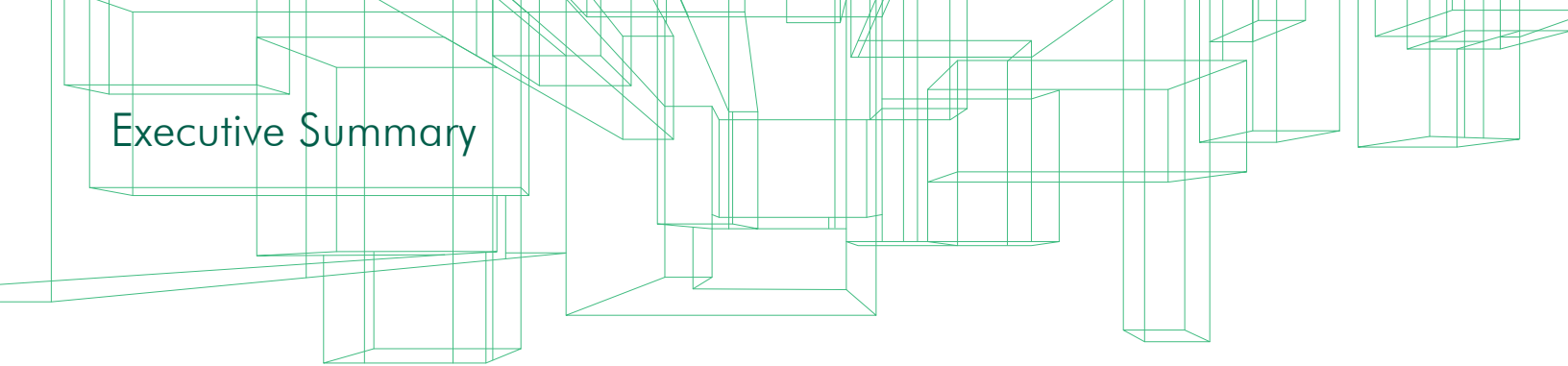


Transformation of the Global Supply Chain

Automated Technology: Driving Change in Real Estate

Introduction



Executive Summary

Autonomous vehicles are here

Autonomous trucking technology is currently being tested all over the world. In April 2016, a caravan of about a dozen self-driving, semi-trailer trucks traveled more than 2,000 miles across four national borders in Europe. The convoy, organized by the Dutch Ministry of Infrastructure and the Environment, included rigs from six manufacturers.

Expansion of distance & coverage for trucking

Self-driving vehicles have the potential to significantly expand daily coverage trucks can provide to a logistics operator. Per U.S. federal regulations, truck drivers are restricted to 70 hours per week, effectively limiting them to a maximum of 3,000 miles of travel. Automated driving allows these restrictions to be relaxed, increasing both distance and coverage, thereby reducing costs. With compression in industrial and distribution cost structures, e-commerce sales are likely to increase.

The rise of 3D printing

Even though 3D printed manufactured goods only represent 1% of all manufactured products in the U.S., it is achieving staggering growth, and has the potential to significantly disrupt the manufacturing sector in the short term. The global 3D printing market is on track to exceed \$21 billion by 2020, and the demand for 3D printers, materials and services will exceed \$10 billion by 2018 (Consumer Technology Association & UPS).

Automation provides greater efficiencies within the logistics space

The cycle time, or time between an order dropping and when it hits the back of the truck, is increased only with enhanced systems and technology, and thus the investment must be

made to drive speed. Automation within the logistics space ensures an optimal balance between space, labor, equipment and cycle time.

Leaner logistics networks, but fewer & larger warehouses

Lower transport costs mean that at a given level, a supply chain can exist with fewer warehouses. We expect that this will lead to further warehouse consolidation and as a result, we are likely to see fewer but larger warehouses being built in remote locations.

Last mile delivery facilities crucial elements in the network

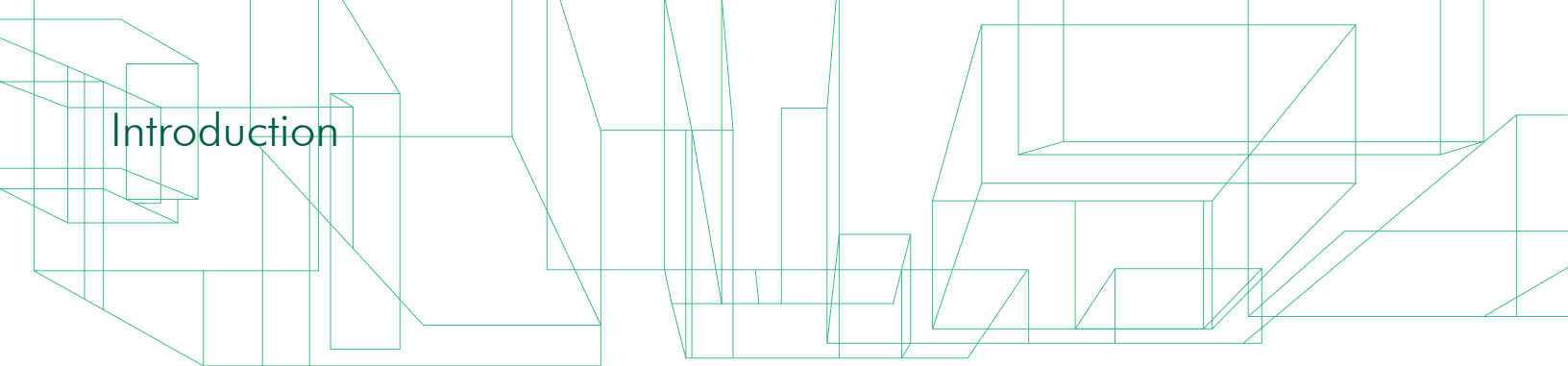
These sites will need to be able to make the modal shift from diesel to electric, receiving large (semi-) automated truck convoys and deploying electric city delivery vehicles. Battery loading stations will need to be installed at these sites.

Shift in the way logistics facilities are built and maintained

The automation of the warehouse space will require accommodations for more advanced technology, including IT infrastructure and new software programs that will be interconnected throughout the space allowing for large amounts of data to be stored and analyzed. Lack of current specifications at existing facilities may lead to a development boom assuming that demand for more modernized warehouses increases.

Vertical solutions with higher overall building heights

The use of robot picking systems will lead to different requirements for daylight and height, prompting high-bay warehousing, multi-layered developments and use of more mezzanines.



Introduction

In this paper, we discuss the role of new technologies in the transformation of the supply chain and the implications for the industrial and logistics (I&L) real estate market. Just as tax software and car-sharing apps have disrupted the accounting and taxi services, automation and 3D printing are having a profound impact on the I&L market, in how cargo is collected, transported and manufactured. Ride-sharing services have revolutionized the way people get from place to place in cities all over the world. The sharing economy has increased the supply of drivers, lowered costs for consumers, and raised the convenience of transport, significantly affecting the taxi industry. Similarly, self-driving trucks and advanced robotics in logistics facilities will likely disrupt the trucking industry and change how we locate and operate warehouses.

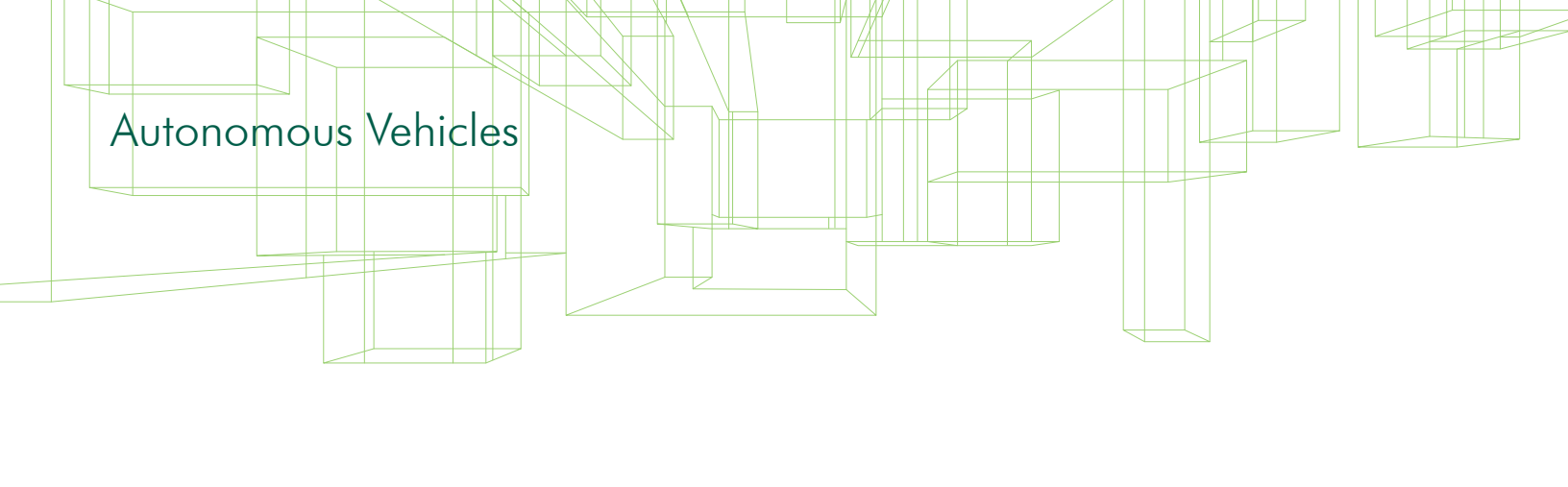
There are three technologies that we expect to be significant game changers for the I&L real estate market. First, with self-driving cars and trucks in the early stages of implementation, it is only a matter of time before the public accepts autonomous

vehicles and legislation is passed to allow the technology to thrive within regulatory boundaries. Second, 3D printing is rapidly becoming an integral part of industrial manufacturing and supply chains. According to a report by UPS and the Consumer Technology Association (CTA), the total global 3D printing market reached an estimated value of \$5.7 billion in 2014—up 30.8% from 2013. Third, automation in warehouse and logistics space will change the way such facilities are built, as the labor component—currently 15%-30% of the supply chain costs—becomes less of a financial burden for occupiers.

Some of these technologies have been around for several years, but they are starting to penetrate the I&L market in new ways. Although many of their expected effects are far from being realized—the more dramatic of which will not take shape for many years—all indications point to the full eventual implementation of these technologies, and it is imperative that I&L owners and occupiers start preparing for the shift today.

01

Autonomous Vehicles



Autonomous Vehicles

We have seen the rise of automation change real estate, such as how automobile ownership has prompted widespread suburbanization. Although the housing sector has been most affected by the ubiquity of motor vehicles; as future vehicles become increasingly autonomous, we will see trickle effects on housing and retail, and direct effects on logistics facilities, from self-driving trucks. In this latter area, one of the major change components will be labor. In the U.S., labor accounts

Meanwhile, trucking has seen a drastic decline in available drivers in recent years—a result of high turnover due to demanding hours and the safety risks of the job. Trucking companies are having difficulty finding younger workers, which directly affects their cost structure. When trucks are converted into mobile computers, companies may have better luck attracting a younger labor pool, as the tech-oriented generation may be more inclined to operate enhanced big rigs.

The growth of e-commerce and the emergence of these technological advances has ushered in an evolution of the physical supply chain...this has spurred a new era of modern site selection and design for investors and users.

Scott Marshall, CBRE's Executive Managing Director of Industrial & Logistics in the Americas

for approximately 75% of the cost to move a full truckload from L.A. to New York.¹ With the adoption of driver-less trucks, the trucking industry will be able cut its labor costs, shifting its focus toward building technological systems that can meet the demand for goods more efficiently while focusing more on inventory and occupancy costs.

Self-driving vehicles have the potential to significantly expand the daily coverage trucks can provide to a logistics operator. Per U.S. federal regulations, truck drivers are restricted to 70 hours per week, effectively limiting them to a maximum of 3,000 miles of travel, or 400–500 miles per day. Automated driving would allow these restrictions to be relaxed, increasing both distance

1. <http://techcrunch.com/2016/04/25/the-driverless-truck-is-coming-and-its-going-to-automate-millions-of-jobs/>

and coverage and thereby bringing currently-remote storage locations into play. The result will be lower delivery costs for the consumer; with compression in industrial and distribution cost structures, e-commerce sales are likely to increase.

Autonomous trucking technology is currently being tested all over the world. In April 2016, a caravan of about a dozen self-driving, semi-trailer trucks traveled more than 2,000 miles across Europe, crossing four national borders. The convoy was organized by the Dutch Ministry of Infrastructure and the Environment, and included rigs from six manufacturers. The trucks journeyed from manufacturing facilities in Belgium, Denmark, Germany and Sweden to the port of Rotterdam in the Netherlands, using a method known as “platooning,” in which they form a column, following one another closely (at about 30 feet) at a constant speed, connected by Wi-Fi. The trucking industry is bullish on this technology, and according to a survey done by *Eyefortransport* (EFT), 59% of respondents anticipate driver-less trucks in their operations in the next 9 years.²

In Asia Pacific, several governments, in partnership with private companies and universities, are road testing self-driving technology, with Australia, Singapore, Japan and China leading the region. In late 2015, Volvo partnered with industry bodies to road-test autonomous vehicles in southern Australia. In Singapore, the government has fast-tracked self-driving technology with the help of technology start-up nuTonomy; they tested fully autonomous taxis in Q2 2016.

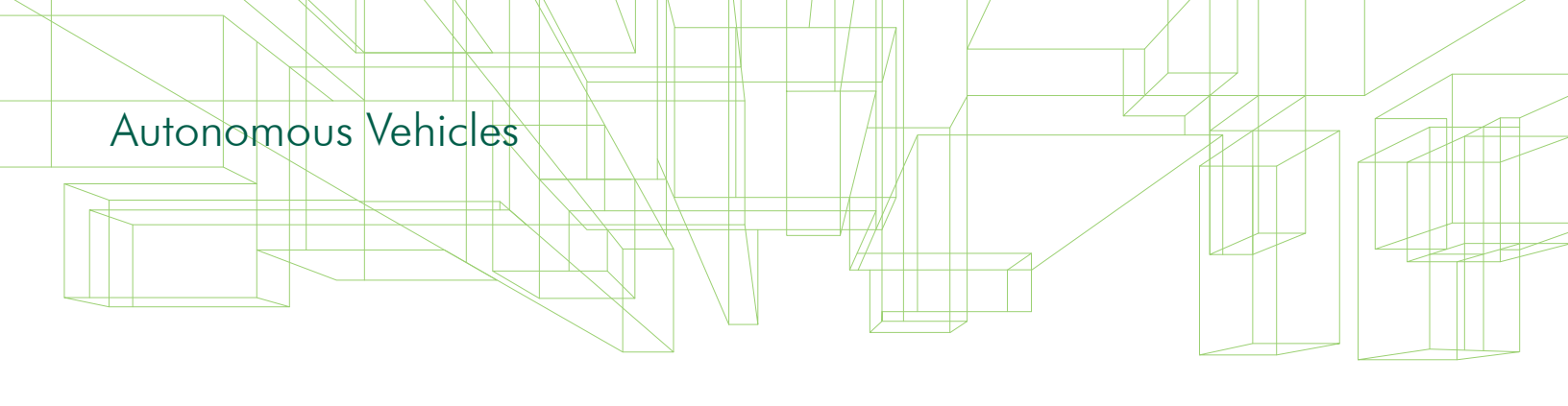
Local testing has also been done in China and Japan, helping to pave the way for autonomous vehicles in both the consumer and industrial markets. Ford and local partner Changan Automobile completed a 1,200 mile road test from Chongqing to Beijing in six days. While many of these pilot studies have been for the consumer, they can easily be adapted to the industrial transportation market. Singapore’s Ministry of Transport (MoT) and Port of Singapore Authority (PSA) aim to utilize the platooning method to increase logistics efficiency and reduce traffic congestions in the small city-state.

The rise of self-driving trucks will lead to growth in IT infrastructure and data centers, as there will be a need for real-time traffic data and for providers to be located near their end users. This proliferation will support the development of the “internet-of-things,” with electronic sensors and software in devices, vehicles, buildings and other items collecting and exchanging data.

Last-mile delivery

Autonomous technology will also have a significant impact on last-mile delivery. It is unlikely that driverless trucks will be able to handle the doorstep delivery of parcels anytime soon, but we may see the automation of the delivery support vehicle. Some speculate that automated handling technologies may be able to deliver parcels to fixed loading stations. In addition to the fixed locations, driverless trucks may even act as mobile

2. Eyefortransport Reports. *Supply Chain Hot Trends Q1 & Q2 2016*.



Autonomous Vehicles

repositories, available for parcel delivery and pickup in certain locations at certain times of the day.³ It is important to note that last mile delivery facilities will need to make the modal shift from diesel to electric, and be equipped with extensive battery loading stations.

Autonomous vehicle technology timeline

The timeline for the realization of autonomous vehicles can be broken down into three stages: the technological development stage, the partial driver substitution stage, and the complete self-driving stage, evolving into widespread penetration of driverless cars and trucks. We are currently in the first stage. Here we see the introduction of autonomous features, but the continued need of a licensed driver with full legal responsibility. The corresponding implications will be experienced by long-haul freight and logistics, storage facilities and retail.

In the second stage (partial driver substitution), the requirements for a legally responsible operator will be relaxed, and the driver of the vehicle will be able to multitask. During this stage, one effect may be increased urban sprawl, as self-driving cars will make long commutes more tolerable. During this period, logistics facilities may start to drift further from the seaports, as proximity to the transshipment point will not be as critical for the truckers.

Farther out is the complete self-driving stage, where cars and trucks will be able to drive from point A to point B without human intervention. This stage may usher in a substantial increase in global demand for goods, with transshipment capacity growing exponentially. Fuel consumption would likely be reduced for regional transport; the freight transportation industry could potentially save upwards of US\$170 billion as a result, according to some industry experts. Such implications would likely vary by carrier, however, as larger, well-capitalized fleets would have a competitive advantage.

Although full implementation of driverless trucks remains far ahead in the future, advances in the technology have come quite rapidly—quicker than experts had expected. The adoption of this technology may also come faster than anticipated, like smartphones and other transformative products that have been accepted quickly throughout the world. Overall, the industry is on board, and according to EFT, 51% of the trucking industry is expecting driver-less trucks by 2025.

Which regions will adopt this technology?

Since basic infrastructure is necessary for the functionality of self-driving vehicles, developed markets are better suited for this technology in the short term. The ability to pay for and implement the technology is also higher in these markets than in emerging hubs. The U.S., European, and developed APAC markets (Australia, Japan, China and Singapore) are currently

3. Jason Henderson and Jason Spencer. *Autonomous Vehicles and Commercial Real Estate*. (May, 2016).

Figure 1: Timeline of autonomous vehicle technology: Short, medium and long term



Source: CBRE Research, Q2 2016.

most likely to adopt self-driving vehicles—particularly as they are already testing the technology. However, emerging markets stand to benefit the most from this technology, as traffic congestion and traffic-related deaths are more prevalent in countries such as India, China and Brazil, and autonomous vehicles would likely improve driving standards if the cars are controlling the flow of traffic. Furthermore, as these economies mature and their middle classes grow—especially in China—demand for goods will rise, which will mean greater need for

Singapore's new "SMART Nation" policy, which seeks to digitally connect everything and everyone in the city.

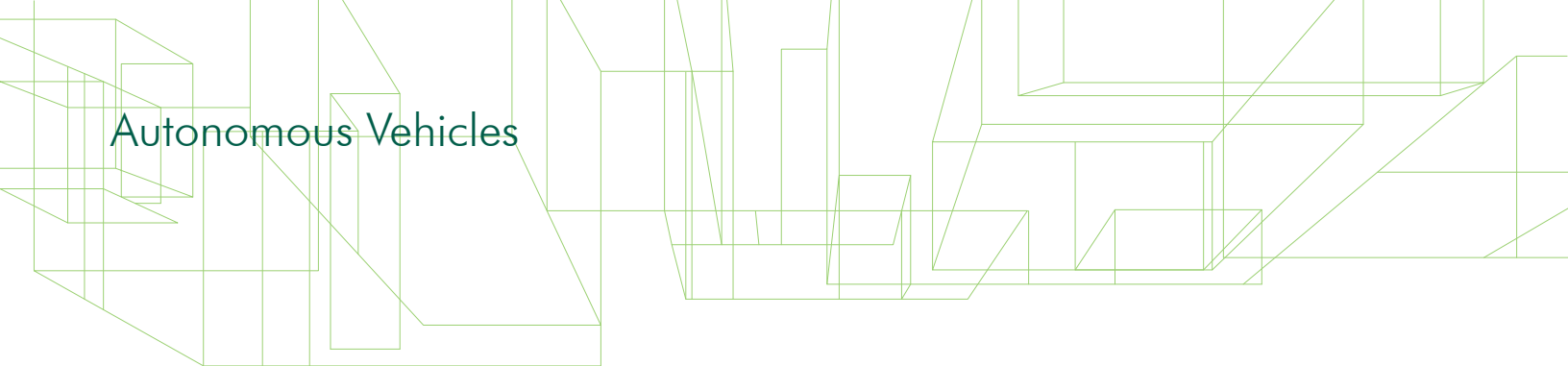
Legal implications

While some legislation on automated vehicles and standards has been passed, there is still a long way to go in order for this technology to operate within legal boundaries. Cyber security

Although full implementation of driverless trucks remains far ahead in the future, advances in technology have come about quicker than experts anticipated. The adoption of this technology will also come faster than anticipated. Richard Barkham, CBRE's Chief Economist

additional logistics space and distribution capacity. Finally, China and Singapore may well become leaders in the implementation process, as the technology has strong government backing and faces fewer regulatory hurdles in those countries. Singapore's Ministry of Transport is committed to developing the autonomous technology, which should be aided by

laws will be necessary as well, since large amounts of data will be generated. In the U.S., for example, the initial steps have been taken to formulate a legal framework, with California and Nevada granting licenses to self-driving autonomous vehicles and the U.S. Department of Transportation issuing guidelines for the implementation of autonomous vehicles. At least 23



Autonomous Vehicles

states have passed 53 pieces of legislation on the subject; however, some argue that federal regulation is necessary to prevent varying state laws from hindering state-to-state implementation. The White House proposed a \$4 billion bill that aims to connect federal regulators with automakers, to develop policies and laws that enable safe and reliable driverless vehicles. This bill has neither congressional approval nor appropriation at this time, however. In Asia Pacific, China and Singapore should have fewer legal issues, with a more concentrated regulatory system. Other nations like Australia and Japan, as well as European countries may have more regulatory issues to overcome, before any self-driving technology can be implemented.

Consequences for real estate

Ultimately, autonomous trucking technology is likely to affect industrial real estate in three important ways:

1.

Lower transport costs will mean that, at a given level, a supply chain will need fewer warehouses. We expect this to strengthen the already visible trend of warehouse consolidation and increase in scale. As a result, we are likely to see fewer but larger warehouses being built in remote locations.

2.

Last-mile delivery facilities will be crucial elements in the network, as they need to be able to make the modal shift from diesel to electric. They will need to be able to receive large (semi-) automated truck convoys and deploy electric city delivery vehicles. The sites will need to be equipped with extensive battery loading stations.

3.

All warehouses will need a courtyard that allows automatic maneuvering, accommodating the self-driving trucks as they pass to and from the facilities.

02

3D Printing

3D Printing

Manufacturing is being transformed by 3D printing, and especially the high-tech and healthcare industries are likely to see huge advantages, with the rapid production and replication of products like smartphones and hearing aids. Some logistics companies have branched into the 3D printing sector by offering 3D printing services located near their logistics hubs, creating a timely and efficient manufacturing network for parts.

3D printing is a subset of additive manufacturing, a technology that uses 3D modeling software (computer-aided design or CAD) to build 3D objects by adding layer-upon-layer of material,

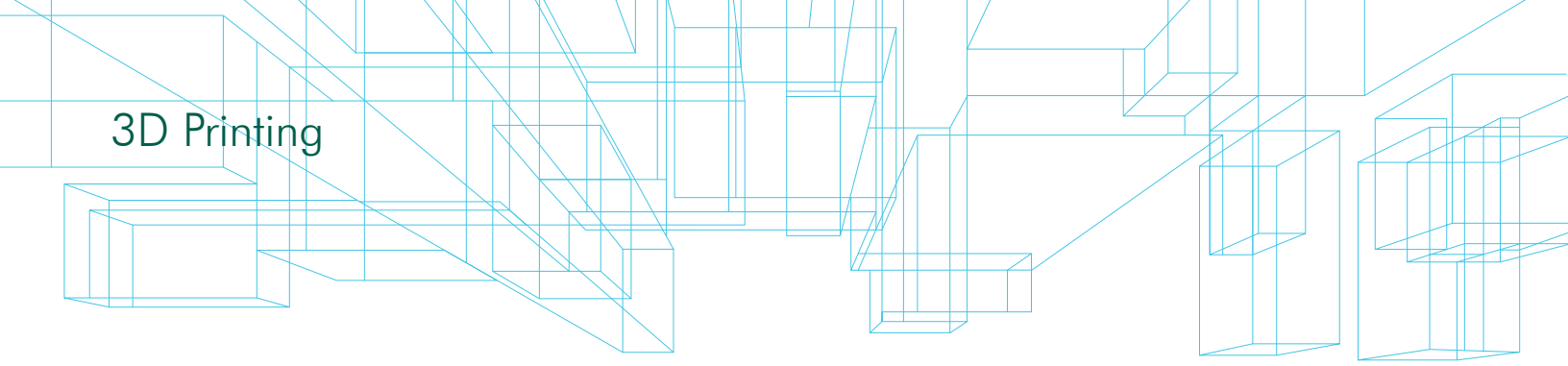
whether plastic, metal or concrete. The virtual design can also be made using a 3D scanner, which makes a 3D copy of an object. The 3D modeling software “slices” the final model into hundreds or thousands of horizontal layers. When the sliced file is uploaded in 3D printer, the object can be created layer by layer. The 3D printer reads every slice (or 2D image) and creates the object, blending each layer seamlessly, resulting in the 3D object.

China has invested significant sums into 3D print technology, as it looks to lower costs and decrease its reliance on other countries for parts. Its investment has allowed manufacturers

Figure 2: Supply chain challenges and the advantages of 3D printing

1.	Parts are expensive to manufacture	Can help stabilize costs and keep price-per-unit low
2.	Long lead time	Can help companies meet demand in real time, in situations when long lead times are costly
3.	High inventory costs	Enables companies to print just in time and on demand
4.	Parts sole-sourced from suppliers	Reduces risk associated with relying on a specialty machinist that can go out of business or be acquired by a competitor
5.	Remote locations	Parts can be made where and when they are needed
6.	High import/export costs	Can eliminate costs associated with import and export fees
7.	Low functionality	Enables design of new parts and products rather than being limited by what already exists

Source: CTA Research, Q2 2016.



3D Printing

to recapture products formerly made elsewhere. This impacts the supply chain, as it shifts the production and distribution towards regionalization.

3D-printed manufactured goods only represent 1% of all manufactured products in the U.S., but the sector is achieving staggering growth and has the potential to significantly disrupt the manufacturing sector in the short term. The report by UPS and CTA found that the global 3D printing market is on track to exceed \$21 billion by 2020, and the demand for 3D printers, materials and services will exceed \$10 billion by 2018. Among the benefits of 3D printing are that it stabilizes costs and keeps price-per-unit low, allowing companies to meet demand in situations where long lead times are costly, and enabling companies to print on demand and just in time, mitigating high inventory costs. Figure 2 shows a breakdown of supply chain challenges and the corresponding advantages of 3D printing.

The industries that are most affected by 3D printing are high-tech and healthcare. Smartphone manufacturers already use 3D printing to build their products, specifically the hardware and internal parts. Some medical device companies also have embraced

3D printing; the *Wall Street Journal* reports that more than 10 million 3D-printed hearing aids are in circulation worldwide today.

3D printing provides a viable solution for many cost vs. service challenges. Implementing a high service promise (fast, cheap

delivery) is quite expensive for manufacturers, and building out the last mile is difficult and costly. With few existing or development options in infill locations, the real estate is in short supply. A real 3D printing solution has the ability to bring last-mile costs down while keeping the consumer happy.

Consequences for real estate

3D printing influences the supply chain in three major areas: flexibility, quality and cost. First, 3D printing helps streamline the development and delivery of customized products, while increasing customization opportunities, improving inventory management and adding flexibility to on-demand production. Secondly, the overall quality of the product is enhanced through the use of lighter parts, better ergonomics and increased serviceability. Finally, the manufacturing cost is affected, though by how much will depend on the production volume, part size, geometric complexity, material composition and other factors.

The impact of 3D printing on industrial real estate is not likely to be dramatic; 3D printing is more likely to make horizontal shifts inside the supply chain. It is possible that fewer large sites will be needed, with last-mile delivery points becoming production locations. Until that point, raw materials will need to be shipped—pallets in and parcels out. Thus, there will be more emphasis on bulk transport, which can be facilitated by automated vehicles. Also, it would indicate less need for central hubs and more emphasis on last-mile distribution facilities.

Figure 3: Three major impacts of 3D printing on the supply chain



Source: CBRE Research & CTA Research, Q2 2016.

03

Automation within the Logistics Space



Automation within the Logistics Space

The “lump of labor” fallacy contends that since human needs are infinite, there will always be a demand for labor. All labor does not have to be provided by humans, however. The rise of automation will affect logistics facilities, transforming the labor component and altering the way operators configure and build their warehouses and distribution centers. Robots are already deployed in warehouses, hospitals, retail stores and industrial parks, as well as on city streets and college campuses around

intelligence, as the robot market is expected to be worth \$US135 billion by 2019, according to the International Data Corporation.

Some of the most innovative technology today is machine learning—sets of computer algorithms that are able to learn to detect patterns, develop strategies, and refine their behavior by analyzing streams of digital data. The technological advancement in robotics has come about quite rapidly; funding over

The use of robot picking systems will lead to different requirements for daylight and height, stimulating high-bay warehousing, multi-layered developments and greater use of mezzanines. This could lead to a new development cycle.

Matt Haddon, CBRE’s Senior Managing Director of Industrial & Logistics in Asia Pacific.

the globe. A boom is taking place in Asia; Japan and China, in the early stages of reshaping the region’s manufacturing sector, are accounting for 69% of all robot spending, according to reporting from the *Australian Financial Review*. This has led to an increased financing boom in robotics and artificial

the past five years by DARPA, the research arm of U.S. Defense Department, has brought about such improvements as computer vision, which allows machines to “see” the environment in which they operate.



Automation within the Logistics Space

The use of advanced robotics is expected to rise from 2%–3% annually to about 25% by 2025, according to Boston Consulting Group. It predicts that average manufacturing labor costs in 2025 will be 33% lower than expected in South Korea, and 18–25% lower than expected in countries including China, Germany, the U.S. and Japan.⁴

strong e-commerce boom, has robots and elevators do the walking and picking goods for workers. These robots run along an elevated track above the warehouse pallets. Bundled into a “goods-to-person” (G2P) strategy, these technologies allow for greater efficiencies within the logistics space.

Automated systems require economies of scale. This may place further pressure on warehouses to become larger, with fewer sites and leaner logistics networks. Vertical solutions are likely consequences for the denser hubs. Dennis Yeo, Managing Director, Asia

Since labor accounts for approximately 20% of total supply chain costs⁵ in the U.S. and the Western European markets, higher technological efficiencies can have a significant impact on the bottom line. In Japan, Australia, and Hong Kong, where labor is relatively more expensive, robots are gaining traction in the warehousing space to increase productivity. Robotic “butlers” help transport racks to workers so less time is spent walking and more time picking. Another technological advance, driven by the

Automation is becoming critical for the logistics space, but it is important to note that human labor will not be phased out completely, as there will always be a need for skilled laborers to make higher-level decisions that robots are incapable of making. The likely scenario will have humans working alongside additional robotic technology that will make them more productive, but may demand higher skills. Meanwhile, labor is becoming more expensive—especially in the U.S., where several

4. <http://theloadstar.co.uk/supply-chain-revolution-globalisation-regionalisation-just-five-years/>.

5. Chainalytics, November 2015.



Automation within the Logistics Space

states and municipalities are proposing and passing legislation to increase the minimum hourly wages above the federally mandated \$7.25, to as much as \$15. As a result, there is a large incentive for logistics operators to invest in automation technology.

Need for Speed

G2P technologies such as advanced robotics and automated systems are becoming more justifiable not only because of the labor component, but there is also a need for increasing the speed of the cycle time, which in most cases is the time between an order dropping and when it hits the back of the truck. This cycle time is increased only with enhanced systems and technology, and thus the investment must be made to drive speed. This would ensure an optimal balance between space, labor, equipment and cycle time.

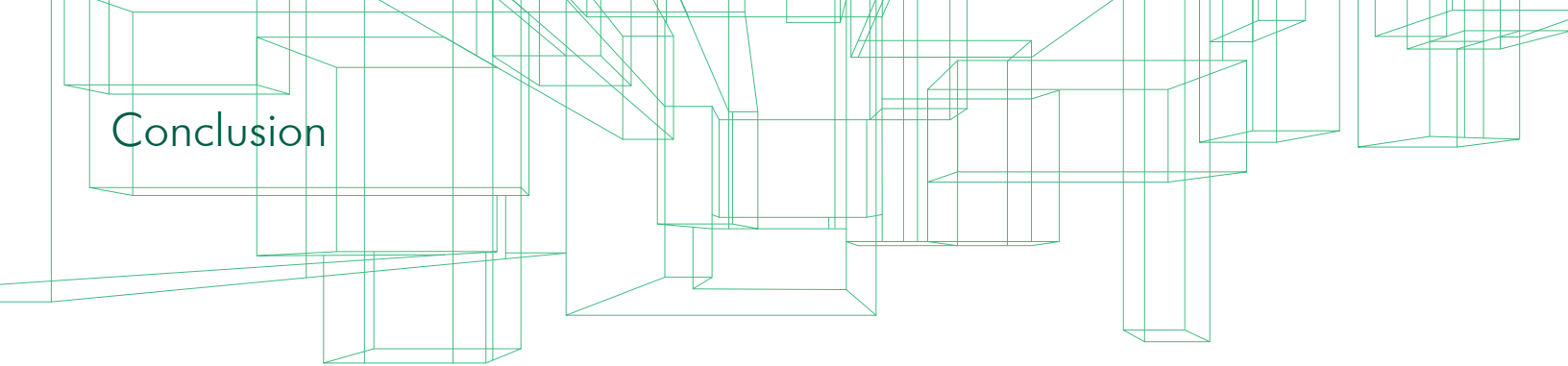
Consequences for real estate

The automation of the warehouse space will likely bring a shift in the way logistics facilities are built and maintained,

requiring accommodations for more advanced technology, including IT infrastructure and new software programs that will likely be interconnected throughout the space, allowing for large amounts of data to be stored and analyzed. This may increase the cost of building new facilities, which will drive up rents in the short term, until the technology becomes more widely adopted and utilization costs decline. This could lead to a new development cycle, if current distribution centers fail to adapt to the rise in automation, which would spur demand for more modernized facilities.

The use of robot picking systems will lead to different requirements for daylight and ceiling height, stimulating high-bay warehousing, multi-layered developments and greater use of mezzanines, especially in land-constrained markets. Automated systems are large and costly, requiring economies of scale. They are mostly used for high-volume picking, such as for e-commerce operations, which also require economies of scale. This may place further pressure on warehouses to become larger, with fewer sites and a leaner logistics network. Vertical solutions with higher overall building heights are likely consequences for the denser hubs in Asia Pacific and Europe.

Conclusion



Conclusion

Industrial real estate is poised for significant change, with the rapid rise of automated technologies and 3D printing significantly disrupting the global supply chain. In summation, the main impacts of self-driving vehicles, 3D printing and automation within the logistics space are as follows:

- Lower transport costs will lead to a less dense warehouse network; there will be greater demand for cheaper land in remote locations.
- There will be less need for central hubs and more emphasis on last-mile distribution, with the last-mile delivery points becoming production locations. Thus, last-mile facilities will become crucial elements in the network.
- Last-mile delivery facilities will need to be able to make the modal shift from diesel to electric, and be equipped with battery-loading stations.
- Every warehouse will need a courtyard that allows automatic maneuvering, to accommodate self-driving trucks as they pass to and from the facilities.
- The demand for modernized, high-tech distribution centers will increase. This could lead to a new development cycle, as logistics operators' requirements may not match the available facilities.
- Specialized developers may play an important role in building properties capable of meeting future technology and occupier requirements for automation.
- The use of robot picking systems will lead to different requirements for daylight and height, and will stimulate high-bay and multi-layered developments and additional mezzanine space. Reduced light in general, whether artificial or natural, will provide energy cost savings.

Those that will be best positioned for this disruption in the supply chain will start making the necessary investments today. The technology is here, and is being implemented in hubs around the world, with developed markets in the U.S., Europe and Asia Pacific leading the way. The timeline for full implementation will certainly vary by country, and will depend heavily on wide public adoption and proper legislation; however, just like the rapid spread of mobile device technology, self-driving vehicles and other types of automation may develop more quickly than expected. Logistics companies, owners, and operators alike need to start planning for these changes now in order to remain competitive and to avoid being left behind.

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