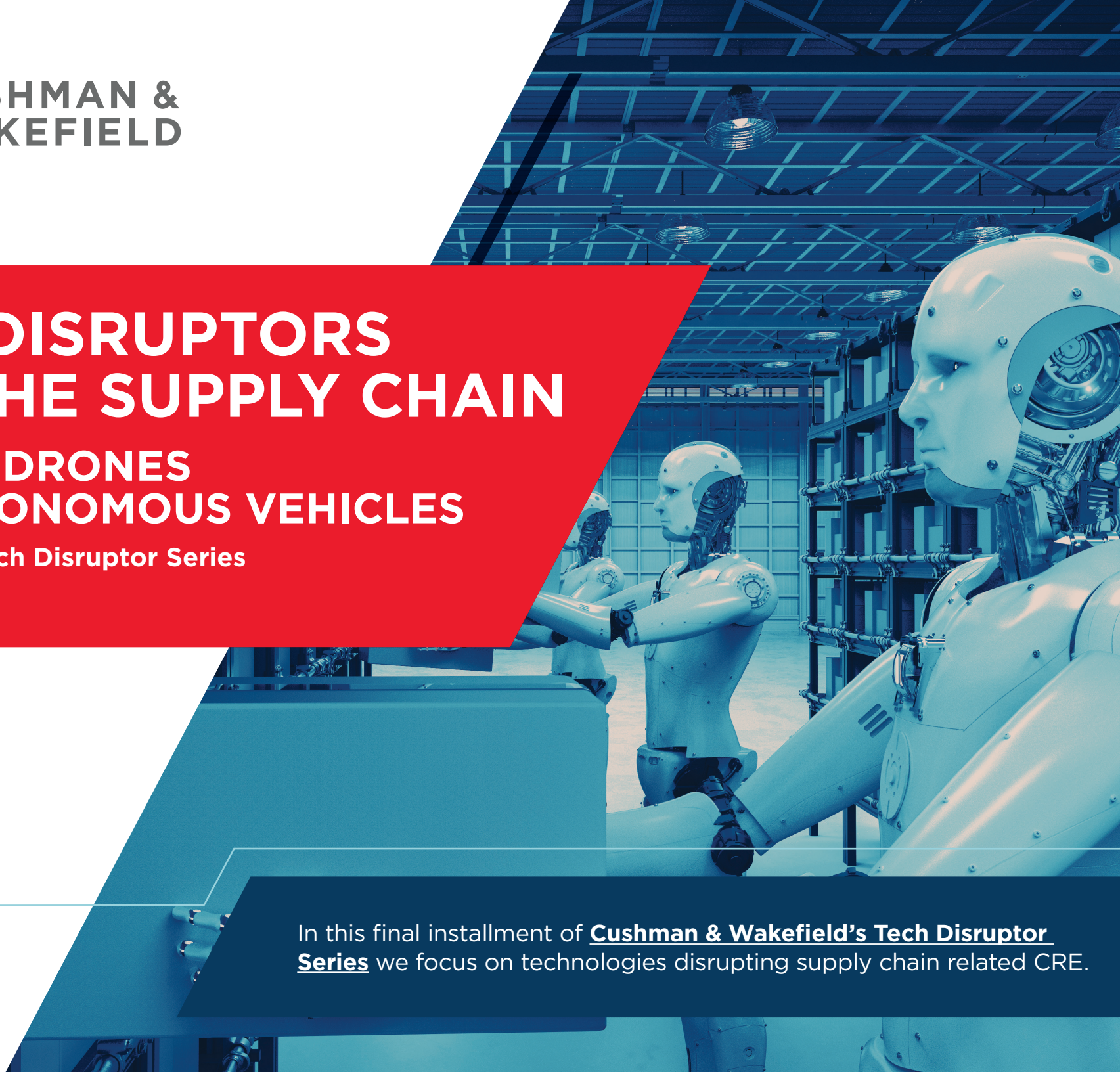
CUSHMAN & WAKEFIELD

TECH DISRUPTORS AND THE SUPPLY CHAIN

ROBOTS, DRONES AND AUTONOMOUS VEHICLES

Part 4 of the Tech Disruptor Series
AUGUST 2019

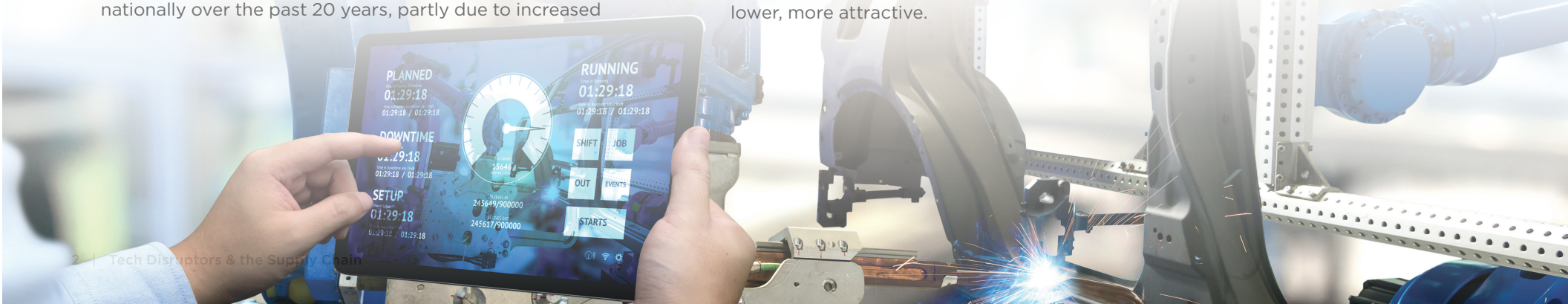


In this final installment of **Cushman & Wakefield's Tech Disruptor Series** we focus on technologies disrupting supply chain related CRE.

Executive Summary

It reads like something out of a science fiction novel. The world's first 3D printed bridge, created entirely by a 3D printer in just three months, opened in the Netherlands in 2017. 3D printing and technologies such as robots, drones and autonomous trucking—the focus of this paper—are transforming how goods are manufactured, shipped and distributed.

- Adoption of these technologies is expected to more than double in the next five years.[1] The resulting disruption to supply chain-related commercial real estate (CRE) is expected to be widespread and will redefine where facilities are located and designed. Most importantly, **these technologies will affect the speed, accuracy and cost of delivery of products, leading to a very different customer experience**.
- Industrial real estate in particular—including the current last-mile delivery model—will be affected, as will retail space. Real estate development as a whole will also be impacted by 3D printing.
- Two-thirds of the total industrial inventory in the U.S. is devoted to logistics and a majority (60%) of the available space is more than 20 years old. Over half of the inventory has clear heights below 28 feet. This limits options for tenants seeking modern space, although construction is also at historic highs to meet some of this demand.
- **Supply chain CRE of the future will not just be built for people but also for robots.** The average rentable building area for newly delivered warehouse product has increased by 60% nationally over the past 20 years, partly due to increased inventories driven by eCommerce. **Clearer differentiations in asset quality are likely to emerge** as some technologies—such as advanced automation/robotics—require higher ceilings (32 to 36 feet clear) and very flat floors.
- In order for existing inventory to keep pace and avoid becoming obsolete, certain design considerations will need to be implemented. See page 3.
- However, closer to urban cores, warehouse/distribution facilities will be smaller and less automated than regional distribution centers (which will focus on labels, stocking, picking). Infill locations will more than likely need to maintain lower ceiling heights for high-velocity goods.[2]
- **The logistics map will also be redrawn to some extent.** Demand for warehouses in major port markets such as Los Angeles and Inland Empire, those close to large population centers (e.g., New Jersey) and in major distribution hubs including Chicago and Atlanta, will remain strong due to the ever-increasing need for services. Fully autonomous logistics—although still decades away— will, however, lower transportation costs and make remote locations such as secondary/tertiary markets, where CRE costs are typically lower, more attractive.



DESIGN CONSIDERATIONS FOR LARGE WAREHOUSES TO MITIGATE RISK OF OBSOLESCENCE

INSIDE

WIDER COLUMN & BAY SPACING

- 50' to 60' standard column spacing.
- Speed bays of 70' to 80'.

HIGHER CEILINGS

- Strong demand for 36' clear heights.
- Increased preference for 40' clear heights.

AC

- For mezzanine/ increased air exchanges due to higher headcounts and workplace amenities.

POWER AND CONNECTIVITY

- Higher power amperage (e.g., 8000) with access to more.
- 5G connectivity.

LED INTERIOR AND EXTERIOR LIGHTING

THICKER LOAD BEARING WALLS

FLATTER, THICKER FLOORS

- Critical as ceiling and rack heights increase.
- AMR functionality requires consistent flooring throughout the warehouse.

OUTSIDE

DOCK DOORS & DOCK PACKAGES

- Dock door ratios are increasing, more is typically better.
- Full dock packages with 35-40K lb. locks, 7' x8' levelers (preferably hydraulic), and lights.

SEGREGATED TRAFFIC

- Improving truck, auto and pedestrian flow.
- For example, two ingress/egress options, on-site queuing, ring roads to separate traffic, lighted intersections.

Source: Cushman & Wakefield Research

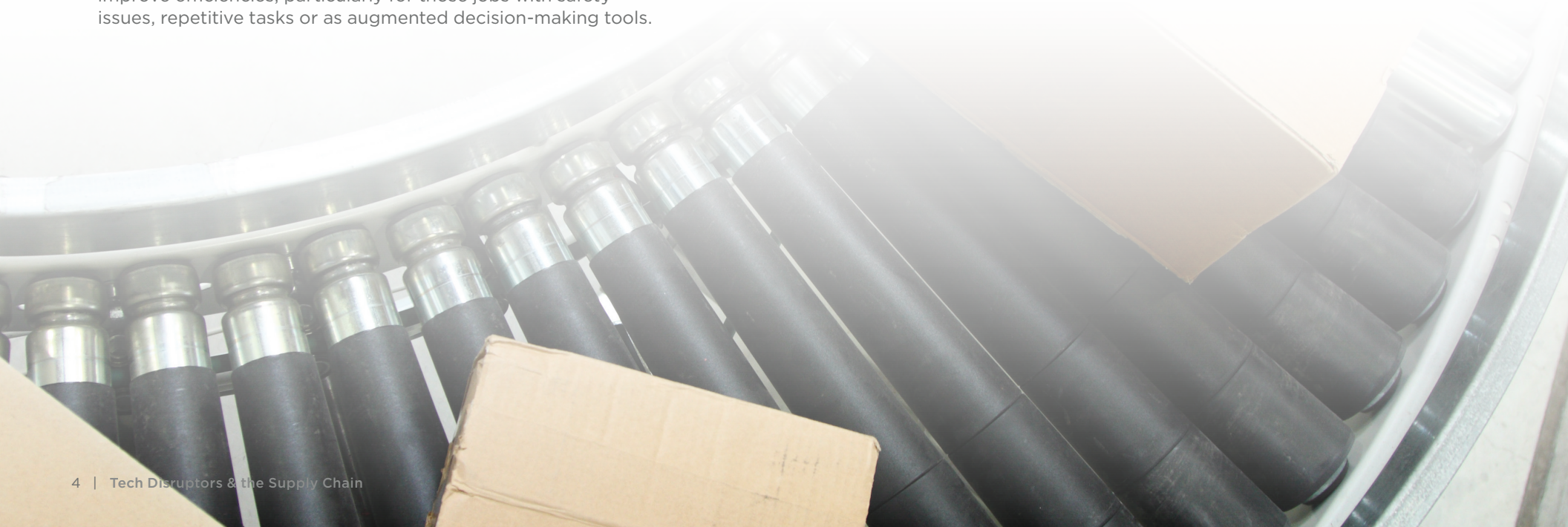
Executive Summary cont.

- Last-mile delivery and services will also be transformed. Currently, cost is the number-one reason people don't choose same-day delivery. An Amazon Prime product delivered by a drone could cost as little as $1.00 in the future[3] compared to $9.00 for a comparable delivery today. In addition, while drones get more attention there will likely be wider adoption of final delivery "bots" and that transition will happen sooner. As technology facilitates same-day delivery, **the need for urban warehousing for high-velocity goods will increase. In order to mitigate the costs of urban locations, multi-tenancy and asset sharing may increase.**

- Humans have a primal fear of being replaced by robots. While supply chain automation will undoubtedly result in some job losses, the sector is actually suffering from a skills shortage, particularly for the "right" skills. Labor shortages in both trucking (174,000 by 2026) and manufacturing (2.4 million by 2028) will persist. Robots will make up for the shortfall and improve efficiencies, particularly for those jobs with safety issues, repetitive tasks or as augmented decision-making tools.

- Any job losses will be offset by some workers being retrained for the right skills and completely new jobs being created in which people and robots collaborate, so-called "cobots." It's worth noting that app developer jobs were not widespread 10 years ago. **New jobs will emerge as the supply chain becomes increasingly automated.** Consider this: metropolitan areas with current high rates of automation such as Toledo, Detroit, Grand Rapids, Louisville and Nashville, have added jobs at a 1.9% annualized rate over the last five years, outpacing the national employment growth of 1.8% over the same time period.

- Increased automation in almost every aspect of the supply chain is inevitable. While there are several technological hurdles and regulatory policies that need to be worked out, innovation will continue. However, it will be decades before the supply chain is a fully automated system. For the foreseeable future, human labor will remain vital to operations.



Implications for the Supply Chain Network

Over the last decade, eCommerce has irrevocably changed supply chain networks, disrupting logistics and retail CRE along the way. Emerging technologies have the potential to further disrupt the supply chain from product creation (manufacturing) to distribution (logistics), affecting the industrial sector including the current last-mile delivery model and the retail sector. Some initial impact on the office and hospitality sector will be seen in improvements to operations. Development will benefit initially from improved efficiencies; however, long-term implications have the potential to completely revolutionize the sector.

Near-term impact (now-10 years) | Mid-term impact (10-15 years) | Long-term impact (15+ years)

	Autonomous Mobile Robotics	Drones/Final Delivery Bots	3D Printing	Autonomous Vehicles
WAREHOUSE/ DISTRIBUTION CENTERS	Additional infill warehouses for smaller packages. Redesign to accommodate mobility and higher stacking. Warehouse/retail hybrids. Redesign for fewer employees.	Increase in urban micro warehouses for same-day delivery models (drone delivery, within "bot range"). Repurposing of parking (drones/ bots eliminate need of delivery van/ truck parking areas). Greater clear heights for dense stacked staging of bots. Multi-story with steeper grade ramps for bots.	On-demand creation of product (quicker go-to-market time). Manufacturing process brought in-house for limited, customizable products.	Closer to permitted AV roadways (highways). Larger distribution centers along highways in rural areas where land is cheaper.
MANUFACTURING	Requirement for mobile robotics includes increased aisle space to allow room for navigation.	Higher ceilings to accommodate drones in the manufacturing process.	Super flat floors for mobile 3D printers.	All facilities will need to be fully connected with IOT integration. Smart elevators and docks to allow movement of AMR throughout facility.
RETAIL	Warehouse/retail hybrids; at big box-lower levels converted to warehouse space. Labor replacement/service work. Restocking, cleaning. Changes the economics of renting retail space.	Increase foot traffic as consumers shop in store and have items delivered autonomously (or bring items from the store to your car for you).	Increase in experiential retail (3D printing, custom manufacturing on premises): urban high street retail and suburban malls.	Designated zones for autonomous deliveries.
CURRENT APPLICATIONS	• **Walmart** uses robots to clean floors and scan inventory. • **XPO Logistics** deployed 5,000 GreyOrange cobots across its global warehouses.	• **Fedex** teamed up with **Pizza Hut**, **Walgreens** and others to deliver goods via bot. • **Uber Eats** testing drones in San Diego for food delivery.	• **Adidas** opened a pop-up in Berlin where customers wait for sweaters to be custom 3D printed.	• **U.S. Postal Services** is testing autonomous semis to deliver mail across state lines.

For a full discussion of autonomous vehicles and implications on other sectors see our paper on Mobility.

A Journey Through the Supply Chain

To understand the impact of the technologies under discussion on the supply chain, let's move sequentially through the supply chain process, starting with manufacturing, logistics (including warehouse and last-mile delivery) and finally the shop where the product is delivered to the customer. We also look at development and the impact on jobs.

MANUFACTURING FACILITIES OF THE FUTURE

A quarter (24%) of the total industrial inventory in the country is devoted to manufacturing (over 3.5 billion square feet).[5] Implementation of autonomous mobile robotics (AMR) has begun at many manufacturing facilities; however, robots will need to cross several thresholds before widespread adoption can occur. These include continued improvements in affordability, dexterity, enhanced AI and size (footprint). Existing manufacturing facilities will need to be upgraded to accommodate mobility of AMR, ceiling clearance for drone flights and completely wired throughout for wireless communications. For more details reference page 16.

LOGISTICS: ASSET AND OPERATIONS IMPLICATIONS

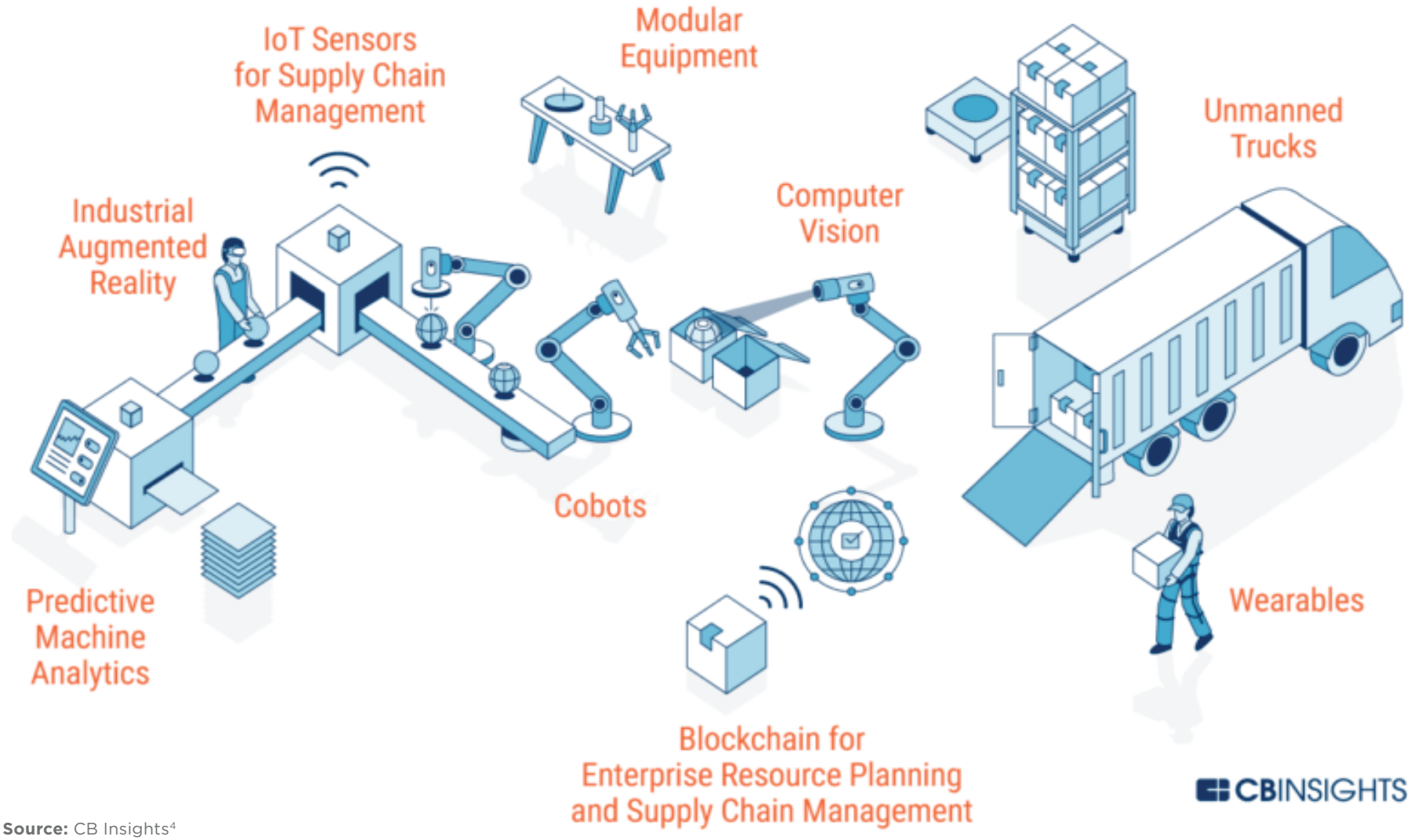
Logistics facilities—warehouse, distribution and fulfillment centers—dominate the U.S. industrial market, accounting for 67% of total industrial inventory (nearly 10 billion square feet).[5] Today, logistics facilities are concentrated in major ports, with 29% of inventory located in the port markets of Los Angeles and Inland Empire, New Jersey and the major distribution hubs of Chicago and Atlanta. These locations are also large population centers and have distribution networks that send goods throughout the country on various modes of transportation. However, supply chain technologies will redefine where logistics facilities need to be located; they will also define what is considered a warehouse, particularly in relation to mixed-use spaces that might include warehousing.

3D Printing Takes Flight: A Case Study

Many aerospace companies have implemented 3D printing in the manufacturing process of small aircraft parts. Boeing 3D prints small parts for their 787s through partnerships with General Electric and Norway's Norsk Titanium. Implementation resulted in cost savings by decreasing production scrap.

Source: Aerospace America

FACTORY OF THE FUTURE

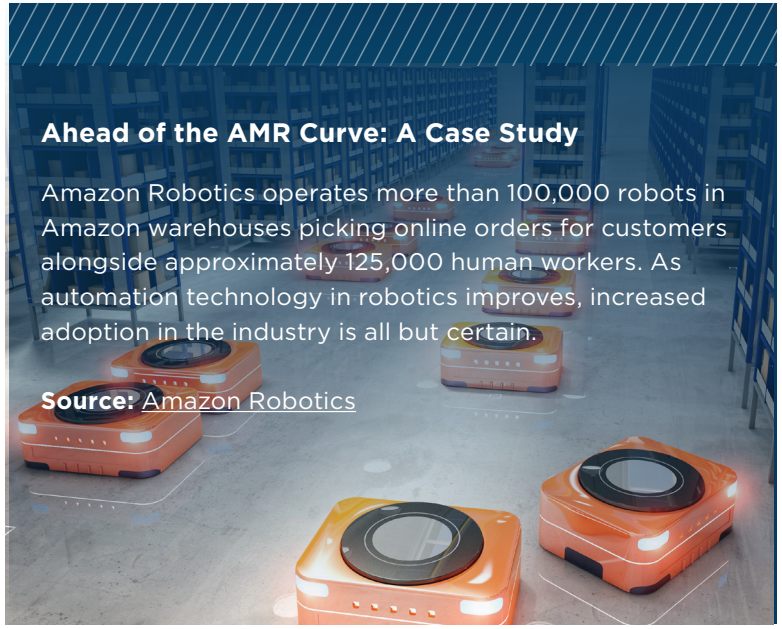


Source: CB Insights[4]

LARGE-SCALE WAREHOUSE AND DISTRIBUTION CENTERS

The two underlying factors shaping logistics networks are urbanization and the ever-increasing service-level migration ("we want what we want when we want it...bring the mall to me"). Demand for logistics assets near ports and population centers will remain strong with AV logistics technology ultimately altering demand profiles in between. Fully autonomous vehicles—while still decades away— lower transportation costs and make remote locations, such as secondary/tertiary markets where CRE costs are typically lower, more attractive.

AMR and drones deployed in warehouses could potentially automate the entire process by receiving, sorting and packing goods. A smaller crew of human labor will be focused on monitoring the technology in warehouses. Warehouses will need to be "smart" to communicate with mobile robotics, drones and trucks.



Ahead of the AMR Curve: A Case Study

Amazon Robotics operates more than 100,000 robots in Amazon warehouses picking online orders for customers alongside approximately 125,000 human workers. As automation technology in robotics improves, increased adoption in the industry is all but certain.

Source: Amazon Robotics

LAST-MILE WAREHOUSE

Over the last decade eCommerce has redefined last-mile delivery and services. With widespread adoption of supply chain technologies, warehouses in core urban markets will proliferate as same-day delivery gains traction. In today's eCommerce environment, customers don't want to pay for shipping.[6] A recent study from FuturePay found that 86% of those surveyed abandoned their online shopping cart due to high shipping costs[7].

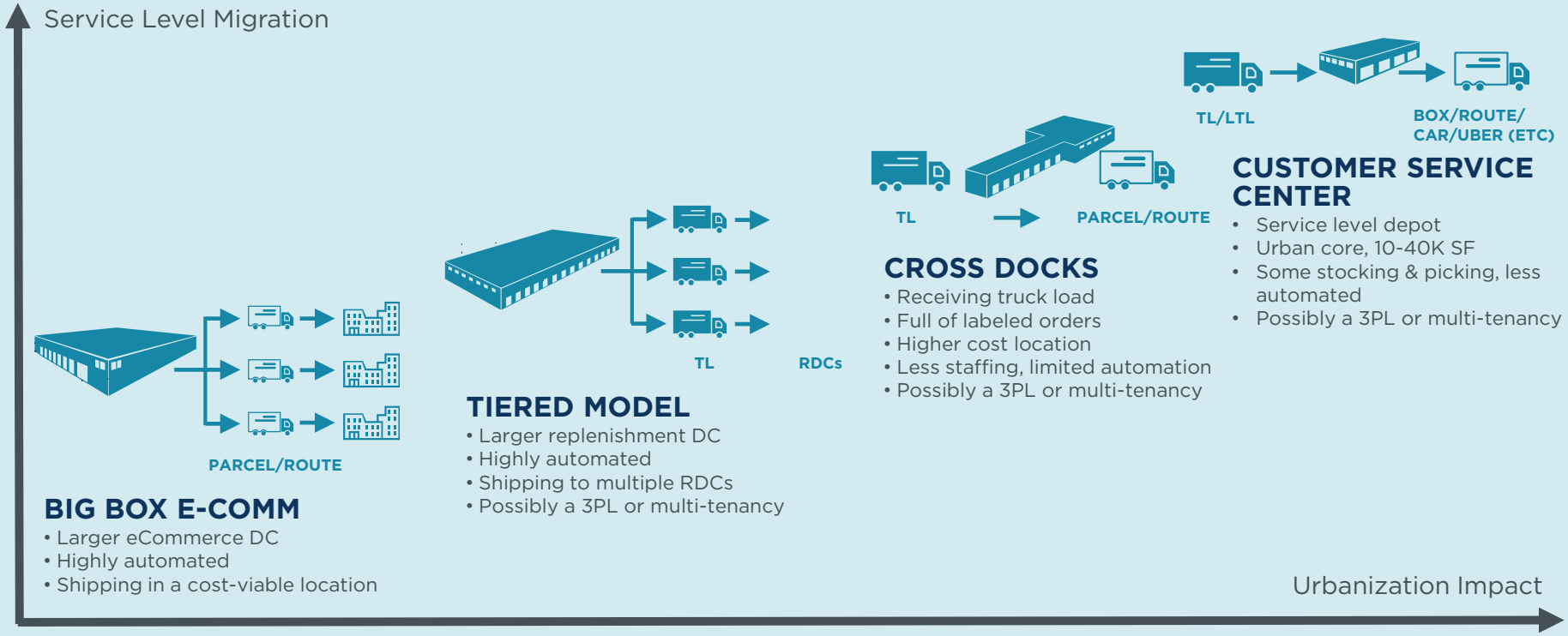
As last-mile delivery costs decrease, same-day delivery is likely to become the gold standard. According to ARK Invest, an Amazon Prime product delivered by a drone could cost as little as $1.00 compared to $8.99 for a comparable delivery today.[8] Amazon already provides one-day delivery for 10 million items and is planning to upgrade its prime delivery model from two to one day.[9]

Current FAA regulations limit drone flights around residential and commercial structures. However, recent developments bode well for industry adoption. Wing, a Google subsidiary, has FAA approval for drone delivery in in rural Virginia,[10] while Amazon debuted a FAA-certified drone for a one-year test period in authorized flight areas.[11] Privacy and safety remain areas of concern for drone operations and those concerns will likely delay widespread adoption. For more details reference pages 16-17.

Other delivery models include autonomous vehicle delivery and autonomous locker delivery. Last-mile delivery in the future could include a combination of drones and autonomous fleets delivering products from multi-tenanted warehouses. But while drones garner the most media attention, autonomous delivery vehicles (ADVs) are gaining traction in the delivery space. At scale, adoption/deployment will drive impacts to supply chains – to DC (distribution centers) locations – to building and site design.

Two trends—urbanization and the increased service expectations of consumers—have moved supply chains closer to the consumer's doorsteps with more forward stocking locations. This has generated CRE demand for a wide swath of properties from large, highly-automated distribution and replenishment centers in areas with lower land costs and good accessibility, to urban cross-docked facilities where moving product through the facility quickly is key, to smaller customer service centers in the urban core that enable ever-faster delivery. As eCommerce grows, so too will demand for these varied types of industrial properties.

SERVICE LEVEL AND URBANIZATION DRIVE SUPPLY CHAIN LOGISTICS



Source: Cushman & Wakefield Research

ASSET LEVEL IMPLICATIONS: A LOOK INSIDE

Both manufacturing and logistics facilities will need to be redesigned to accommodate new technologies or risk obsolescence. Clearer differentiations in asset quality are likely to emerge since some technologies—such as advanced automation/robotics—require certain building specifications such as power, flat floors or higher ceilings.

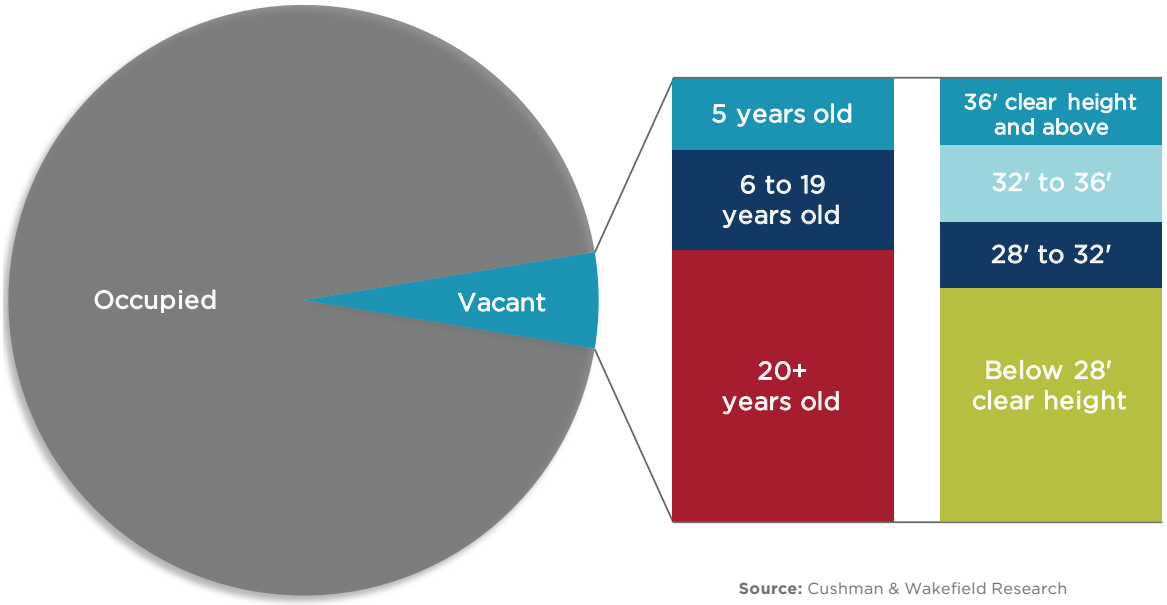
Existing inventory availability is tight. The national industrial vacancy rate is 4.8% as of the second quarter of 2019, significantly below the ten-year average of 7.8%. In addition, 60% of currently available logistics space is more than 20 years old and over half of it has clear heights lower than 28 feet. Both factors mean there are limited options for tenants seeking modern space. On the positive side, speculative projects under construction are also at historic highs; consequently, some of this demand will be met.

Over the past 20 years, warehouses have become bigger and taller. This trend will continue as the pace of automation/robotics implementation accelerates. The average rentable building area for newly delivered warehouse product has increased by 60% nationally.

The average clear height for a new 300,000-sf warehouse has increased from 25' clear to 32' clear with a move toward 36' clear. In mega-sized distribution buildings, 36' clear is common, with clear heights rising past 40' in modern fulfillment centers for some retailers such as Amazon and IKEA.

However, when clear height exceeds 32' the flatness of the floor may require tighter specifications to ensure the stability of the rack. Increasingly, in modern fulfillment centers very narrow aisle (VNA) racking systems and VNA lift trucks allow an operator to travel up and down in a pick basket with the load. The higher the operator rises, the more pronounced the flatness and levelness

COMPOSITION OF VACANT WAREHOUSE PRODUCT
BY VINTAGE AND CLEAR HEIGHT



Source: Cushman & Wakefield Research

of the floor becomes so that a slight slope at the ground level is more noticeable and dangerous the higher an operator rises. Column spacing often must be expanded to accommodate the larger forklifts needed to reach the taller pallet positions, and if exterior walls are load bearing, they will likely need to be thicker.

Closer to urban cores, warehouse/distribution facilities will have much smaller footprints and be less automated than regional distribution centers (labels, stocking, picking). Infill locations are more likely to maintain lower ceiling heights for high-velocity goods. Due to the high cost of urban space, some warehouse capabilities will likely be integrated into existing infrastructure, taking below-grade space in high street retail and multifamily. Repurposing some of this space is a less costly alternative and inventory would be limited to high-velocity goods. The inclusion of warehousing in these typical mixed-use assets will be innovative.

LOGISTICS: INCREASED DOCK EFFICIENCY

Docks have a significant impact on operations. Automation can increase efficiency inside a facility, but if product cannot move out the door or raw materials brought in efficiently, the overall efficacy of automation and other investments can be affected. Small- and medium-sized tenants are likely to be hit especially hard by mismatches in required efficiency of operations and dock equipment.

New investments will continue to not only improve efficiency, but also safety. Integrated dock controls can collect valuable data—e.g., whether certain docks are used more often than others so their planned maintenance schedules can be adjusted accordingly. In the future, an integrated system may go even further, detecting truck presence, track leveler cycles, record the duration of each door opening and quantify utilization by recording how long a door stays open without forklift traffic. This information will help schedule deliveries to avoid back-charges for slow unloading, or schedule maintenance events during the least disruptive time.

Blockchain: Disrupting Supply Chain Processes

eCommerce has increased the volume of goods moving along the supply chain, resulting in increased costs throughout, but particularly at the last mile. Blockchain tracks and documents products through the supply chain process—reducing time delays, added costs and human errors. Blockchain would facilitate the automated ordering of items as it becomes integrated with a warehouse's IOT.

Click here for more information on Blockchain disruption.

Improving the Retail Experience

Driving foot traffic to retail space may be a welcome result of the implementation of supply chain technologies. The novelty of 3D printing is building enthusiasm around experiential retail experiences. As the technology matures, retailers will be able to take custom orders online from consumers. Customers will then be able to "witness" the manufacturing of their items, participating in the production experience. Additionally, drone and autonomous delivery options may enhance consumer experiences as customers visit stores to select items and have them delivered the same day.

Retailers will need to respond to the new delivery paradigm by creating dedicated areas that can accommodate drones and autonomous vehicles. Manufacturing a limited number of customizable products could potentially be brought in-house, particularly since future 3D printers are expected to be smaller and with higher capacities. The need to maintain significant inventory would diminish as products are printed on demand. For more details read page 18.

Foot Forward: A Case Study

In 2018 Adidas launched its 3D printed sneakers branded as Futurecraft 4D to customers in a select number of stores in New York City. The $300 sneakers sold out and Adidas is planning to expand its offering of 3D printed sneakers. An increase of foot traffic to Adidas stores would occur if the company also provided in-store measurements that would evaluate gait to produce customized sneakers. Additionally, while Adidas manufactures most of its shoes in Asia, a move to 3D printing could result in increased manufacturing in the U.S.

Source: Adidas

Development: The Next Generation

The construction industry has experienced significant change over the last decade. From prefabricated multi-housing projects to modular skyscrapers, the sector—typically considered resistant to change—is utilizing technology to effect process improvements. Drones and robotics are already used at construction sites, assisting in surveys and collecting data to assess building process and pinpoint areas of concern.

While an invasion of autonomous robots at construction sites is not here yet, some developers are harnessing the technology. In 2017 Pennsylvania-based Brayman Construction Corp deployed an autonomous robot named Tybot to tie rebar to form bridge decks. The robot can expand up to 140 feet across the width of a bridge. Tybot reduced the number of man hours and costs and resulted in a safer environment for construction workers who would typically be the ones framing the site.[12]

Like something out of science fiction, 3D-printed (aka Additive Manufacturing or AM) structures are slowly making waves in the construction industry. The world's first 3D-printed bridge opened to the public in the Netherlands in 2017.[13] Constructed of approximately 800 layers of concrete laid down by a 3D printer, it took just three months to complete. The bridge is small, spanning just 26 feet and built for cyclists or pedestrians, but according to its designers it could take the weight of 40 trucks. Other 3D-printed structures include a building in Denmark[14] and 3D-printed wind turbines.[15] While 3D-printed commercial construction may be several decades away, the use of 3D printing for emergency shelter and military applications is more probable within the next decade.

While the construction sector is notoriously slow to change, several factors have contributed to its increased interest in AM. Labor costs are the largest component of construction costs followed by materials. Labor shortages have led to rising costs and significant improvements and innovations in AM have led developers to take note. Automation of some construction processes is expected to result in cost savings. Initial costs will be high since most of the technology is new and very costly. Training users will incur additional cost. But as the technology matures, costs are expected to decrease significantly, improving the cost savings. For more details read page 19.

Advances in additive manufacturing could impact the costs associated with supply chain infrastructure in the future, making the construction of warehouses and stores cheaper. Additionally, increased popularity of controlled manufacturing environments such as modular construction will have an effect on the supply chain. Cushman & Wakefield Research plans on studying additive manufacturing and modular construction disruptions in a future report.

3D PRINTING IMPACT ON CONSTRUCTION COSTS

SIGNIFICANTLY LOWER | SLIGHTLY LOWER | EQUAL | SLIGHTLY HIGHER

COST	IMPACT	
Labor (35%)	↘	Reduction in onsite workforce
Architects, designers, engineers	↗	Initial increase in cost due to training; however, will decrease over time
Installation	↓	Initial training cost but less supervision leads to overall cost savings
Equipment (15%)	↔	High cost of 3D printers but will replace heavy construction machinery
Materials (30%)	↘	Current materials are expensive but fewer materials are needed and additional cost savings from reduced waste
Logistics (13%)	↔	Increased cost for transportation of printers to site but offset by reduced use of other construction equipment
Delivery (7%)	↓	Printers can operate 24/7 reducing delays related to deliveries and coordination

Source: Cushman & Wakefield Research, Buildings Guide, Boston Consulting Group

Job Disruption

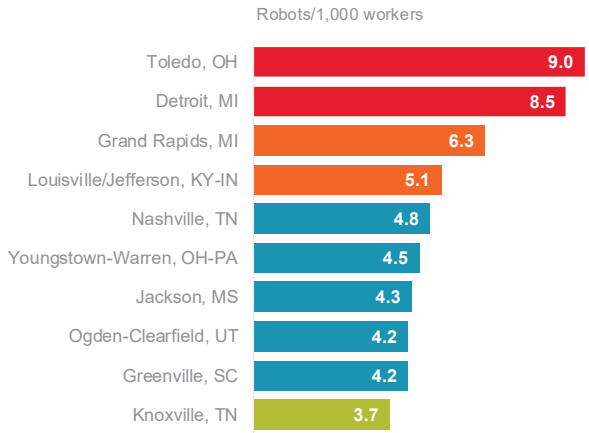
Robotic automation of the supply chain will undoubtedly be a major source of job disruption. In our first report in this series, Will Robots Take Over CRE, we noted that the OECD expects 14% of jobs to be at risk globally over the next decade, particularly those that are repetitive, mechanical or dangerous.[16] This includes most manufacturing jobs as well as couriers, messengers and postal service workers. At the same time, Deloitte and the Manufacturing Institute report that filling open positions in manufacturing has become increasing difficult due to an aging population, tight labor markets and major skills gaps.[17] The difficulty in filling manufacturing jobs is forecasted to accelerate in the next decade, creating a shortfall of 2.4 million (53 out of 100) positions which will go unfilled through 2028. This employment gap is expected to put approximately $2.5 trillion in economic output at risk through 2028.

Enter robots. Robots have been in the workplace for decades. Looking at the top 100 U.S. metropolitan areas, markets with high robot-to-worker ratios also have a high composition of highly automatable jobs (manufacturing, couriers, warehousing, etc.) A number of these metros have been at the forefront in automation innovation, particularly Detroit where the use of industrial robots nearly tripled to over 15,000 in 2015 from 2010. Interestingly, employment in some of these markets has been resilient with most continuing to add jobs even in the face of increasing automation. Employment growth in the top five automation metros, Toledo, Detroit, Grand Rapids, Louisville and Nashville has outpaced the five-year annualized national employment growth of 1.8%. Going forward, industries will continue to turn to automation to fill labor gaps and improve efficiencies throughout the supply chain.

What does this mean for the existing workforce? App developer jobs were not widespread 10 years ago. Likewise, new jobs will emerge as the supply chain becomes increasingly automated. Additionally, controls systems and preventative maintenance requirements are already straining recruitment in rural locations that have transitioned to a partially automated environment. Training and incentives will be critical in giving existing employees the skillsets necessary to work with technology requirements for new jobs. Amazon just announced their goal to spend over $700 million to retrain 100,000 of their 300,000 U.S. employees by 2025 in higher skilled jobs[18]. The training is voluntary and free, and should allow employees to move to advanced jobs within Amazon or outside of the company.

This also means that the CRE of the future will not just be built for people but also for robots. Shifting some of the CRE use to accommodate robotics will require modernization of existing space as well as implementation of smart technology. Redesign of warehouses will likely include repurposing employee parking and break rooms which could be converted to logistics space, increasing the built inventory. Widespread adoption of these technologies is expected to occur within the next 5-20 years. However, resistance from labor groups, particularly unions, will likely slow automation momentum.

TOP TEN METROS FOR HIGH AUTOMATION



	CAGR Total industrial robots, 2010-2015	Composition Automatable Jobs	Employment 5yr Growth 2013-2018	Employment 5yr CAGR 2013-2018
Toledo, OH	28%	16.9%	4.2%	0.8%
Detroit, MI	21%	13.4%	7.9%	1.5%
Grand Rapids, MI	23%	21.4%	12.6%	2.4%
Louisville/Jefferson, KY-IN	27%	17.5%	8.7%	1.7%
Nashville, TN	23%	10.2%	17.5%	3.3%
Youngstown-Warren, OH-PA	16%	13.3%	-3.3%	-0.7%
Jackson, MS	21%	9.1%	6.3%	1.2%
Ogden-Clearfield, UT	16%	14.3%	15.9%	3.0%
Greenville, SC	22%	8.8%	10.1%	2.0%
Knoxville, TN	17%	11.3%	7.3%	1.4%

Source: Cushman & Wakefield Research, Moody's Analytics, The Brookings Institute

CUSHMAN & WAKEFIELD RESEARCH

TECHNOLOGY PRIMER

AUTONOMOUS MOBILE ROBOTICS (AMR)

While robots have been used in manufacturing since the 1960s, their limited mobility meant human labor was still critical to operations. Recent innovations, however, have resulted in increased mobility, automation and a reduction in size. This frees up human labor to focus on tasks that involve manual dexterity and those requiring cognition such as programming and operations.

Adoption rates of autonomous mobile robotics—AMR—in logistics has been increasing exponentially as robotic technology innovation progresses at a breakneck speed and becomes more affordable. While wages continue to increase, ARK Invest estimates that it takes less than a year for a company to break even when replacing employees with industrial robots.[19]

Forecasts from the International Federation of Robotics estimate that in the next few years, the number of industrial robots shipped annually in the U.S. will nearly double, from 28,000 in 2018 to nearly 55,000 in 2021. In 2018 a record number of robots were shipped to U.S factories and warehouses. The automotive industry typically outpaces other industries in terms of the number of robots acquired annually. However, 2018 was the first time in eight years that other industries outpaced the automotive industry, accounting for 51% of total units acquired.[20]

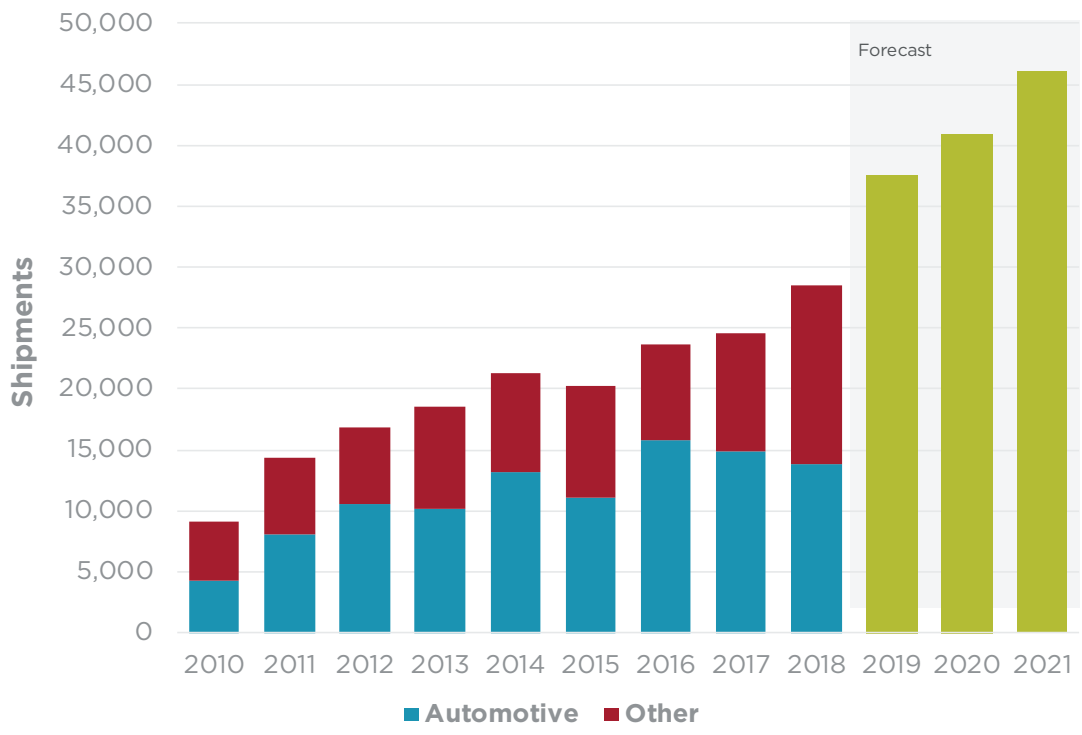
An increasingly popular subset of AMR is cobots (collaborative robots). These robots are not tethered to a work station and so can roam freely. They have sensors that allow them to work alongside humans complementing their tasks. Cobots are typically cheaper than traditional robots and easier to program.

According to the International Federation of Robotics, the use of cobots in the manufacturing and logistics space is forecasted to grow 35% in the next five years.[21]

UNMANNED AERIAL SYSTEMS (UAS) / DELIVERY BOTS

McKinsey estimates that 80% of packages will be delivered autonomously in 10 years, both by ground and air[22]. For context, UPS delivers an average of 20 million packages a day in the U.S. Automation of last-mile delivery would help cut costs as well, since final delivery costs account for more than 50% of total shopping costs. According to KPMG, autonomous final delivery could cut shopping trips by as much as 50%[23] thereby prompting one-and-one half to three times additional shopping transactions per week, all while reducing total delivery cost. The key options for final-mile

U.S. SUPPLY OF INDUSTRIAL ROBOTS



Source: Cushman & Wakefield Research, Association for Advancing Automation

delivery are drones and delivery bots. While drones have been garnering a lot of media attention, we believe that delivery bots will probably be here sooner and be more widely adopted.

Thus far the use of drones has been primarily for military operations. Drones have not yet had an impact on the brick-and-mortar side of the CRE industry, facilitating instead improvements in efficiencies of land surveys, detailed property inspection reports (e.g. Kespry), and enhancements of property listings. The commercial U.S. drone industry is forecasted to grow from $1 billion in 2017 to between $31 and $46 billion by 2026.[24]

However, current delivery drones are constrained by load size (limited by size of the drone) and weight limitations (up to 5 pounds).[25] Additionally, battery life is short, averaging about 30 minutes. Unlike vehicles which can carry multiple packages on a single delivery run, drones are limited in the number of packages they can deliver in one run and during one battery life.

FAA regulations limit drone activity in residential and commercial areas. Several exceptions have been granted to test drone delivery in limited areas. In the next few years, we should begin to see some clarity in FAA regulations regarding drone delivery of goods in urban, suburban and rural markets.

Delivery bots—or autonomous delivery vehicles (ADVs)—are another AMR subset making headway with potential to disrupt the supply chain at the last-mile. While legislation may impact drone density—similar to radio licenses—ADVs may have an easier adoption path. With customer expectations for immediate delivery continuing to intensify, the use of delivery bots has begun to gain traction as bots are deployed in test markets across the country. The market for bots is forecasted to grow to $34 million globally at a 19% CAGR through 2024, with North America capturing the largest share.[26]

ADVs are also more popular than general autonomous (self-drive) vehicles (AVs). In the U.S. consumers are more likely to use ADV service than ride in an AV vehicle themselves. A recent Axios survey found that 64% of those polled were afraid to ride in AVs, but had no problem with “risking the eggs” or other items for delivery.

DRONE FLIGHT LIMITATIONS

Current Drone Flight Regulation | **Potential Resolutions**

Source: Cushman & Wakefield Research, Federal Aviation Administration UAS Guidelines

AUTONOMOUS VEHICLES FOR LOGISTICS:

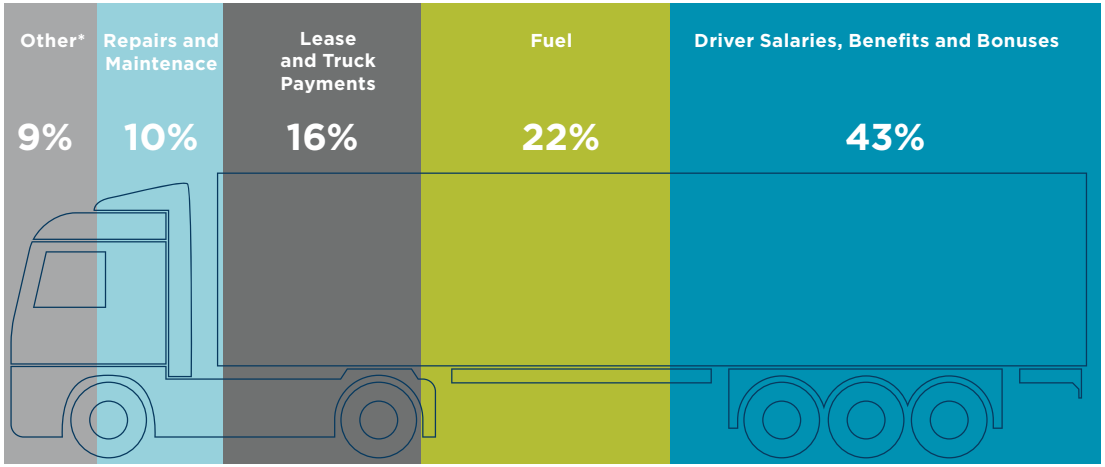
The logistics supply chain has become increasingly automated, yet trucks are still totally operated by people. Several factors are motivating the trucking industry to look at autonomous technology. Truck drivers increase the costs associated with the supply chain. Driver shortages are plaguing the industry; an aging population coupled with more drivers leaving the industry than joining it, are adding pressure to these on labor shortages. The American Trucking Association estimates current driver shortages at 50,000, and those shortages are forecasted to further increase to 174,000 by 2026.[27] Furthermore, federal regulations mandate that a truck driver spend no more than 11 hours a day driving without taking an 8-hour break.

Major truck manufacturers and technology companies have made significant investments in autonomous technology. In the U.S., 20 states have authorized the testing of driverless trucks in a "platoon" formation.[28] Platooning allows for a group of trucks to drive in a convoy. The lead truck includes a human operator and the trucks in the convoy follow the instructions from the lead truck. As of July 2019, 10 states have fully authorized platooning without any restrictions: Oregon, Nevada, Utah, Wisconsin, Michigan, Indiana, Tennessee, Georgia, North Dakota and South Dakota. An additional 10 states have authorized platooning with minimal restrictions: Texas, Arkansas, Mississippi, Alabama, Kentucky, Louisiana, Minnesota, Pennsylvania, North Carolina and South Carolina.

In June 2018, a group led by Volvo Trucks North America successfully demonstrated truck platooning technology.[29] Three double 28-foot trailers formed the "platoon," with three trained, professional truck drivers for monitoring. The trucks traveled up to 62 mph with a time gap of 1.5 seconds, a closer distance than what is typical for on-highway trucks with an average of 4.0 seconds, which can double at higher speed or in adverse weather conditions.[30]

However, the viability of the autonomous technology in inclement weather, the cost of deployment, safety, regulation and insurability, and popular acceptance are all obstacles. In the short term, application of AV logistics will most likely be limited to adaptive cruise control and lane keeping which will increase safety and reduce fuel consumption, moderately changing the economics of trucking.

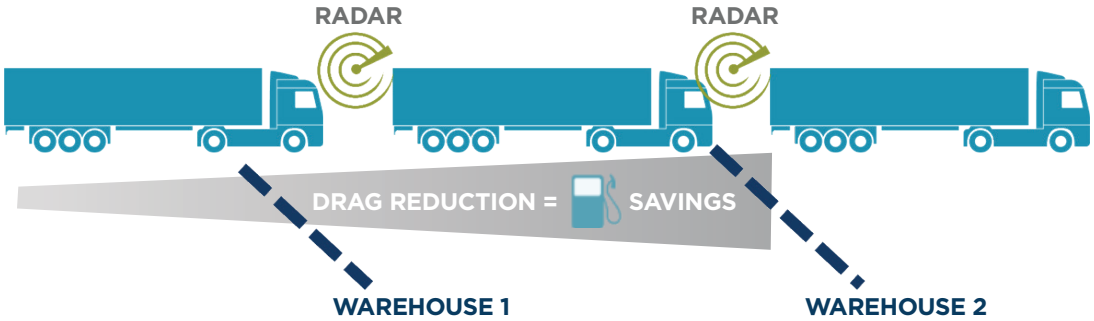
TRUCKING OPERATIONAL COSTS



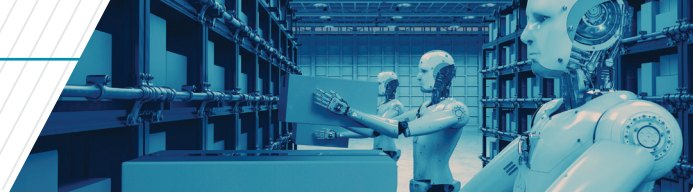
*including vehicle insurance, permits, tolls and tires

Source: Cushman & Wakefield Research, American Transport Research Institute

AUTONOMOUS TRUCK PLATOONING



Source: Cushman & Wakefield Research, Peloton

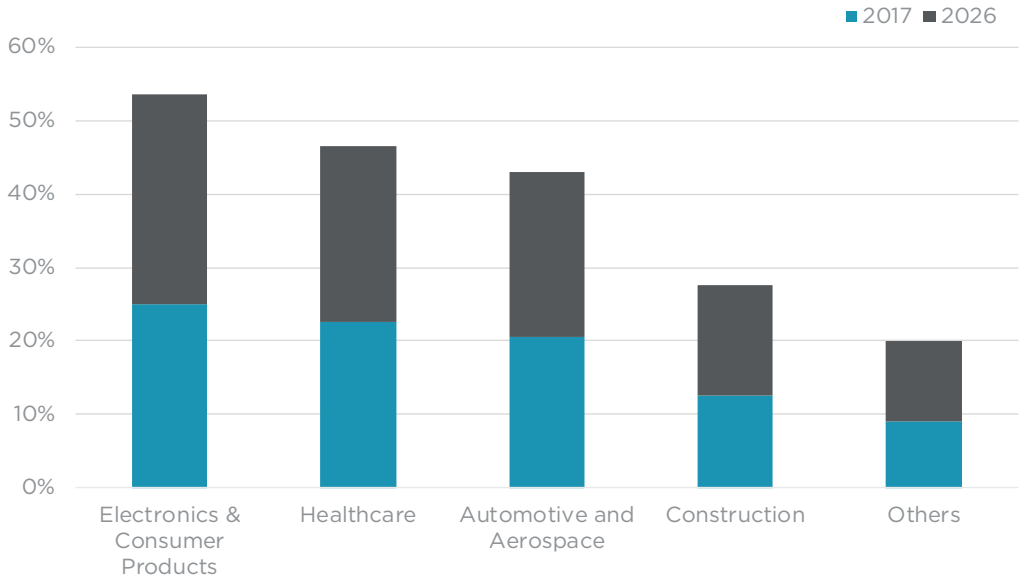


Autonomous trucks are forecasted to reach level 4-5 autonomy (all driving is automated, no driver required) before consumer vehicles by 2030.[31] Driving on highways is less complicated for computers that need to factor in pedestrians and curbs, among many other obstacles, on city and suburban streets. Additionally, trucks can house systems which are currently too heavy for personal cars.

ADDITIVE MANUFACTURING (AM):

In North America, market capitalization of 3D printing is expected to reach approximately $17 billion by 2025, a 20.8% CAGR over 10 years.[32] The primary industries driving the growth of additive manufacturing include electronics and consumer products, healthcare, aerospace, automotive and construction. AM application in these industries is expected to nearly double through 2026.

GLOBAL MARKET GROWTH BY APPLICATIONS



Source: Cushman & Wakefield Research, Inkwood Research

REGULATORY HURDLES

Technology	Regulatory Bodies	Regulatory Hurdles
DRONES	Federal Aviation Administration (FAA)	• Commercial drone flights restricted to a pilot's visual line of sight[33] • Drones can only be flown over people participating in its flight operation • Residential air rights[34] extend up to 365 feet above ground and commercial air rights can go much higher • Drones must fly below 400 feet as to not interfere with air traffic
3D PRINTING	Environmental Protection Agency (EPA)	• Building materials must meet code • Other regulatory bodies need to be consulted, e.g., FAA in printing of aeronautics
AUTONOMOUS TRUCKING	U.S. Department of Transportation (DOT) States	• U.S. DOT released a Broad Agency Announcement in late 2018 seeking to "develop an innovative and synergistic truck platooning pilot deployment concept,"[35] the first step in a regulatory framework • Individual states have passed regulatory guidelines that allow or restrict AV trucking in their state

Source: Cushman & Wakefield Research

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