

ZF Friedrichshafen AG
Löwentaler Straße 20
D-88046 Friedrichshafen

**EuroTransportMedia Verlags-
und Veranstaltungs-GmbH**
Handwerkstraße 15
D-70565 Stuttgart

**Fraunhofer-Institut für
Materialfluss und Logistik IML**
Joseph-von-Fraunhofer-Straße 2 – 4
D-44227 Dortmund

www.zf-zukunftsstudie.de

ZF FUTURE STUDY 2016

Last Mile Logistics



Commissioned by ZF and ETM-Verlag.
Written by the Fraunhofer-Institut für
Materialfluss und Logistik IML

ZF Friedrichshafen AG

ZF is a global leader in driveline and chassis technology as well as active and passive safety technology. The company has a global workforce of around 137,000 with approximately 230 locations in some 40 countries. In 2016, ZF achieved sales of approximately €35 billion (preliminary figures). ZF annually invests about five percent of its sales in research & development – ensuring continued success through the design and engineering of innovative technologies. ZF is one of the largest automotive suppliers worldwide. ZF allows vehicles to see, think and act. With its technologies, the company is striving for Vision Zero – a world of mobility without accidents and emissions. With its broad portfolio, ZF is advancing mobility and services in the automobile, truck and industrial technology sectors.

ZF customers from the automotive and industrial sectors value the company's consistent focus on improving products and services for their benefit. Moreover, as a supplier to the commercial vehicle industry, ZF sees the people who use its innovative technology in their daily work environments as important success factors in product development. The company's strategic focus, new findings based on ZF future studies and trends from the logistics branch are currently being integrated into cutting-edge mobility concepts.

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EuroTransportMedia publishing house specializes in the commercial vehicle sector, primarily focusing on international transport, commercial vehicles and professional fleet management for both trucks and cars. Together, ZF and ETM commissioned the ZF Future Study to provide a targeted analysis of the transport industry. ETM intends to use the study to highlight the strong performance capability in this sector and its future development potential while also improving the image of the transport industry.

Fraunhofer IML

Fraunhofer Institute for Material Flow and Logistics (Fraunhofer IML) is considered the number one stop when it comes to integrated logistics research, which covers internal and external logistics. Fraunhofer IML is a public research institution that is part of the umbrella organization, the Fraunhofer-Gesellschaft. It was founded in 1981 and currently employs 200 scientists as well as 250 doctoral candidates and undergraduate students; it also receives support from colleagues in workshops, laboratories and service facilities. In addition to its Dortmund facility, Fraunhofer IML has locations in Frankfurt on Main, Prien am Chiemsee, situated on Bavaria's largest lake, and Hamburg as well as international offices in Lisbon and Beijing. Teams assembled specifically to meet project and customer needs design and develop customer-specific solutions across several industries and in the following areas: materials handling, warehouse management, business modeling, simulation-supported corporate and system planning as well as transportation systems, resource logistics and E-business.

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Management Summary

The ZF Future Study 2016 closely examines last mile logistics. Based on published sources, interviews with relevant experts and stakeholders as well as the considerable expertise within Fraunhofer itself, the authors have identified major trends and their ramifications in configuring future last mile logistics systems. In its analysis of the findings, the study distinguishes between rural, urban, and metropolitan areas. Three key assumptions form the methodological basis of the study:

- Assumption 1: The end customer is the final destination of any last mile delivery activity. Customer wishes and requirements will directly or indirectly impact the design of any last mile system
- Assumption 2: The local surroundings, such as infrastructure, buildings and traffic volumes will define the way last mile logistics solutions are designed and implemented and these local factors must be taken into account in the design process.
- Assumption 3: Due to the conflicting priorities between end customer requirements and the restrictions imposed by the local surroundings, innovative approaches will clear the way for new last mile designs.

The study describes four trends which are expected to heavily influence customer behavior. These include demographic change, fresh produce logistics, same-day delivery, and environmental awareness. All in all, these trends will increase cost pres-

ures and result in stricter time constraints for the last mile. Yet rural, urban, and metropolitan areas all have different issues to consider. For example, rural areas are already expensive for logistics companies because of the low stop densities. Transport volumes increase at below-average rates and limit possible efficiency gains.

Urban areas enjoy average growth in transport volumes. Additionally, the populations in these and metropolitan areas have similar logistics needs. Since urban areas are not as productive compared to metropolitan areas, the study concludes that cost pressures are the biggest issue for the last mile in urban, rather than metropolitan areas. Also, because metropolitan areas attract transport volumes with above-average growth not only in terms of tonnage, but also in terms of service quality (same-day delivery, fresh produce logistics). These factors therefore result in substantial economic incentives to shorten the last mile and to move logistics hubs closer to the customer, so as to at least guarantee the utmost availability of goods required for rush deliveries. Lastly, people who live in metropolitan areas expect logistics companies to find solutions for problems such as traffic-induced air pollution and noise.

Logistics companies must meet customer demands, but also have to consider the local surroundings (Assumption 2). The next chapter of the study describes the different framework conditions, including major issues such as transformation in the retail sector (mushrooming urban convenience stores and small supermarkets, em-

phasis on the shopping experience, convergence of physical and digital retail), declining availability of skilled workers, actions taken to reduce pollution and traffic noise as well as safety requirements for new technologies. Like customer-driven trends, local conditions are contributing to cost pressures on the last mile due to rising labor costs.

Continuously high cost pressures, unwillingness on the part of consumers to pay extra for logistics means the only option is to increase efficiency through innovation. Different technical trends ranging from digitization, the Internet of Things and 3D printing are therefore enabling logistics companies to overcome these challenges.

Autonomous vehicles and electric drive technology are paving the way toward entirely new concepts for last mile structures, business models (such as night delivery) and even vehicle designs. Drones will improve and become part of the last mile solution for specialized niche applications. Small ground vehicles (robots) will support package distribution and connect retailers with their local end customers. "We are seeing a potential annual volume of up to 400m packages distributed by autonomous robots and probably ten times as many as air drones," says Prof. Uwe Clausen, Director of the Fraunhofer-Institute (IML).

In order to exhaust the potential of current trends and technical innovations, logistics companies, politicians and the society in general must decide on several important issues. Companies have to train their work-

ers to use digital technology; they have to provide substantial support for their subcontractors who often lack resources to handle such challenges on their own. New standards for mobile communication, along with open standards for data exchange, encryption and security are critical technological factors for successfully implementing new technologies and garnering acceptance.

3D printing produces instant customized products and has the potential to make the rush delivery of spare parts or medical supplies superfluous. Logistics companies should embrace this technology in order to drive its change instead of being stamped out by it. Cooperation with local retailers looks promising.

One major finding in the study reveals that customers will require a shorter "last mile" with many smaller depots offering short service times. Suitable locations can easily be found in rural areas while more densely populated regions will be harder to serve, according to the study. Yet customer proximity will make it easier to send out electric vehicles and offer same day delivery services. New vehicle concepts are expected to enter the market and will require logistics companies to think outside the box. It will take a while yet to kill the diesel engine as it is gradually replaced by cleaner and more silent engines. Self-driving trucks in the service of commercial freight forwarders will be the first to successfully navigate safe and contained environments and learn as part of pilot projects.

Introduction

When looking at the often conflicting priorities between e-commerce, automotive engineering and connectivity as well as customer requirements and the different factors involved in delivering to urban vs. rural areas, we are seeing that “last mile” logistics is changing dramatically.

The ZF Future Study 2016 “The Last Mile” therefore closely analyzes these changes, projects forecasts for the next 15 years, delivers recommendations for a forward-looking, sustainable logistics approach and describes the opportunities and challenges associated with current technological trends.

Fraunhofer IML works closely with companies from many industries, not just logistics, and is in constant contact with members of professional associations, politicians and other institutes within the Fraunhofer Group and beyond. Access to this network was an invaluable resource for the team of authors led by Prof. Dr.-Ing. Uwe Clausen. Internal workshops and interviews with external experts thus represent two of the three main support pillars on which this study is based. Moreover, a balanced review of personal opinions and forecasts can only be achieved if the results of the interviews are thoroughly analyzed with support from other publications and publicly available statistics. As such, traditional research work represents the third support pillar in this study.

This study takes the three following assumptions as its methodical starting point:

- Assumption 1: The end customer is the final destination of any last mile delivery activity. Customer wishes and requirements will directly or indirectly impact the design of any last mile system
- Assumption 2: The local surroundings, such as infrastructure, buildings and traffic volumes will define the way last mile logistics solutions are designed and implemented and these local factors must be taken into account in the design process
- Assumption 3: Due to the conflicting priorities between end customer requirements and the restrictions imposed by the local surroundings, new last mile designs will be the result of innovative and out-of-the-box thinking and solutions.

Following Assumption 1, the first chapter of the study begins with a description of the end customer and examines the basic demographic trends in society that affect the end customers’ logistics expectations and demands. In the last few years, we have seen the growing trend of replacing brick and mortar retailers with online commerce, which has meant an increasing reliance on logistics. This move toward e-commerce concerns not only the consumers’ willingness to buy certain goods online at all (such as medicine), but the online/offline purchase ratio as well as the older generation’s increasing use of e-commerce (“silver surfer”). The growing customer demand for faster delivery

means that logistics companies must focus on express and same day delivery. The authors have therefore compiled a list of requirements regarding different trends in last mile destinations to help logistics providers navigate the challenges of the future.

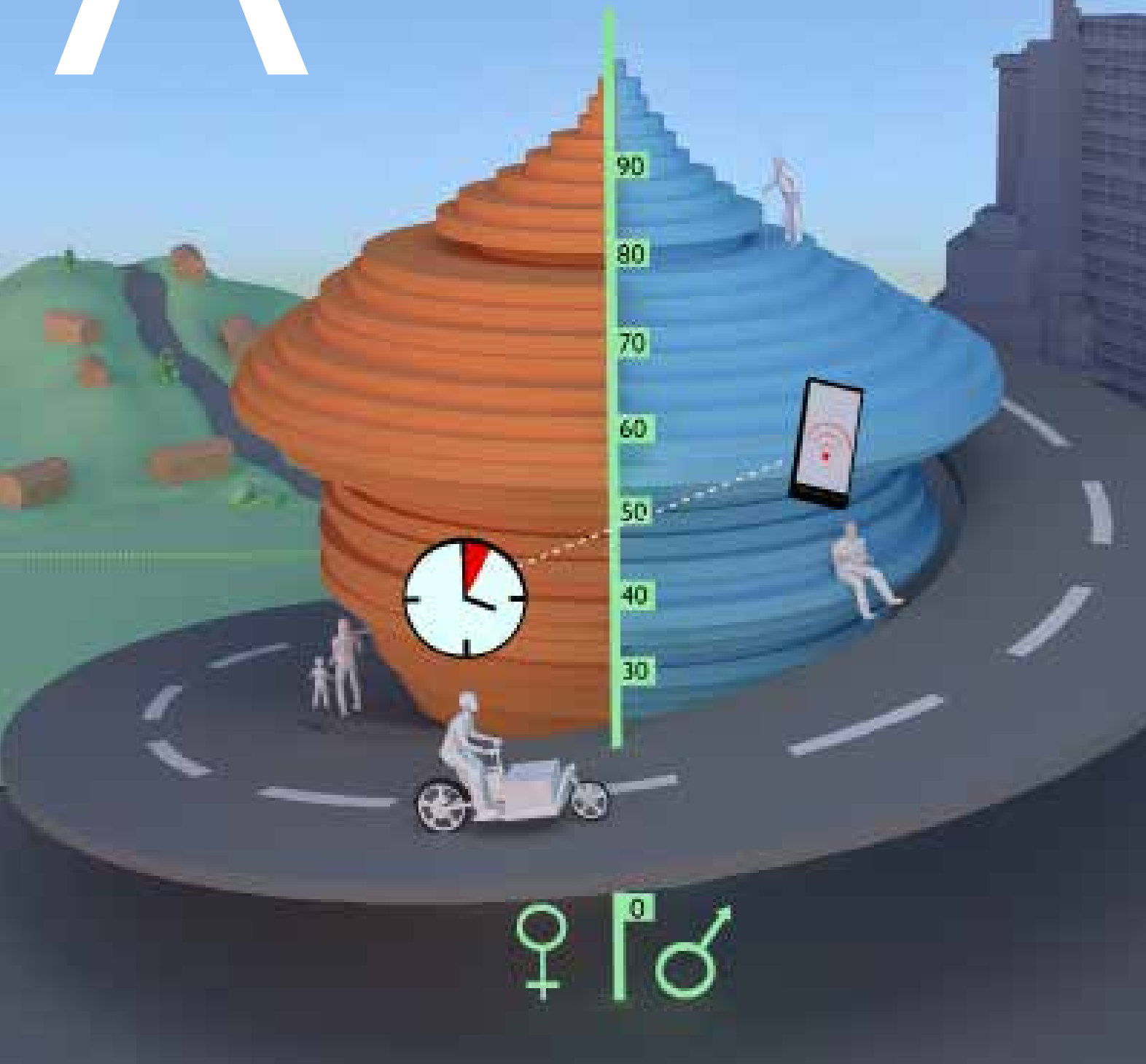
The second chapter addresses the freedoms that logistics providers do have in meeting customer requirements especially because said requirements are increasingly coming up against regulatory restrictions. Responsibility for humans and the environment requires a clean, quiet and safe last mile. While many people benefit from a “sharing” economy, they want to be less weighted down by goods transport. Various courses of action are being discussed in communities on local, state, country and EU levels. Chapter two therefore focuses on the general framework conditions that will have an increasing impact on the last mile. Societal demands regarding logistics are thus examined from the points of view of both the goods recipients and citizens unwilling to accept restrictions to their quality of life due to transport and delivery issues. From the interconnections between these first two chapters, conflicting priorities emerge that will create problems for those involved in last mile logistics.

The third chapter deals with requirements and framework conditions that emerged from the first two chapters. Based on Assumption 3, this chapter also describes selected technologies and concepts that

will considerably impact the last mile in the near future. It analyzes the potential of these technologies to meet future customer requirements or to respond to stricter general framework conditions. Such responses include new methods of transport such as autonomous vehicles, transport robots and drones and alternative drive systems such as electric vehicles and, ultimately, technologies that may have a more indirect impact on last mile transport, such as digitization, the Internet of Things and 3D printing. Since innovative technologies cannot be the sole solution to society’s problems, but bring with them certain success factors and, in turn, raise new questions, the findings to date must be compiled and synthesized.

The fourth chapter concentrates on the need for decisions to be made based on the conclusions from the third chapter. It therefore creates a link between customer requirements, general framework conditions and technological trends to identify the necessary decisions to be made by logistics companies, society and lawmakers. It also reveals the challenges to be confronted and the way in which businesses, in particular logistics companies, can contribute to successfully developing last mile logistics in the next 15 years.

A



End Customer Requirements

END CUSTOMER REQUIREMENTS

Introduction

Logistics is not an end in and of itself, rather its purpose is to make goods and information available. Ultimately, it is the end customers who indirectly determine how to design the logistics chains that deliver goods to them. The end customer, whether a company or a private person, is always the destination and target of the last mile. This ZF Future Study therefore takes the end customers' requirements and needs as its starting point. Of course, there is no such thing as one "end customer" which is why the ZF Future Study uses different perspectives to describe the attitudes, expectations and characteristics of potential end customers. In other words, this study defines the end customer not only as a household that orders goods from an online site, but also as the retailer or craftsperson to whom goods or urgently needed spare parts are delivered by a product line or company. The main characteristics used to describe the end customer as a specific group include, for example, the age and profession of the private persons and, in the business sector, the size of the company's operations.

“For those looking at the future of logistics, they are right on track with “the last mile.” There is almost no other area that so many future developments and potential logistics concepts will concentrate on.”

Prof. Dr.-Ing. Uwe Clausen,
Director of Fraunhofer IML

In reality, every company and every private person has individual demands and expectations regarding last mile logistics. However, there are several social trends that cannot be ignored either now or in the future, these include:

- Demographic change, i.e. shifts in the age pyramid that are, to some degree, moving in totally different directions, depending on region, but especially in metropolitan areas
- Changes in the way food is delivered to the end customer, i.e. increasingly through pre-packaging and flexible delivery or pick-up
- Accelerating delivery to end customers to include, for example, services such as same-day delivery
- Environmental trends which are manifesting themselves increasingly in the form of environmental awareness among consumers and in the efforts of business and industry to reduce environmental pollution and health hazards, i.e. to act as responsible members of society.

Since these trends are so socially relevant, they are impacting current and future last mile logistics requirements. Taking these trends as a starting point, a general picture of the social expectations regarding the last mile emerges. In contrast, the needs of specific end customers, such as small and medium-sized manufacturers and single households, are not addressed until last mile business models and technologies are compared and contrasted against changes in customer require-



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ments. That means that demographic change is the first trend that will have a major impact on society in the near future and thereby the last mile requirements that society demands.

Demographic Change

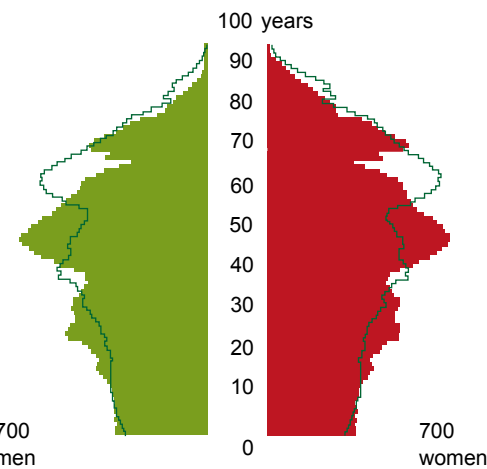
Demographic developments, i.e. socio-political and political-economic population trends will influence last mile logistics because of changes in the available workforce and consumer behavior.

Despite the high number of migrants and a slight increase in birth rates, the German Statistical Office is forecasting that the German population will decrease and its average age will increase. Forecasts indicate that in 2030 there will be 77 million citizens (down 4 million compared to 2016) and that only about 17 % of them will be younger than age 20 (down 1 % compared to 2016), all this means about 29 % will be older than age 65. The number of wage earners will decrease at a disproportionally high rate and by 2030, the number of people needing care will continue to grow, i.e. more than 3.4 million people will need long-term home care.

Currently, about 75 % of the German population lives in urban or metropolitan areas, with this trend on the rise. Every third German lives in a city with more than 100,000 inhabitants and roughly one in four Germans live in Berlin or in the Ruhr region. Urbanization is resulting in an increasing housing shortage, competing utilization needs and major traffic congestion. More than half the households in big cities are occupied by singles (forecast for 2030 almost 60 %).



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The German population according to age and gender in 2014 and in 2030 (green line). Source: Destatis

Order and delivery services will be offered as a combined service focusing on target groups. Customized delivery concepts will become decisive factors that will make retailers stand out against their competitors.

The last mile will become more service-oriented, adapting to the individuals' needs, the needs of an aging population and smaller households as well as to demands for greater convenience. The supply of goods needed on a daily basis will increase considerably due to the fact that retailers are moving out of rural areas. To improve efficiency, the currently separate processes of delivery, home care and food services will be increasingly consolidated.

The greatest challenge over the next few years is to design a last mile that is both compatible with urban and metropolitan areas yet still efficient. The concept of individualization conflicts directly with economies of scale and the logistics concept of pooling.

The logistics industry has a poor image, its wages are below average and, in frequent cases, the working conditions are not attractive. Transport and logistics companies will find it increasingly difficult to find good professional truck drivers as well as medium and higher-level managers and executives. There is also a shortage of low-skill workers for package handling and delivery. In the future, there will be a decline in the number of skilled IT workers, mainly in small and medium-sized companies, and they will have a hard time keeping up with the pace of digitization in the logistics industry.

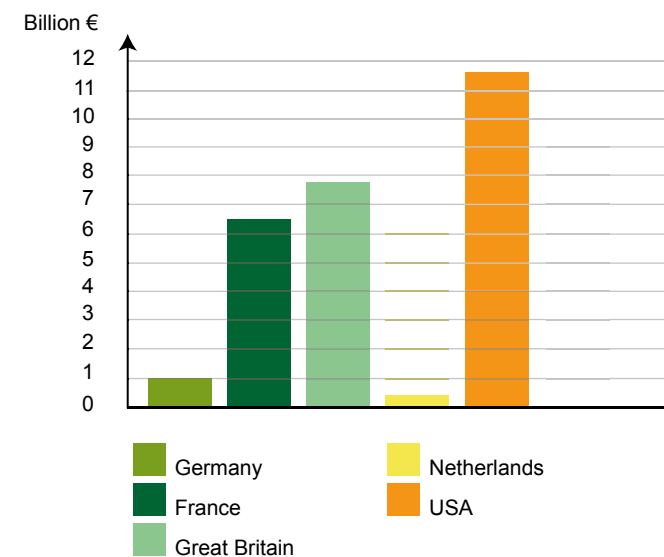
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END CUSTOMER REQUIREMENTS

Convenience

Last mile logistics also affects the supply of food and other perishable goods. Not so long ago, the buying and selling of food or perishable goods, like houseplants and flowers, relied on the simple "pick-up" principle. The customer was, and for the most part, still is accustomed to selecting these products personally at the store, purchasing them and taking them home. From the logistics point of view, the last mile destination is the store.

The delivery of hot meals to end customers (for example, pizza delivery or meals on wheels services) was exclusively organized by local service providers and, in general, by those who sold the goods. Currently, regular groceries, pre-prepared box meals and complete plant arrangements are playing an increasingly important role in e-commerce.



Convenience Food – Annual Sales in Various Countries 2016

In 2016, 1 million Germans bought their groceries online. The market share for online food retail only is roughly 1 % or the equivalent to annual sales € 1.2 billion. A representative Bitkom study shows that it will be brick-and-mortar retailers that jump-start the German market in this sector, while only 15% of online customers buy groceries from sites such as e-Bay or Amazon. Experts assume that the reason for this is the high concentration of supermarkets in Germany. It is just easier and cheaper for potential customers to buy groceries from "corner grocery stores" instead of making the effort to buy groceries online, deal with delivery and pay extra for it. So it comes as no surprise that smaller markets such as

France or Great Britain are already posting sales of € 6.7 billion or € 7.8 billion in online grocery sales. This shows that there are well-founded reasons to expect dynamic growth in fresh produce and convenience logistics. Conservative forecasts estimate that the German food retail sector will reach a market share of 5 % by 2030. Particularly for consumers who do not have much time to go grocery shopping, the option of purchasing fresh produce online or doing some or all of their shopping online may be attractive. Consumers with heavy workloads or family responsibilities are ideal target customer groups.

Convenience and fresh produce logistics place high demands on transport processes. Goods must be kept fresh through passive refrigeration and delivered promptly to prevent spoiling. For these reasons, such shipments must be delivered not only on time, but also successfully the first time around. Take the example of plant deliveries: If a shipment of plants is not successfully delivered on a Friday, the plants may have already wilted or died by the time they are next delivered on Monday, which means they are of no use to the receiving end customer. Precisely because of such issues, individual retailers, particularly in the food retail sector, organize deliveries themselves (for example Rewe/Billa). Small shipment quantities and low delivery densities often make transports, especially in the food retail sector, look more like an expensive and time-consuming courier service. Currently, the returns from one grocery delivery must cover costs of roughly € 7 – 15, which, considering retail margins, will be quite a challenge. To compare, shipping a standard package currently costs a leading courier service € 2.50 – € 3.50. Industry experts assume that current market growth will allow for delivery synergies, which, using courier-like services, will enable shipping costs to fall to € 5 – 7 by 2030 due to a combination of improved delivery methods and vehicles.



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Same Day Delivery

Same-day delivery means that an ordered product is delivered on the same date it was shipped. International experts have different views regarding the future significance of same-day delivery, which range from “relevant niche market” to a “revolution in logistics.” Yet don’t forget that in markets that cover large geographical areas or in markets with less infrastructure, for example, transport and delivery will take longer than in Germany. A non-express package that can be delivered in Germany within 24 hours will take a week or even more to be delivered in North America. This means the same-day delivery there is rare.

With its slogan “heute da” (here today) and in cooperation with the courier service Tiramizoo, „Notebooksbilliger“, a German electronics and appliance retailer introduced its same-day delivery service in the greater Hanover region in April 2012, thus making it a pioneer in same-day delivery business. However, in May 2013, it halted this service due to low demand. But by the end of 2015, the time seemed ripe for same-day delivery in Germany. This time, Amazon began offering same-day delivery and pioneer Notebooksbilliger tried again, this time working with the German logistics company GLS. Same-day delivery is usually offered in selected regions, generally those with dense populations. The fast-moving urban lifestyle featuring small households with high income earners seems to be the strongest growth driver in the same-day delivery market. Currently, same-day delivery is considered a niche market, an opinion shared by

“ Package delivery must be adapted to the customer’s daily routine, not vice versa. ”

Nils Fischer,
CEO of „Liefery“
(German delivery company)

potential service providers. According to a study conducted by the German e-commerce and cross channel association in Cologne (EEC Köln) and time:matters, a provider of customized transport services, only about 3 % of all German online retailers offer same-day delivery, though one third of them could imagine offering it.

In principle, 40 % of German consumers would be willing to pay for same day delivery and 50 % of online consumers in Germany, France and Sweden say that they would be willing to pay approx. 10 % of the product’s value. The study also states that 70 % of German consumers would consider paying between € 3.50 and € 4.50 for same-day delivery. There is little expertise on the market potential of same-day delivery and any existing expertise is based on a McKinsey study that puts Germany second, behind Great Britain, in its

ranking of same-day delivery market potential in 2020. According to this study, the market potential is estimated at € 1 billion, mainly based on luxury goods, like fashion or electronics. However, the study also shows that many synergies between same-day delivery and convenience or fresh produce logistics can be leveraged since perishable goods or refrigerated goods will benefit from being delivered as fast as possible. Same-day delivery could gain an above-average market share, particularly in urban areas and could even replace, in part, conventional next-day delivery. Both local densities and demographic trends will create promising market conditions, while same-day services in suburban areas is still considered a challenge because of delivery time and effort. Therefore, in suburban and rural areas, same day delivery will still be the exception and not the rule, even by 2030. At the same time, same-day delivery can be viewed either as an opportunity or a threat to local retail businesses in urban areas. If online markets, supported by courier, express and package services, succeed in imitating the unique selling point „immediate availability,“ they might put pressure on local businesses. Before that happens, during the early stages of same-day delivery, local companies could establish their own delivery service, thus increasing the quality of the short distance supply line and make themselves more attractive. Sales will then stay local instead of being transacted in cyberspace.



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“ By 2020 a market potential of 15 – 20 % of B2C packages for same-day delivery is quite realistic. ”

Dr. Karl Pfaff, Director Sales Development,
General Logistics Systems Germany GmbH & Co. OHG



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Same-day delivery is a new phenomenon on the last mile. Its primary goal is to successfully transfer the pizza delivery service concept to any business sector. In general, same-day delivery is not suitable for traditional package services and would have to create new last mile routes short enough so that the promised delivery times can be met. Retailers will not only need storage space closer to the end customer, but also the ability to get a quick overview of their inventories, a cost-efficient method for compiling orders and the ability to proactively plan and forecast throughout the entire system. Same-day delivery also requires high flexibility when it comes to integrating last-minute orders into ongoing processes. There are several realistic options for retailers themselves. For example, they may either trust in the innovative thinking of the conventional courier, express and package delivery service (for example the cooperation between DPD and Tiramizoo), hire local courier services or establish their own fleets (Sainsbury and Tesco in Great Britain and Rewe/Billa in Austria). DHL is a good example of changes occurring in the courier, express and package delivery service industry. It offers two fixed delivery time windows (6 – 8 p.m. or 8 – 10 p.m.) for certain same-day regions (densely populated areas). Same-day shipments are delivered during these time windows, but only regular packages. Sensitive goods, such as those delivered by convenience and fresh produce logistics, will have to be delivered separately in the future. If same-day delivery can establish itself as a standardized mass product, warehouses will move closer to the end customer. This will make the costs worth it because they will be lower than with conventional package shipments because there will be no longer be a need for long distance transport between sorting facilities. However, what remains uncertain is whether the end customer will notice this benefit. Decentralization will reduce cost benefits in warehousing.

Sustainable Local Transport

Combustion engines and diesel engines, in particular, are the main producers of NOx and particulate matter (PM) emissions. Not only that, the use of fossil fuels in the transport industry is a major contributor to global greenhouse gas emissions. The debate on climate change often focuses on the regulatory requirements regarding environmental sustainability along the last mile. In contrast, this section of the study focuses first on the needs of consumers as the final decision-makers primarily at the point-of-sale, and not as political decision-makers at the ballot box. In other words, since customers pay more attention to environmental factors when buying products, they therefore expect that the delivery of their goods be just as “environmentally sustainable” (on the part of the retailer or the delivery service).

Logistics is often perceived as a source of irritation, especially on the last mile, either as a traffic obstacle or, increasingly, as a factor that has a negative impact on air quality and, thereby, quality of life. There is general consensus that air quality in cities has gone from acceptable to making people sick. This has caused environmental groups and local citizens to campaign for traffic restrictions on high-emission roads. Yet Germans have a somewhat ambivalent attitude toward nature and when it comes to logistics, they “want to have their cake and eat it too.” Consider these statistics: 93 % of Germans consider clean air a sign of unspoiled nature while one-third of the population feels close to nature and considers protecting the environment a personal concern. Also, while 21 % share a feeling of closeness to nature, they do not think that there is an urgent need to protect the environment. In fact, since the 80s, there has been less of a

willingness, mainly among those under age 35, to accept lifestyle restrictions that will benefit the environment. However, there are a few areas in which environmental protection trends have been identified, for example, detergents. Since the beginning of this century, European households have been changing over from doing their laundry in hot water to cold water. In Great Britain, the percentage of cold-water laundry rose from 2% to 21 % and, in the Netherlands, from 5% to 52 % in 2012. However, the reason for this change is not a rise in environmental awareness, rather the need to reduce energy costs. In U.S. households, roughly 3 % of their overall power consumption is used for hot-water laundry cycles. These figures demonstrate that there doesn't always have to be a conflict between environmental and economic objectives.

Other examples of an alignment between environmental and economic objectives include coffee or plants. Consumers accept markups of more than 10 % for these products if they are labeled fair trade goods or goods from organic growers (the “Fair Trade” seal coaxes 70 % of US Americans to pay 15 % more for coffee while the GEA label encourages the Dutch to accept a 30 % markup for plants). Nevertheless, consumers are very price sensitive in several sectors, for example meat prices. The organic meat market is still a small niche. Yet compared to such products, environmentally-sustainable logistics is a novelty. Though several package delivery service providers advertise the option of “CO2-neutral shipments,” they still deploy conventional transport vehicles for which they make compensation payments to environmental protection groups or projects.

Comprehensive zero local emission transport is currently found only when bicycles are used along the last mile. “Green package” delivery is still a niche. According to the sustainability report from DPDHL, the Deutsche Post DPL Group, a leading mail and logistics company, this shipping option represented only 4% of shipments. Meanwhile the company has made it a standard practice to provide CO2-neutral transport for packages sent by private people without charging additional fees. The group assumes that as early as 2020, roughly 30 % of end consumers will be willing to pay extra for “green packages”. Among consumers between the ages of 20 and 39, it's already two in five. Major corporate customers believe that by 2020 already 77 % will expect them to provide sustainable local transport options. According to the German Federal Environmental Agency and GfK, a major German market research company, the “green product” market is growing by more than 5 % per year. This is in line with the trend for 2030 that environmental awareness will continue to rise. However, whether consumers will be

willing to accept restrictions or to pay considerably more for “green services” has yet to be determined. From the consumer's perspective, it is up to logistics companies to make the next move while logistics companies believe that consumers first have to be willing to pay more for it and require the government to establish clear regulations or framework conditions at national level or, even better, at a European level.

The many stops and starts during deliveries are why the last mile causes a disproportionately high percentage of emissions. Equally high is the public pressure placed on logistics companies to make this part of the transport chain “green.” Traffic emissions are generated by the following four driving factors:

- Traffic volume along the last mile which is increasing at a disproportionately high rate
- The type of delivery truck or vehicle
- The specific energy consumption of the transport vehicle, i.e. the fuel consumed per mile or kilometer
- The volume of pollutant emissions per energy unit, i.e. the “cleanliness” of the energy used.

These four driving factors show the need for action that is emerging based on society's demand for environmentally-sustainable transport. Since consumption patterns in our society determine the transport volumes, last mile logistics has the following options:

- Shorten transport routes
- Use highly efficient delivery and transport vehicles
- Choose “clean energies” as the “fuel” for transport vehicles



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Preliminary Conclusions

What image of the pending future can be drawn based on the various end-customer trends? The answer to this question will determine how potential approaches to last mile logistics emerge.

First of all, existing studies and forecasts have not formed a uniform image, rather several diverse images of current customer requirements and their resulting changes in the economy and consumer behavior – and therefore also the last mile. With this in mind, the following working hypotheses should not be considered universal, but should simply help to typify developments in rural, urban and metropolitan areas by making fundamental statements on overall trends.

Rural areas

The appeal of urban and metropolitan areas has drawn many young professionals and their families away from rural areas. This has meant that the average age of people living in rural areas has rapidly risen along with a higher average number of people in one household (lower number of single households). Also in line with this migration away from rural areas is the rising number of quality conscious consumers who value robust, technologically mature products with long service lives that are easy to use. By 2030, the generation of consumers who have experienced the evolution of the home computer will be in their 50s and 60s, so that familiarity with digital technology and e-commerce can be assumed.

In addition, older consumers in rural areas will have more free time and a higher disposable income compared to young professionals with families. This means that they will not rely on same-day delivery and other online services as much. Potential delivery services provided by local supermarkets will therefore compete with a majority of residents who own their own cars and have little need of grocery deliveries compared to working profes-

“ We assume that B2C volumes will grow faster than B2B volumes. This will not only change the group of recipients, but also destinations. Because goods will be increasingly delivered in city centers, last mile delivery will become more difficult. [...] I imagine that logistics companies will have to rely on separate delivery systems for B2C and B2B. ”

Dr. Joachim Goller,
Vice President Strategy Overland,
Kuehne + Nagel

sionals in cities who do not own a car. That's why, in rural areas, the demand for convenience logistics will mainly be relevant for local or specialized retailers. Since the driving factor „food logistics“ is, in fact, no longer a factor and the expenses for fast deliveries in rural areas are considerably higher than in urban areas, same-day delivery does not hold a great deal of market potential. Lastly, longer delivery routes and distances in rural areas is just one more reason why consumers will not be interested in zero local emission delivery, especially since air pollution will not reach hazardous levels.



In conclusion, the transport volumes in rural areas are rising at a below-average rate. In fact, there is a greater demand for high-quality products; groceries and fresh produce logistics is therefore appealing only to local providers. Vehicles that deliver bulk goods and package delivery service providers must drive long distances with transparent shipping volumes which considerably increase last mile expenses in rural areas. Environmentally-friendly or green logistics are low priority concerns in rural areas.

Urban areas (small and mid-sized cities)

Mid-sized cities often grouped around larger metropolitan areas and used as bedroom communities by people working in metropolitan areas will experience exponential population growth in the near future. Families seeking a balance between good infrastructure and outdoor recreational opportunities are moving to such areas. Due to their proximity to



metropolitan areas, there are extensive networks of freight forwarders and courier services so that residents can also benefit from same-day delivery and fresh produce logistics. In contrast to large metropolises, cities with lower population densities create greater pressure on delivery success because there are fewer delivery alternatives (delivery to neighbors, mail stores or delivery to automated package storage station). Residents of smaller cities will demand environmentally sustainable delivery options as much as people living in metropolitan areas since their city is a place of rest and relaxation, which means clean air is an absolute must for a high quality of life.

In conclusion, the transport volume in mid-sized cities is growing at an average rate, consumer patterns are similar to those in metropolitan areas, but are mainly driven by families with little time for shopping. The demand for same-day delivery and environmentally-sustainable deliveries are the same as those in metropolitan areas, but for different reasons. Alternative delivery options are difficult and routes are longer which make last mile logistics more expensive.

Metropolitan areas

The dynamics of heavily populated metropolitan areas are the reason why the trends described here have a significant impact on the last mile. High population densities and numerous single households with little time for shopping are creating the perfect conditions for convenience and fresh produce logistics. In other words, metropolitan areas offer a strong market potential with short distances between cold storage warehouses and the end customers as well as numerous delivery alternatives. This also applies to same-day delivery,

which is considered particularly appropriate for grocery delivery. In the future, environmental restraints will increase in urban and metropolitan areas. In fact, the EU is already exerting pressure on several cities whose emissions values are exceeding contractually agreed limit values to make a serious effort to better protect the health of their residents. Stuttgart and Leipzig are just two examples to mention here, along with other cities facing similar problems, such as Graz and Bratislava. The pressure to take action by redesigning the last mile based not only on goods in demand but also for health reasons has reached an urgent level if looked at against the backdrop of decarbonization goals described in the White Paper.



In conclusion, transport volumes in metropolitan areas are growing at an above-average rate. Demographic changes are creating more young professional family households and single households in cities. These consumers will use grocery delivery services more frequently than in the past and will drive the same-day delivery trend, which will require goods to be available locally in order to shorten the last mile. This will require smaller distribution centers. These two factors will drive the growth of same-day delivery. Overloaded infrastructures will be faced with additional transport demands which will require creative solutions when it comes to delivering goods to the customer quickly while keeping emissions low.

B

GENERAL FRAMEWORK CONDITIONS

General Framework Conditions



Introduction

The last mile exists neither in a vacuum nor on the logistics planner's drawing board, but in, physically, highly heterogeneous environments in which the delivery destinations, addressees and recipients are all located. A distinction between private and commercial recipients clearly shows that even in areas which are presumably quite homogeneous, delivery conditions might be quite different. As a rule, most deliveries to commercial customers are made to industrial areas outside the city. Retail stores and businesses, however, need to be close to the customer and are located in city centers, which are not reached so easily. No two private customers are the same. Detached single-family homes in rural areas offer easy parking and maneuvering options which means that even cargo deliveries can go smoothly. Lack of space in preferred residential neighborhoods in metropolitan areas with restricted maneuvering options already makes reaching the delivery destination difficult. Furthermore, there is a significant difference between private and commercial customers concerning the time of day they can be reached. In contrast to private residences, companies have fixed business hours and staff to accept deliveries.

Accordingly, this study assumes that the surroundings along the last mile will define the game rules and design options that logistics must adhere to along the route to the end customer. There are other special factors that are linked with the geographic surroundings themselves, including infrastructure, traffic volumes but also delivery time frames and restricted access to low-emission zones. The availability of skilled workers is another essential factor in logistics because skilled workers are indispensable in last mile transport and delivery. This chapter will purposefully highlight the following trends that define the playing field of the last mile in terms of freedom to operate and the design options open to logistics companies:

- Change and renaissance in city centers
- Availability of skilled workers
- Clean air regulations
- Quiet logistics
- Requirements for a reliable last mile supply chain

The above-mentioned factors are already foreshadowing future developments. That is why they will first be characterized and ultimately blended with customer requirements to create an overall image of the desires and targets as well as opportunities and limits along the last mile. Last mile logistics companies must find the answers to these emerging challenges. The next step will be an analysis to determine whether specific innovations will provide solutions to these challenges and what impact this will have on the stakeholders of the last mile.



City Center Changes and Renaissance

Urban and metropolitan areas are popular residential areas and have therefore always been attractive to retailers, though, with the onset of the e-commerce revolution, they are facing a rising number of challenges. Brick-and-mortar retailers are responding to these challenges, especially in city centers where they can reach a high number of consumers with little effort and where convenience and a fast lifestyle dominate shopping behavior. As a marketplace, the city center is changing so fast that for certain trends, such as convenience shopping, the pace has further accelerated over the last 5 – 10 years.

We have identified three essential trends that will mark these years until 2030. The first is downsizing and population density. Only 5 % of all new stores opened between 2011 and 2012 were located in rural areas, while, in contrast, about 80 % opened in city centers. Even business sectors that normally flock to rural areas are trying to obtain retail space in city centers. Take IKEA as example. It opened the world's first IKEA franchise in a pedestrian zone in Hamburg-Altona. Bauhaus, an important German DIY chain opened a box store in the center of Stuttgart in 2015. In 2000, roughly half of all shopping centers were built in city centers, but by 2014, this number had risen to 78 %.

The food retail industry is expanding into related business sectors by opening urban convenience stores, small stores

covering a surface area of about 130 square meters in busy areas, such as near bus or metro stops or pedestrian zones. The REWE Group's new retail spin-off "REWE to go" offers freshly made food ready for immediate consumption. One of the advantages of this new business model is the fact that it is limited to about 1,500 different products. The Swiss co-operative association „Migros“ highlights this trend with its new convenient store concept. It targets young people on the go who don't have time to cook by offering a bit of comfort to their fast-paced lifestyle. With EDEKA's takeover of Spar Germany in 2005, the opening of the first REWE to go market in Cologne in 2011 and, more recently, the entry of Dutch Ahold Group („AH To Go“) into this market in 2012, this convenience store trend is rapidly gaining momentum.

The „Spar Express“ brand gives EDEKA access to its 13,000 JET gas station convenience stores. Because roughly 60 % of fuel station revenue is generated in the store, it is not surprising that Ahold has enjoyed a cooperative agreement with Shell since summer 2016 to increase its presence in Germany. Moreover, REWE is working on a special concept

“What we all want is a colorful city worth living in. Logistics ensures a broad range of available goods and thereby attractive city centers.”
Rainer Kiehl,
Project Manager,
City Logistics United Parcel Service Germany



for cities with 100,000 or more inhabitants, namely, its Rewe CITY markets. These are small stores with a surface areas ranging between 500 and 600 square meters, making them smaller than standard supermarkets and without offering the full product range. The idea is to improve local supplies through greater proximity, individuality and service. Here is where this trend overlaps with the next rising trend of upgrading the shopping experience. The CITY concept has intentionally moved from the suburbs into cities to offer shorter distances, consulting and other services. One example of how market upgrading works can be seen in a Lidl subsidiary in Berlin where several apartments were built on top of it to integrate the supermarket into the city landscape instead of continuing to build look-alike stores. In the non-food sector, the success of the shopping center shows that shopping at brick-and-mortar stores is increasingly viewed as a social event. Therefore, a conscious distinction is made between the impersonal online world and products that can be touched, face-to-face consulting and other services, the shopping ambience and various associated services, including delivery, installation and disposal of old products. Shopping centers are increasing their presence in city centers and are trying to rid themselves of their alleged faceless image. ECE, the operating company behind 136 German malls, sees the shopping mall as a „unique identity-forming destination of the respective city, which is in line with the goal of turning „shopping“ into a special event.

Yet not every upgrade effort can guarantee success. The German start-up "Emmas Enkel [Emma's Grandchild]," which is a reference to what the German's call a Tante Emma Laden [Aunt Emma shop] or small corner store from the last century, was founded in Duesseldorf in 2011. However, it was taken over by Metro in 2016 and has totally shifted to the world of online retail, so that all subsidiaries were closed. The

merging of the online and offline worlds is the third essential trend. The success of various e-commerce platforms is impressive. For example, between 2008 and 2016, total sales more than doubled from € 18.9 billion to € 43.3 billion. It is expected that sales will triple to € 60 billion by 2020, compared to the volume generated in 2008. It is not surprising

“The city with all its local retail branches is a gigantic warehouse for fast and efficient delivery – but many retailers have not noticed that yet.”

Nils Fischer,
CEO of „Liefery“
(German delivery company)

that brick-and-mortar retailers want to return to the good old days of strong sales and compete with exclusively online retailers by establishing online presences themselves.

Since 2014, local retailers in one city have joined together under the „atalanda“ platform to offer their products along with either same-day delivery or by click and collect. The platform itself provides active training and support to the local retailers in the design and display of their goods online. The initiative „Moenchengladbach at eBay“ uses a similar approach. Brick-and-mortar retailers are displayed on a



special subpage of E-Bay. Such brick-and-mortar stores can now enjoy greater visibility and yet another bonus, their online stores are always open. So even if consumers understand the store as a mere showroom, these retailers may succeed in diverting sales away from the online world. While the brick-and-mortar retailers are moving toward an online option, online retailers are becoming more interested in a physical presence in stores. Online retail giant Amazon plans to increase the number of its pop-up kiosks covering 30 – 50 square meters to about 100 locations in North American

shopping centers. Currently, the primary objective of these locations is to display its „prime“ video and music streaming services as well as Amazon’s own electronic products (Fire TV, Echo loudspeakers or Kindle devices) and boosting sales. Not only that, Amazon intends to return to its roots as a mail order bookstore by opening physical bookstores. This trend can also be seen in Germany where, in 2014, Zalando opened several stores, which it considers more of a pilot project and sales outlet for class B merchandise. Other retailers, like Cyperport, mymuesli and Notebooksbilliger are already operating numerous branch stores (for example in Munich, Berlin, Hamburg) to support their online presence. This clearly shows that online retailers are opening stores almost exclusively in urban and metropolitan areas. The Cologne Retail Research Institute (IFH Köln) assumes that the current number of stores, which is currently around 100, will rise to 2,500 by 2020.

What do all these trends in city center retail mean for the last mile? If the number of urban convenience stores operated by larger retailers rises, thus consolidating local supplies, it would also mean these stores will need fresh produce deliveries. Since they are quite small compared to conventional supermarkets and operate in line with the daily routines of their local customers and their food needs, each market will require several fresh produce deliveries a day. A study conducted by the Bochum Chamber of Industry and Commerce revealed that hybrid business models in online and offline retail increase distribution (+31 % of truck traffic by 2025) from and into the city. Since these markets are located close to heavily frequented areas, both getting there and goods delivery will be time-consuming and cost-intensive particularly compared to other last mile transport options. The trend of upgrading the shopping experience will impact the last mile only in that logistics services (for example assembling, installation, disposal of old products) will be in greater demand to create a particular shopping experience. Only if we go back to the old days when goods were not brought home by the purchasers, rather delivered by the retailer, will conditions become more favorable for same-day systems that will collect the goods in a city and deliver them within specific time windows in the evening. If stores in city centers are turned into showrooms with an online store, the impact will be almost the same. In both cases, however, the need for warehousing goods in high demand near the point of sale will grow since the last mile must be covered quickly. In metropolitan areas, there is already intense competition for retail space. Due to the low margins, logistics service providers cannot pay the high rent or lease for city center locations. Noteworthy is the fact that these trends in the food retail sector occur almost exclusively in big cities (see REWE’s



focus on cities with 100,000 inhabitants or more). Rural areas are looked at when planning retail chains because the concepts are designed to counteract the effects typical for urban environments. Bulk processing, standardization, de-individualization all mean a lack of service orientation. Even before online retailers rose to such prominence, the number of local retailers was falling in rural areas, but rose in the surrounding urban areas. When looking at the future, we foresee that growing online retail will exert pressure on the remaining brick-and-mortar retailers in rural areas and the volumes of goods to be delivered there.

Shortage of Skilled Workers

For several years now, the logistics industry in Germany and in other countries has been facing a growing shortage of skilled workers. However, one of the goals of this study is to focus on skilled workers active in last mile logistics. After all, they are also the “face” that the customer sees. Keep in mind that this shortage is also a problem upstream from the last mile, for example, in logistics centers and long distance transport.

Germany’s Federal Employment Agency assumes that it is solely demographic issues that explain the falling workforce numbers, especially the availability of skilled workers with a view to 2030. By 2025, the number of workers on the job market will drop 6.5 million, and 50 % of the population will be older than age 50. Accordingly, the logistics industry may have fewer potential last mile employees to tap into over the medium term. Currently, we have already seen that the logistics industry has lost roughly 60,000 drivers due to the economic crisis of 2008/2009. Moreover, we expect that about 200,000 drivers will have retired from the workforce by 2020. According to estimates, the number of drivers will further drop by 9,000 per year despite training opportunities. In addition to this shortage, the economic upswing and the German minimum wage act have put additional cost pressure on last mile logistics. According to studies conducted by the German Association of Commercial Transport and Logistics, wage costs in the local transport and delivery segment amount to 45 % of the total costs which makes it the biggest cost factor and the fastest-growing cost expense.

Both industrial and private customers are exerting consistently high cost pressures on logistics. This means any innovative last mile solutions, such as improved delivery services, will be welcomed by recipients, though they are only willing to pay so much more for this service. The last mile therefore operates under a high wage-driven cost pressure, which makes German freight forwarders employ drivers who are willing to accept moderate wages. About 13.7 % of logistics drivers are foreigners, which is above the average of 9.6 % in Germany. Foreign employees are definitely an important pillar of last mile logistics. According to findings from the German Federal Employment Agency, logistics is the second most popular industry to work in among refugees. However, the last mile is an industry that requires intense contact with the end customer. Job advertisements placed by courier services require not only that employees „enjoy meeting people,“ „physical strength,“ but also „a very good command of the German language.“ Training and eliminating language barriers are very important requirements in this business. Courier, express and package delivery service providers

have begun to address these issues. The German inter-trade organization BIEK is currently cooperating with the German Ministry of Traffic and Digital Infrastructure and with the Federal Employment Agency to establish a training program adapted to the special needs of migrants. Solving the dilemma of cost and quality will be one of the biggest challenges for last mile logistics up until 2030. Forecasts are being made that the shortage of professional drivers will rise to about 30,000 to 50,000 by 2020. This development is not limited to Germany. In the U.S. there was a shortage of roughly 200,000 drivers in 2011. By 2020, 1 million people will be needed to replace those heading into retirement.

Logistics companies are currently relying on specialized satellite navigation systems to use time and fuel as efficiently as possible along the last mile. UPS uses a special routing software to avoid as many left turns as possible on the last mile, thus minimizing stops at main roads and traffic lights. With a view toward 2030, the advancing deployment of digital technology and assistance systems will mean higher driver qualification requirements which will not ease the search for well-qualified and skilled drivers.

Worker availability is a factor that will increase cost pressures on service providers in last mile logistics. Even assuming the unrealistic scenario that the same things will have to be transported at the same quality and speed in 2030, it must also be assumed that an overall older workforce will have to perform these tasks – unless workers are recruited by offering them higher wages, which means last mile wage costs





will continue to rise considerably. In low-population areas where a lot of time and energy has to be invested in driving from one stop to the next, there is a rapidly growing incentive to try innovative solutions. Moreover, society's rising average age will be a challenge since the high work-related stress caused by last mile logistics, combined with aging, might have negative effects on health and productivity. The shrinking pool of qualified employees will encourage logistics companies to make every effort to keep experienced workers on as long as possible and to align physical strains required by the job to the employee's age. There is a need to increase technical productivity and ergonomics in existing solutions to keep workers satisfied in their jobs and in good health for a long time. Digitalization may provide opportunities, but the downside could certainly be the need to demand better qualifications from a small pool of employees. In the near future, shared economy phenomenon will raise the question of whether growing pressures on the last mile caused by a shortage of skilled workers (cost pressure in rural areas, time pressure in urban areas) could be compensated for by micro

jobbing or crowd sourcing the delivery of smaller shipments. The international success of Uber or Lyft shows that fundamental digitalization of the last mile may open the door for such options.

Clean Air Regulations

The debate on climate change, carcinogenic air pollutants and reduced life expectancy among city residents are driving society's demand to reduce traffic emissions by banning conventional fossil fuels (decarbonization). The climate conference held in Paris in 2015 defined the period between 2045 and 2050 as a target corridor for greenhouse gas neutrality. In the context of this study, we have assumed that

“ One of the biggest challenges and imperatives over the next few years will be the transformation toward more sustainable metropolitan logistics. Sustainable means cleaner and quieter! There is no magic formula to achieve this goal – but innovative ideas will be useful. There are already signs that logistics companies are thinking outside the box and coming up with innovative solutions! ”

Frank Horch,
Senator of Economics,
Traffic and Innovation
of the Free and Hanseatic
City of Hamburg

by 2030 a substantial percentage of the traffic volume along the last mile will be subject to more rigorous social and political control with regard to saving the environment and protecting human health. This means that also by 2030, last mile concepts and technologies that allow for environmentally-sustainable traffic must be visible.

Since January 1, 2005, particulate emission limits have been in place for all of the EU, allowing an annual average of 40 micrograms per cubic meter per day as well as a maximum of 50 micrograms per cubic meter in one day. The annual daily average must not be exceeded on more than 35 days a year. According to measurements from Germany's Federal Environmental Agency, these values are regularly exceeded in many German cities, not only in densely populated areas such as Berlin, Leipzig or Stuttgart, but also in mid-sized cities and towns such as Frankfurt an der Oder or Muehlhausen (Thuringia). This has caused the EU to initiate treaty violation proceedings against Germany regularly since 2009 to put pressure on Germany to take action. The situation is similar with nitrogen oxide emissions, whose threshold values were exceeded in Cologne, Bonn, Aachen, Duesseldorf, Essen, Gelsenkirchen and Frankfurt on Main in 2015. This caused organizations like the Deutsche Umwelthilfe (German Environmental Relief Association) to take legal action against several German states.

In 2011, as part of the international effort to drastically reduce greenhouse gas emissions worldwide and keep global warming levels below 2 °C, the EU issued a white paper entitled “Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system”. To achieve the end goal of reducing emissions in the EU by 80-95 % compared to 1990 levels by 2050 means that traffic emissions will have to be reduced by 60 % compared to 1990 levels or by 70 % compared to 2008 levels. Traffic emissions are currently about 10 % above the 1990 levels. Since logistics is the physical backbone of a sharing economy, artificially restricting the mobility of goods is not an option for the EU. Rather, efforts are being made to increase efficiency and distribute new technologies in the transport industry. With regard to the last mile, the EU has been very clear regarding urban and metropolitan areas: It essentially wants to achieve zero local emission city logistics by 2030. The Clean Air for



Europe or the CAFÉ initiative shows that the EU is taking action based on this white paper. The initiative's goal is to reduce air pollutants to levels that prevent sustained damage to humans and the environment. Shell's commercial vehicle study assumes that by 2040 the energy demand from trucks will decrease by about 13 % and emissions by about 20 %. Based on a study released by the research institute AVISO, the German Association of the Automotive Industry (VDA) expects that by 2020 fleets will be modernized to reduce nitrogen oxide emissions by about 17 %. When measured against the EU goal to reduce greenhouse gas emissions by about 80 % by 2050, the auto industry must develop clean and efficient alternatives to the diesel engine and that certain sections of the transport chain along the last mile must be completely reconfigured.

Actions to reduce or prevent air pollution have been noticeable in Europe for several years. These actions, in terms of both carrying them out and the public's perception, are coinciding with efforts by cities to reduce traffic volume. Take London's Congestion Charge, a city toll that drivers pay to drive their cars into London's city center. Since traffic problems have been an issue for city decision-makers longer than clean air regulation compliance, more than 500 European cities have imposed city entry restrictions, while only 200 of them have explicitly established low-emission zones. Cities such as Dortmund are setting an example with their fleets of electric vehicles and the ability to charge those vehicles with locally produced green energy to show that technology is available to provide clean energy (the „Metropol-E“ project was recognized by the German government as a milestone project in the field of mobility). Since 2008, London has been trying to keep the heaviest air-polluting transport vehicles out of the city. To this end, London has established clear rules which define the types of vehicles that are acceptable and those that aren't. Anyone wanting to drive into the city center in an environmentally non-conforming vehicle may still do so. However, drivers will have to pay a fee (depending on the vehicle type) between £100 and £200 per day. Those who enter illegally are penalized by having to pay five times that amount. In 2015, France initiated a similar approach by imposing special regulations for the beltway around Paris. Ambitious, clearly communicated and consistently enforced emission standards are considered success factors for achieving local environmental protection targets. Continuous video monitoring and automated license tag identification are already a standard nowadays (for example in Amsterdam and Lisbon). Against this backdrop, we can make the following statements about the future as we approach 2030:

- Last mile logistics companies will increasingly face low-emission zones with different local threshold values, rules, methods of enforcing these rules and fines.
- Certain vehicles (heavy-duty trucks, some mid-sized trucks) will not be allowed entry to cities or will have to pay expensive tolls to do so.
- Financial and non-financial incentives to make clean vehicles attractive will increase, including exempting electric vehicles from the congestion charge (London) or from parking fees. This is already the case in Norway. The city of Hamburg has had such regulations since 2015 and Dinslaken since 2016. Amsterdam has set up special truck maneuvering and unloading areas in the city.

Last mile logistics companies are not only facing the challenge of establishing clean supply chains in cities and densely populated areas. They also have to consider the individual regulations established by each city, which means there may be many different restrictions in just one region. Clean air initiatives are therefore making it increasingly difficult from not only a technological standpoint, but also in terms of last mile planning and design.



Quiet Logistics

A survey conducted by the German Federal Environmental Agency revealed that in 2012 roughly 54 % of the population was disturbed or troubled by road traffic in their residential areas. The European Commission estimates that the costs due to traffic noise are about € 40 billion and 90 % of it is caused by road traffic. For the populations, this means an increased health risk even with low continuous noise levels of 40 dB [A] at night. According to the World Health Organization (WHO), Western Europe's population is losing 61,000 "healthy" years of life due to cardiovascular disease caused by traffic noise. The EU therefore has explicitly integrated traffic noise into its environmental action program up to 2020 ("Living Well, Within the Limits of our Planet"). Members states are obligated to develop "strategic noise maps" and take action to protect EU citizens particularly in densely populated areas and near roads with heavy traffic volumes.

The concept of "quiet logistics" is considered an essential noise reduction factor since truck engines are noisier than car engines because they are bigger and more powerful. The goal of "quiet logistics" is to considerably reduce the noise emissions in commercial trucks, but also in logistics equipment to make deliveries in urban areas quieter and, thereby, healthier. This will allow logistics companies to work in more sensitive areas and at more sensitive times.

Deliveries made during off-peak hours or at night help reduce traffic volumes, thus offering numerous benefits along the last mile, ranging from less stop-and-go traffic, reduced delivery times and less time spent looking for a parking space. Using traffic infrastructure more efficiently will reduce fuel consumption significantly. In a day-night comparison under real conditions using conventional trucks, driving time

“Electric mobility is the foundation of night-time deliveries.” was reduced by one third and fuel consumption by one quarter on the 35 km route

from Tilburg to Eindhoven in the Netherlands. This demonstrates that the need "quiet logistics" will not only create restrictions but also offer a wide range of benefits.

Quiet logistics concepts have been around for a long time and are being applied all over the world (New York, Barcelona and Lyon). For example, in the Netherlands, there is a seal of quality (Piek certificate) for quiet logistics. Vehicles bearing this seal of quality may not be louder than 60 dB (A).



Only certified vehicles are allowed to make deliveries in the city centers during off-peak hours and at night. German lawmakers believe the Piek limits too high. Guideline limits for immissions in urban areas are 40 or 45 dB (A). Currently, these values can only be achieved if electric trucks are used, though there are still noise issues caused by loading and unloading, loud door slamming, the rolling of lift trucks and loading ramps.

Mandatory noise action plans have been developed in 71 metropolitan areas in Germany. They specify the necessary noise reduction actions based on the environmental noise directive of the EU. One preferred option is to create 30 km/h speed limit zones as well as imposing truck bans. Since clean air initiatives overlap with noise reduction actions, they have a similar impact on the last mile, which limits the options of logistics companies to the following:

- Reduce transport distances
- Use quieter vehicles and transport equipment (for example noise-dampened lift trucks)
- Make last mile employees more sensitive to noise issues

For some companies, the second bullet point means that currently available vehicles may be used for quiet logistics only to a limited degree since their noise emission levels are above the established noise thresholds.

B⁵

Requirements for a Safe Supply Chain

Safety, which is generally understood as protecting people and things from damaging external influences, has traditionally played an important role in road traffic. Within the framework of this study, however, we will define safety as the safeguarding of the physical integrity of all people and things located along the last mile. This includes traffic safety issues, but also the question of how can goods be delivered to the destination without being damaged.

Due to ambitious goals and actions, the number of road fatalities in the EU dropped in 2014 by 30% compared to 1991 and the total number of accidents by 25%. This means that in the entire EU, roughly 26,000 people died in about 1 million traffic accidents. In the last few years, the number of traffic accidents and injuries have stagnated in both Germany and Europe. Some statisticians, however, are assuming that this trend will change and that the number of accidents will rise. Demographic shifts have also been identified in the statistics. For example, one in six people who died in a traffic accident in 1991 was age 65 or older, in 2015, it was one in three. EU-wide, Germany ranks in the top third of countries with the safest traffic record, if you look at the number of road fatalities in relation to the total population. The most depressing result seen in these statistics by far is that the highest number of fatal traffic accidents, at 40%, occurs in urban areas. With this in mind, cities like Augsburg, Cologne or Sydney have striven to address the rapidly rising number of fatal accidents caused by careless mobile phone users by installing traffic lights at ground level. In Sydney, the number of such lights doubled between 2014 and 2015.



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As we look toward 2030, the number of electric vehicles on the road can be expected to increase substantially. Daimler is forecasting that electric cars sold in 2025 will have 15 – 25 % market share of the total number of cars sold. Based on comprehensive studies conducted in 2009 and 2011, the National Highway Traffic Safety Administration (NHTSA) concluded that precisely this form of modern mobility will double the risk of traffic accidents, particularly for pedestrians and bicycle riders in urban areas, because electric vehicles travel at lower speeds and cannot be heard compared to conventional vehicles. The German Federal Highway Research Institute is more reserved due to the low market penetration of alternative drive systems, but does expect a continued dynamic increase, particularly with hybrid vehicles. In April 2014, the EU Parliament therefore passed a resolution that particularly quiet electric vehicles will be equipped with special acoustic signals (“artificial engine noise”) to make them safer.

The subject of safety is just as extensive as the number of factors that influence the last mile. Safety affects every aspect of the last mile, whether it is the qualifications of logistics workers, who must have official driving licenses and, in the future, maybe even a drone or robot license, or the infrastructure, which must permit safe transport. To increase safety standards, transport vehicles will soon have to meet the “safe by design” requirement because it can be assumed that there will soon be more diverse transport options (not just traditional delivery vans and trucks) along the last mile that the general population is not expecting and is unaware of. Accordingly, when faced with spontaneously combusting batteries, for example, the increasing use of electric vehicles will raise several questions for the police and fire departments. For example, how can a self-driving transport vehicle on fire be safely stopped, how can the fire be safely extinguished and are flocks of delivery drones desirable? The goods to be transported will also have to be protected and may not become a potential danger along the last mile. The increase in convenience and fresh produce logistics will bring more hazardous goods to the last mile since frozen carbon dioxide (dry ice) is frequently used for refrigeration.

B⁶

GENERAL FRAMEWORK CONDITIONS

Preliminary Conclusions

The framework conditions along the last mile are becoming tougher for logistics companies. The shortage of skilled workers that is already being felt and will only increase in the future is already causing an increase in the cost of labor, which, in turn, raises the cost of delivery. If delivery companies intend to meet this challenge through innovative technologies, this may require higher driver qualifications as a next step, for example to operate the new digital technology or as a “conductor” for a range of autonomous auxiliary vehicles.

The falling number of skilled workers and an aging workforce in this society will create problems, especially for last mile logistics companies because of the industry’s physically demanding work. Logistics jobs must be made more appealing to attract young and recruit physically healthy workers. These requirements will, in turn, drive qualification requirements and also labor costs.

Clean air regulations are also resulting in higher costs, but, and even more importantly, are exerting pressure on companies to develop more efficient and cleaner delivery concepts in urban and metropolitan areas. This is necessary especially since these areas are increasingly restricting access to delivery vehicles or charging fees for the “license to pollute” or prioritizing delivery based on the vehicle’s emission levels. In social terms, we have to ask whether air pollution as a whole should be reduced or whether the problem will shift from densely populated areas to the outlying rural areas which have not been affected by it yet.

Similarly, quiet logistics is forcing last mile service providers to offer innovative delivery concepts, whereby deliveries to less densely populated areas will represent a major challenge. This is because the demand and stress levels in these areas are lower and the technological challenges higher than in densely populated areas. That is why quiet logistics will focus on medium-sized and big cities. The need to employ skilled workers outside normal business hours will create additional challenges due to the high labor costs in this industry. This, combined with demographic change, could require quiet logistics concepts to be developed that will reduce the human factor or at least make it less physically demanding.

Simplistic solutions to these demographic problems could boomerang when it comes to guaranteeing a safe supply chain. If less-skilled or less-experienced workers are employed in higher numbers in response to the burden of high labor costs, there is a risk that safety standards will knowing-



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ly or unknowingly be neglected. There is an urgent need for further training if the worker shortage is to be covered by training new workers from other industries or professions. The use of modern driver assistance systems (brake/evasive maneuvering/maneuvering assistance systems) will certainly provide relief by 2030. However, both existing and new drivers must be trained how to best use these assistance systems in the classroom and out on the road.

The rules of the last mile will raise qualification levels and labor costs in particular. Since the logistics industry will continue to experience intense cost pressures even up to 2030, the only way out is to improve productivity on the last mile.

The next chapter closely examines current trends in technology to find out whether and under what conditions they can better meet customer requirements, while also keeping in mind the rise in planning complexity, costs and environmental protection requirements.

“

The city is the place where the analogous effects of digital actions occur.”

Kerstin Gross,
Head of the Division of Industry, Energy, Transport, Environment
of the Chamber of Industry and Commerce of the Central Ruhr

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PRINT SHOP 3D



Trends in Technology

TRENDS IN TECHNOLOGY



Introduction

The previous chapters described trends that are significant for last mile logistics in two ways. First, the end customer or the recipient of goods has an essential impact on the destination of that last mile transport. Secondly different trends will alter the framework conditions and thereby the options for shaping last mile traffic flows. Logistics companies will have to effectively meet the demands not only of the goods recipients but also comply with the changing requirements. Diverse trends (from the recipients' perspective and in terms of framework conditions) will place greater economic pressure on logistics service providers. The option of these providers to pass this pressure on to their clients and, in turn, the goods recipients, in the form of higher prices or surcharges have been and still are limited. However, if consumers do not have a change of heart and become willing to pay more for these services in the next years, the last mile will face the following conflict of interests:

- Improved logistics performance quality, i.e. higher-quality services demanded by customers/recipients while taking challenging general framework conditions into account, which will make planning and implementing last mile transports more complicated.
- Few options to pass on, at a 1:1 ratio, the costs incurred to produce higher-quality services due to higher prices.



The only option for last mile logistics to handle the foreseeable cost increases caused by tougher framework conditions and more demanding customer requirements is technical innovation. Such innovation is necessary from a technological perspective in order to reduce hazardous fossil fuel and noise emissions and to improve productivity to respond to cost increases. For this reason, this chapter will explore different technical advancements which will be ready to launch on the market in the near future and whose special relevance for the last mile is anticipated, especially with a view to 2030:

- Advancing digitalization
- The Internet of Things
- The increasing spread of 3D printing or additive manufacturing
- The use of drones
- The use of automated delivery robots
- Battery-powered electric delivery vehicles
- Self-driving or autonomous delivery vehicles

Digitalization

Digitalization is a technological and social process that describes the continuously growing network that links all business and industries, cities, infrastructure and private people together. Players along the logistics chain use digitalization and the links between systems, data and services to different degrees, but it affects them all.

Digitalization is a prerequisite for innovative approaches and technologies, including Big Data, Industry 4.0 or Augmented Reality. The digitalization process has just begun, but by 2030, it will be fully integrated as the Internet of Things into everyday life and business operations. As sharing relationships intensify between growing numbers of companies and private people to become more complex systems, digital efficiency in information sharing will be a must. Currently, 20 billion computer devices can communicate via the Internet. By 2030, more than 500 billion networked objects, machines and sensors will send and receive data in cities, factories, vehicles or packages. Those who can filter these volumes of data and benefit from it, will also benefit from digitalization. There is a shortage of 43,000 IT specialists in Germany who are needed to drive the digitalization process. This shortage is having a particularly severe impact on medium-sized logistics companies because medium-sized companies are the latecomers to digitalization. They often have their own Internet presence, but the use of big data or cloud computing is a low priority.

Digitalization via mobile data communication, open interfaces, universal process transparency, shipment tracking and proactive customer information is reflected in new and more customized services along the last mile. Additionally, more in-depth data collection along the last mile enables all suppliers involved to make better decisions regarding existing processes, especially in scheduling, tours and route planning but also in terms of their network structures, for example, finding better locations for distribution centers. More finely resolved time and place data as well as more comprehensive order data volumes will enable proactive logistics and enable suppliers to alleviate time pressure along the last mile. Urban and metropolitan areas will benefit in particular.

Amazon, for example, is already pursuing the use of what is called anticipatory logistics to forecast customer orders in densely populated areas and initiate the logistics process before the order is even placed. This will reduce response periods and also storage and transport costs. In turn, such an

approach will then reduce the still high cost of same-day delivery, thus lessen the benefit off immediate availability of goods offered by brick-and-mortar retailers. The Amazon Treasure Truck that drives around Seattle demonstrates how the company is putting pressure on brick-and-mortar retailers. Digital communication technology (Apps on smart phones, vehicle dispatch) will continuously link statistical findings based on customer preferences as well as personal and geographic data. The vehicle transporting the goods for future orders will go to the very location where the relevant customer is assumed to be. And customers living within the truck's range will be selectively targeted by a smart phone app.

If digitalization creates data pools for logistics suppliers as well as dispatchers and recipients, this targeted cooperation may increase efficiency. When it comes to supplying commercial retailers, such cooperation could help prevent inefficient jams on the loading ramps. The sensor technology required is not so complex but both sides would have to coop-



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erate on implementation and agree on the information interfaces. Looking at the Amazon concept from an industrial point of view, digitalization of the last mile offers valuable insights into delivery reliability and efficient lead times. Even simple digital technology along the supply chain can considerably support order dispatching in both industry and retail, thus allowing shipments to be consolidated and warehouse inventories to be reduced. Retail in urban and metropolitan areas will particularly benefit from reduced inventories because the less space needed for storage means more space for retail.

An increase in spontaneous orders and a decrease in storage area in city centers will also mean more frequent deliveries with smaller vehicles from the outside urban areas.

The vision of the smart city where all information on city infrastructure, players and events are integrated into a digital map of the city will help improve last mile routing and package delivery. Sensor technology will be critical for this because sensors provide precise information on current weather conditions, free parking areas, road conditions and traffic and, if desired, exact position information can also be transmitted. One example is the planned city Songdo in South Korea near Seoul where a digital network of education, safety, transport, healthcare, parking and building automation has been created in cooperation with technology companies. The entire city was planned right from the start using smart design.

Such a planned city will not be built in Germany. This country requires smarter design in the existing infrastructure. In a metropolitan area like Berlin with almost 3,400 miles of public roads, 2,000 traffic lights and more than 95,000 public parking spaces in use, this means considerable financial costs. Germany's metropolitan areas would benefit more from better knowledge regarding stress on infrastructure and active traffic flow control since each driver must calculate that every trip will take about 30 % more time during peak hours. Many stationary sensors already exist in Germany's road network and collect important traffic data. Digitalization enables data to be collected more intelligently. Car-to-x technology, which refers to the data sharing between vehicle and infrastructure, is already used for recording traffic flows or for updating navigation data. Only a few vehicles are equipped with this technology and there are many restrictions on its lawful use.

The use of data on the movement of vehicles and people is possible from a technological perspective, but very critical in terms of data privacy. The willingness of consumers to disclose personal data must go hand in hand with the use of new services by consumers. If the logistics service provider knows the recipients' whereabouts or even the future points they pass on their route, delivery can be carried at the desired time and at the desired location. Long delivery distances in rural areas will not be driven unless the recipient is actually at the delivery address. As an alternative, goods could be delivered to the workplace or placed in the trunk of a car. A 100% delivery rate can be achieved by 2030.

New transparency also holds risk for logistics companies because it will be easier for consumers to compare prices and services. Logistics companies will increasingly try to keep their customers by using their own logistics apps to display the delivery status and to allow deliveries to be rerouted. Digitalization will lead data-based services and logistics services to merge into one unit that is available to the end customer.

Data transparency will create new competition along the last mile. In Germany, there are still legal restrictions, but U.S. and Swiss logistics companies have developed platforms that have opened up goods transport by private people as a new business segment in the gig economy. There is a kind of market exchange that connects those buying and those offering services. Private parties offering package transport services can advertise price discounts of 80 % compared to professional delivery providers. Due to high traffic, such private services could drastically reduce price and delivery times especially in urban areas. Private people on their daily commutes will function as couriers and deliver packages on the same day on their direct route.

However, digitalization has raised questions that have not yet been answered. Who is the owner of the data? Who is allowed to use the data, and at what time and in what way may it be used? Who is responsible for data safety and privacy? Cities, especially, are experiencing a conflict of interest between an urgent need to improve efficiency in the traffic sector and the monitoring of public space. The fear of passing sensitive data to competitors often hinders cooperation along the last mile that would make sense from a social or environmental perspective.



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The Internet of Things

Compared to the Internet for people, the Internet of Things connects many technical devices such as vehicles, loading equipment and goods to one another. The appropriate sensors (RFID, QR codes) or microcomputers installed on or in these devices can read their status (such as filling level, temperature, location), transmit and analyze the status, which, in turn, creates benefits. One example is package tracking which involves recording the time that a package passes through each station along the delivery chain, thus tracking the package en route from start to recipient.

The Internet of Things supplies a great deal of useful information for the last mile because it connects vehicles with their surroundings. The more information stationary sensors on roads and mobile sensors in the vehicles share, the better the image will be of actual traffic volumes that can be created by using appropriate analysis methods. This enables traffic flow to be redirected around roads experiencing heavy traffic volumes or road blocks which can minimize delivery delays. Such data from the Internet of Things help logistics providers to dynamically change delivery routes and inform the recipient of the up-to-date delivery status. Drivers who go to check mail or package drop boxes are informed by the Internet of Things if the mailbox is empty or if there are

packages in the drop. This information is gathered by a sensor in the mail or drop box. If there are no letters or packages, the driver will not have to stop and can continue on to the next collection point. This example shows how digital technology can rethink the signal flag principle used in U.S. mailboxes to improve delivery efficiency.

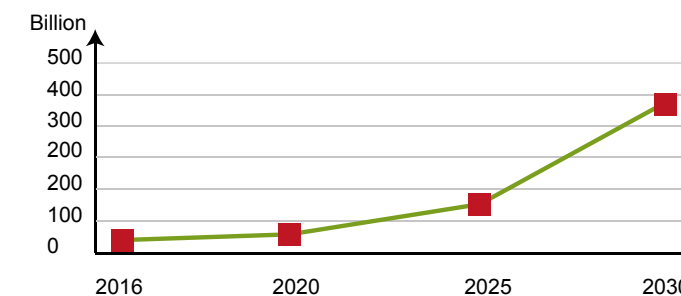
The German logistics provider DHL expects that 50 billion computer devices will be connected to the Internet by 2020. The Internet of Things will significantly encourage the self-monitoring of devices and in just five years smart objects will play an active role in self-monitoring logistics networks. Other technologies such as autonomous driving and digitalization will benefit from the opportunities provided by the Internet of Things and its further expansion.

The advancing miniaturization of computers and the further development of sensor technology are encouraging the use of the Internet of Things along the last mile. However, data privacy issues still have to be resolved and efforts made to prevent abuse.

The Internet of Things supports the general customer desire to receive the necessary goods any time or at least as quickly as possible. Sensors enable automatic refilling messages to

be transmitted whenever the store item is about to run out. This means that there is always a sufficient warehouse supply and guarantees the same-day delivery of these items from warehouses near the customer.

Temperature-measuring sensors installed on the goods to be delivered will enable the end customer to monitor whether the required minimum or maximum temperature limits have been permanently adhered to en route to the customer. This application of the Internet of Things is useful for both fresh produce and pharmaceutical products. With the right package sensors, the contents can be classified, for example if the package contains fragile goods or not. The delivery driver will then know that this package must be handled with care without explicitly knowing its contents. This will improve the quality of both the delivery and collection service along the last mile.



Worldwide number of computer devices connected to the Internet

Using the Internet of Things for autonomous driving indirectly solves the problem of a driver shortage. The better the self-monitoring of goods and vehicles can be technologically planned and implemented, the less the need for qualified drivers to transport goods.

When it comes to security issues, data privacy is important for the Internet of Things and must be guaranteed – and not only along the last mile. When people use the Internet in the conventional sense, i.e. through a computer, they are responsible for updating their data privacy and data protection software. Users also update security software themselves from time to time to protect their computer against malware and misuse from the Internet. In the Internet of Things, so many computer devices are involved that most times no one

feels particularly responsible for protecting these devices or no one is able to protect the device because there is no user interface. The older the devices are, the greater the risk is that their obsolete firmware will enable unwanted access and become a security hazard, for example as part of a botnet that is misused for denial-of-service attacks.

Since the Internet of Things is a technological innovation with many possible applications that support the use of other technologies such as autonomous driving functions, it is having an intense impact, in its own right, on both urban and rural areas. The indirect effects have been described along with those technologies that benefit from it and will not be repeated here.



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3D Printing

3D printing involves the use of a special printer that produces three-dimensional parts made primarily of plastic materials, ceramics or metal and is based on designs generated by computer-aided design software. Since it is a step-by-step production process that adds layer upon layer, it is often referred to as additive manufacturing. 3D printing is a relatively young technology that has greatly advanced in the last few years, particularly regarding the materials to be processed, different materials used to manufacture one product and the complexity of the parts to be manufactured. The advantage over conventional manufacturing is that almost the only material for the part being manufactured is needed, which reduces waste considerably. 3D printing is not only ideal for manufacturing individual parts such as prototypes and spare parts, but is also being increasingly used in volume-production. While this technology was initially used only in industry and research, the first 3D printers for private use have been introduced, though their performance capacity is still quite low.



The market research company IDC estimates that between 2016 and 2020 global expenses for 3D printing will double from US\$ 17.7 to US\$ 35.4 billion. Germany is the world's leader in the use of 3D printing. The automotive industry is using it increasingly for rapid prototyping in development and for producing spare parts.

3D printing will not only impact logistics as a whole but also along the last mile because it means that the process of producing goods is no longer tied to brick-and-mortar factories. Now, parts can be manufactured almost anywhere and in close proximity to the end customer. The impact of 3D

printing on logistics could be compared to how e-mail affected postal mail, which plummeted once e-mail became more widespread.

There are several forms of production shifts that will be relevant for the last mile. The manufacturer will no longer concentrate production at one or a few locations, but at many subsidiaries that will no longer require expensive production facilities, rather just powerful 3D printers. This, in turn, will considerably reduce transport distances between the production site and the end customer. Also, major sections of the main production line will not be required or the main line will be done away with completely. Another potential scenario with a similar impact is that the logistics service provider could take over the production process from the actual manufacturer. 3D printing contracts would be concluded at the logistics provider's subsidiaries nearest the customer. This would shorten delivery times considerably because the distance from the production site to the end customer will also be reduced and, strictly speaking, consists only of the last mile. This service already exists for document mailing.

There are two other potential ways to shift production where 3D printing would have a huge impact on the finished product. If businesses were able to produce end products themselves by concluding contracts with goods manufacturers that legally allow their products to be 3D printed, the customer could manufacture the product "on demand" at the logistics provider's subsidiary and take it with him. The last mile, previously organized by a service provider, would no longer be necessary in this scenario since the customer manufactures the object himself. The fourth and most extreme form of shifting production is to do away with the last mile completely. The customer will simply be able to print the desired product at home on his own 3D printer after buying the print files he needs from the manufacturer.

This last or fourth form of shifting production represents a distant future, but considering how quickly 3D technology is advancing, a high number of consumer goods will probably be manufactured using this technology in the 2020s. By then 3D printers may be affordable for private households. Two-dimensional paper printers went through a similar evolution. Technological progress made them smaller and more efficient. When initially launched, there were only black-and-white printers for commercial use; now color printers in people's homes are nothing new.

However, the last mile will not completely disappear due to products being manufactured by means of commercial or

private 3D printing capacities. While it may no longer be necessary for the final end product, the last mile will still be needed for the raw materials required for 3D printing. In the past, when a customer ordered a household appliance, for example, he received only one shipment. In the future, 3D printing could require several shipments since several raw materials will be needed which may have to be ordered from different manufacturers. We cannot currently predict whether 3D printing will be done extensively by the end customer. A conventional printer needs paper and a color print cartridge to print documents, drawings and photos. 3D printing will require many different raw materials, many of which may not be able to be stored in homes, so the jury is still out on whether this new technology will be appropriate for private use.

It will not be possible to transfer production to logistics companies, retailers or the end customer if they do not have the raw materials required or if they cannot access the print file. To make this happen, agreements must be concluded between the manufacturer and the owner of the 3D printer. Such agreements will require prior price negotiations and

must also address copyright and intellectual property ownership issues.

Same-day delivery by means of 3D printing may meet the end customer's goal of obtaining the desired product as quickly as possible if said end customer owns a 3D printer, if the product is appropriate for 3D printing and the end customer actually has the required raw materials. In this case, the finished product would not have to be delivered by road. This would benefit the environment, reduce traffic noise and also get around the problem of the shortage in skilled workers. Yet raw materials must somehow be delivered to the end customer, otherwise he or she will not be able to use the 3D printer. Local transport and delivery needs will only be reduced if such materials are seldom ordered and when ordered, then in higher quantities. One area where this approach could be successfully implemented is prosthetics. Dentists and orthopedists are already using 3D printing and it is having a massive impact on the last mile because the demand for express package delivery to transport dentures is falling and soon they won't be needed at all. The only items that will have to



be delivered are the raw materials for 3D printing, and, for dentistry and prosthetics, these can be purchased in bulk.

City businesses would reap the rewards if local companies offered 3D printing services. It would be an incentive for end customers without 3D printers to go to the city. By purposefully integrating the customer into product design and making 3D printing more visible, shopping can be transformed into an educational experience. The 3D printers required for this will not be sufficiently available for private use nor will they be affordable for consumers to buy themselves. Brick-and-mortar retailers will therefore still be able to draw in customers.

If 3D printing evolves the way paper printers did in their time and if many consumers own 3D printers by 2030, there will be no considerable distinction between urban and rural regions



in this scenario. Ultimately, paper printers and e-mail used in private homes became ubiquitous not only in urban but also rural areas. Currently, there is no reason why this might be different with 3D printing. Similarly, spare parts delivery would still be needed everywhere. The broad spread of 3D printing would mean a dramatic reduction, or at least consolidation, of last mile transport volumes particularly in rural areas. On-demand, on-site production would not depend on the timely availability of raw materials, so that in terms of transport, orders could be pooled to increase efficiency and reduce transport costs. In an extreme scenario, the supply of consumer goods would then depend only on the availability of 3D printing services, and even in rural regions, the quality of supply services would be almost as high as in metropolitan areas.

On the other hand, if 3D printing does not become available to consumers nationwide in a few decades and production is transferred only to the service providers or retailers, it will mainly impact medium-sized and bigger cities. Larger retailers would then be the ones to make this technology available to the consumer and there are not many large retailers located in rural areas.

Transport Drones

A transport drone is defined as an unmanned aerial vehicle or aircraft system used for delivery purposes. Rooted in the word “helicopter”, the term “copter” is another common name for it. A numeric prefix is sometimes added to indicate its number of rotors, e.g. quadcopter for a drone with four rotors. DHL selected a German portmanteau term that is translated as “parcelcopter” in English. This word was created to show that the group’s drones have been developed to transport parcels and packages. Drones are either controlled manually by an operator on the ground or partially or fully autonomously by a computer system.

The idea of using unmanned aerial vehicles for transport in logistics dates back to the early 20th century when there was much excitement, particularly in mountainous regions, about the idea of “mail rockets.” These experiments ended in the 1970s after several accidents during public demonstrations

“ Transport drones have the potential to be a last mile transport tool for regions with low population density in the future. This will require, however, that legal and safety aspects are taken into consideration. ”

Prof. Dr. Wilfried Sihm,
Director of Fraunhofer Austria

and increasing safety concerns. Two decades later, biologists were the first to develop unmanned aerial vehicles to

observe wild animals. Around 2000, government security agencies further improved the design. When NASA engineers successfully tested the drone as a transport vehicle in 2010, logistics companies became interested.

Today’s transport drones use an electric drive system, i.e. they are equipped with a rechargeable battery pack for power supply and electric motors for the rotors. Drones used for commercial purposes typically have eight rotors. This redundant design prevents failure. The maximum distance between the pilot and drones is not much more than 100 meters and not greater than 1 - 2 kilometers for manually controlled models. However, autonomous drones such as the DHL “parcelcopter” have shown in initial tests that they can fly distances of several kilometers away from their base station. Speeds ranging from 30 to 50 km/h are considered standard. Special racing models reach speeds of 100 km/h or more. Current standard flight times are about half an hour carrying payloads weighing between 0.5 and 2.5 kg. One particular disadvantage is that they consume a lot of power during flight compared to overland transport. Even if battery power is able to double by 2020, it still means that the drone’s flying range will be quite limited and that a base station must be nearby



for recharging.

So far, there has been no distinct field of application for transport drones along the last mile. While Amazon experiments with the express delivery of packages weighing roughly 2.5 kg to destinations near its logistics centers, DHL is showing that express goods such as medications can be transported to difficult-to-access areas such as the North Sea islands or mountain pastures. It is therefore not surprising that the Amazon drones (Amazon Prime Air) and DHL drones (parcelcopter) have different designs and features.

The Amazon drone has a maximum range of 15 kilometers and reaches an average speed of 30 km/h in the estimated flight time. The DHL parcelcopter has covered similar ranges in test flights but reaches speeds of 70 km/h, which is more than twice the speed of the Amazon drone. This maximum speed is just slightly lower than racing drone speed. Both types are designed for a payload of about 2 kg.

By 2030, drones will generally be able to deliver goods over short distances cost-efficiently and with zero local emission and, for technological reasons, focus on extremely urgent express deliveries for packages weighing 2 - 5 kg. Drones are yet another way for logistics companies to bypass busy roads and traffic in metropolitan areas. If there is no infrastructure at all, for example, in the mountains, on islands, outdoor locations like construction sites, or even large sporting or cultural event venues (Olympic Games, church, etc.), the use of drones will create a new last mile for which no transport vehicle has ever existed in the past. Drones are the ideal solution for such exceptional situations. Experts and decision-makers from major logistics companies, however, doubt that mail and mass goods will be able to be delivered to urban areas solely by drones in the near future.

The “Mercedes Vision Van” was unveiled in 2016. It is a delivery vehicle with a drone platform on its roof and was designed to enhance and not replace current transport vehicles. It would enable a traditional freight forwarder to replace the need for the driver to climb stairs or expend physical effort with drone delivery (of a meal, a document or a classic package) to the recipient’s balcony in urban areas. UPS, for example, considers the use of drones as part of their delivery service in rural areas as an added value. Drone operators can launch drones carrying a few small goods directly from a vehicle and do not have to leave the main street. This would mean a considerable increase in the efficiency of small package delivery in rural areas. According to Amazon, 90 % of shipments would be drone compatible in weight. It remains to be seen whether this will also apply to overland transport of goods by 2030. There are currently very few solid market potential estimates regarding drone use. One well-known estimate from the consulting firm Ark-Invest regarding Amazon drones, for example, estimates delivery costs of less than one Euro per package as well as a drone transport volume of 400 million packages annually, which would equal approx. 25 % of all packages shipped to private recipients in Germany in 2016.

The advantage of the drone lies in that they require no infrastructure and can bypass all obstacles. Drone delivery may make sense in surroundings with little or no infrastructure, if a certain range is not exceeded and if the low-weight payload is taken into consideration. Extremely urgent orders and infrastructures that are chronically bottlenecked or only allow limited use will encourage the deployment of drones. However, there are numerous reasons why drones are not in use currently and will remain so until 2030. These include:

- Since they are aerial vehicles, drones must comply with aviation laws. Commercial drone users, in last mile logistics, for example, will have to launch permits. Additionally, drones may not leave the operator’s range of vision. Furthermore, their range is much more restricted than generally expected. Besides obvious examples like the Government district in Berlin or airports, there are various sensitive areas that drones may not pass over.
- Drones are a potential hazard to humans and animals since they might not only use payloads but may also crash due to unpredictable events (e.g. bird collision). Frederick W. Smith, CEO of FedEx and a highly experienced helicopter pilot personally, categorically rejects the deployment of drones along the last mile. There is quite a high risk due to



the fact that drones use GPS signals for navigation. As early as 2012, scientists from the University of Texas succeeded in intentionally creating an interfering signal and proved that they could have either stolen the payload, destroyed the drone without any effort or used it as a weapon.

The shared vision of UPS and Mercedes for a package transport vehicle that carries drones piggyback for more efficient delivery seems to be a potential response to the specific cost pressure along the last mile in rural areas. But the real question is why a drone with limited payload and range should be critical for transport in rural areas. Expectations that demographic factors in rural areas will shift e-commerce more in the direction of premium convenience goods seem to contradict the wisdom of drone deployment in these areas. If drones were deployed despite the above-mentioned factors (e.g. in mail delivery), compliance with safety regulations would be easier in rural areas because of lower population densities.

From a technological perspective, it is realistic to imagine that by 2030 areas with increasing urbanization will see drones flying express goods to the recipient either directly from a distribution center in the city or from a mobile delivery vehicle. We have no experience to draw on as to how governmental authorities and the public will react if a logistics company were to place several hundred drones in densely populated areas. It can be assumed that illegal activities regarding aerospace and personal safety will not be tolerated. UPS therefore expects that drones in metropolitan areas will, instead, cover the mile before the last mile and establish fixed routes between sorting facilities and post and package stores. Special point-to-point connections to commercial recipients with a strong interest in express document delivery is also an option. Such recipients might include financial service providers, some of whom have their own helicopter landing pads installed on the roofs of high-rises. In medium-sized and big cities with sufficient demand for express delivery of premium convenience goods, drones could transport small purchases in boxes with passive cooling directly to the place of use. The dense network of supermarkets and convenience markets would then have a unique selling point compared to online retailers (“have an Angus steak delivered

directly to the barbecue in your yard in only 20 minutes”). Strong city-wide demand would raise questions on how to secure the transport chain. If such “high value transports” regularly occur in certain areas, selective attacks on such transports are to be expected. Such business models would therefore have to offer special security protections.

Metropolitan and urban areas have been identified as ideal environments for industrialized same-day delivery. This might be sufficient reason to assume that drones would be the perfect support for same-day delivery. In fact, current plans for a streamlined same-day delivery instead aim to use traditional package transport vehicles for volume delivery during late afternoons or in the evening. Such a system would leverage economies of scale and economies of scope for cost-efficient express deliveries of large volumes of packages over large areas. A drone system would have to act as a shuttle service, collecting each individual package from the depot and delivering it, flying back to the depot and repeating the process. Various experts are therefore critical of the potential cost savings of drone transport because they do not fly along routes with several delivery stops. That’s why we can safely say that by 2030 the last mile in metropolitan areas will be a good potential candidate for the use of drones. The above-mentioned special transports are certainly exclusive to the drone, but do not represent the majority.

Regardless of the level of urbanization, drone deployment generally raises the question of how much recipients are willing to play an active role in the delivery process (dispatch notification, authentication, safe delivery of goods, to name a few examples) and learn to use the required software and hardware. Young urban millennials who have grown up with the Internet and new technologies may be more willing to do

“There will be a revolution in parcel delivery in cities. Autonomous delivery robots will pay a decisive part. I presume that air drones will be deployed rather in logistics centers than in public areas.”

so than baby boomers in rural areas who probably have enough tech savvy to do so, but just want the personal delivery experience. Replacing human

delivery drivers with drones, which they may never see since the drones will just leave the shipment and then return, raises two other questions. First, the elimination of the human component could create the impression of a loss in service quality, which could mean consequences for the logistics company. Secondly, goods must be sufficiently secured

Prof. Dr. Boris Zimmermann,
Professor of Logistics,
University of Fulda



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between drone delivery and collection by the customer. Unlike the first question, there are at least feasible technical solutions for the second question. From the service provider's point of view, having menial tasks such as age verification performed by a delivery driver or cash-on-delivery payments carried out by a drone will create additional challenges for the service provider. It will also additionally restrict the range of application for this transport solution.

If drone deployment becomes more popular, there will be yet another issue that is still unknown in rural areas. Added to the familiar noise of delivery vehicles will be the noise of drones. The convenience of high-speed delivery will become a boomerang in urban and metropolitan areas. There is a conflict between quiet logistics and the whirring of many hundreds of rotors.

Delivery Robots

This study defines a delivery robot as a driverless transport vehicle not intended for use on roads with the purpose of transporting individual shipments to a private end customer across short distances. Since this vehicle is designed with minimal transport space, no driver compartment and primarily runs on sidewalks, these vehicles will be much smaller than traditional trucks.



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After the 2002 market launch of the "Roomba" robot, a self-operating vacuum cleaner that vacuums the home independently, more than a decade passed before robots evolved sufficiently enough to reach the last mile. In 2014, Janus Friis and Ahti Heinla, two members of the Skype development team, introduced a package delivery robot under the brand name "Starship Technologies" in the Estonian city of Tallinn. Following that, in spring 2016, additional delivery robots were developed out of the public spotlight, including a robot introduced by the U.S. fast food chain "Domino's" in cooperation with the company "Marathon Targets." This robot is especially designed to deliver hot and cold food. Another example is "Relay," a robot developed for delivery in hotels or high-rise buildings.

Despite their different application areas, delivery robots have several features in common. They are quite small compared to light trucks and are designed for low-volume shipments, in extreme cases, maybe only one, and they are battery-driven. They have been tested to see whether the shipments can be successfully delivered within 20 to 30 minutes of the recipient ordering them online. These vehicles independently find their way to the recipient's location and operate best on sidewalks to avoid obstacles. In situations where the vehicle's autonomous control cannot find a way out, an operator takes control and gives commands from a remote control device. Starship Technologies is striving to reduce driving time that requires human interference to 1 %, it is currently 50 %. When the destination has been reached, the recipient has to enter a code that he or she alone knows to make the robot release the goods that have so far been secured against unauthorized access. There are significant differences between the Starship Technologies and Domino's/Marathon concepts. Weighing roughly 20 kg with a maximum range of 5 km, the Starship robot is much lighter than the Domino's model at 150 kg and a range of 20 kilometers. Also, the package robot travels at a maximum speed of 6 km/h while the pizza service robot moves much faster at 20 km/h.

Although there is a clear difference in the areas of operation between the Domino's vehicle and the Starship robot, their impact along the last mile is similar. Both make deliveries based on request calls from a customer. This is a standard for pizza delivery (Domino's core market), but new for package delivery services (Starship's planned area of operation). For this reason and based on the ability to keep the pizza hot and the drinks cold, the Domino's robot will easily integrate into existing fast food delivery service concepts. Since the demand for freshness requires fast successful delivery in this area, the robot's inability to handle delivery runs with numerous stops is not considered a disadvantage.

The Starship robot uses the on-demand principle to transport packages, deliver purchases or medications and was developed for short-distance delivery to the end customer. When used to carry shopping bags, the robot's limited transport capacity can be a negative since it will have trouble with stairs. It can only transport goods to the front door. It is occasionally discussed as an assistant to people with limited mobility, but will fail whenever it has to deal with stairs along the last mile. Use as an autonomous shopping cart in shopping centers or for package delivery seems to be more realistic.

Using the Starship concept for package delivery will upend existing delivery logistics along the last mile. While a delivery driver currently delivers goods to the recipient based on the

“ We, Starship Technologies, see us as a new last mile delivery service, not just a robot vendor, and we will operate our own service as well as services together with licence partners owning and hosting our robots. ”

Allan Martinson,
COO Starship Technologies,
London

service provider's schedule and hopes that delivery will be successful, robot delivery occurs in two steps. In the first step, the package deliverer drops off the package at

a location where delivery robots are available and which is close enough to the actual destination. The recipient is informed that his package is ready for delivery. As soon as the recipient issues the delivery order, the robot sets off, announces its arrival by sending a text to the recipient and waits until the recipient opens the door. Since summer 2016, Hermes Logistics has been testing this very process in cooperation with Starship Technologies using three vehicles in the Hamburg districts of Ottensen, Volksdorf and Rotherbaum (Grindel quarter). Transferring delivery services from the actual recipient to a robot depot (a package shipping store is used by Hermes in Hamburg) will shorten the original last mile. The goods have to be transported to the robot depot, or post and package store, anyway, but now it will receive more packages. This will make last mile transport more efficient and also lower costs. This approach will create a new but shorter last mile between the local depot and end recipient, all without almost any human intervention.

The Starship robot design and field tests carried out by Hermes in Hamburg, by Metro in Duesseldorf and in different Swiss cities by the Swiss mail leave almost no doubt that this

transport vehicle focuses on serving end customers, in other words, mainly B2C shipments. While commercial recipients function as both recipients and dispatchers, robots are designed to deliver one medium-sized package or a few small ones at the most. From a technological perspective, it would also be feasible for them to pick up packages for shipping, but this is not being discussed at present. The emphasis of delivery on the desired date within 30 minutes of the call being placed addresses problems experienced by the end customer who, in contrast to commercial recipients, does not run a personal goods receiving office and is frustrated by failed delivery attempts. Since deliveries to private households is unappealing to logistics companies because of lack of accessibility and the number of delivered packages, a delivery robot is an interesting option for service providers to improve last mile efficiency. Thanks to the boom in e-commerce, the B2C package volume is on the rise, which makes the use of robot delivery vehicles more attractive. One essential argument in its favor is that robot delivery will considerably reduce labor costs compared to those for conventional delivery. It is assumed that only the Starship robot is capable of transporting 95 % of all package types currently shipped. However, the fact that Domino's basic robot model is considerably heavier and offers a broader distance range shows that the delivery of heavier or bulkier packages by delivery robots is also available as an option. Logistic companies must set up the infrastructure required to successfully deploy robots. Each vehicle needs not only a base station for loading or unloading packages, but also for charging or replacing batteries. Since supplying a small robot fleet and storing the packages to be delivered will require more space than current post and package stores offer, reducing the last mile will not be feasible unless storage space located near the recipient is available.

Another necessary requirement is sufficient sidewalks. Rural areas are more of an obstacle because of the lack of sidewalks. Robot deployment in metropolitan areas, however, is just as critical. Both the Starship and Domino's robots can independently identify obstacles and will stop if in doubt to avoid collisions or tripping hazards. Crowded sidewalks therefore will permanently hinder the robot's movement. Both concepts are explicitly designed for cities with population densities of roughly 1,000 inhabitants/km² and not for metropolitan areas or city centers. This means that cities like Berlin, Munich or Cologne will not be suitable deployment locations, but Erfurt, Hamm, Jena or Salzgitter might work. The reason why Hermes carried out the field test in Hamburg is that the company is headquartered there. Acceptance by consumers is the main factor in determining whether robot

delivery is successful or not. That's why Starship emphasizes the "cute" appearance of its robot while Domino's expresses it more directly: "A friendly character [...] to encourage customers to identify and interact with it." The fact that a Hitchbot robot was vandalized in a field test does cast doubt on whether "cuteness" will contribute to the acceptance of this technology by consumers. Bear in mind that placing delivery robots at the side of a human deliverer or nearby is a realistic option, but mainly outside metropolitan areas and not too far out in the countryside. This will require that consumers accept robots but also the clear legal framework conditions that accompany their use. The fact that cities and towns independently decide on the rules and regulations regarding robot deployment is a point of contention because it means that interested service providers must negotiate separately with each town or city where it wants to set up operations.

The above-mentioned Mercedes Vision Van is designed not only as a base station for drones but also for delivery robots. This concept appears quite feasible when it comes to battling the increasing costs of the last mile in selected rural areas with sufficient sidewalks - also taking into account the fact that drones have a limited payload capacity compared to a robot. This approach, however, reduces the original concept of "on call" delivery and borders on the absurd since the robot acts as the deliverer's extended arm. Deployment as an "escort vehicle" to make deliveries to residential areas easier would be an option since it would reduce the number of times the robot has to return to the base vehicle. The robot would then function along the last miles as the feeder for the actual delivery process. This means that the base vehicle will have to be able to load all packages onto the feeder and sort out undelivered packages. Looking ahead to 2030, broader use of this option seems unrealistic. If robot base stations, like



post and package stores, are available in rural areas, the only issue is whether robots have sufficient range. The deployment of delivery robots in rural areas may be of interest to local retailers (provided that there is a sufficient infrastructure) who can establish their own delivery capacities at a low cost and use robot delivery to improve customer loyalty. Local grocery deliveries would be easy to implement in rural areas using this approach.

By 2030, small and medium-sized cities will be placing particularly high demands on the last mile. The demand from former big-city residents for quiet and clean deliveries will run up against less favorable delivery conditions (lower stop densities, fewer delivery alternatives). Robots, with their quiet electric drives, can handle both of these expectations from private recipients. Starship advertises its delivery solution explicitly using the phrase "zero environmental impact." Compared to rural areas, smaller and mid-sized cities have a certain supply of potential robot bases in the form of post and package stores that can serve as a starting point for a new short "last mile on demand." For retailers expanding into the convenience sector, delivery robots could help narrow the gap between the requirements for successful express food delivery and industrialized same-day delivery focused on evening delivery. If you combine the fast lifestyle of residents in suburban areas, on the one hand, and local retail business seeking new options, on the other, together with the option of a quiet and environmentally- friendly delivery service, a favorable scenario emerges for delivery robots as we approach 2030. Moreover, robots represent a cost-efficient delivery option for brick-and-mortar retailers if on-demand delivery combined with on-time services is to successfully compete with the online order business. In one far-reaching vision beyond 2030, delivery robots could interact with a package unloading point integrated in the home to automate regular last mile delivery and on-demand delivery.

A package delivery network or a same-day system that is working at full capacity can use delivery robots as a stop-gap measure in small and medium-sized or selected cities during times of delivery overload. Moreover, new services that will use automated delivery as a standard delivery method will be available by 2030. Individual recipients might feel that robot delivery is impersonal or they may not have the technical skills and/or may not be willing to take the required steps for delivery. Integrating robots into the delivery process will enable post and package services to focus their employees on particularly productive processes and to provide them with a transport tool for reducing high, stressful workloads, thus compensating somewhat for demographic changes. It has

been roughly estimated that the total potential resulting from standard packages weighing less than 10 kg to be delivered in regions with high population densities and from shipments of new same-day services in Germany may amount to 400 million deliveries annually.

In conclusion, regardless of how delivery robots will be deployed by 2030, this technology requires storage or transfer locations close to the customer. Also, society must accept non-personal delivery and remove both physical obstacles as well as legal ones. There is also an inherent risk of robot theft, as with drones, even though the Starship robot itself weighs as much as 20 kg. Robot manufacturers have already recognized that not only the goods, but also people along the last mile must be protected. For this reason, they are trying to consciously set their systems apart from the drone concepts.

Electromobility

For the purposes of this study, we define the term electromobility as the increasing availability on the market of electric commercial vehicles or trucks suitable for use along the last mile. The only thing that sets electric trucks apart from trucks powered by an internal combustion engine is driveline technology. Chassis, assemblies and vehicle interior may be identical. Electric trucks use a rechargeable battery pack ("traction battery") to power one or several electric motors. The traction battery provides electricity to all other vehicle functions, such as light bulbs, power steering and air-conditioning.

Historically, electric drive systems and electric trucks are nothing new. In fact, they dominated road transport until the onset of World War I. In niche areas, such as the distribution of basic foodstuffs in Great Britain, electric trucks were a common sight up to the end of World War II. After the oil crisis in the 1970s and a short time after the turn of the millennium and motivated by health, environmental and climate issues, electromobility has

“ The future lies in zero emissions, zero noise deliveries to city centers. The most important German truck manufacturers have failed to take advantage of pure electromobility and have left it up to medium-sized companies. Instead, they have focused on hybrid drive systems which will not lead to zero local emissions goods transport. ”

Robert E. Orten,
CEO of Orten Electric Trucks

electric trucks benefit from the high efficiency of the electric driveline and the "recuperation" function which recovers some of the power consumed when driving by feeding the braking energy to the traction battery. This can result in fuel savings of about 50 - 65 % along routes with frequent stop-and-go compared to the combustion engine. The biggest disadvantage of electromobility is its dependence on the traction battery. The distance that an electric truck can drive ranges from 80 to 120 kilometers with lightweight trucks and 200 to 250 kilometers with medium-weight long-haul trucks. By 2030, this range will increase due to advances in production as well as power density increases in the traction batteries that are optimistically forecast to go as high as 50 % also by 2030.

Plans from automakers Daimler and VW indicate that electromobility will be a drive system to be taken seriously in the near future. Both companies intend to generate about 15 - 25 % of their sales from electric drive systems by 2025. We can there-

been a top priority for policymakers and the business world. Its focus rests essentially on the fact that electric trucks can be operated with zero local emissions and are relatively quiet. Drivers of



fore predict that by 2030, the use of electric trucks and vans along the last mile will not be a unique, rather a real option. Pilot tests carried out by the package transport companies DHL and UPS or by companies REWE and TEDI as well as research projects like the "Electromobility and Urban Commercial Transport" from the Fraunhofer IML show what is feasible today. There are various kinds of electric drives, including electrically-assisted cargo bicycles and traditional trucks with electric drive systems are available and there are hints that entirely new vehicle concepts are in the works. In 2012, Austrian engineers presented a vehicle with a single wheel drive and steering system that can turn on the spot just like a shopping cart. In the future, this technology will enable electric trucks to replace trucks with combustion engines along many last mile transport routes. New kinds of vehicles that could not be imagined without an electric drive system will create completely new options for the last mile, as shown in many of the previously described tests with delivery robots, which also rely on the electric drive.

Currently, there are very few electric trucks on European roads. Single isolated exceptions are densely populated areas like London where a few hundred electric trucks have been de-

ployed to avoid paying the congestion charge that has to be paid by drivers of gasoline-engine cars and trucks. The combined environmental and financial incentives show that the demand for zero local emissions and quiet logistics will have significant impact on the use of electromobility. Fraunhofer IML studies show that the use of electromobility in transport can bring down CO₂ emission amounts by 30 and 40 kg in light trucks and 120 - 150 kg in medium-weight trucks along with a drop of 1-4 kg in NO_x emissions. Due to truck size and more intense use, these values are several times higher than those recorded for electric cars. That is why we can expect that certain regions will identify last mile road traffic to be an essential factor in achieving local clean air targets and will force electrification well before 2030. Establishing emissions limits and, even more importantly, consistently enforcing them is a big opportunity for electromobility. Neither the goal of zero local emission deliveries to metropolitan city centers by 2030, as set forth in the EU white paper on Traffic 2050, or the creation of low-emission zones alone will help electromobility advance along the last mile. Comprehensive market availability of electric trucks at competitive prices is another critical factor from a logistics perspective. If you look at street scooters against this whole backdrop, then you will under-

stand why DHL acquired the start-up company that makes them. DHL plans to have the street scooter modified to meet its needs in order to bypass existing market gaps and the high prices for single-item manufacturing. Currently, no electric trucks have been mass-produced specifically for the last mile which makes acquiring one a very expensive proposition. Electric trucks often cost twice or three times the price of a truck with a diesel engine and their purchase price must be justified by low operating or power costs.

“ The focus on and the proximity to the customers is essential for alternative drive systems because of their low drive range. ”

Rainer Kiehl,
Project Manager City Logistics,
United Parcel Service Germany

However, truck manufacturers are planning to introduce electric trucks into volume production in Germany by 2020 to replace

the currently prevailing single-item and small series manufacturing. Economies of scale will help reduce the cost price of these vehicles and also improve quality, variety and availability. Nevertheless, as we approach 2030, the traction battery will continue to be a determining factor regarding their intended purpose and deployment along the last mile. This is because the battery will

Advantages and Disadvantages of Electromobility

- | | |
|--|--|
| <ul style="list-style-type: none"> + Zero local emission + Low noise and vibrations + Energy-efficient drive system | <ul style="list-style-type: none"> - Limited range - Limited number of vehicle models - Higher vehicle prices |
|--|--|

considerably impact the price and the truck's range, and, in turn, its intended purpose. Deployment ranges are limited to city centers and metropolitan areas and often conflict issues such as multi-purpose uses and time flexibility.

Since the vehicle range will still be a limiting factor by 2030, there is little reason to assume that electric trucks will dominate the last mile in rural areas. Efficient combustion engines and long distances with low stop frequency are an economic obstacle to electromobility. Problems with traffic noise and emissions, though not frequent in rural areas, are additional hindrances. However, this applies only if you replace combustion-engine trucks on a 1:1 basis with electric trucks. In many cases, small

customized electric trucks with additional logistic benefits are offered that have no equivalent combustion-engine model.

The denser the population is, including local industrial facilities, the shorter the single leg of a delivery run along the last mile and the higher the fuel consumption and wear on combustion-engine vehicles. The logistics industry often points out this fact by claiming that one year of use as a delivery truck results in as much wear and tear on the vehicle as ten years of private use. Electric trucks are built for this kind of use because the number of components subject to mechanical wear is quite low. The service life of electric trams, like the ones used in Geneva, Riga, Quito or Solingen show that electric vehicles can be used in continuous service for many decades. Also, fuel savings can be achieved through continuous operation (electric power costs instead of diesel fuel costs). Generally speaking, electric trucks are particularly cost-efficient in areas with a high start/stop frequency when driving. Electric trucks relieve high traffic volumes in urban areas as well as when driving short distances between the individual delivery stops in urban and metropolitan areas, they are also useful for delivery runs in urban areas that rarely exceed 100 kilometers and are often considerably shorter. Even if ranges moderately increase by 2030, it can be assumed that the last mile will become electric. For the same reason, the frequently-mentioned requirement of an infrastructure with short distances between charging stations will not be problematic for last mile transport. The traction battery will be charged during idle periods or when loading or unloading in the logistics center.

Zero local emissions makes electric trucks ideal for use as part of the green logistics chain. The main benefit of the electric drive is that it operates with zero local emissions and is more effective if deployed from logistics centers close to urban areas. Because they generate no emissions, electric trucks can be loaded inside buildings without any difficulties. Amazon has experimented with this loading approach at its location in Munich and initial results show that it reduces loading and unloading time from 30 to about 8 minutes per vehicle. Also, logistics zones in urban areas could be designed to be more flexible and even integrated into buildings. As an example, the Fraunhofer concept of “ebase-4Mobility,” is described as a multi-purpose area located in city centers used for mobility and the supply of goods.

The project “GeNaLog – Low-Noise Night Logistics” has proven that these vehicles are the key to quiet logistics in compliance with the German Technical Instructions on Noise Prevention. The quiet logistics certificate introduced in the Netherlands is an appropriate seal of approval that not only makes the investments of service providers more secure, but also communicates



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to the public that local businesses and local governmental authorities take noise protection seriously. In urban and metropolitan areas with very busy infrastructures, quiet logistics in the form of electric trucks can make continuous deliveries over multiple shifts to the many logistics centers that are cropping up in these areas. Deliveries made during off-peak hours will make logistics more productive and will help reduce deliveries during daytime peak hours.

If electric trucks are integrated into existing same-day delivery routines with evening delivery, battery capacities and charging times could cause problems if used in parallel during the day. For example, at package centers, which will have become more numerous in metropolitan and urban areas by 2030, workers on shift between 8:00 a.m. and 6:00 p.m. will have to do regular deliveries at almost zero emissions and quietly, yet, have to recharge their traction batteries sufficiently for the same-day evening shift. Advances in battery pack and charging technology are still needed on the technology end. Otherwise, last mile logistics companies will not be able to leverage the synergies required to lower costs, rather, instead, will have to cover the additional costs of spare vehicles or spare battery packs.

New vehicle concepts that are emerging due to electromobility could also be a potential response to demographic issues along the last mile. The Norwegian federal postal service “Posten Norge” developed the “Paxster” vehicle, a kind of one-person cabin scooter with storage compartments within the driver’s reach and featuring additional cargo space. Many drivers in Germany appreciate not only its 90-kilometer range and its maximum speed of 45 km/h, but also its good maneuverability and the fact that they can approach the mailbox fronts from the side. The German media group DVV, which provides mail delivery services and various magazines in Saxony, used this

vehicle to solve the demographic issue (recruiting new employees, illness rates among employees), especially for longer delivery runs in areas with lower population density. Rising costs due to high labor costs can be offset by improved productivity. Also, driving such a vehicle does not require a special vehicle driver’s license which solves problem of a shortage of skilled drivers.

Autonomous Driving

Today, vehicles are no longer solely operated by drivers behind the steering wheel or stepping on the gas and brake pedals, rather an increasing number of driver assist systems are taking over certain driving functions to relieve the driver. For years, fully automated systems have been successfully used in logistics, production facilities and warehouses, even in public rail transit and have continued to dynamically branch out into other fields. When it comes to road traffic, we can therefore expect that assist systems and pilot projects that support automated driving will continue to advance under real traffic conditions and that this technology will become more relevant even though, at the moment, highly automated driving on public roads still represents a technological challenge.

In this study, as well as among the committees of the German Association of the Automotive Industry (VDA) and most scientific organizations, the term “autonomous driving” represents the top of six hierarchical levels in assisted or automated driving. While automation is supported by powerful sensors, the human capacity to understand and interpret the behavior of other road users must not be underestimated. Nevertheless, even though the world accepts that humans are prone to errors while driving, as evidenced by the millions of traffic accidents every year, there is comparatively little tolerance for any kind of severe accident caused by automated systems, nor is this issue intensively discussed. Out on the roads, partially automated driving has already played an important role in 2016 because more and more



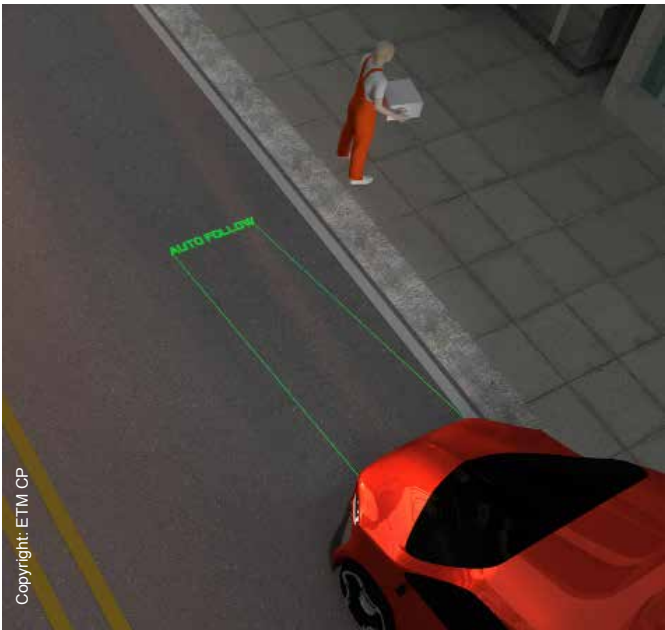
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driver assist systems are being installed in new vehicles. Also, the first vehicles to be classified as “highly automated” are hitting the road.

The automation of road and rail vehicles will change the logistics industry over the long term because vehicle operation, the economy of road traffic and also the nature of logistics services could change and become safer and more reliable. This applies especially to the last mile. However, when it comes to platooning, which involves electronically coupling of trucks to one another to create an automated truck convoy on highways, the last mile has not yet been directly affected. Instead, logistics companies are planning to have the individual trucks leave the convoy once it has exited the highway to drive to different delivery destinations. This would mean that the drivers would take back the wheel and drive while also performing important communications functions.

Automated driving will have a far-reaching impact on the last mile, ranging from new kinds of small delivery robots to trucks that can drive automatically up to the receiving ramps of a major delivery destination.

Already new applications and business models are emerging that will rely on flexible vehicle pool concepts and new logistics and mobility concepts. However, the option of deploying vehicles for longer periods of time during the day without incurring direct driver expenses are coming up against a series of challenges. It is still unclear how driverless vehicles



will communicate with those receiving the goods and how reliable the delivery will be. Additionally, there will be a longer period during which conventional and highly automated vehicles will have to share the existing traffic infrastructure; this phase will be a challenge for (Car2Car) communications and traffic organization.

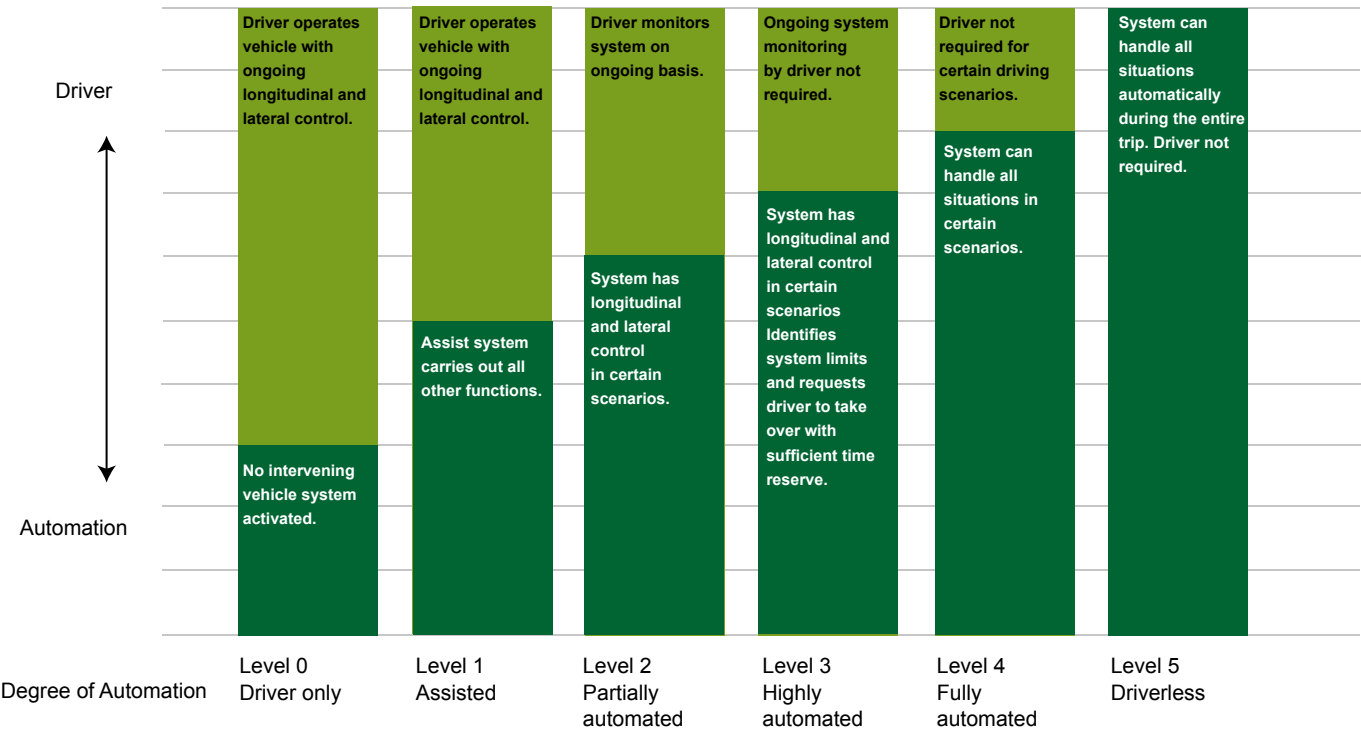
In general, the desire for increased safety on the roads is the driving factor behind autonomous driving. For last mile logistics, autonomous driving will make it easier to meet rising customer requirements more efficiently. Small, easily maneuverable and flexible vehicles will be used more frequently. Important building blocks in all of this include digitalization, Industry 4.0 and interconnecting the supply chain, which will

“ The question is not whether autonomous driving will become a reality, but when it will be accepted by the public and sufficiently regulated by policy-makers and local government authorities. ”
Dr. Karl Pfaff,
Director Sales Development,
General Logistics Systems Germany
GmbH & Co. OHG
make it possible to better control traffic and coordinate the individual components that make up the supply chain as a whole. Industrial production and distribution

logistics will become more tightly woven so that distribution logistics can dynamically respond to fluctuations in production and demand and also join the trend toward product customization and batch size 1. The delivery driver can thus concentrate more on delivering the goods and interacting with receiving customers while the vehicle handles the driving (for example: the vehicle follows the delivery person who walks on the sidewalk while delivering the package). Currently, rural areas are particularly expensive for last mile logistics companies to serve, but by using autonomous transport vehicles at shorter intervals (several times daily), the delivery level could be brought up to that of urban or metropolitan areas. This will require, however, that residents in rural areas embrace the concept of robot or driverless deliveries. At the same time, the average age of rural residents is expected to rise considerably in the near future, which means that it is a bit optimistic to assume that this technology will be welcomed with open arms in these areas. In regions suffering from a shortage of drivers, the use of automated vehicles will help logistics companies to offer last mile services at a reasonable cost.

Technological advancements are still needed before highly automated driving becomes the rule rather than the exception. But it will not be long before it is used in long-distance transport where framework conditions and other relevant

Levels of Automated Driving



factors are straightforward. There is much design and development work to be done before highly automated vehicles can hit the roads in urban and rural areas where there are still too many surrounding influences to be taken into consideration, including pedestrians in the city or fork lift truck traffic in industrial areas. One general challenge in this field is the need to create reliable communication channels that share trip and position data between the vehicles and the infrastructure using long-distance (such as the upcoming 5G mobile communication network) and short-distance communications (such as Bluetooth, NFC or wireless LAN) and uniform standards that all manufacturers abide by. In this case, the best approach is to integrate infrastructures, forward information or keep data ready for vehicles using their own sensors. In any case, it is clear that an automated vehicle will place much higher demands on the existing infrastructure than a human driver. A driver can recognize a severely damaged traffic sign and is still able to understand its meaning while a dirty traffic sign presents a major challenge for image recognition algorithms.

Above and beyond these issues, there are other relevant legal and ethical questions that must be discussed or regulat-

ed, including the question of who shoulders the blame if an automated or driverless car causes an accident and what about data privacy.

Autonomous driving affects numerous end customer requirements and framework conditions, however it offsets demographic change by solving the problem of the shortage of skilled workers and increases the appeal of the workplace. As an example, imagine a truck weighing 12 tons that could be operated by a delivery driver who does not have a special driving license or, in an extreme case, any driving license at all if the truck is equipped with an autonomous control system. Deploying autonomous vehicles in package delivery logistics will reduce the costs for customers in rural areas, even if delivery drivers are still used. If such drivers live close to their delivery area, they can jump in the truck, avoid commuting and thus offer higher productivity along the last mile in rural areas. One challenge for completely driverless transport is to get end customers comfortable with the idea of driverless or robot delivery and to teach customers without much technological savvy how to use and benefit from the automated delivery process. In an industrial or commercial environment where things revolves around partial or full

payloads being transported to a loading ramp at a specified time, this technology has a major savings potential. For example, a platoon made up of numerous trucks can drive through an industrial area and the individual trucks can branch off and drive independently to their destinations.

Autonomous driving allows higher delivery frequencies for same-day delivery in urban and especially in rural areas by using small autonomous delivery vehicles. Currently, whether and to what extent this technology lowers carbon emissions in road freight transport is hotly debated, with scientists exploring this issue. While combining the future technologies of electromobility and autonomous driving does offer the potential of developing a reliable logistics concept that will preserve the environment, it could also lead to previously cost-inefficient transport options which will additionally stress road infrastructure also along the last mile.

In conclusion, if innovative city center retailers jump at the chance to offer delivery services featuring autonomous driving to set themselves apart, there is also the risk that traffic problems in urban and metropolitan areas will intensify due to additional traffic caused by autonomous delivery transports. However, targeted deployment of autonomous electric vehicles could allow for delivery transports during off-peak hours, thereby promoting the idea of quiet logistics while also eliminating the problem of night-time delivery surcharges in addition to drivers' wages.



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Preliminary Conclusions on Trends in Technology

As we approach 2030, various technological developments and trends will impact the design of the last mile, with some having more of an impact and some less. As digital technologies continue to find their way into social and economic processes, the emergence of the Internet of Things and the spread of 3D printing are becoming top agenda items for logistics companies and are igniting social discussions, also for the case that players along the last mile are not open to these trends.

Even today, digitalization and the Internet of Things are offering logistics companies many potential approaches and methods for improving the efficiency of existing processes and developing innovative new services. Most of all, complete digitalization allows for higher availability and faster delivery for the benefit of the customers. Major challenges include preparing organizations for the future by equipping them with new technologies, broader use of IT and addressing data privacy and data protection issues, while also keeping in mind demographic issues and the shortage of skilled workers. If companies do not view digitalization as an opportunity that demands investment in its technologies, they will be unable to tap into new opportunities.

3D printing can make existing last mile transports unnecessary and replace them with more consolidated and less urgent deliveries. If this technology moves production much closer to the customer, perhaps even into their places of business, deliveries of products produced by 3D print shops will not be required any more. This technology can offer added value for customized services at affordable prices and directly on site so that same-day delivery will not be difficult even with complex products that have to be modified, such as prosthetics. In extreme cases, the spread of 3D printing could improve the supply quality in those areas that are currently suffering from an exodus of skilled workers. It also seems realistic to think that retail chains in metropolitan and urban areas would welcome this technology to enhance the appeal of their local goods. Service providers along the last mile must decide whether they want to cooperate actively in shaping these developments or whether they will just accept the slow decline in express delivery transports.

Autonomous transport systems such as driverless trucks, robots or drones are currently in the pilot phase and are, in principle, an option for the last mile of the near future. The deployment of drones will perhaps be limited to certain types of deployment due to existing safety concerns and restrictive regulations. This is because the deployment of aerial motor vehicles consumes a lot of power compared to surface

transport and can carry minimal payloads only. More comprehensive deployment of drones is considered as critical anyway due to existing demands for quiet transport. Ground systems, on the other hand, can considerably reduce risks that may hinder a successful delivery to private people, particularly in medium-sized cities. Instead, as an alternative, the end customer could call in an “on-demand package delivery” by autonomous vehicles such as delivery robots.



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In urban areas with sufficient infrastructure, delivery robots could support local package deliveries and are therefore of interest to both changing city center retailers and same-day delivery providers. Considering their limited operational ranges, robot solutions also benefit from the customers' wish to reduce the last mile and from the retailers' desire to move closer to their customers, for example, by opening urban convenience stores. Larger autonomous vehicles or trucks are gradually being modified to support driverless operation. This may be useful in solving the problem of worker shortages due to demographic change and domestic migration trends, but makes a well-developed and maintained infrastructure a high priority, along with the important ethical and moral questions regarding safety and liability. Nevertheless, for larger vehicles, we expect that this technology will first establish itself in sectors with fewer potential hazards and that can adapt more easily to autonomous driving. Accordingly, it offers a good potential for general goods transports in rural areas, which benefit from platooning and from autonomously maneuvering trailers.

The readiness of the market for electric drive systems means that a plethora of currently established vehicles and engines and new electric vehicles and drive concepts for the last mile will be available and deployed by 2030. An essential factor

driving this development is the demand for quiet and clean last mile logistics. Noise and pollutant emission restrictions will result in conventional gasoline-engine vehicles being replaced by electric vehicles on the last mile, at least in metropolitan and urban areas. In conjunction with this, the fact that electric drives are not very complex opens up options for the industry to use them in previously unknown vehicle concepts. In densely-populated regions, electric vehicles will foster the opening up of new business fields by introducing new delivery concepts such as night-time logistics. The development of local distribution systems and their focus on synchronized same-day delivery will essentially determine the degree to which distribution in city centers will go electric. But even if they do become fully electric in metropolitan areas, last mile road transport will still rely on conventional technologies in 2030. In fact, conventional approaches will still prevail in rural areas where deployment of electric vehicles is hindered by limited drive ranges, the issue of emission is less prominent and conventional driving systems provide economic benefits.



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CHALLENGES / DECISION REQUIREMENTS

Challenges / Decision Requirements

Introduction

The previous chapters have shown that different technological trends are influencing the actions of logistics companies along the last mile and will continue to do so in the future. On the one hand, these trends are raising fundamental and general questions that society, policymakers and businesses have to address. On the other hand, raising and answering such specific questions is necessary to create the foundation on which the success of certain technological innovations along the last mile can be built. This chapter therefore summarizes issues brought up in the preceding chapters and identifies the issues that must be addressed and the actions to be taken in the near future.

Ultimately, we found that last mile logistics is under increasing cost and time pressures. Demographic change and a shortage of drivers, for example, have increased labor costs, all of which make delivery services to rural areas particularly expensive. Also, by 2030, small and medium-sized cities will “import” the demand for quiet and clean logistics from metropolitan areas, even though they are less densely populated. This, in turn, means that the hot spots with the greatest need for action will be in these areas and in metropolitan areas with serious traffic problems. In the case of environmentally-at-risk cities, this pressure affects not only the companies but local communities.

Actions by Logistics Companies

Understand the challenges of demographic change as an opportunity for innovation

Demographic change represents a dual challenge for logistics companies. First, they have to acknowledge that an aging population will require different services that focus more on high quality and less on speedy delivery. Companies that want to provide services to the older generation are developing innovative delivery solutions that may involve technological advances, such as robots. However, their end customers should not be given the impression that these new last mile concepts will mean a loss in the quality of the service. If drones and robots are deployed in rural areas, the issue of anonymity associated with this technology to serve private customers must be resolved.

Both in the particularly challenging medium-sized cities and rural areas, a system of provider-neutral package drop boxes can make things easier for both logistics companies and the end customers. Consumers enjoying their life after retirement and families moving to the suburbs and who are used to the convenience of mail order service will benefit from using online retail services.



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Efficiently implement convenience logistics through communication and digital technology

Convenience and fresh produce logistics place high demands on successful on-time delivery to the place of use, if possible. Also worth noting is that recipients or end customers see goods and logistics as one unit, so that logistics errors influence the perceived quality of the overall product. Simply depositing a freshly cooked meal in a package drop box or delivering garden plants just before dark will not be sufficient. Logistics companies are well advised to use the opportunities created by advances in digitalization to deliver such items to precisely the location of the recipient at any given time to guarantee successful delivery. Cooperation from the end customer is decisive because they are the ones who provide information on their location at an early stage or other information to ensure a successful delivery. By involving the end customer in the process using appropriate technology such as mobile apps, logistics companies must naturally verify confidentiality and security in handling sensitive recipient data.



Standardize same-day delivery to open up potential cost savings

Same-day delivery is often considered the equivalent of a courier service and therefore just as expensive. Only by standardizing this service can logistics companies tap into economies of scale and thereby reduce costs and prices. Strictly speaking, this means that same-day delivery will become a success if logistics companies define set times of day when shipments have to go out and when the delivery will be made, thus creating time windows in which standardized delivery runs are made instead of using customer-specific courier services.

Small is beautiful: smaller logistics hubs near the end customer promote sustainable city logistics

Places where same-day shipments are sorted and loaded onto delivery vehicles must be located near to the potential recipients. Logistics suppliers should therefore establish appropriate sorting centers or micro depots, particularly in metropolitan areas. This allows for short delivery runs that are predestined for alternative transport vehicles such as cargo bicycles, delivery robots or electric trucks. Medium-sized cities are a good base because the traffic is not as heavy as in metropolitan areas and there is more availability of space in city centers.

Act Local: on-site logistics locations sustain local businesses

If logistics companies reduce the last mile by establishing sorting centers in close proximity to end customers, local businesses will benefit because they will be able to offer same-day delivery just like their online competitors. Another benefit for local retailers is that they can leverage convenience in consumer shopping behavior by delivering the goods to the customer's home. If a logistics company tries to find solutions for local businesses, synergies emerge that enable same-day systems to be well utilized. If a logistics company operates micro depots in the city, it can offer warehousing services to local businesses.

Leverage the opportunities of digitalization through skilled employees

Digitalization requires that organizations and their employees learn how to handle higher data quantities and how to work with computer-generated decision proposals to make sound decisions. The use of intelligent infrastructure and tools, in particular, requires the organizations involved (dispatcher, logistics company, recipient, operator of infrastructure) to provide a high level of IT security and to immediately respond to security holes to make the Internet of Things successful. Preventing both new and existing employees from drowning in a flood of data is the key to making large masses of data a valuable resource. Confidence in integrity, protection against unauthorized access and data privacy are essential for this purpose.

Open standards allow for confidential cooperation along the last mile

Since logistics makes the job-sharing economy possible, it requires a mutually trustworthy use of data above and beyond the confines of organizations and national borders. The success of the OpenStreetMap project shows that this can succeed if open standards are applied instead of proprietary ones. Using data pools on the basis of trust along with the

concept of industrial data space can be helpful in gaining acceptance by the public.

Support subcontractors in the digitalization process

The structure of the logistics industry is heavily dependent on small and medium-sized companies that act as subcontractors to handle last mile deliveries under intense cost pressures. Those who want to benefit from the digitalization of the last mile must improve the IT expertise in both their own organizations and those of their subcontractors and support them actively in obtaining qualifications regarding data protection, security and privacy.

Actively shape industrial changes in 3D printing

The prevalence of 3D printing processes offers major opportunities for business and industry. The cost-efficient and fast on-site production of custom-made objects, prototypes and spare parts will enable logistics companies to reduce some of their time-critical service volumes. They will have to include 3D printing services in their product portfolios if they want to avoid becoming a victim of progress and, instead, be a designer, like UPS and FedEx began doing some years ago. This will help them open up potential new business fields in the area of delivery of individual consumer products by cooperating with city center retailers.

Despite the use of drones, last mile logistics will stay mainly on the ground

Despite all assurances from numerous drone manufacturers, the concept of the transport drone is affected by safety issues and the high level of power consumption required by engine-powered flight. Those logistics companies that nevertheless pursue the use of drones would be well advised to take the safety concerns of the population and of aviation authorities seriously and to design these aerial vehicles to be safe. Regulatory requirements will remain strict so that drones will not provide much relief to people along the last mile. The desire for lower costs in delivery services to rural areas will not be met in the foreseeable future. Logistics companies should therefore continue doing standard deliveries along the last mile using today's current standard methods as we move toward 2030 and arrive safely at the customer's instead of flying.

Use drones for new transport solutions in selected niches

In exceptional cases, the transport drone can be a flexible and cost-efficient alternative to special transports if conventional transport vehicles can only reach the destination with a lot of effort and expense. Keeping drones available and applying for appropriate licenses for set routes is recommended to service

providers for use during major sporting events with thousands of spectators, natural disasters that make roads impassable, or for cost-efficient express transports between the mainland and islands. Against the backdrop of reducing traffic noise, which is the goal of many cities, the mass deployment of drones is still fairly improbable. Logistics companies should therefore focus on using drones for internal transport processes in facilities, for example, on factory premises and in warehouses.

Use delivery robots for innovative services and find synergies with local retailers

The delivery robot concepts thus far explored are not intended for mass deployment right from day one, rather emphasized inherent safety based on slow ground operation. New players on the market and well-established logistics companies are now faced with the decision to develop reasonable services and concepts that will integrate robots into the delivery process to relieve delivery drivers from the physical work involved. Robots would be a welcome addition to urban logistics systems, like those used for same-day delivery, and could be selectively used in the final phase of goods delivery. "Fleet operators" for delivery robots in metropolitan areas should consider the dual-use potential of their infrastructure. If retailers in medium-sized cities increasingly identified robot technology as useful, this would also be a good opportunity to utilize robot fleets efficiently right from the start. Companies that want to make robot delivery a quick success should build up a network of small stations close to the end customers recipients to support automated and reliable goods delivery (a kind of "package drop box plus").

Gather information on electric transport

Since electromobility is an efficient instrument for quiet and clean logistics, it is the preferred option for many cities. Companies involved in the last mile should start gathering information on electric transport even now since there is more to the deployment of electric vehicles than simply being powered by electricity instead of diesel fuel. Purchasing and fleet planning employees who supply vehicles and equipment to last mile depots currently have little knowledge regarding the actual opportunities and limits of this technology. The same applies to dispatchers and drivers. According to findings from the Fraunhofer IML, "fear of short range" also haunts companies and is standing in the way of using electromobility in an economically reasonable manner. If companies became familiar with this technology at an early stage, they would have accurate information on hand and be prepared for electrification by the time electric trucks enter comprehensive volume production and become ubiquitous on the roads.

Use electromobility to develop new transport vehicles and last mile concepts

The example of the “Paxster” demonstrates that electromobility along the last mile can initiate the development and introduction of new transport vehicles. Both Paxster and Streetscooter were designed and manufactured to meet the needs of a logistics company. It also shows that last mile logistics companies should think outside the box. Last mile planning should not focus exclusively on known vehicle types, instead it should consider the option of having customized vehicles designed for specific applications and business models to better meet last mile requirements from end customers and policymakers. Innovative electric vehicles are not limited to metropolitan areas, after all the Paxster was explicitly designed for rural areas and the Streetscooter for urban areas.

Opt for a mix of different drive technologies but with common business sense

It is reasonable to assume that traditional trucks equipped with electric drivelines will be available by 2030, however, mass production and pricing similar to current diesel trucks by that year is unrealistic. This will force companies to look hard at yet another issue. While vehicle costs are fairly standard in a vehicle fleet that consists solely of diesel vehicles and only the fleet’s average diesel fuel consumption is tracked, a diverse vehicle fleet that also includes electric trucks requires that companies track the actual consumption data and expenses which will enable them to make economically reasonable decisions. If only the average values of the entire vehicle fleet are looked at in the decision-making process, the diesel truck vs electric truck benchmark figures are not likely to reveal the most cost-efficient areas of application. If metropolitan areas and medium-sized cities require zero local emissions along the last mile, logistics companies must respond, but should first act on the cost efficiency principle with a focus on the most lucrative areas of application for electric trucks or substitute diesel trucks in situations where this can be done with minimum loss. Logistics companies thus make the costs of meeting clean and quiet delivery requirements transparent for the customer and recipients of a product. The question of how credible the current surcharges for diesel fuel are considering the rising use of electric vehicles in delivery fleets is interesting since the extremely high fuel consumption generated by local transports can now be avoided.

Driverless vehicles will change transport logistics and will become an important element along the last mile

Neither autonomous delivery robots nor traditional trucks will need human drivers in the future. This means that those who are directly affected by this technological advance, the profes-

sional truck drivers, will have to be wooed for their acceptance. Complex logistics services will also require a human presence along the last mile, either as an escort or at least as monitor or manager.

Simple deliveries in secured surroundings are a good first step toward autonomous driving

Example: General goods transports in rural areas

Identifying appropriate areas of application that are sensible both in technological and economic terms is a major issue that logistics companies need to resolve. One less technologically demanding solution compared to full automation is to join several trucks together in a small platoon for general goods delivery. This involves one lead truck operated by a human driver that is followed closely by driverless trucks. The platoon can then separate and dock in parallel at several ramps in secured surroundings, for example, the recipient’s truck terminal. This concept requires acceptance by the recipient and IT and technological support to be successful. Also, such a concept makes the delivery and the collection of goods much more efficient, particularly for those industries that have historically developed in rural regions which do not have good road infrastructure.

Successful autonomous driving pilot projects solve the driver shortage problem

If we take successful pilot projects in which driverless electric trucks are deployed as a platoon in manageable and secured areas to show that this technology works, then we can think about rolling it out in more challenging areas. If the lead truck described in the above paragraph is autonomously operated, in extreme cases, the “driver” will not need a special driving license, which will ease the pressure of having to find qualified drivers.

Driverless trucks allow last mile logistics employees to live near their assigned delivery area

The use of driverless trucks, for delivery in package logistics, for example, means that the driver does not have to be in the truck when the delivery run begins. If a loaded delivery truck is sent out on a delivery run, it can collect the driver on its way. The driver can then use his or her work time more efficiently and reduce commuting time. If the driver lives close to his assigned delivery area and far from the truck terminal, a driverless truck will reduce previously non-productive labor costs (driving to and from the assigned delivery area).

Actions by Society and Policymakers

Solve demographic challenges and worker shortages together with local businesses and logistics companies

Logistics is an industry that is experiencing a rising demand for more skilled and qualified workers than are available in some regions. Delivering supplies to local businesses and the greater population and the attractiveness of a region are all interconnected and should not be seen as separate issues. Especially in rural areas, the players involved should consolidate their efforts and find mutually beneficial solutions to attract and keep skilled workers in the area by offering a high quality of life and training and job opportunities. Openness to innovative technological solutions, like driverless delivery trucks, might make people see it as an attractive and forward-looking location, particularly in rural areas.

Shape uniform clean air and noise prevention regulations across Europe using common sense

No one disputes that last mile transports can contribute to reducing traffic noise and improving air quality. That’s why it makes more sense to define specific business incentives to accelerate the spread of low-emission or zero-emission technologies along the last mile. The widely diverging low emission zones currently seen in Europe should be replaced by clear, uniform regulations that provide a better planning basis for last mile logistics. Binding definitions of exactly what quiet logistics and low-emission logistics mean are already being established so that they can be applied across the board by regulators to set up last mile rules and regulations. This will create incentives for companies to take action. One major result of the project “GeNaLog – Low-Noise Night Logistics” is the “Piek-Certificaat” which is a now well-established seal of approval for quiet logistics in the Netherlands and could serve as a model for a German or European seal of quality.

Public acceptance goes hand in hand with confidence in the safety of new last mile technologies

Various technologies are being tested along the last mile and will be ready for operation by 2030, whether it is driverless trucks, transport robots or drones. Besides reliable legal framework conditions, the first step for successful field tests is broad acceptance by customers and companies receiving the deliveries. The main factor that helps to garner public acceptance is that everyone trusts that the new technology used in the public sphere does not create excessive potential risk. Ethical issues must be addressed, but everyone has to understand that risks cannot be 100% ruled out. For cities looking at night-time logistics as a way of relieving traffic

congestion and infrastructure overload, we recommend establishing clear, safety-oriented rules and regulations.

Open standards and protocols, safe data management and comprehensive IT infrastructure form the basis for successful digitalization along the last mile

Broad acceptance of digital technology by the public and its new areas of application have already been mentioned. In this regard, supporting the use of open communication protocols and standards makes it possible to share valuable data along the last mile to all parties and not only monopolists. Together with local businesses, local communities should establish fiduciary data pools for a confidential and safe use of local data. Additionally, efforts should be made to ensure the availability of the 5G mobile communication network. Since complaints have been made over the years regarding gaps in providing such services to rural areas, but also to various small and medium-sized cities with broadband internet, this issue must be a priority to close this gap.

Create digital jobs and provide job-training for workers

Digitalization is opening up new business models, particularly in the transport industry, and is stimulating growth in digital car-sharing companies in the passenger transport industry under the catch phrase “the sharing economy.” The public and policymakers must look at how this development could impact the last mile. One thing is certain: digitalization will require higher-skilled workers on the last mile. To create such forward-looking jobs, policymakers must therefore establish appropriate certificate and job training programs for these jobs.



View 3D printing as an opportunity for new production and logistics structures and to alleviate skilled worker shortages in local areas

Up-and-coming 3D printing technology will revive manufacturing in urban areas, particularly for specially produced or customized products. In rural areas where there is an increasing shortage of skilled workers, 3D printing can open up opportunities to improve deliveries of local supplies. Policies that support local businesses in the introduction and use of 3D printing can positively impact the quality of life on local levels and mitigate the effects of demographic change and national migration patterns.

Keep opportunities for local retailers and industrial companies in sight when licensing delivery robots

The delivery robot has been designed to be used mainly in medium-sized cities. If delivery robots are used more over a wider area, then policymakers will have to walk the fine line between two issues. The first is that robots make it easier to deliver packages, thus relieving the workload for delivery service providers and faster service to recipients, but, on the other, robots do not make a distinction as to the origin of their payload. Just because local city authorities willingly grant operating licenses and set up areas for robot package drop boxes and robot package stations, this does not guarantee that only local businesses will benefit. For cities that expect robot systems to be embraced by the public, the local authorities should first bring local businesses on board as a definitive partner to leverage deliveries in city centers to make them more appealing as a good business location. In rural areas, especially, robots could take on the role that was originally assigned to the drone if they travel on a conventional vehicle. This system cannot work without a reliable infrastructure. Both in rural and in urban areas, robots benefit from advanced communication networks, yet there is no point in deploying this technology if there are unpaved roads that might present obstacles for the robot. Cities and towns that want to welcome package delivery trucks with swarming delivery robots must be proactive in providing good roads and ensuring safe traffic.

Establish transport drones as special transport vehicles

Safety concerns and limited deployment options will force transport drones into niche markets. Local communities should review whether transport drones would be suitable as an emergency delivery option (express delivery of medication, blood reserves, etc.) in areas other than delivery for islands and remote mountain areas. Doing so would only impact a last mile to be driven in case of emergency but not regularly. Strong safety concerns among the general public is

one reason why a recommendation for the widespread and regular use of transport drones in package delivery cannot be made.

Realistic estimates regarding electromobility and acceptance of diverse drive systems

Electromobility is a top priority among politicians and is on course to become an integral part of commercial deliveries along the last mile. As this study has already shown, this is an ambitious goal that can be achieved only in some metropolitan areas and a few small and medium-sized cities with a view toward 2030. There will be few alternatives to the combustion engine in rural or urban areas far away from general freight and package sorting centers, particularly because electromobility will be a new technology on the market even in 2030. This is because the major manufacturers of commercial vehicles will not get these new technologies into volume production until at least 2020.

Welcome logistic companies to cities but insist they provide clean logistics

In areas where distances along the last mile are short enough, cities and communities have a powerful tool, namely, they can link the use of clean and quiet logistics with economic incentives. Regions heavily affected by structural changes such as the Ruhr region in Germany or metropolitan areas like Vienna, where the rail network is thinning out, can provide open industrial areas with good access to local road networks. For example, a DHL package sorting center with good road access is currently being built on the site of the former Opel plant in Bochum while the Opel group is providing street scooters for existing delivery stations. If cities consistently provide open areas for logistics with the caveat that last mile deliveries in their areas will be low-noise and low-emissions, then the needs of logistics companies and the city's requirements are met and an incentive for the use of electromobility is created. If heavy city traffic makes it difficult for logistics companies to reach service and cost targets and micro depots in the city represent a good solution, then it will not be necessary to ban diesel trucks to promote electric energy. However, it is important that the regulations for acquiring these valuable open areas are fair and apply across all regions or even nationwide so that no one location in a town or city has a competitive advantage over any other, this would be a lose-lose situation for the cities, the logistics companies and the environment.

Designate clear deployment areas, traffic regulations and maneuvering areas for driverless vehicles

Driverless vehicles, whether it's a truck, robot or drone, require a clear legal framework that ideally conforms to national or European laws and regulations. In addition to traffic regulations, clear liability regulations will be required to create legal certainty for any typical traffic or road incidents. Questions such as who is liable in case of an accident? How are robots or driverless trucks that have broken down towed away?

The use of large delivery vehicles, in particular, raises ethical questions as soon as there is a risk of injury to people. The risk of a driverless vehicle being intercepted through the use of jamming transmitters must be able to be identified and proactively reduced. This can be achieved by developing a supporting infrastructure, to include digital "position lights." Roads and the surrounding infrastructure must facilitate autonomous driving and their quality improved, if necessary. For economic reasons, driverless vehicles must be deployed on clearly defined routes during specific time windows and for specific purposes. This not only promotes acceptance of the technology by the public and its users, but also encourages a targeted focus on the most reasonable applications at the respective times. These regions, interrelationships and street networks systems must be defined in a joint effort between goods suppliers, the general public and the logistics industry.

With further advances in robot technology, the line between delivery robots and driverless trucks will become much fainter if such vehicles take over transporting small pallet shipments and become increasingly interesting for commercial customers. The last mile for general freight logistics could change considerably, but will require special designated transfer and depot areas for final distribution by a robot.

Summary

No one knows exactly what the future holds. While the forecasts and projections systematically derived from the findings in this study and the associated recommendations harbor some uncertainty, there are a few things we do know for certain. One is that societies provide strong workforces, active consumers and make decisions regarding an economic regulation framework and thus expect last mile logistics providers, as an essential connecting element in a "sharing economy," to be able to adapt to changing conditions. Service providers along the last mile would therefore be well-advised to ensure that their employees and organizational structures are open to change and, instead of getting left behind, are ready to shape the coming transformation in the logistics industry with innovative applications and groundbreaking concepts.



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This study is also available for download from our website. There you can also access the previous edition and a blog with interesting information as well as films and photos on this subject.

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Media Partners

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Verlags- und Veranstaltungs-GmbH
Handwerkstraße 15
D-70565 Stuttgart

Author

Fraunhofer-Institut
für Materialfluss und Logistik IML
Joseph-von-Fraunhofer-Str. 2 – 4
D-44227 Dortmund

Prof. Dr. Uwe Clausen
Dr. Sebastian Stütz
Arnd Bernsmann
Hilmar Heinrichmeyer

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