swisslog

Member of the KUKA Group

FUTURE PERSPECTIVES:

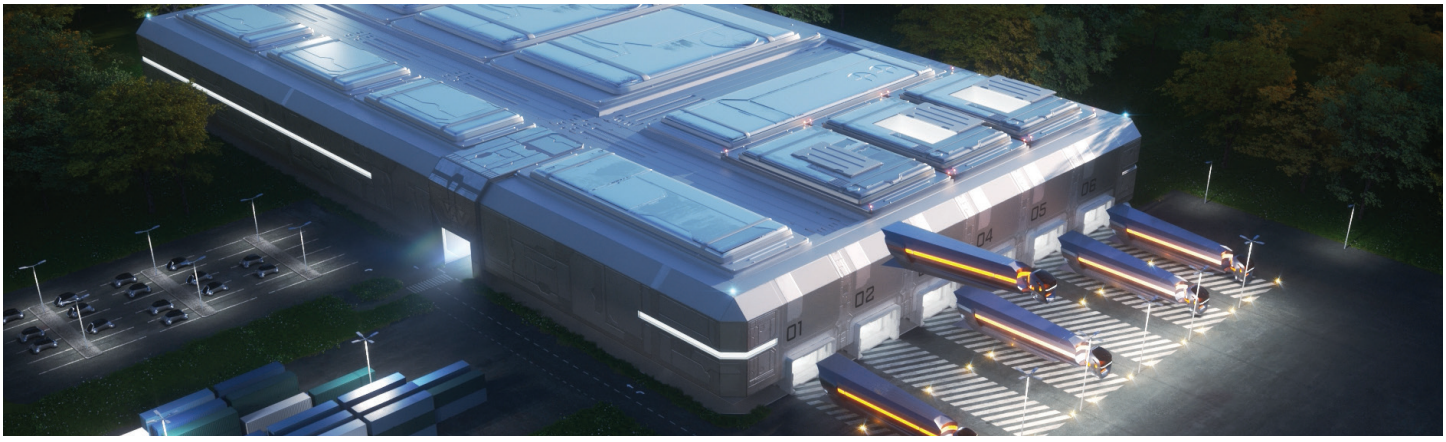
PLANNING FOR THE WAREHOUSE OF THE FUTURE

TABLE OF CONTENTS

INTRODUCTION

The pace of change has never been as fast as it is today, and those changes will ultimately influence the warehouse of the future. From demographic shifts to increasing urbanization, and from drones to 3D printing, social and technology changes will put pressure on supply chain managers to move goods closer to consumers and develop warehouses with the flexibility and speed to support local, faster delivery through multiple channels.

This paper reviews the major social and technology trends that will shape the warehouse of the future, analyzes their impact and presents a vision for how the industry can provide the speed and agility to support the expected demands of the market in 2030 through the development of hyper-local, urban distribution centers.



The warehouse of 2030 may not look as radically different from the ones today as this image shows. But it will have to adapt to dramatic changes in society and technology.

TRENDS IN SOCIETY

The goods that make their way through supply chains ultimately end up with consumers, and consumers not only drive demand but set expectations for delivery. That makes it valuable to quickly review the macro changes occurring in society as we consider the warehouse of the future. Here are the major trends:

Aging Population
In the coming years, global demographics will change due to increasing life expectancy, declining fertility rates and rising levels of education. The number of people older than 65 is expected to double in the next 25 years, reaching 13 percent of the global population. This will impact global productivity, personal savings and the labor force. It will also change consumption and spending behavior on a global scale, impacting production, logistics, warehousing and retailing.

Expanding Middle Class
The global middle class is projected to more than double between 2009 and 2030, rising from less than 2 billion to nearly 5 billion people. The middle class will then account for 60 percent of the world's population (ESPAS, 2015, p.19). Formerly poor populations, while still lagging behind developed countries, will have more purchasing power and greater access to information and communication technologies and enjoy greater mobility (ESPAS, 2015, p.20).

Urbanization
Urban population is expected to pass 6 billion by 2045. In 2015, 54 percent of the world's population was living in cities; by 2050 it will reach 66 percent. It is predicted that by 2030, the world will have 41 mega-cities with 10 million inhabitants or more. These developments will impact where goods are produced and consumed.

Growth of the Sharing Economy
Uber, Airbnb and TaskRabbit are examples of the rapid emergence of the sharing economy. According to PwC, the five key sharing sectors — travel, car-sharing, finance, staffing and music/video streaming—have a potential to generate global revenues of $335 billion by 2025 (PwC, 2015). The concept is already being extended to the construction industry and sharing will eventually come to logistics with its heavy assets and infrastructure.

Globalization and De-globalization
Globalization is the increased movement of goods, capital and workers across national boundaries. Today it is common for companies to develop a product in the United States, manufacture it in China and sell it in Europe or Africa. Some experts also note the value created by the global flow of data and communication, which is often referred to as globalization 2.0. According to McKinsey, "data flows enable the movement of goods, services, finance, and people. Virtually every type of cross-border transaction now has a digital component."

While globalization continues to advance, a counter-movement is also emerging as nationalism and the desire to source products, particularly food, locally grows. This de-globalization is already impacting the decisions consumers in some markets are making about the products they purchase.

Increased Connectivity
The increasing connectedness of people and information is creating greater transparency, better information provision, more critical thinking and more creative and dynamic individuals. It is assumed that pressure for greater accountability and transparency at the different levels of governance—and within industry—will increase.

Changing Labor Market
The demographic landscape is changing at the international level, with global population growth in developing countries and population aging in developed countries. The projected change in working-age population predicts an explosive workforce growth of nearly 1 billion in the developing countries, mainly driven by high fertility rates. The opposite trend is predicted for the most advanced economies, with a future decline in the working age population (Rand, 2015, p.15). In the short term this is increasing the value placed on ergonomics and other factors that increase worker satisfaction in developed countries where the labor force is shrinking. In the longer term, China and India may gain importance, whereas Europe may lose traction in global governance and economy (Rand, 2015, p.16).

TRENDS IN LOGISTICS

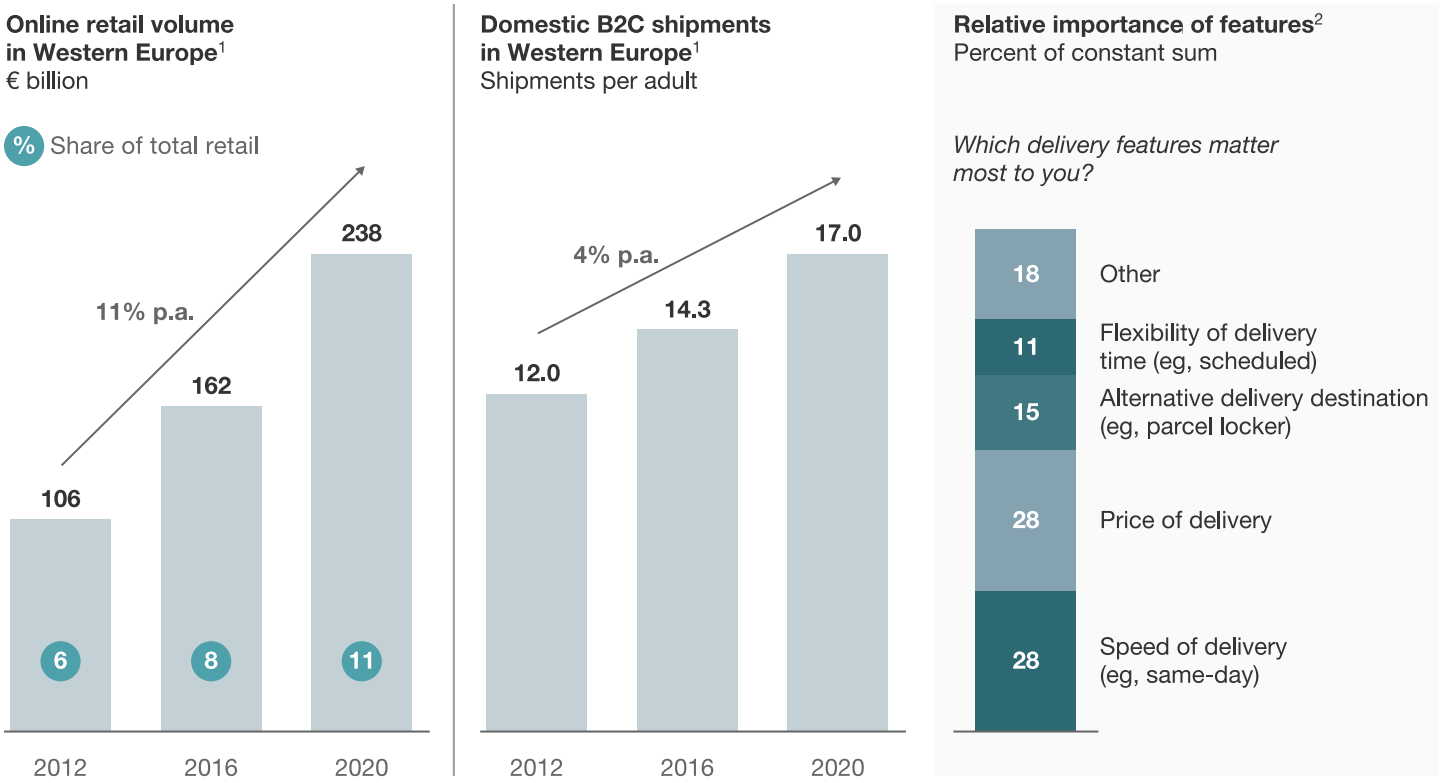
The supply chain is being impacted by a number of trends resulting both from the broader changes in society and advances in technology. These include:

E-Commerce

One of the biggest current trends already creating significant disruption in the supply chain is the continued growth in e-commerce. In Europe, the average share of e-commerce in retail was 7 percent in 2015, 8 percent in 2016 and projected to reach 8.8 percent in 2017. Globally, retail e-commerce is expected to increase to 14.6 percent of total retail, with a market volume of more than $4 trillion (eMarketer, 2016).

E-commerce has continued to experience high growth rates, in part by shrinking the time between order and delivery. Early in its development, consumers often waited a week or more to receive their orders. While this may still be the case in some specialty categories, major e-commerce players now routinely offer two-day delivery on many orders while next day and even same day delivery is increasingly common. This is creating higher expectations among consumers and, as e-commerce expands to new categories such as food, delivery times are continuing to be compressed and e-tailers are exploring multiple options to consistently achieve next day or same day delivery.

E-COMMERCE BOOM AND PREFERENCE FOR CONVENIENCE DRIVE DEMAND FOR NEW DELIVERY OPTIONS AND FEATURES



[1]Included countries are Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Norway, Sweden, Switzerland, UK.
[2]Only delivery features included, not general delivery conditions (eg, goods not broken).

McKinsey&Company | Source: Forrester; Datamonitor; online survey conducted in June 2013, n = 1,016 (UK, France, Germany, and Sweden)

Source: https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/same-day-delivery-the-next-evolutionary-step-in-parcel-logistics#

By 2030, the omni-channel journey of a customer will move further, and the channels might be even more diverse than today.

Anticipatory Logistics
Anticipatory logistics is a process that foresees which logistic services will be needed in the future and in which region. The area where anticipatory logistics has already developed is anticipatory shipping. This allows online retailers to predict orders before they have occurred, based on previous customer behavior data. This information is then used to ship or move goods closer to the potential customer to enable faster delivery. In the future, we will see anticipatory logistics extend across the value chain.

Customer-Centric Production/Batch Size One
In the future, the customer will increasingly become the center of production. The result will likely be more localized production, as customers do not want to wait for their individualized product. The trend of 3D printing will drive both the individualization and the localization of production. The Adidas Speed Factory in Germany, which allows customers to customize their shoes, is an early example of this trend. (Adidas Group 2015).

The impact on warehousing and logistics are significant: these customized shoes never see a warehouse; they are shipped directly from the factory to the customer, reducing the need for warehouse space. However, the logistics required to support individualized production increase.

Even if we are not yet at a point where "batch-size-one" production is feasible for most products, it seems likely that as this trend develops, companies will move production closer to their customers, and focus on next-shoring and near-shoring.

Omni-channel Logistics
Consumers are already using multiple channels for their shopping. They start and end their buying journey at different points and expect lots of information, a certain delivery speed and personalized experiences. This is creating opportunities for retailers to merge the different channels and optimize the whole journey for a customer, rather than optimizing each channel separately (DHL Trend Research, 2015).

From the retailers' perspective, omni-channel logistics can achieve an increase in customer base and loyalty, and also improve profitability. Shoppers using multiple channels for their shopping spend 15-30 percent more than traditional shoppers.

By 2030, the omni-channel journey of a customer will move further, and the channels might be even more diverse than today. Home delivery is currently the most preferred mode of delivery¬—nearly 70 percent of all online shoppers make use of it. Yet around 50 percent of them have already experimented with buying online and picking up in a store. In a survey by PwC in 2017, 33 percent of shoppers were open to curbside pickup and 28 percent to pickup at a third-party location. These modes are commonly referred to as 'click and collect' and experts assume that these models will grow even more (PwC, 2017). As noted in DHL's 2015 Trends Report:

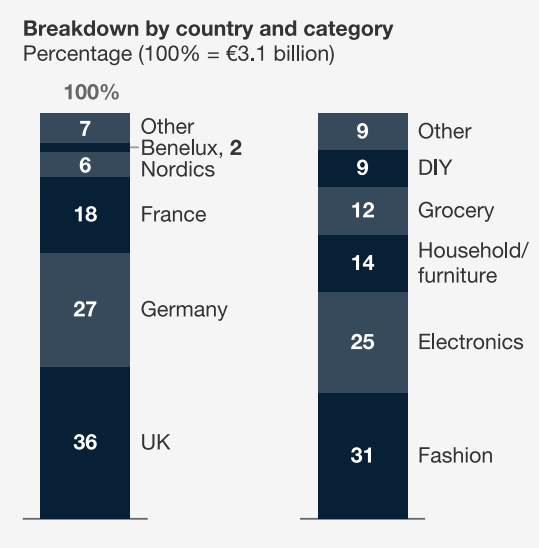
Looking ahead, we expect to see the physical assets of logistics networks being virtualized and managed much more dynamically in line with customer demands. It is also anticipated that there will be more focus.

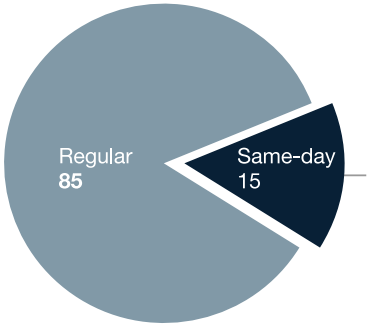
Same-Day (or Faster) Delivery
As noted earlier, e-commerce has continued to grow by shaping and meeting consumer expectations for faster delivery. The next frontier is same-day delivery. According to DHL's 2017 Trend Research: Sharing Economy Logistics report, "41 percent of U.S. consumers have used programs offering same-day, expedited, or on-demand delivery services."

Other studies show that 20 to 25 percent of consumers would pay significantly more to receive items on the same day. These premiums would be up to 3 Euro, 20 RMB and 3 US dollars for the respective regions. Assuming that the customers would have to pay the full costs for this fast delivery, only around 2 percent of all customers would be willing to pay more than that. McKinsey experts predict that "same-day and instant delivery will likely reach a combined share of 15 percent of the market by 2020" (McKinsey, 2016, p. 9).

BY 2020, THE SAME-DAY DELIVERY MARKET IS EXPECTED TO BE AROUND €3 BILLION IN WESTERN EUROPE

Market revenue from Western European B2C domestic parcel deliveries, 2020[1]
Percentage (100% = €20 billion)





[1]Countries included are Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK; B2C market is expected to constitute approx. 38% of total parcel domestic market in 2020.

McKinsey&Company | Source: Euromonitor; McKinsey

Source: https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/same-day-delivery-the-next-evolutionary-step-in-parcel-logistics#

EMERGING TECHNOLOGY

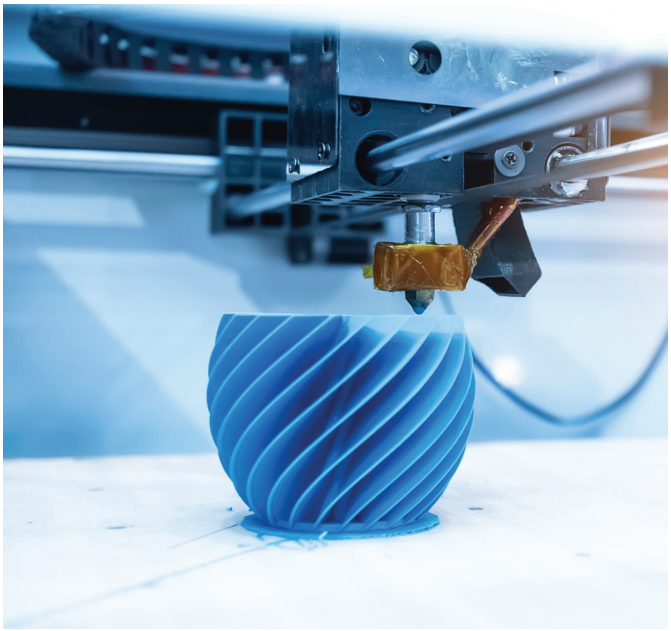
Emerging technologies will play a significant role in shaping the warehouse of the future and supporting faster delivery. The major technology developments on the horizon include:

Drones
Leading companies like Amazon and DHL are actively exploring the potential of drones and filing patents for the use of drones in logistics. Amazon has patented an idea for an airship that can launch drones over larger cities. At the same time, many people see issues with thousands of drones flying over a city. These include traffic congestion, noise and an obstructed view of the sky. Energy wise, flying is the most inefficient means of transportation.

In 2030, drones should play a role in the supply chain, although legislation could delay their application. The greatest potential may be in non-urban areas where drones would allow consumers to get the same high-speed, i.e., 2-hour delivery, as is possible in cities.

In addition, larger drones may play a role in connecting cities and even doing long-haul cargo flights. Inside cities, drones could play a role in ultra-high speed or short-distance deliveries. What percentage of parcel deliveries drones will carry in 2030 is still uncertain, but any future distribution solution should be designed to interact with drones.

EMERGING TECHNOLOGY



3D Printing

3D printing will significantly change the way many products get to market. The most common 3D printing application today is small plastic parts. This is still a slow and, therefore, expensive process, but should become radically cheaper and faster as the technology matures. Plus, more advanced machines that can print complex parts of multiple materials, including metal, will emerge. There are even companies creating machines that will enable 3D printed food. By 2030, it is possible that we will see a three-tier approach to the use of 3D printing:

1. Some consumers will have cheap, easy-to-use 3D printers that allow them to print small plastic parts based on licensed 3D models they buy online. This would apply to things like replacement parts for home appliances, a plastic case for a mobile phone or toys for children.

2. For less tech-savvy consumers, or larger, more complicated parts, there will be "print shops" in cities. Consumers could either send their digital designs to be printed or order a product online and never know it was printed on-demand for them. Ideally these print shops would be integrated in urban distribution centers.

3. Complex industrial applications, which use multiple materials including metal, would be supported by sophisticated 3D printers within manufacturing or service centers.

Autonomous Vehicles

Autonomous guided vehicles (AGVs) have been used in warehouses for 30 years. In the next 10 years, the use of AGVs in warehouses will grow exponentially.

There are several drivers behind this trend. First, there is an increasing demand for flexibility in warehousing. Changes in processes, product ranges or distribution channels are all impacting warehouse requirements. Traditional, bolted-down automated conveyor systems are not able to adapt to these changes. AGVs provide the required flexibility.

The other driver is the simultaneous decrease in cost and increase in performance of AGVs as the core components increasingly support consumer products, such as robotic vacuum cleaners and automated lawnmowers. The economies of scale are much greater for consumer products than for warehouse technology and could drive down the costs of the underlying technologies, such as sensors and navigation systems, used by AGVs. A similar impact could result from the technologies used to support self-driving automobiles

Where early AGVs still relied on fixed infrastructures, such as reflectors, floor markings or tags, the technology is available today to allow AGVs to navigate with the help of on-board radar and camera systems. Intelligent software and self-learning capabilities interpret the images and instruct the vehicle where to go. This makes the systems plug-and-play and, therefore, easy to deploy and more flexible.

Replacing a large conveying system with flexible AGVs could require hundreds or thousands of small AGVs operating together. This would have been impossible in the past, but today, and certainly in 2030, the combination of peer-to-peer communication, faster wireless networks and cloud-based processing power enable coordinated operation. As the technology progresses, advances in sensors and electronics will allow AGVs to move faster, even when interacting with people.

EMERGING TECHNOLOGY

Mobile Robotics
In this context, a mobile robot is an AGV with a robot on top. This allows the robot to drive through the warehouse to where products are stored and retrieve them. For this to work effectively, these robots need robust navigation, vision systems and multi-functional grippers. A level of artificial intelligence is also required to deal with the near-infinite variety of products, shelf configurations and product placement. All of these supporting technologies are advancing rapidly.

IoT Connectivity
As more sensors are installed in machines and processes, the opportunity exists to connect groups of machines or entire facilities into IoT networks that provide visibility into product movement and enable capabilities such as predictive maintenance. Industrial IoT networks will soon become an essential component of efficient warehouse management as they provide the connectivity and data that the smart warehouse will depend on.

Big Data
Big data programs are already shaping everything from marketing to forecasting. They will also drive key advances in logistics, such as the predictive shipping model discussed earlier and will enable machine learning as the integration of real-time and historical data is what allows machines to continually improve their operation based on past actions.

THE IMPACT ON DISTRIBUTION

The changes in society and technology will certainly influence how products are stored and distributed in the future. Based on those changes, key capabilities of the supply chain of the future will include:

Storing Products Closer to Consumers

Many of the trends lead to the same conclusion: more people living in cities and ordering products online, which will increase the need to support same-day delivery. At the same time, cities will be battling increased congestion and air pollution.

Small, self-driving vehicles and local delivery robots, such as Starship, and possibly drones could be part of the solution to this challenge. However, these systems are typically meant for short-range transport, which will require that distribution centers be located in cities, close to large groups of consumers.

Yet, this presents its own set of challenges. The number of SKUs is already in the thousands or tens of thousands in many warehouses and could grow to more than 100,000. With the space constraints inherent in most urban environments, how can an urban distribution center support the needs of the market it is positioned to serve?

Customized Production

As seen with the example of the new Adidas factory, products that are custom-made for one consumer do not require warehouse storage. These articles will be sent from the manufacturing site to the consumer directly upon production.

While this minimizes the requirement for storage space, it will require fast transport and sortation networks, and potentially some ultra-short storage to synchronize product flows with consumer schedules.

In 2030, customized production will most likely be limited to luxury items, spare parts or fashion products. Basic essentials will still be produced to stock – probably in smaller batches than today, but enough to require some form of warehousing.

Omni-channel Support

Supporting omni-channel retail requires providing consumers with options that extend beyond traditional delivery. By enabling options such as in-store or curbside pickup, retailers can give consumers more control over how they receive products and eliminate some of the frustrations with home delivery, such as product security and returns, while minimizing the cost of same-day delivery by shifting the cost of the "last mile" to consumers.

These various impacts are all addressed through the development of urban distribution centers that bring distribution closer to consumers, support custom production and enable fast, efficient delivery based on consumer preferences.

THE URBAN DISTRIBUTION CENTER OF 2030

Societal trends are driving the shift to numerous urban distribution centers that bring key logistics capabilities close to consumers. Urban DCs will likely be shared-service facilities that optimize all logistics flows for the area or community they serve, including the following core functions:

1. **Inventory and Order Picking**
   Similar to many warehouses today, the urban DC will need to hold some inventory. However, since space in cities is limited and product ranges are likely to continue to expand, this inventory will be limited. In principle, smaller items, and products that are sold regularly would be held in stock. Inventory size would be minimized through 3D printing and use of big-data to predict behavior and distribute articles to the urban DC just before they are ordered.

   An order picking process, using automated picking systems described later in the paper, would also be required. Because the urban DC will support multiple sellers in a shared service model, this creates the opportunity to consolidate articles from different sellers into one shipping carton to reduce shipping costs and enhance the customer experience.

2. **3D Printing**
   Products not available in the limited inventory may be 3D printed. This reduces inventory requirements and allows the creation of individualized products. The urban DC is an ideal location for several large, sophisticated and fast 3D printers. With the picking scenario described above, it is also possible to consolidate printed items with items picked from the inventory into one parcel.

3. **Parcel Consolidation**
   The urban DC of the future will consolidate pre-picked parcels coming from multiple sellers or parcel companies into one last-mile transport to the consumer. Functionally, this is no different from the many parcel sortation hubs that exist today. The difference is that flows will be consolidated. In today's networks, companies like DHL, UPS and FedEx do their own sortation and last mile transport, for their customers. The future urban DC will consolidate flows from all companies.

Key Enabling Technologies
In addition to supporting these core tasks, urban distribution centers will need to incorporate a number of advanced technologies to meet the distribution requirements of 2030.

For picking, intelligent robots with advanced grippers could not only pick individual products, but also assemble products from several parts produced inside the warehouse, and consolidate orders from multiple sellers, including 3D printed products, into one shipping carton. Robotic goods-to-person or fully automated picking solutions, such as Swisslog's AutoPiQ, would support the high pick speeds required by the urban DC.

Big data and smart, self-learning analytics will predict what consumers will be ordering to minimize inventory; however, the predictions will not always be correct, and that will create additional product movements. Technology advances, such as self-driving trucks and robotic loading and unloading systems, will minimize the costs of those movements.

For products that can't be printed and are not predicted, new means of fast, long-distance transport could support delivery of products not stored locally. Emerging transportation solutions, such as Hyperloop, could connect large, central warehouses with urban DCs in major cities. Alternately, larger, long-distance cargo-drones could offer flexible, infrastructure-independent transportation over longer distances. In addition, automated storage and retrieval systems could be deployed to maximize the amount of product that can be stored in the available space.

Online marketplaces would need to be employed to manage supply and demand among sellers vying for space in the DC, allowing sellers to balance their costs against the need for delivering very quickly. This will reduce the number of distribution centers within a particular city and maximize space utilization.

THE URBAN DISTRIBUTION CENTER OF 2030

Source: http://media.daimler.com/marsMediaSite/en/instance/picture/Mercedes-Benz-Vision-Van.xhtml?oid=13546503

Last Mile Delivery Options
Many different solutions will exist for last mile delivery and the urban DC will need to interact with a multitude of delivery options.

A significant percent of parcels will still be delivered in a multi-delivery vehicle. Most likely, this will be an electric, and potentially driverless, version of the familiar delivery van. Loading such a vehicle efficiently requires that a high number of parcels be loaded simultaneously in as short as time as possible. Very likely some kind of drop-sequence will be required for that as well.

For this, we can imagine standardized loading modules where parcels can be staged before the vehicle arrives and loaded into the vehicle "in one go." Inside the vehicle, there may be a form of automated handling, presenting individual parcels to the driver. The Daimler Vision Van is an early example of this concept.

The urban DC will also need to support customer pickup, and a network of mobile pickup points.

To support pickup, the DC will require a "parcel station" similar to those used by overnight shippers today. But, being located within an automated warehouse, it will allow for automatic loading of individual lockers, from which consumers would receive their purchase from the back.

Mobile pickup points would be filled quickly with multiple parcels at the community warehouse and then driven to a spot even closer to the consumer (e.g., shopping mall parking lot) where consumers would pick up their parcels.

Some parcels may need even more individualized transport methods. Parcel-drones or small autonomous vehicles similar to Starship could accomplish this. These methods will require different loading processes, since each vehicle will only be loaded for one stop. The warehouse will need a series of small "docks" for these vehicles, and a way of automatically loading into the drone or vehicle.

Another potential scenario is that consumers will send their self-driving vehicles to collect their packages. For that, the DC could use mobile robots to place the goods in the trunk of the car. It is not difficult to imagine a next generation of KUKA's Mobile Robot (KMR) doing this.

SCALE, FLEXIBILITY AND THE NEED FOR AUTOMATION

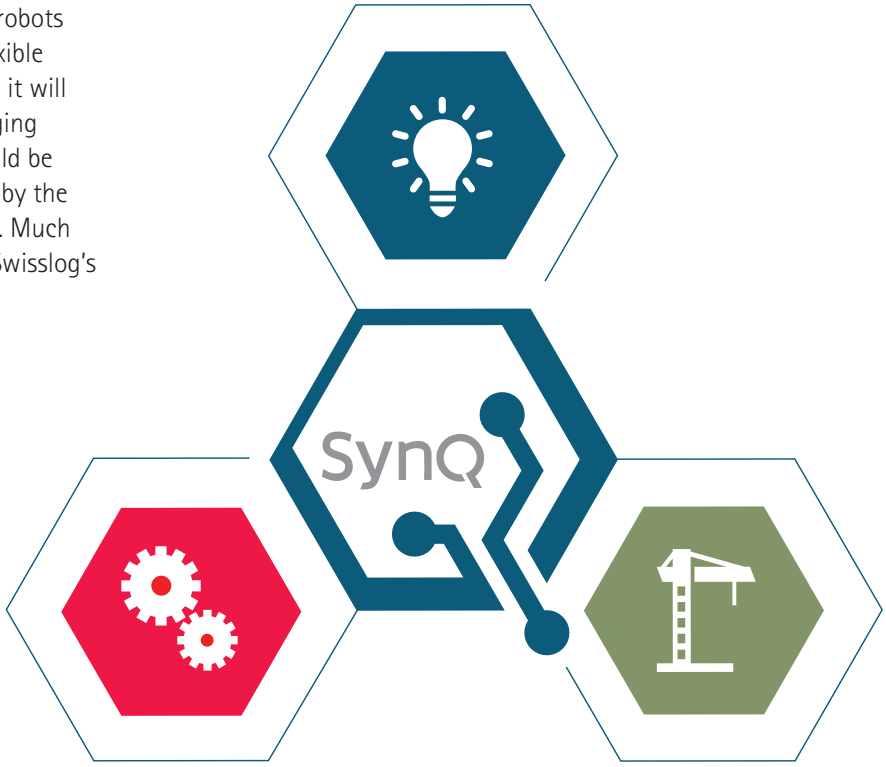
Distributing warehouse capacity across multiple small centers within a city that directly interact with consumers does introduce the challenge of increased volatility on DC demand. At the same time, the aging population, labor shortages and new labor regulations will all require a higher level of automation inside these DCs.

Traditional automated systems have not proven to be well suited to deal with volatility. In addition, the size restrictions imposed on the urban DC by its location may prove to be a barrier to traditional automation. The necessity for custom engineering, project management and software coding all create an "overhead" cost to projects of any scale, often destroying the business case for traditional automation in small spaces.

Newer automated solutions will, however, address these challenges. Systems based on small AGVs or mobile robots will be more adaptable to small spaces and more flexible in dealing with volatility. With these mobile systems, it will be easy to change routing or logic to adapt to changing demands. One could even imagine that vehicles would be moved from one DC to the other, based on demand, by the very same trucks that supply the products to the DC. Much of that is already possible today with solutions like Swisslog's CarryPick system.

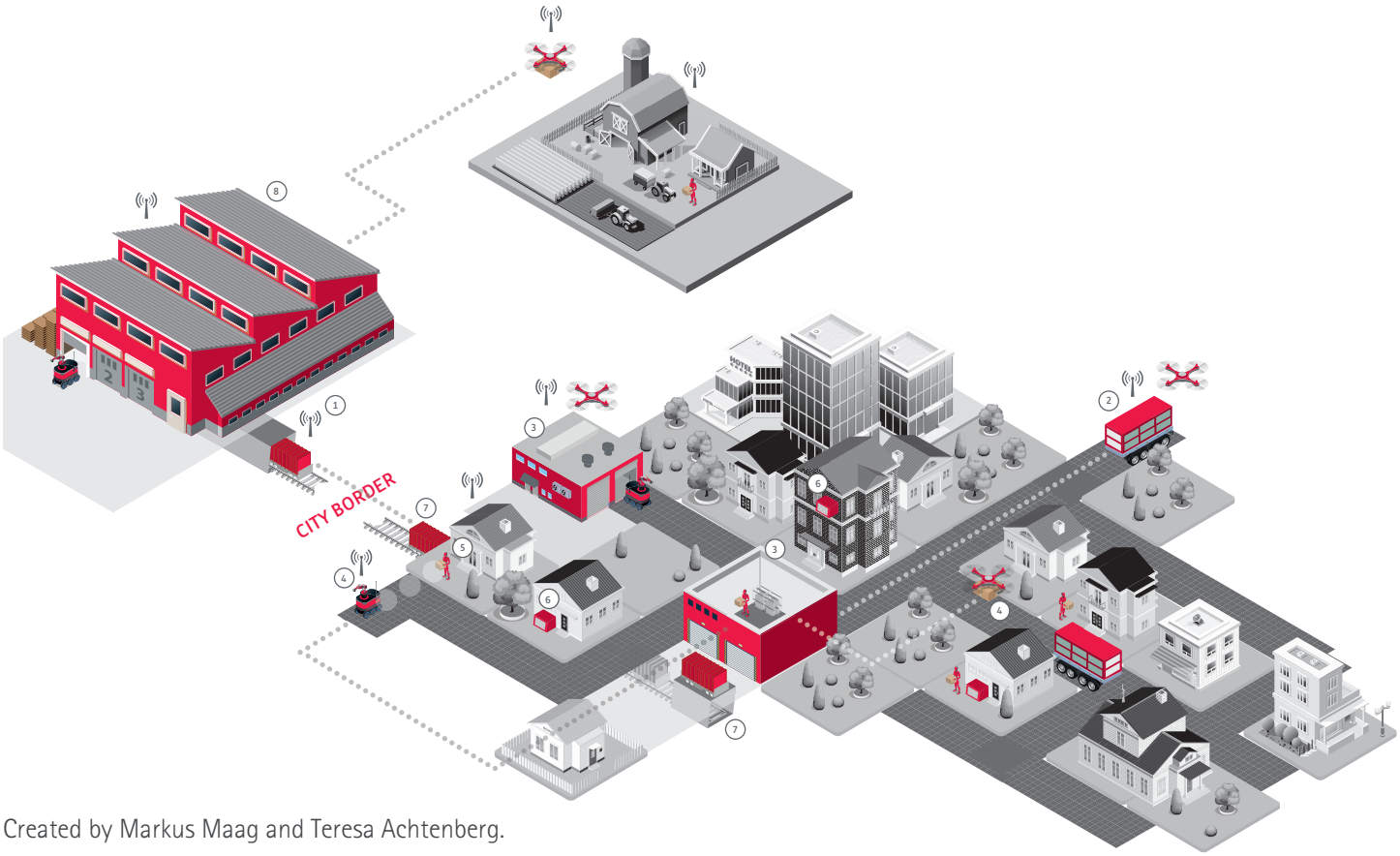
Self-learning software and peer-to-peer communication would make these vehicles "plug and play," eliminating much of the fixed, front-end costs required for traditional automation systems. This will not only allow for the flexibility needed but will also make small-scale automated systems feasible.

Warehouse management software is already evolving in this direction, with platforms, such as Swisslog's SynQ, integrating multiple functions, including automation control, into a modular architecture that more easily adapts to changing technology while also providing the business intelligence that will be required to support predictive logistics.



SCALE, FLEXIBILITY AND THE NEED FOR AUTOMATION

Conceptual view of distribution in the future, showing a large warehouse outside a city supporting multiple urban distribution centers with a variety of transportation options from the central warehouse to the urban DC and from the urban DCs to consumers.



Created by Markus Maag and Teresa Achtenberg.

1. Advanced digital connection:
   Warehouse will be connected to home order system
2. Mobile hot spot hubs
3. Many smaller local logistic hubs in cities, every neighborhood has its own hub
4. Last mile delivery with drones and AGV
5. Household robotics in every home available
6. Households will have an interface to accept delivery
7. Transport and logistics will have partially moved underground
8. Bigger warehouses will be outside of the cities

THE QUESTION OF OWNERSHIP

A key question to answer considering the shared nature of these urban DCs is who would own and operate them. The essential characteristic is that these centers will consolidate the flow of goods from many different sellers, and may consolidate transport with many different means, by different providers.

Three models are possible, two of which can already be found today.

1. Large e-commerce companies can set up their own community warehouses. Already, large e-tailers act as a platform where other sellers can sell their goods, so it isn't hard to imagine that as long as goods are ordered via the e-tailer's platform, all resulting flows can be routed though the community warehouse. The question is, would they open up their warehouse for sellers who aren't using their platform?

2. Logistic service providers or parcel companies like DHL, FedEx or UPS could build and operate these new urban distribution centers. Warehousing and distribution processing for a multitude of sellers are already one of their core competencies. The downside of this approach is that normally the service of such a parcel company is limited to those sellers who have contracted the parcel company—and all compete with each other—which would make it difficult to come to one consolidated flow.

3. Local governments or cities could regulate what distribution flows are allowed into their city. They would enforce consolidation to reduce traffic and pollution. In doing this, they would need to facilitate the solution as well. It is doubtful they would actually own and operate a DC; they might periodically tender that process on the market. That brings it back to the two parties above, who may or may not want to bid on such a request. But if they do, by default their solution would have to be open to any seller/transport who wants to deliver to a consumer in the city.

CONCLUSION

Supply chain managers are already dealing with a myriad of technology and market changes as they implement modular, automated solutions to increase productivity and throughput in their warehouses.

However, the changes occurring in society, with more disposable income and higher consumer expectations, may stretch existing distribution networks beyond their ability to adapt. This paper presents a vision for the future of the warehouse that assumes the need to move products closer to consumers, support individualized production and provide same-day deliver through multiple channels.

The solutions emerging today in terms of AGVs, automated picking and intelligent, modular software provide the speed and flexibility to support these core capabilities and will continue to evolve to meet the demands of the future.

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