially responsible company. [4]

The growth of logistics operations in cities additionally directs the public's attention to the ever-present environmental problems, problems in traffic, transport and distribution, as well as to the declining quality of life in cities. Therefore, many cities around the world are shifting towards a sustainable development strategy.

Sustainable development is the development of society that satisfies human needs with available resources, while at the same time not endangering the natural environment.

In response to overexploitation of natural resources, population growth, increased pollution, etc., the United Nations adopted a special program in 2015. with the goal of ending poverty, protecting and preserving the planet, and ensuring peace and prosperity for all people in the world by 2030. The program itself has seventeen goals aimed at sustainable development (Sustainable Development Goals -SDG). [5]

Sustainable Development Goal number 11 is important from the aspect of urban logistics and it reads: "Make cities and human settlements inclusive, safe, resilient and sustainable". Making cities sustainable means creating career and business opportunities, safe and affordable housing, and building resilient societies and economies. It involves investment in public transport, creating green public spaces, and improving urban planning and management in participatory and inclusive ways. [5]

In order to be economically competitive, socially responsible and meet the user demands, transportation and logistics companies must implement new technologies.

One of the ways that leads to sustainable development in the cities is the combination of new transportation and urban planning solutions. The combination of micro-depot as a logistics facility and micro-mobile or LEV vehicles in form of a delivery vehicles leads to more efficient logistics chain.

2. Micro depots

Observing the position of the facility in relation to the end user as well as in relation to the size of the facility, urban logistics facilities can be classified into logistics centers/warehouses (usually located in suburban areas), consolidation centers, micro depots and pick up points/parcel lockers. [6]

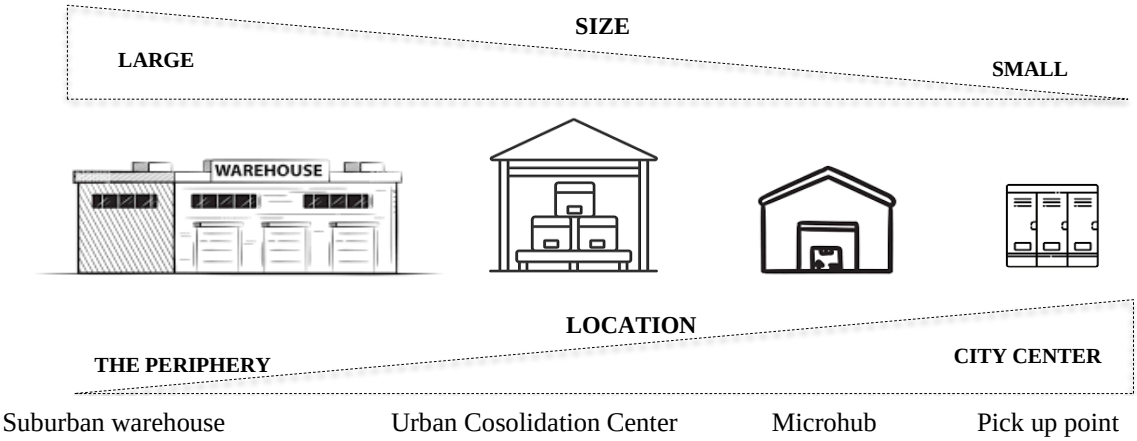


Fig. 5. Classification of logistic facilities by size and distance from city center
(Source https://www.mdpi.com/2071-1050/14/1/532)

In order to bring the location of the logistic facility closer to the users and thereby lower the transportation and delivery costs, many logistics companies are introducing micro depots into their transportation networks. [4]

A micro depot is a type of logistic facility that covers a small delivery zone, is physically located close to end users, has small dimensions and low installation and commissioning costs. A micro depot is a hub where goods are consolidated and stored just before delivery. Very often, the authors call the micro-depot a micro-consolidation center. By consolidating goods from multiple sources, the number of delivery vehicles is reduced, the vehicle utilization is increased, routes are optimized, the total cost of transportation is reduced. In this way, service providers can reduce the price of service, which has a positive impact on users.

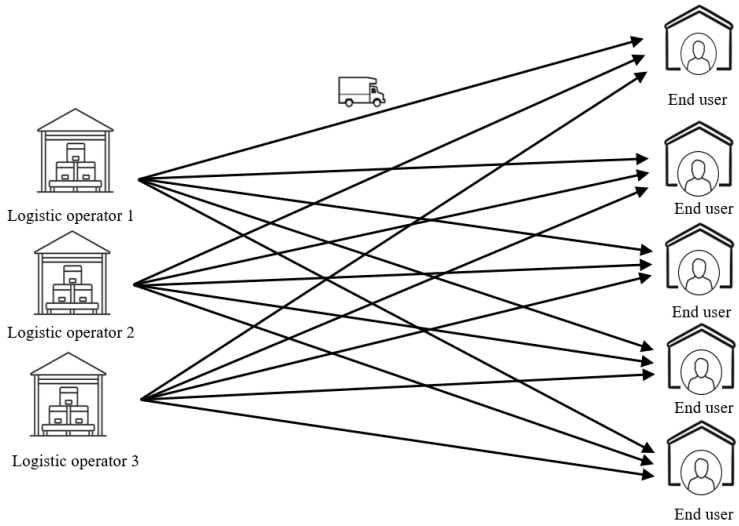


Fig. 6. Traditional model of delivery

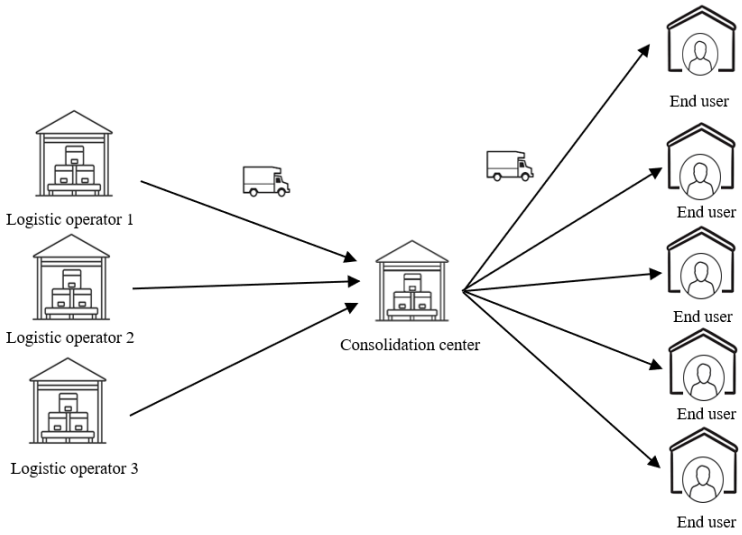


Fig. 7. Model of delivery with consolidation center

The aim of the micro-depot is to take over the role performed by large delivery vehicles in cities. The use of micro-depots will reduce emissions of exhaust gases, noise level in urban areas, delivery time and increase user satisfaction.

The application of micro depots is justified in those areas where delivery activity is difficult primarily due to limited traffic and infrastructure conditions, as well as in areas of high population density with a potential for accumulating a large number of shipments for delivery. [7]

In the classic logistics chain, goods are transported by conventional delivery vehicles from the logistics center/warehouse to the delivery point. At the same time, this way of functioning is not socially and environmentally friendly (Figure 8.).

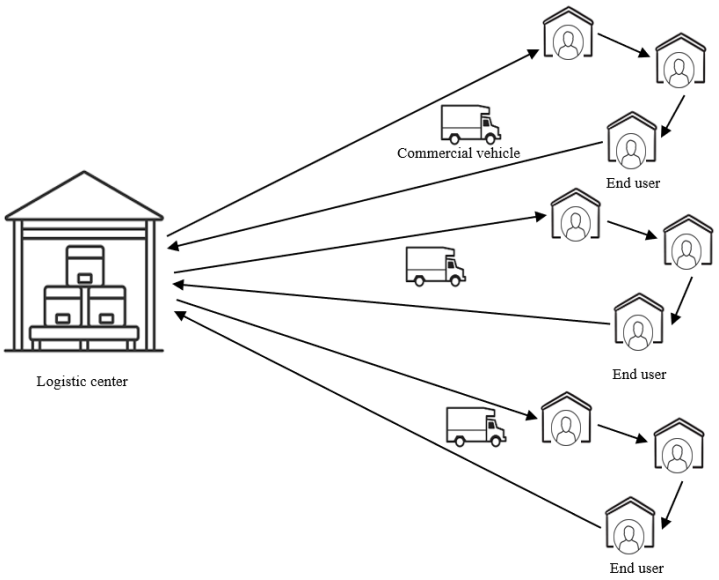


Figure 8. Organization of delivery without micro depot

In the model that uses micro depots, the goods are delivered to the micro depot, where they are sorted and prepared for delivery. The delivery itself is carried out by electric vans, cargo bikes, other micro mobile vehicles and if necessary, on foot. Since electric vehicles are used for the last mile delivery, carbon dioxide emissions and noise levels are drastically reduced. By using small-sized vehicles, the problem of parking is eliminated, and vehicles are enabled to use pedestrian and bicycle paths, which significantly increases the mobility of the delivery vehicle, the delivery time is reduced, and the user's satisfaction is increased (Figure 9.). [4]

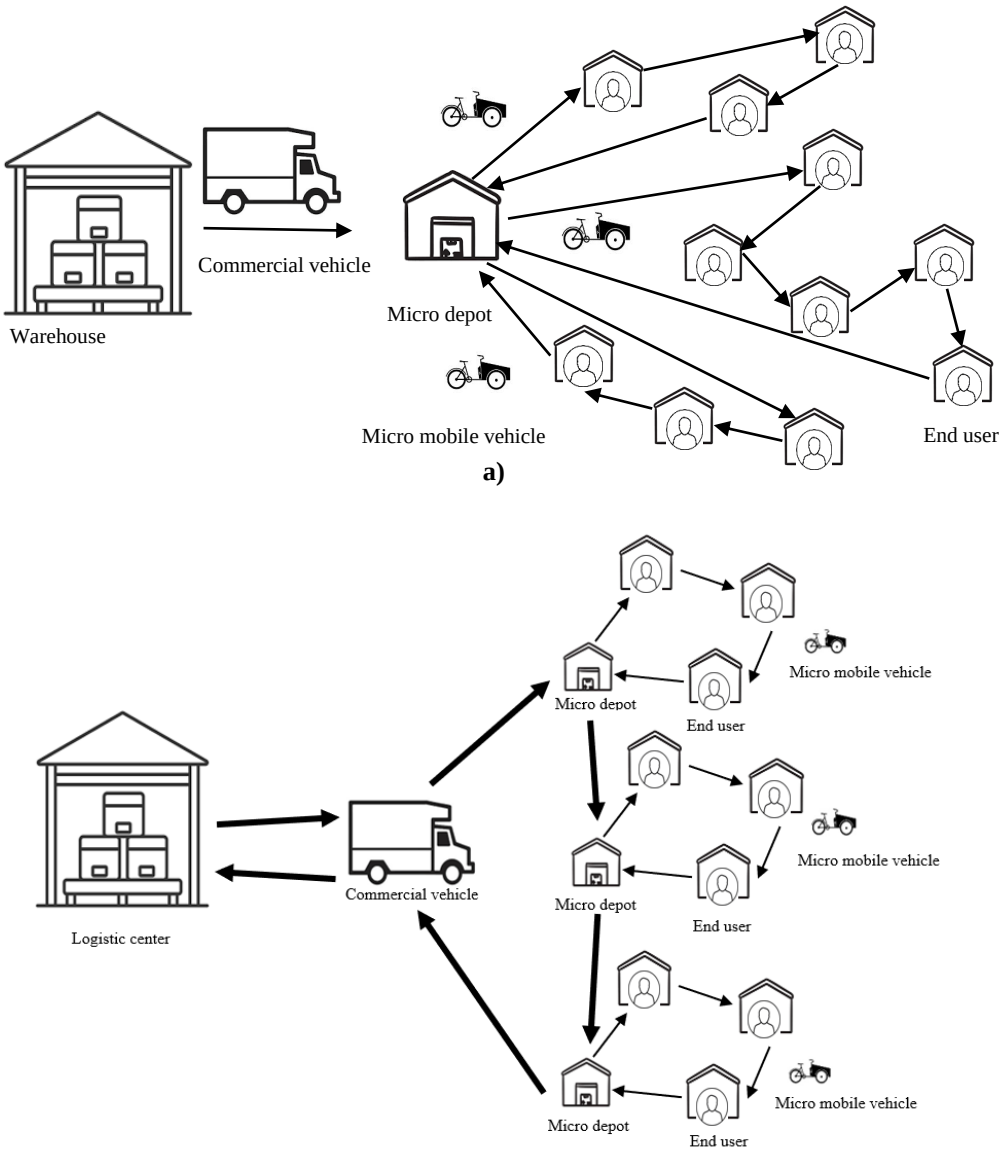


Figure 9. Organization of delivery with one micro depot (a) and with multiple micro depots (b)

Maximum cost efficiency is achieved in the optimal scenario when single route is needed to serve all users and the delivery is made using one delivery vehicle. User demand on the route is lower than vehicle capacity. The vehicle returns to the depo after the route is completed.

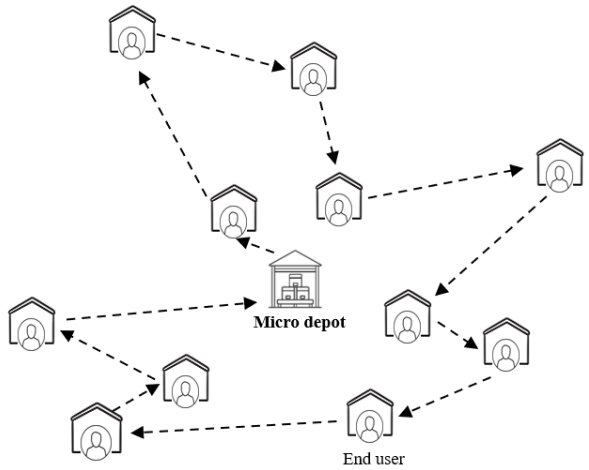


Figure 10. Optimistic scenario of delivery in a single area with micro depot

Minimum cost efficiency is achieved in the pessimistic scenario when single route is needed to serve each user. This scenario is the least acceptable because it implies the longest time spent on delivery.

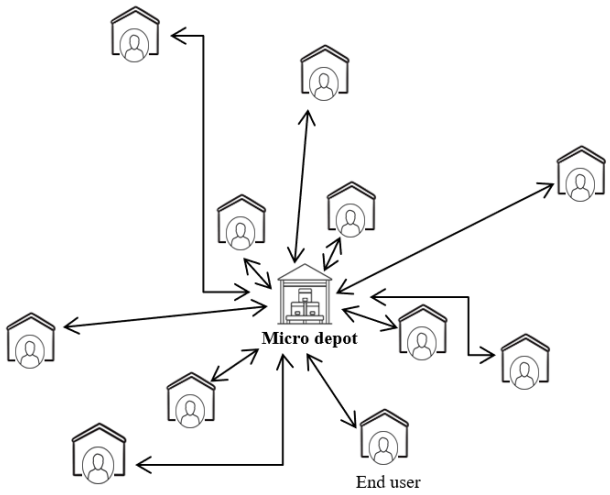


Figure 11. Pessimistic scenario of delivery in a single area with micro depot

In order to be more efficient, micro depots tend to perform technological operations independent from peak traffic hours. That is why the operations are divided into two phases.

- The first is carried out in the early morning hours when parcels are delivered to micro depots from consolidation or logistics centers located on the outskirts of the city.
- After sorting, the parcels are sent for delivery, which is mostly carried out on low-level roads, i.e., bicycle and pedestrian paths. Delivery is made within a small urban area by environmentally friendly vehicles or on foot.

Considering that light delivery vehicles are used, this organization of delivery tends to focus on more frequent deliveries of small sized shipments.

Micro depots reduce the distance traveled in the last stage of delivery, which results in a shorter delivery time. In this way, last mile logistics is cost effective, socially responsible and directed towards sustainable development.

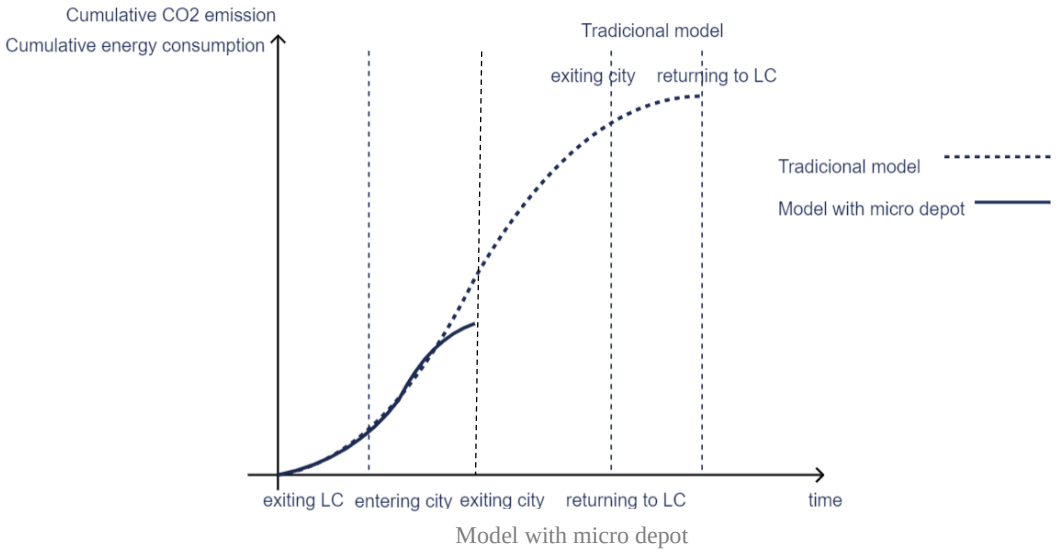


Fig. 12. Cumulative CO_2 emission/energy consumption for traditional and delivery model with micro depot

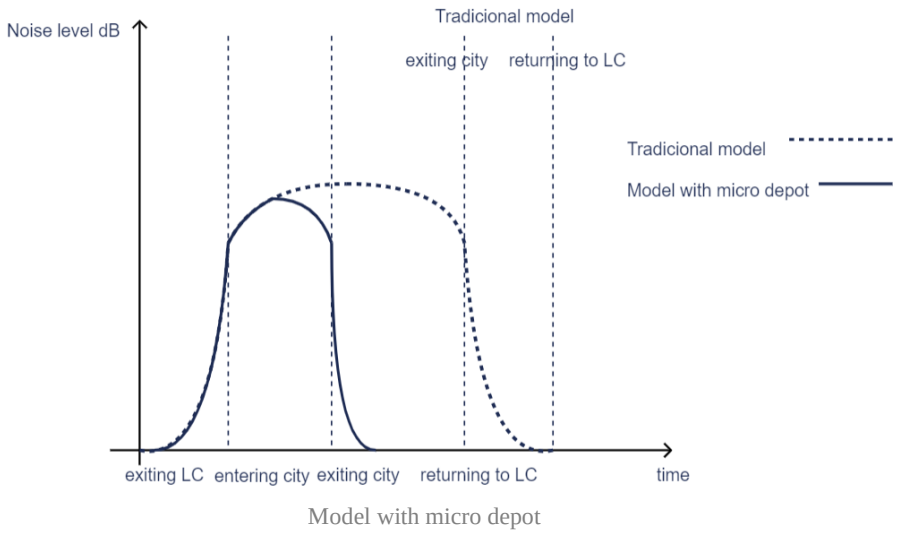


Fig. 13. Generated noise level with traditional and delivery model with micro depot

2.1 Organization of network with micro depots

Micro depots can be organized in several forms:

- A stationary facility positioned at strategic locations in urban areas:
    - permanent facility (Figure 14.);
    - temporary facility (such as containers) (Figure 15.).

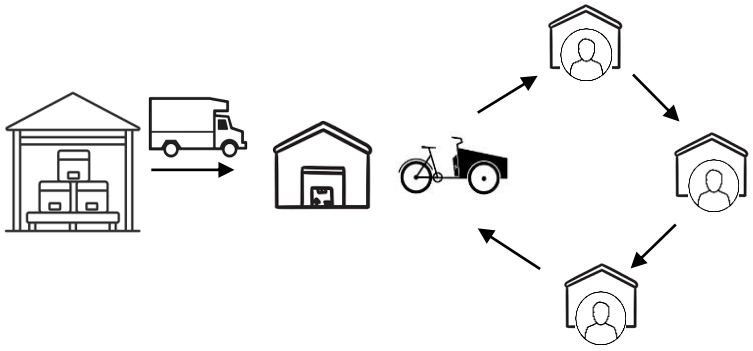


Fig. 14. Organization of delivery with fixed micro depot (permanent facility)

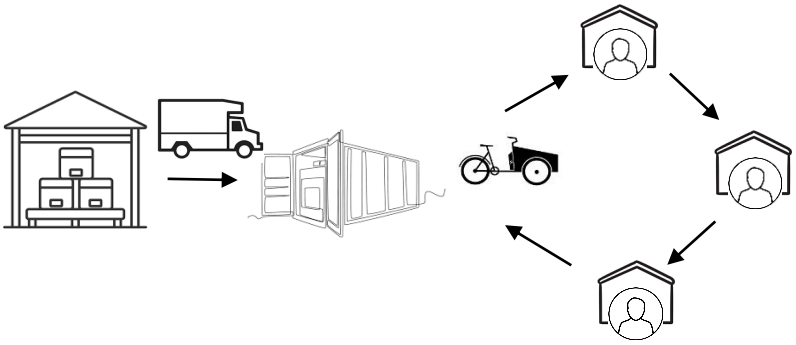


Fig. 15. Organization of delivery with temporary micro depot facility (container)

Stationary micro-depots are used in densely populated residential areas. They can have a larger capacity than mobile micro-depots and can cover a larger delivery area. In order to serve a big amount of users more efficiently, these micro-depots employ a larger number of couriers.

The following activities are available:

- The user can personally pick up the parcel at a time of his convenience;
- When the user has requested delivery to the home address, in advance via electronic application, the courier makes delivery on foot or by micro-mobile vehicle.
- The third option is to leave parcels that the user has not picked up or that have not been delivered to them in the parcel locker (which can be part of the micro-

depot or in the parcel locker of the user's choice if there are more of them in the delivery zone).

- Mobile micro depots - Cargo vehicles used to perform the role of micro depots. Mobile micro depots can change locations and thus contribute to greater ground coverage using ecofriendly delivery vehicles (Figure 16.).

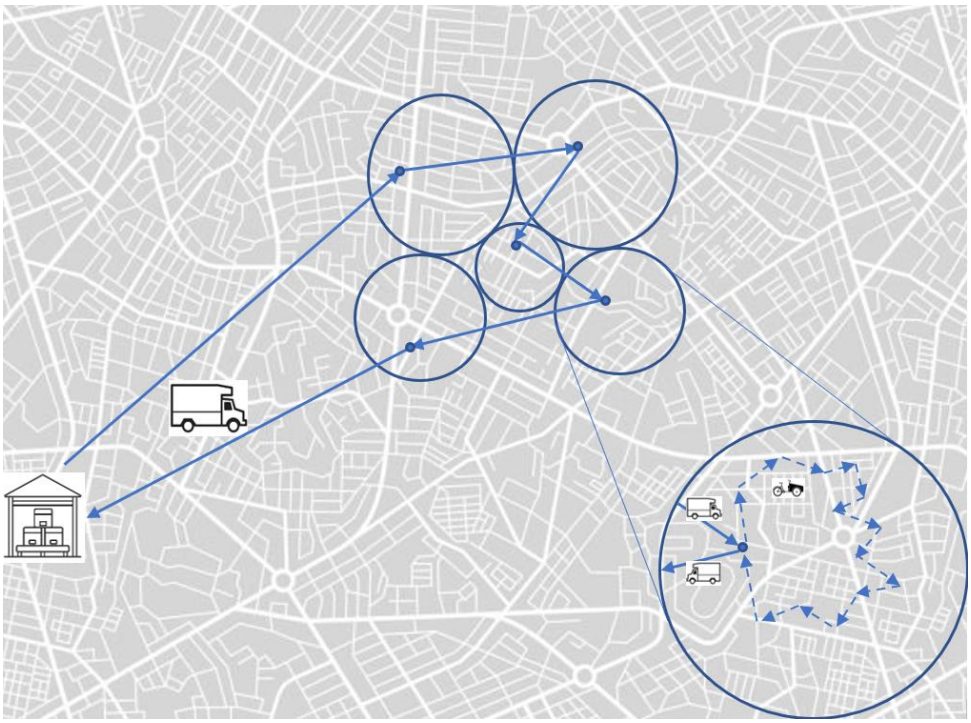


Fig.16. Organization of delivery with mobile micro depots

Mobile micro-depots are used in central city areas, where there is a lack of free space (city land). They are mostly organized in the form of modified delivery vehicles of large and medium capacity. Mobile micro-depots are designed to serve few delivery zones every day. Upon arrival at the delivery zone, the vehicle is parked, after which the delivery is made on foot or using a cargo bike. After serving one zone, the vehicle moves to the next. The number of delivery zones that would be served by one mobile micro depot directly depends on the capacity of the vehicle, the number of users to be served and the mass and dimensions of the shipments. Mobile micro depots can be placed in pre-booked parking spaces or specially defined spaces in pedestrian zones. Mobility allows them to stay in certain delivery zones for a limited period of time.

Stationary or docking time can be:

- fixed - defined in advance (there is a time schedule for each delivery zone, which is convenient for users if the micro-depot provides the service of picking shipments)
- variable - defined by the time required to service each delivery zone. Each zone has a unique time window for delivery depending on the number of users.

Mobile micro-depots can visit and serve several delivery zones during one day, thus replacing several stationary micro-depots. The total costs of operating a mobile micro-depots are lower, since there are no fixed costs for setting up and operating the facility itself. Also, the degree of utilization is higher because the idle time is reduced. A great cost advantage of mobile micro-depots is achieved by the fact that the consolidation of shipments and their preparation for delivery is carried out earlier in the logistics center. After the vehicle leaves the logistics center, only time-consuming activities are transport and delivery.

A mobile micro-depot has a predefined route to follow. The goal is to visit all delivery zones by following the shortest path. Upon arrival in each zone, the following activities are available:

- The user is informed through the mobile application that the micro-depot is present in his delivery zone and that he can personally pick up the shipment;
- In the case when the user has requested delivery to the home address in advance via the mobile application, the courier delivers the parcel on foot or by micro-mobile vehicle.
- The third option is to leave the shipment, which was not picked up by the user or was not delivered to him, in a parcel locker.

- Cooperation between parcel lockers and fixed facilities outside the logistic system that act as partners in the delivery process (various forms of retail stores) (Figure 17.).

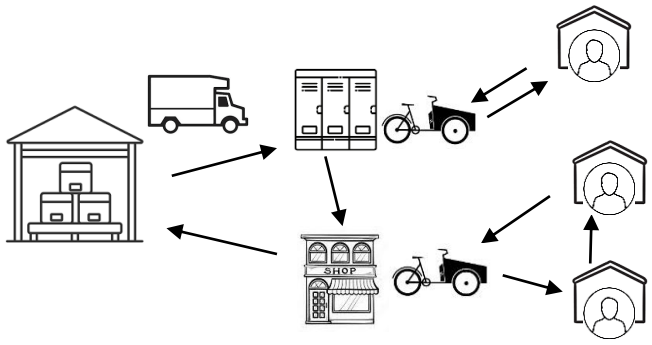


Fig. 17. Organization of delivery based on cooperation between parcel lockers and fixed facilities outside the logistic system

2.2 Micro depots and sustainable strategy

Micro depots support the sustainable development strategy in several ways.

- The use of vehicles with internal combustion is minimized since they are only used to deliver parcels from logistics centers to micro depots, and lately that role has also been entrusted to electric cargo vehicles.
- Due to the proximity of the end users, delivery is carried out using micro mobile vehicles, which does not pollute the environment, does not create noise and does not disturb the peace of residential areas.
- Micro depots support sustainable development and can achieve the fully planned effect if in cooperation with micro mobile and environmentally friendly vehicles.

Another important feature of micro depots is that they are intended for use in specific urban areas, such as dense residential areas, dense business zones, urban areas with insufficient parking space that meet the demand for dedicated delivery etc.

Micro depots can be located in buildings that are abandoned or underutilized. By revitalizing abandoned buildings or repurposing underutilized spaces, newly formed distribution centers are brought closer to end users and thereby reduce operating and transportation costs. [4]

2.3 Micro depots and shared mobility

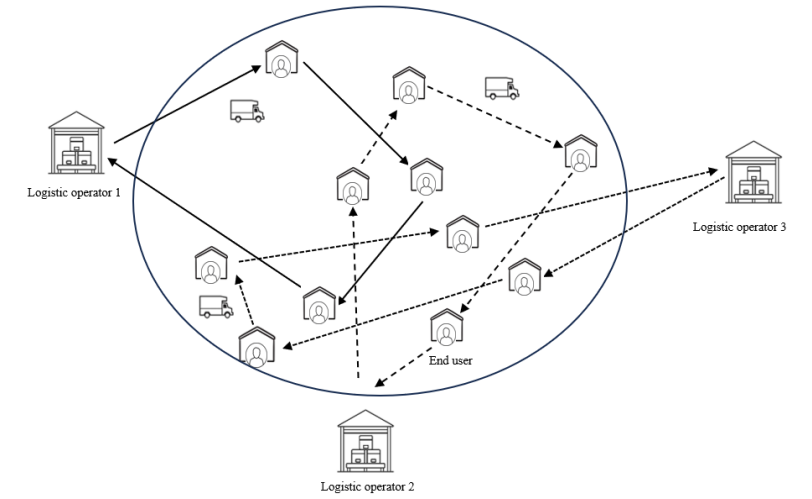
Looking at the business model, micro depots can be independent, shared or consolidated. A particularly convenient form of using micro depots and micro mobile vehicles is the shared

mobility system. This system is based on the sharing economy where the emphasis is on access rather than ownership.

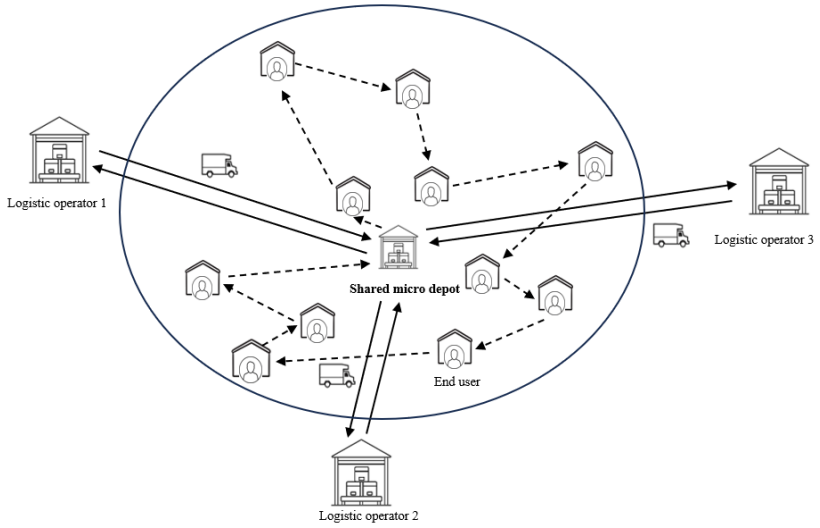
The sharing economy represents a new paradigm that changes the existing consumer society into a more transparent, inclusive and responsible system. The concept of the sharing economy based on access to goods/services versus ownership can be applied as a new business model of both logistic operators through various forms of infrastructure sharing, but also by organizing partnerships in shared delivery – crowd shipping delivery. [8].

The concept of crowd shipping can be implemented by including local residents or small businesses in the delivery. Their activity in the delivery process can be full time or part time (as needed).

The concept of shared economy is applicable in cases where there are several logistics operators in the city. Delivery costs are individually largest costs in logistic chain, so in order to be more efficient these costs should be divided or transferred to a third-party logistics. Shared micro depots would represent a solution that brings multiple benefits to both users and logistics companies. Instead of each logistics operator being a generator of traffic, noise and pollution, common/shared micro depots would take on the role of consolidating shipments and delivery of all logistics operators present.



a)



b)

Fig. 18. Traditional organization of delivery (a) and organization of delivery using shared micro depots – shared economy concept (b)

Adopting the shared economy concept, the number of transport vehicles is smaller, as is the distance traveled and the number of routes, thus the generated costs are lower.

The process of delivery can be entrusted to one of the operators or to a third party. The contract would regulate the rights and obligations of the parties involved, as well as monetary compensation for the delivery services.

2.4 Micro mobile vehicles

With the introduction of a micro logistics facility, the transportation network is reorganized. There is a change in the technology of shipment processing through the consolidation of a smaller volume of shipments in zones that are close to the end users. In order to achieve the desired goal,

which is to reduce delivery costs while maintaining the quality of service and simultaneously improving the quality of life in residential areas, micro depots must be used in combination with light electric delivery vehicles – micro mobile vehicles. Micro mobile vehicles are the result of the need for greater mobility and flexibility in cities.

Micro mobility refers to a group of small, light vehicles whose operating speed is below 25 km/h and which are driven by the users themselves. This group of vehicles includes bicycles, e-bikes, electric scooters, electric skateboards, fleet of shared bikes as well as bikes with auxiliary electric drive. [9]

Micro mobility vehicles can be powered by human power as well as by an electric motor.

Micro depots are located in areas that are geographically small and have a large number of users. In these delivery areas, the movement of commercial delivery vehicles is difficult (narrow streets in the city center), undesirable (densely populated residential areas) or strictly prohibited (pedestrian zones). Due to delivery efficiency and quality of life, it is preferable to use micro mobile delivery vehicles instead of light commercial vehicles. Because of their small dimensions, these vehicles are extremely flexible, resistant to traffic jams and do not affect traffic in the way that conventional vehicles do.

The micro mobile vehicles are cost-effective considering that most of these vehicles are powered by electric motors or are combination of electric and manual drive. This also makes them extremely environmentally friendly due to the fact that they do not produce exhaust gases and that the level of noise they generate when moving is extremely low. All this makes them ideal for moving in areas and on the roads that are not designed for motor vehicles. The fact that they require less parking space means less time spent looking for a parking, fewer illegally parked vehicles, fewer blocked vehicles, shorter delivery time which all contributes to the reduction of delivery costs and the improvement of the user's experience.

3. Facility location

A key decision when planning the logistic operation using micro depot is determining its location. The facility location can be more or less influenced by numerous factors that can be classified into logistic, socio-economic and urban-traffic factors. Also, when choosing the location of the micro depot, the aesthetics of the living space, its functionality, should be

preserved. The noise level should be acceptable for the residential area where the micro depot is located**.** [4]

Areas that micro depots cover must meet certain conditions in order for their application to have maximum effects in terms of cost and time efficiency. It is necessary to justify the use of micro depots, considering that they lead to change in the organization of urban distribution and also in order to enable efficiency and sustainability.

In order to define the locations of a micro depots, the combination of multi-criteria decision-making models and user data collected over time (user locations and frequency of service use) must be applied.

The authors propose the following approach to determine the location of a micro depot.

1. Defining delivery zones: In order to determine the location of a stationary micro depot, it is necessary to begin with the basic assumptions, which are: The area served by the micro depot should have a large number of users on a relatively small area and this area should be characterized by difficult/ undesirable/ prohibited traffic performed by classic commercial delivery vehicles. Micro depots can achieve the best effect in densely populated residential areas, student campuses, large business complexes, narrower central city zones with poor traffic accessibility and a lack of parking spaces, etc.

   The size of the delivery area should be limited by certain criteria such as: delivery time to the most distant user, the number of users as well as the number of potential deliveries.

   Bearing in mind that the courier makes the delivery either using a micro mobile vehicle (whose speed is limited to 25 km/h) or on foot (average speed of 6 km/h), as well as that the time spent traveling to and from the user should be minimized, it is recommended that this zone be no larger than 1km in radius (or that the total delivery time – travel time to and from the most distant user plus the time to complete the delivery should not be longer than 10 minutes). For practical reasons, the boundaries of delivery zones can be roads with high traffic intensity, rivers, railways and other infrastructural or geographical obstacles.

   These areas are best determined using a geographic information system. The areas with a large concentration of users who receive parcels to their home address can be clearly seen, as the areas with high parcel locker activities.

2. After the delivery areas are defined, first the ideal location of micro depot is calculated using one of the following methods (for each delivery area):

- Center of gravity method; Using this method, the location of the micro depot is determined in such a way as to minimize the total transportation cost between all users and the logistic facility.

$$x = \frac{\sum_{i=1}^{n} x_i w_i}{\sum_{i=1}^{n} w_i};\ y = \frac{\sum_{i=1}^{n} y_i w_i}{\sum_{i=1}^{n} w_i};$$

  - where x is the x coordinate for the new facility;
  - y is the y coordinate for the new facility;
  - x_i is the x coordinate of destination (user) i;
  - y_i is the y coordinate of destination (user) i;
  - w_i quantity (number of parcels) to be transported to destination i.
- The median; In the case of the median problem, it is necessary to locate one or more facilities on the network, so as to minimize the average distance (average travel time, average transport costs) from the facility to the user or from the user to the facility.

  - $G = (N, A)$ - transport network
  - N - set of network nodes
  - a_i - demand in node i
  - d_{ij} – min distance between node i and node j
  - p - total number of objects to be located

  Also, objects can be located in any network node.

  In case of one median problem criterion function is:

$$\min F = j = 1 n a j \cdot d ij$$

  For p median problem a criterion function is:

$$min F = i = 1 n j = 1 n a i d ij x ij$$

  The defined criterion function reflects the tendency to minimize the total distance traveled between objects and users. [10]

- Determining transportation network centers

When locating centers we strive to minimize the distance (travel time) to the farthest user. Shortest paths between all pairs of nodes must be calculated before applying a suitable algorithm for determining the center of a given transportation network. [10]

Secondly, for each defined area, it is necessary to define an alternative location that meet the following conditions (traffic and transport connectivity, sufficient free space for installation, proximity to points of concentration of users (supermarkets, bus stations, shops and fig.).

3. AHP model like is used. The model helps decision makers to find the decision that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions. [11]

Calculated location and all alternatives go through three evaluation cycles.

The first cycle in which the logistics company/companies evaluate the traffic accessibility of the location, fixed and variable construction costs, the size of the potential facility (which should serve for consolidation + storage + pick up and drop off), the range of services, the potential cost savings of shipment delivery, the potential of reverse logistics, the safety of couriers and pedestrians, the efficiency of micro mobile vehicles in relation to commercial vehicles.

The second cycle in which the users evaluate the aesthetics of the building, the range of logistics services, the range of additional services, damage to the city's aesthetics, safety, noise level, emissions of harmful gases, the quality and price of the service, the impact on the increase or decrease in the price of real estate for housing, etc.

The third cycle in which the city authorities and postal regulatory agency evaluate the benefit for the community, the effect of pollution reduction, noise reduction, the cost of construction, possible benefits, further infrastructure upgrades, the effect on parking spaces, the possibility of realizing the project, other restraints.

In each cycle, the location evaluation process is carried out as follows First, each attribute is assigned a weighted factor w_i (between 0 and 1). Each attribute can have more or less

influence on the final grade, which is achieved by a weighting factor whose sum must equals 1.

For each location, attributes are then rated between 1 and 10 (10 being the highest score). By multiplying each score with a weighted factor and adding them together, the total weighted score for each location in each cycle is obtained.

Logistic companies' evaluation of alternative locations for micro depot	**Location *i***		
Attributes	Score	w	Weighted score
Traffic accessibility of the location			
Fixed and variable construction costs			
The size of the potential facility			
The range of services			
The potential cost savings of shipment delivery			
The potential of reverse logistics			
The safety of couriers and pedestrians			
The efficiency of micro mobile vehicles in relation to commercial vehicles			
		Total weighted score	

Table 1. Logistic companies' evaluation of alternative locations for micro depot

Residents' evaluation of alternative locations for micro depot	**Location *i***		
Attributes	Score	w	Weighted score
The aesthetics of the building			
The range of logistics services			
The range of additional services			
Damage to the city's aesthetics			
Safety			
Noise level			
Emissions of harmful gases			
The quality and price of the service			
The impact on the increase or decrease in the price of real estate for housing			
Etc.			
		Total weighted score	

Table 2. Residents' evaluation of alternative locations for micro depot

City authorities' and postal regulatory agency evaluation of alternatives for micro depot	**Location *i***		
Attributes	Score	w	Weighted score
the benefit for the community			
the effect of pollution reduction			
noise reduction			
the cost of construction			
possible benefits			
further infrastructure upgrades			
the effect on parking spaces			
the possibility of realizing the project			
other restraints			
		Total weighted score	

Table 3. City authorities' and postal regulatory agency evaluation of alternatives for micro depot

In the third step, total weighted scores from each cycle are combined and an ultimate weighted score is generated.

	Location *i* score	**Weighted factor for decision maker**	**Weighted score**
Logistic companies' weighted score			
Residents' weighted score			
City authorities' and postal regulatory agency weighted score			
Ultimate weighted score for location *i*			

As in the previous step, all three participants can have an equal role in decision-making, or someone's opinion can be valued more. The obtained location of the micro depot should be the best of the offered alternatives (location with highest ultimate score) that is, it should best reflect the satisfaction of the needs of the participants in the logistics chain.

In addition to determining the location of the micro depot, the location of shared parcel lockers can also be determined in a similar way based on data on the percentage of users who receive parcels at home and those who pick up parcels at parcel lockers.

Conclusion

Modern life in cities imposes numerous challenges. Traffic jams, air pollution, insufficient parking spaces, long commutes are just some of them. The increase in the number of transactions related to internet commerce causes an increase in the number of deliveries in cities. In order to increase the efficiency of operations, reduce costs of transport, storage and delivery and at the same time preserve the residential environment and increase the quality of service, numerous postal and logistics companies are turning to the strategy of sustainable development. One of the

ways to achieve sustainable development is the transformation of infrastructure and the introduction of new transport solutions. The introduction of micro depots enables the consolidation of shipments, which reduces transportation costs, optimizes routes, increases the utilization of transport vehicles and increases user satisfaction.

The best effects of using micro depots are achieved in cooperation with micro mobile delivery vehicles which are eco friendly and contribute to the efficiency of delivery.

It should be kept in mind that the full effects of the application of new technologies in logistics are achieved only if the needs and restrictions imposed by all participants in city life are met.

Literature

[1] (https://population.un.org/wup/publications/Files/WUP2018-Report.pdf, 01.09.2023).
[2] Rose, W. J., Bell, J. E., Autry, C. W., & Cherry, C. R. (2017). Urban logistics: Establishing key concepts and building a conceptual framework for future research. *Transportation Journal*. 56(4), 357-394.
[3] https://www.adlittle.com/sites/default/files/viewpoints/adl_the_future_of_urban_mobility_report.pdf, (10.09.2023).
[4] Veličković, S., Milutinović J., Grgurović, B., Micro Depots and Micro Mobility in the Function of Sustainable Development, *International Academic Conferences on Transport, Logistics, Tourism and Sport Science* (IAC-TLTS), , 2023, Vienna.
[5] (https://sdgs.un.org/2030agenda, 01/09/2023).
[6] https://blog.locus.sh/microhubs-for-sustainable-urban-freight-logistics/, (10.09.2023).
[7] Veličković, S., Grgurović, B., Milutinović, J. & Radosavljević, S. Impact of micro depots on the efficiency of urban distibution, *International Symposiumon New Horizons 2023 on Transport and Communications*, Doboj.
[8] Dumnić, S., Ninović, M., & Dupljanin, Đ. (2021). Logistička saradnja u ekonomiji deljenja. XXXIX *Simpozijum o novim tehnologijama u poštanskom i telekomunikacionom saobraćaju– PosTel* 2021, Beograd.
[9] Institute for Transportation and Development Policy, The Electric Assist: Leveraging E-bikes and E-scooters for More Livable Cities. 2019.
[10] Teodorović. D., Transportne mreže, Saobraćajni fakultet, Beograd 2016.
[11] https://en.wikipedia.org/wiki/Analytic_hierarchy_process#cite_note-FormanGass-1)