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Smart City Logistics: Recommendations for the City of Prague

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***Abstract*—This review paper gives a brief introduction to Smart City Logistics and uses different sources to ultimately present recommendations for Prague city to achieve better solutions in the area. With large numbers of people expected to move to cities in the coming thirty years, smart logistics will become even more important than it is today. Four different projects from three different cities in Europe are described, ITSLOG and SAILOR projects from Amsterdam, SmartPort from Hamburg and the Dachser project from Stuttgart. The benefits and learnings from these projects are presented with an additional SWOT-analysis which presents the opportunities and threats that could come with similar implementations in Prague. Recommendations based on the findings regarding smart loading zones, micro-hubs, and virtual depots and how they could be implemented in Prague are made. It turns out that their implementation could give several benefits for Prague and help the city become more smart, both in terms of logistics, but also in other ways.**

***Keywords*—loading zones, smart city, smart logistics, virtual depot, micro-hub**

I. Introduction

According to the United Nations Department of Economic and Social Affairs approximately 68 % of the world population will be living in cities within the next thirty years. To manage the rapidly-expanding urban population, cities need to act quickly to anticipate and overcome considerable challenges in many areas just like health and safety, waste management and transportation. To accommodate the ever-growing needs of citizens, many cities have transformed to the concept of a “Smart City” as the ultimate solution to this immense question [1]. A smart city can be defined as a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business. Besides dimensions such as upgraded water supply or waste management, one of the main fields that must be considered in the transformation into a smart city is the development of smarter urban transportation networks [2]. Especially in the rapidly growing era of e-commerce the demand for faster, more efficient and sustainable deliveries in urban areas is growing, which challenges the field of transport and logistics to develop new smart urban technologies and networks [3].

The key objective tackled in this paper can be classified as the identification of smart city logistics schemes and to point out opportunities, threats, strengths and weaknesses of certain smart city logistics applications for the city of Prague and how to implement them.

II. Foundations of Smart Logistics

The fourth industrial revolution is delivering and will continue to deliver new solutions in all of the fields of the lives of societies. In addition to these considerations, the growing importance of the urbanisation of societies, will be a major challenge to provide sufficient solutions. Various devices and tools in the field of Logistics can be implemented to contribute to the successful transformation into a Smart City. The literature provides different approaches to characterize the possible applications of Smart Logistics in Smart Cities. Some of the most important are:

- *Distribution and logistics models:* Such as off-peak deliveries, urban consolidation centers or collaboration schemes and joint operations.
- *Capacity sharing*: Infrastructure and equipment can be distributed amongst multiple service providers, stakeholders and transportation modes, like multi-use lanes concepts.
- *Advanced information technologies:* Intelligent transport systems or the use of information and communication technology and further proactive technology platforms.
- *Route Optimization:* Concerning infrastructure and road marking or improved signing for route optimization.
- *Training:* Activities like the tutoring and promotion of safe and eco driving.

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- *Regulations:* Activities to enable certain measures that determine logistics processes for certain types of vehicles at certain times per day, such as loading/unloading, time windows, parking regulations and further soft measures.
- *Future Technology:* Such as drones and robotics [4].

III. Examples of Smart Logistics Projects

This chapter will describe the projects of smart city logistics which are researched and used for development of the recommendations.

A. The ITSLOG and SAILOR projects

The ITSLOG and SAILOR projects were two pilot projects conducted in Amsterdam, Netherlands, during 2016-2018 with a goal to increase traffic flow and decrease emissions. ITSLOG focused on the effects of using real-time traffic information to do re-routing of delivery vehicles and therefore increase effectiveness. The main features of the project were to use data from actual position of trucks and connecting it to the loading- and unloading zones occupation status and ongoing traffic jams to give the drivers live updates on possible new locations and ETAs. Ultimately this would lead to less time for trucks stuck in traffic and unnecessary waiting times at occupied loading zones. This benefits both the delivering companies in terms of less fuel costs and faster deliveries and the city traffic flow in general thanks to better distribution of traffic.

Although there is a lot of potential in the field of using these types of data for more efficient deliveries in city centers, there are several challenges faced. For example, during the project it turned out that there were missing policies regarding shared data needed for optimal usage of these kinds of projects. There were also problems connecting data between different stakeholders, which is essential for effective re-routing. Finally, the human factor is concluded to be the most important factor in determining the effectiveness of the implemented system.

The SAILOR project had similar methods of trying to streamline last mile transportation within the city but with more focus on the digital information and the types of vehicles that use the load zones.
The main part of the project was that with signs, with built-in digital information display, it would be possible to reserve load zones and at the same time, with the help of bluetooth beacons, be able to read if these have been occupied by faulty vehicles. It would also be possible to give green vehicles, i.e. electric vans, priority in the reservation systems. The digital sign would give warnings information to any cars passing by not allowed to use the loading zone.

Although having a very ambitious approach, the SAILOR project encountered many problems which led to only one digital sign being used during the pilot. The main issue was that the sign provider went bankrupt, but there were also problems with the bluetooth signal not being able to penetrate some van windows. This made it difficult to measure the effects of the main KPIs such as CO2 and cost per delivery. However, the results measurable from the pilot were all positive in terms of vehicle monitoring, robustness in bad weather conditions and connectivity uptime. To be able to fully measure the effects of this type of digital architecture, more data would be needed [5].

B. SmartPort - Hamburg

In the Port of Hamburg, Hamburg Port Authority provides state-of-the-art digital intelligence that makes operation in the port smoother and more efficient. The control systems provide an enormous increase in efficiency. This is not only good for business, but also for the environment. With the SmartPort-philosophy, the Hamburg Port Authority promotes sustainable economic growth and the best possible benefit for its customers and the citizens of Hamburg, while minimizing the impact on the environment. SmartPort is also continuously developed and adjusted [6].

The port operates on the basis of 10 systems:

- Navigation in real time: Everyone in the port is provided with a personalised navigation system and receives information about the real time traffic situation.
- Green power from land: Ships in the port are provided with green power from the land.
- The intelligent switch: Sensors can be used to see which points are visited most often. Based on this, degradation can be quickly detected and treated.
- The mobile universal sensor: A mobile GPS sensor is being developed. The sensor can be used for intelligent fleet management, measuring temperature, wind speed and direction, air pollution, etc.
- Smart maintenance: When checking roads, bridges and rails, measurements are automatically sent to an IT system. Data is processed and stored there. This makes maintenance processes more efficient and effective.
- Virtual depot: This system ensures that trucks do not have to return empty. Suppliers can see empty containers in a Cloud-based system and fill them.
- Port monitor: The Port Monitor Control Centre Software keeps all players in the port up to date. This creates electronic maps that are accessible to everyone.
- E-Mobility in the port: There is an increase of charging infrastructure and electric vehicles.
- Parking for professionals: The SmartPort-logistics app ensures integrated parking management and optimal use of existing and new truck parking spaces in the port.
- Renewable energy: In and around the port, they are testing wind, solar and bio-energy. [6]

C. Emission Free Delivery Concept Stuttgart/Prague

The Dachser emission free delivery in Stuttgart aims to provide emission-free deliveries to Stuttgart's city center. An area of 5 km^2 is supplied entirely by electrically powered vehicles. A network was set up consisting of two electric trucks and electric cargo bikes with a capacity of 250 kg. The delivery to the customers in the area is therefore completely electric. Thus, an innovative emission-free delivery system was developed for Stuttgart's city center. To complete the smart green network, a micro-hub is used which is delivered with parcels by an electric truck. The entire retail sector in the area benefits from more flexible delivery and collection times.

In the micro-hub, general cargo pallets and parcels are distributed and loaded onto the cargo bikes. Every day, up to 85 shipments with a total weight of up to 20 tons are distributed in the area. The complete use of electric vehicles has reduced noise pollution to 69 decibels. The system reduces CO2 emissions from the delivery of goods to or from Stuttgart by 23.35%. The significant reduction in greenhouse gases, air pollutants, and noise all contribute to a better quality of life [7].

Due to its great success, the company has decided to expand the concept to other major European cities, including Prague. In 2020, a pilot project was launched to supply Prague's city center with an electric cargo bike. A micro-hub at the Florenc metro stop was used as a consolidation and pick up point for all consignments. In the pilot phase of the project the plan is to supply the pedestrian zones in the Prague 1 district. Every day trucks brought the parcels from Kladno "main warehouse", which is around 30 km away from Prague, to the micro-hub near the city center. The deliveries were then delivered by the electric cargo bike.

In later stages the concept was expected to extend to the city districts of Prague 4, Prague 5 and Prague 7 - supported by electric trucks for heavier shipments. The main focus for the deliveries were recipients like fashion stores, pharmacies as well as DIY stores. The company announced as part of their corporate strategy, that they will replace small conventional delivery vehicles in a sustainable way by that, and also relieve traffic in Prague and improve the smog problem. The pilot project will be continuously evaluated in cooperation with TSK Prague (Technical Road Administration) and the Prague Institute for Planning and Development. During the elaboration of this report the company has not published any more results after the first practical operation besides the fact that the whole concept will be extended also in Prague.

Dachser Emission-Free Delivery is part of the logistics provider's long-term climate protection strategy. By the end of 2022, Dachser plans to extend the concept and deliver to the inner cities of at least eleven European metropolitan regions with zero emissions [8].

IV. SWOT Analysis

This chapter will identify potential strengths and weaknesses, possible opportunities and potential threats for Prague City based on our findings from chapter III. The aim is to take advantage of certain business opportunities that already show success in other cities and adapt the strength while counteracting threats.

Strengths

- Better urban freight transportation management
- Synchronisation of transport operators in loading and unloading areas
- Less empty miles driven
- Improved services
- Noise reduction
- Increased flexibility
- Better service reliability
- Congestion reduction

Weaknesses

- Requires rapid infrastructure switch
- Not much smart logistics in the city now
- No official support from municipalities
- Lack of knowledge in area of city logistics

Opportunities

- Real time navigation for delivery vans
- E-mobility, virtual depot, parking for professionals
- Consolidation of flows to enable intermodal transport
- Better organisation for shopkeepers and transporters
- Improved exploitation of loading/unloading places
- Improved network
- Familiarity with new technologies

Threats

- Limited level of carriers organisation
- Technical problems
- Non-acceptance of the system by users
- High acquisition costs
- Historical center which could hinder some implementations

V. Recommendations

This chapter will give recommendations for Prague city to implement smart city logistical solutions based on the findings from chapter IV. The goal is to use the learnings from other smart projects to develop an even better solution for Prague.

A. Smart Last Mile Deliveries

1) Smart loading zone system

Some of the learnings from the ITSLOG and SAILOR projects can be used to develop smart last mile deliveries in the central areas of Prague. An implementation of a similar project or system would have to be stepwise depending on what would be possible both technically and politically. Since there are currently no dedicated loading zones located in central Prague, the first step would be to develop a system for loading zones. It would require either removing existing parking spaces or making space for new ones. This could be controversial since there already is a lack of parking spaces. However, if done right, it would greatly improve freight deliveries in terms of less emissions and lower costs for the providers and more reliant delivery times for customers.

The next step in creating a smart last mile delivery system would be to establish (or update existing ones) a traffic navigation system with great integrity and live updates of the current traffic situation. This would allow for re-routing when necessary and increase the flow of deliveries. This would also require a great communication with the local traffic control centre. This step would also include creating a map with all locations of loading zones and integrating it with existing navigation systems. However, before implementing this step it is crucial that all legal rights for traffic information needed are in place. This is so that it does not end up in the same situation as in the ITSLOG project where older policies prevented information to be shared between different actors.

The third step would be to create a system where delivery trucks would be notified if a loading zone is already occupied and therefore re-route them to another, non-occupied, loading zone. This requires both reliable occupation recognition and also quick notifications to the navigation displays in the delivery vans. The occupation recognition could be implemented in several different ways. The most effective, but also most expensive, solution would be to use camera based tracking. This would need manual monitoring but would also allow for quick actions in case of someone using the loading zone impermissibly. Another way would be to use bluetooth beacons but then there would be the risk of falling into the same problem as in the SAILOR project.

The final step, meaning full implementation of smart loading zones, would be to also make it possible to book the loading zones using an application integrated with the navigation system. This would also give great opportunities to encourage freight companies to use green vehicles. By implementing this booking system, it would be possible to make it so that electrical trucks or trucks shared by different companies have priority in the booking. It would also be possible to take it one step further and make some loading zones only bookable for electrical or shared trucks.

The second and third steps are already implemented in the Port of Hamburg. There the systems work well. This shows that it is possible to implement a real time navigation system which also shows where there are parking spaces available. The future idea for making loading zones for electrical or shared trucks only, is not yet implemented in the Port of Hamburg. In the future this might be the case, so then Prague could make use of the knowledge of this system.

2) Smart urban delivery network

The learnings from the Emission free delivery concept in Stuttgart show the great potential of the smart urban logistics concept and this is why first pilot projects have been started in Prague and further European cities. The concept proven contributes to a decrease of environmental pollution and due to the noise reduction it also improves the quality of life for the people living in the city center. In comparison to the other use cases this one would not be as technology driven with different data sharing platforms but would require detailed planning and a certain pre-investment for the service providers. Furthermore, close cooperation with the main authorities of the city and the main recipients of the service is needed.

The first step has already been made by the company Dachser with the implementation of an urban consolidation center. Of course this network has to be extended. Micro-hubs can be fixed buildings or mobile structures that are operated on a permanent or temporary basis and used by one or more businesses simultaneously. They can for example be classified as distribution centers, parcel boxes or simple service points in a regular shop for the end consumers. The competitive advantage of service centers would be that the infrastructure is already given. Pick-up stations are publicly accessible facilities, like safety deposit boxes, or Amazon/DHL pick-up units and can be selected as a pick-up point when ordering online. The implementation is probably rather easy, just the most suitable location has to be planned. A distribution center is ideally operated jointly by several partners to improve the capacity sharing. In contrast to the other types of micro-hubs, the distribution center primarily attracts the logistics service providers and is of less importance for the end customer [9].

Even though there is a system consisting of several cycle paths operating in and around Prague labeled as A1-A499, it especially lacks on continuously marked routes in the city center [10]. The implementation of electric assisted cargo bikes for the last mile delivery requires infrastructure changes with more marked cycle paths in the city center. Their main competitive advantage over motorized vehicles is that they are more flexible since they can use cycle paths, can be wheeled through pedestrianized areas and can park "in the second row" when loading and unloading. While the solutions present different features regarding cost/benefit, service quality or daily operations, they all fulfil the main goal of improving mobility, sustainability, and liveability of cities in relation to the goals of smart city logistics.

To complete a full smart sustainable urban logistics network of course motorized trucks have to be replaced sooner or later. Battery electric vans and trucks are currently the most promising option to reinforce the decarbonization of urban transportation and to lower the noise levels [11]. The big challenges are of course the high acquisition costs and sufficient urban planning measurements for recharging.

B. Virtual depot

In the Port of Hamburg, as described earlier, they have a virtual depot. This system could also be implemented in Prague. To introduce this system, a cloud is essential. At first, the system could be tried out in a smaller area in Prague. Suppliers can indicate the time an empty truck would leave some place in the area. Other suppliers can notice it in the cloud and fill the truck with their loading. If the system is working properly, it is possible to enlarge the area. If this system is implemented, it is important to ensure the safety and integrity for all suppliers. The main benefit of a virtual depot is that there will be less trucks in the city. This leads to a decrease of greenhouse gas emissions and a decrease in the traffic density of the city.

VI. Conclusion

In Europe, many cities are trying to increase smart logistics applications to reduce negative consequences of logistics in cities and improve deliveries. As of the time of this report (November 2021), there were first projects started to develop urban deliveries in Prague. As described in the recommendations, Prague has a lot of potential. Prague can use the knowledge of other cities to implement new smart logistics solutions such as a smart loading zone system, a smart urban delivery network and a virtual depot. It is important to take into account the potential threats. By looking at problems that have arisen in other projects, such as the SAILOR projects, Prague can avoid them from the outset. Step by step Prague can evolve to a more smart city, not only in terms of logistics but also in other areas.

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