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ROBOTISATION OF URBAN FREIGHT TRANSPORT

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Abstract

This paper aims to research the developments and innovations in urban freight transport. Thereafter it focuses on the future and implications of robotisation in this field. The developments in urban freight transport from a logistics service provider perspective are based on the constraints space, legitimacy and resources. Governments are slowly starting to focus more on the sustainability of urban freight movement. Though, the progress differs greatly between cities and between European countries. The current innovations in urban freight transport can be divided into five primary categories; transport models, methods, electric vehicles, drones and robotics. Of these five, robotics has the most potential to drastically change the transport field. A combination of robotics with at least one of the other four categories remains possible. Robots can make urban freight movement more sustainable, safer, cheaper, faster and more satisfying for receivers. However, risks of robotics include the replacement of manpower, the lack of noise, additional congestion, and the discrepancy between technology, infrastructure, legislation and other road users. If robotics will be largely implemented, they will first be used for last mile delivery and package deliveries. The acceptance from receivers is pivotal here in order to make logistics service providers willing to apply robots. Governments can steer and stimulate the implementation by creating testing environments, the so-called living labs, and by establishing regulations. The lack of data makes this a tough task for most governments. In order to create a greater market share for robotics, traffic safety must be ensured together with acceptance by all involved stakeholders. Thus, more research is needed on the acceptance of receivers and the necessary government regulations to stimulate the implementation of robotics.

Keywords: city logistics, robotics, automation

1. Introduction

Since the urban population is increasing, so is the demand for goods and services. This results into more congestion and pollution whereas the accessibility and safety decrease (Anand et al., 2012). Forecasts from 2005 show that by 2030 the freight transport activity will have increased with 40%, and by 2050 with 80% (Witkowski & Kiba-Janiak, 2014). Road transport is already responsible for 40% of carbon dioxide emissions in urban areas and is still growing rapidly (Björklund & Gustafsson, 2015). Resource scarcity presents daily challenges to logistics service providers (Rose et al., 2016). Technological and logistical measures and innovations are explored and developed in order to tackle these issues (Macharis et al., 2014). Researchers and policy makers are starting to pay more attention to these upcoming opportunities (Lagorio et al., 2016). Therefore, freight related decisions are becoming more important (Anand et al., 2012). Urban freight movement focusses on city road networks, in which vehicle flow represents urban freight traffic. Though, businesses put urban freight transportation under the concept of logistics management, which includes the whole distribution process. Therefore, the roots of urban freight movement are expanded to the regional, national and international level (Anand et al., 2012). Some freight related aspects are regulated by municipalities, such as location and number of loading zones, environmental rules and guidelines and vehicles' access to certain areas of the city (Björklund & Gustafsson, 2015). Interactions between stakeholders from the commodity, transport and infrastructure sectors result in urban freight transport. Besides this, urban freight transport depends on supply and demand activities from trade and transport markets. The aim of this paper is to show *what role robotics have and will potentially have in this complex urban freight transport system*. This paper researches the developments and innovations within urban freight transport, primarily focused on the Netherlands. Therefore the constraints and various actors in this field will be discussed. Innovations can be categorized as transport models, methods, electric vehicles, drones and robots. This paper will discuss the last three categories. All this is followed by an analysis of the potential of robotics within this field. Also challenges and opportunities will be given. Furthermore, practical implications of robotics in urban freight movement will follow, focused on last-mile delivery, legislation and the market. Finally, a discussion and conclusion will be given.

2. Innovations in urban freight transport

Recently Sustainable Urban Mobility Plans (SUMP) are created at the European level to emphasise the importance of integrated transport planning processes when making the urban transport system more sustainable (Verlinde & Macharis, 2016). Many more initiatives for sustainable innovation are being developed. Meeting the Paris agreement 2050 target concretely means that for transport emissions, the 'carbon productivity' has to increase six fold. This carbon productivity is the amount of freight and passenger transport per unit of carbon equivalents emitted, also called Factor 6. To reach this desired carbon productivity, the existing and planned policies need to be extended by very complex system innovations (Topsector Logistiek, 2017). This shows the importance of innovations in the urban freight transport field. This chapter gives an overview of the main innovations in urban freight movement.

According to the triple helix thesis innovation happens at the intersection of industry, state and research. A triple helix is an organic system, it needs seed to germinate from with a fertile environment in order to grow. The triple helix innovation model thereby states that there is an important role in innovation played by universities (Verlinde & Macharis, 2016). Modelling smart city performance can only be done within such a triple helix context (Lombardi et al., 2012). Partnerships between urban freight actors and local authorities are pivotal in order to innovate (Lindholm & Brown, 2012). The fact that administrations operate on legally and politically divided levels can hinder innovation. Therefore, changes in legislation and regulations will be required for some innovations (Verlinde & Macharis, 2016). The GDZES is an example of such a regulation that enables the implementation of zero-emission technology within urban freight transport (Topsector Logistiek, 2017). A problem occurring when trying to innovate is that initiatives can seem successful in pilots and demonstrations, but may create unexpected side-effects on a large scale or on the long term. This happened for example with the unsuccessful implementation of urban freight consolidation centres in many cities (Macharis et al., 2014; Kin, 2018). Furthermore, change takes time. The involvement of many stakeholders is necessary to come to appropriate innovations, though this prolongs the innovation process (Topsector Logistiek, 2017).

An important innovation within urban freight transport is electric vehicles (EVs). This innovation has a high potential of addressing environmental, social and economic impacts on urban areas (Ahani et al., 2016). Advantages of EVs are for example zero tailpipe emissions (Topsector Logistiek, 2017) and low operating costs. Though, the purchase costs are currently too high for many private stakeholders in urban freight transport. A big portion of these costs are dedicated to the batteries of such an electric vehicle. Now that the costs of batteries have been decreasing, EVs are becoming a more viable option in urban freight movement (Ahani et al., 2016). Other factors to consider when implementing EVs in urban freight transport are the range and charging times of the vehicles, the charging infrastructure requirements and the potential safety risks when the vehicles do not emit enough noise (Topsector Logistiek, 2017; Ranieri et al., 2018; Poveda-Martínez et al., 2017).

Drones can be also be regarded as an innovation. A drone can be defined as "an aircraft that does not have a pilot but is controlled by someone on the ground, used especially for dropping bombs, for surveillance (= careful watching of a place) or as a hobby" (Cambridge Dictionary, n.d., a). This definition immediately shows that it is currently uncommon to use drones in urban freight movement. Though, this might change in the future, especially concerning the delivery of packages to end customers. One main advantage of using drones is that they can be at location very fast (UPS Pressroom, 2016). However, drones face rules concerning flying in the Netherlands; the company needs to have a drone permit, the pilot needs to have a flight certificate and they are not allowed to fly in the dark or out of sight (Rijksoverheid, n.d.). Furthermore, drones cannot fly that far, they cannot carry that much and they need frequent recharging (Elgan, 2016). In other parts of the world, though, drone networks might very well be a solution to delivering medicines to remote areas. An example of this is the Rwanda Drone Network in which The UPS Foundation, robotics company Zipline and Vaccine Alliance cooperate to deliver blood for transfusions in the remote western half of Rwanda. Later on also vaccines and many other lifesaving medicines are supposed to get delivered by this network. The drone delivery operation is expected to save thousands of lives (UPS Pressroom, 2016). Although drones can be useful in situations of high-value items, they are not suited for everyday deliveries (Elgan, 2016). Therefore, drones will probably not be implemented in urban freight transport (Kin, 2018).

Figure 1. Starship robot (Obert, 2016)

A robot can be defined as "a machine controlled by a computer that is used to perform jobs automatically" (Cambridge Dictionary, n.d., b). Although drones itself do not have the capacity to perform last-mile delivery, as explained in the previous paragraph, a combination of robots and drones might be a possibility. An example of this is the rolling drone-base idea by Mercedes-Benz. This idea is called the Vision Van, in cooperation with drone company Matternet. The van includes two internal racks, the robotic system hands the right delivery package to the driver or pushes it through a window in the ceiling to one of the two drones. These drones then deliver the package in the customer's backyard. The advantages of this system are; faster delivery to homes far from the road and possible delivery of two or three packages at once. Furthermore the drones can be used to deliver a package to the van after the driver left the warehouse (Elgan, 2016). Generally speaking, the Vision Van decreases some of the disadvantages of drones on their own (e.g. distance, recharging, flying out of sight). Though, companies implementing this idea would still need a drone permit and flight certificate. Another initiative concerning robotics is the self-driving ice-chest idea. Robots from company Starship gather packages at a central loading hub, followed by a delivery to the customer. These robots use GPS, internal navigation, sensors and nine cameras, they travel on sidewalks at walking pace and stop in case of an obstacle or pedestrian in its path (Elgan, 2016). This makes the Starship robots far safer than delivery drones (Pettitt, 2015). The robots can be opened through a code customers receive on the same app on which they ordered the package. A human operator at a control centre can make contact with people around the robot via a speaker and microphone and take over the control of the robot if needed. Starship robots cost less than 2000 dollar. The operating costs are less than a dollar per delivery, with a potential decrease in the future (Elgan, 2016). The only hurdle in implementing

Starship robots is the lack of regulations on this type of robots in certain countries (Pettitt, 2015). Examples of successful implementations of this kind of robots are:

- The Robovan in cooperation with Mercedes. A Mercedes van carries multiple Starship robots and drives most of the route. At a certain point the van releases the robots which travel the last part of the delivery trip (Elgan, 2016).
- Recently, Domino's started using Starship robots for the delivery of pizzas. The robots are then called Domino's Robotic Units (DRUs) and can carry up to eight pizzas at a time (Domino's, n.d.). A first test was done in New Zealand (Elgan, 2016). Tests in Germany and the Netherlands are currently going on (Domino's, n.d.).
- The robot Relay by Savioke, which helps hotel services. This robot can control the elevator wirelessly and navigate through the hotel with the use of Wi-Fi and cameras. At the guest's room, it dials the phone in the guest's room and opens its lid when the door opens. After, Relay finds its own charger in the lobby (Elgan, 2016).

Other initiatives are in the design process, for instance delivery systems by Silicon Valley startups and Alibaba (Elgan, 2016) and the development of Carry; a bigger delivery robot than the Starship robot (Taves, 2016) and Zume Pizza (Elgan, 2016). There are many more initiatives in the development and implementation phases (see for example Dinale et al., 2013).

3. Future of robotics in urban freight transport

From the innovations discussed in the previous chapter, drones and robots are currently in development and have so far reached the phase of small market niches (Geels, 2005). As said, robotics have the potential to reform the last-mile delivery. Therefore this chapter focuses on the potential of robotics in urban freight transport. There are a couple of developments likely to occur or change within urban freight movement in the near future. These four can be categorised as societal, technical and logistics developments and policy (Rose et al., 2016; Topsector Logistiek, 2017). These developments will affect urban freight activities and the potential of robotics. Robotics are usually seen as sustainable innovations (Muscolo et al., 2014, p.2; Behrends et al., 2008). Therefore robotics have the power to aid at shifting urban freight transport towards sustainability (Dinale et al., 2013). Furthermore, when robots are used for home delivery, customer satisfaction can be increased while safety and environmental impact are improved (Elgan, 2016; McKinsey&Company, 2018). It is important to note that in order to reduce urban transport, and thereby emissions and noise, efficiency within the operation of robots is crucial. Otherwise the positive impact of robotics will be limited (Verlinde, 2018). Robots can also be a solution to the growing shortage of drivers and changing labour conditions (Ploos van Amstel, 2017). Therefore robotisation has the potential to reduce handling costs (Topsector Logistiek, 2017). This is especially the case if personnel costs can be reduced due to autonomous deliveries (Verlinde, 2018). They can also reshape and scale last-mile delivery, as shown by the examples in the previous chapter (Elgan, 2016). Productivity can rise up to a new level, which would speed up the delivery process (Topsector Logistiek, 2017). Robotics fit in all four categories of developments as discussed in the previous paragraph.

Although the opportunities of robotics are vast, the downsides should not be underestimated. The emergence of robotics would lead to a replacement of manpower (Topsector Logistiek, 2017). Currently there is a shortage of drivers, as mentioned in the previous paragraph. However, robots might take over almost all jobs in urban freight transport susceptible to automation, thereby increasing unemployment. Secondly, robots can face the same problems as electric and hybrid vehicles concerning their lack of noise. If the robots do not produce enough noise, accidents with pedestrians and cyclists are more likely to happen (Poveda-Martínez et al., 2017). When it comes to automated vehicles, there is the issue that although the technology might be developed very fast, the infrastructure, legislation and other road users are not ready (Kin, 2018). Furthermore it can lead to additional congestion (Verlinde, 2018).

4. Practical implications of robotising urban freight transport

Now that the potential of robotics has been established, it is of importance to look into the practical implications robotics have on urban freight movement.

It is essential to recognize once again that change takes time (Topsector Logistiek, 2017). Robotics will at first be used in the areas or fields where there is the biggest need for them. From there they will spread across other areas and fields. Time is needed for producers to take investment decisions, to produce and to scale up. Furthermore logistics service providers will slowly, in 15 to 20 years, replace their current equipment by robotics (Topsector Logistiek, 2017), since a sudden change is simply too costly. Thus, the adoption of robotics in urban freight transport should be started as soon as possible. Other obstacles that might occur are; high fixed and variable costs for shippers and logistics service providers and low profit margins (Kin, 2018; Verlinde, 2018); the regulation on emissions; trust issues when it comes to sharing data (Verlinde, 2018); the existence of a stimulating environment for testing and implementing innovations and; the acceptance from stakeholders, mainly the logistics service providers, shippers and receivers (Kin, 2018; McKinsey&Company, 2018). In the early stages of implementation, robotics will be used for last mile delivery. However, a lot of human support will be necessary (Verlinde, 2018; McKinsey&Company, 2018). When autonomous vehicles are used, a huge economic advantage for shippers and logistics service providers occurs (Verlinde, 2018). Acceptance by receivers is a tough issue. When robots get involved in accidents, it is very fast considered a threat. Though, providing a 100% security in such an environment with other road users will not be possible (Kin, 2018). Furthermore, receivers might not want to deal with robots, because they value human contact or do not want to pick up a package from, for example, a mobile locker (Kin, 2018). Logistics service providers highly value good quality of their service towards both receivers and shippers. If they could reduce costs by using robots, but the receivers would not appreciate it, they will not implement the robots (Kin, 2018). Thus, in order to apply robotics in a broad sense, the acceptance of receivers is crucial. According to McKinsey&Company (2018) robotics have the features to create more convenience for customers as well as lower the costs on the long term. This would substantially increase the acceptance.

When it comes to legislation concerning robotics in urban freight movement, there is a role for the government to play. Topsector Logistiek (2017) set up a list of tasks for governments to improve urban freight transport:

1. Develop and introduce common IT and control systems facilitating easy-to-use customized and individualized access to sensitive city centres, based on connected vehicles that are traceable.
2. Mandate and implement green tendering for construction projects.
3. Mandate and implement bundled deliveries for facility logistics.
4. Ensure efficiency improvements through implementation of policies at the national and international level.
5. Create scale: incentivize supply and demand for large volumes of zero-emission vehicles and prevent fragmentation.
6. Urban planning: separate the flow of traffic from areas where pedestrians and cyclists dominate (Topsector Logistiek, 2017, p.9).

Robotics can aid in at least four of these tasks, namely the first, the third, the fifth and the sixth point. Therefore it is important that governments incorporate robotics in their laws and policies. Although it can be stated that the policies, legislation and regulations in urban freight transport highly impact the way in which robotics can be used in this field, little is known about which policies should be in place and what their impact will be (ALICE/ERTRAC, 2014). Governments might be hesitant to subsidise implementations of innovations since they could fail. Another challenge governments face is how to incorporate accountability in the law in case of an accident in which a robot is involved (Kin, 2018). They also have no or limited data on urban freight movement, which makes it impossible to oversee the impact of changes (Verlinde, 2018). Hereby it is crucial to mention that the power of local authorities should not be underestimated (ALICE/ERTRAC, 2014). All levels of the government together determine the implications robotics will eventually have. The lack of manpower in small cities results in a situation in which decisions are not taken from an urban freight transport perspective (Verlinde, 2018). However, local governments should create a stimulating environment, starting with a living lab. Such a living lab enables the testing of robotics and gives room to other cities to follow this example and learn from each other (Kin, 2018). At the same time, governments cannot do much more than supporting by regulations and enabling testing environments (Verlinde, 2018). There is also an important role for the logistics sector in the adaptation of robotics. Topsector Logistiek (2017) set up points of improvement for companies involved in logistics as well (p.9). In all these tasks robotics can either be a solution or an aid. However, traffic safety must first be ensured. This means testing is pivotal (Verlinde, 2018). Furthermore, to tackle the data sharing obstacle, common standards for data exchange are necessary (Verlinde, 2018). The prediction is that robotics will mostly be applied for package deliveries, such as mobile lockers (Kin, 2018). They can also be used on pavements for last mile delivery from a mobile depot (Verlinde, 2018). Robotics might also be implemented in a broader sense, such as construction sites and 'in-house' deliveries (Kin, 2018). Though, the acceptance by shippers, logistics service providers and receivers must be in place before scaling up the operation of robotics.

6. Discussion and conclusion

This paper has delivered insights into the development and usage of robots within urban freight transport. This chapter will first give some comments on this research and the way it was conducted. After a conclusion will be given. This paper has used a number of scientific articles and books on urban freight transport, more specifically on robotics in this field. Also the opinion of two experts is used, mainly to gain more information on the implications of robots. Although this paper delivers a coherent overview of the existing knowledge, perspectives and predictions, the paper itself does not deliver new information. Content wise the focus on the Netherlands limits the results and usability of the research in other countries. This is primarily the case in countries with a fairly different democratic, infrastructural or economical system. Even though some literature and experts opinions were present on the implementation and implications of robotics, it remains a relatively new field of research. Therefore clear examples and predictions for the future are not in place thus far.

An upcoming innovation within urban freight movement is robotics. These robots have the potential to reduce emissions, causalities and handling costs. However, within the implementation of robots several obstacles have to be overcome. One of them is the need for acceptance by receivers. Without this, logistics service providers will not use the robotics. It is to be expected that in ten to fifteen years the change to robotics will be made. However, how this required acceptance can be achieved has not been part of scientific research so far, but it is crucial in order to get the most out of this innovation. When receivers start asking for robotisation in urban freight transport, logistics service providers are left with no other choice but to implement robots. Furthermore, additional research is necessary on how to establish legislation concerning robotics in urban freight movement. It is important for governments to create testing environments, the so-called living labs. Though, it is unclear which regulations on emissions and accountability should be in place to stimulate the implementation of robotics, and innovations in general.

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