Deloitte.
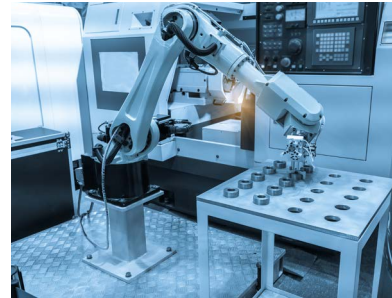
The 2017 MHI Annual Industry Report
Next-Generation Supply Chains: Digital, On-Demand and Always-On
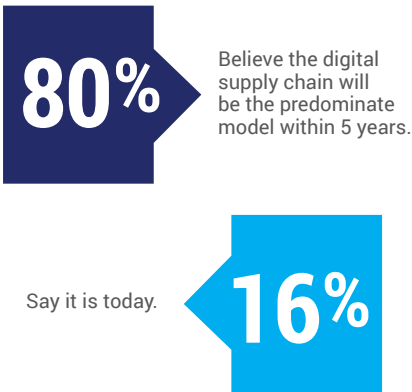
Table of Contents

80% Believe the digital supply chain will be the predominate model within 5 years.

Say it is today. **16%**

DISRUPTIVE TECHNOLOGIES
Top 6 out of 9

Potential to disrupt or create competitive advantage.

Technology	Percent
Robotics & Automation	61%
Predictive Analytics	57%
Internet of Things (IOT)	55%
Driverless Vehicles & Drones	54%
Sensors & Automatic Identification	53%
Inventory & Network Optimization Tools	50%
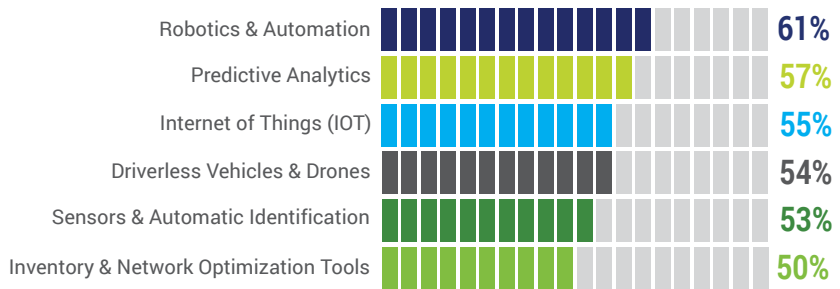
ADOPTION RATE

— In-use Today   — 5-Year Compounded Annual Growth Rate

60%
50%
40%
30%
20%
10%

Cloud Computing & Storage | Sensors & Automatic Identification | Inventory & Network Optimization Tools | Robotics & Automation | Wearable & Mobile Technology | Predictive Analytics | 3D Printing | Driverless Vehicles & Drones | Internet of Things*
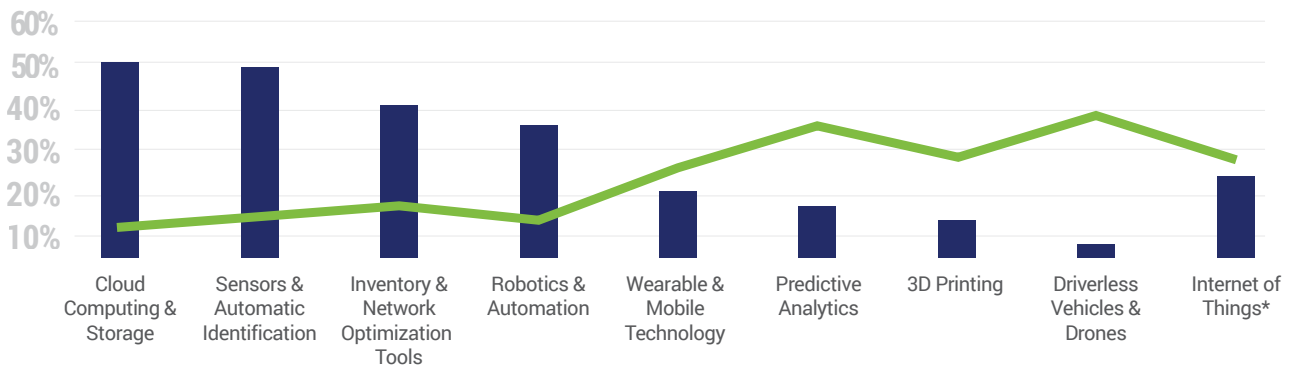
* First year of data

TOP CHALLENGES

63% Hiring and Retaining a Skilled Workforce

55% Customer Demand for Faster Response Times

53% Customer Demand for Lower Delivered Costs

BARRIERS TO IOT ADOPTION

56% Cyber Security

45% Lack of talent to utilize technology effectively.

44% Lack of a clear business case to justify investment
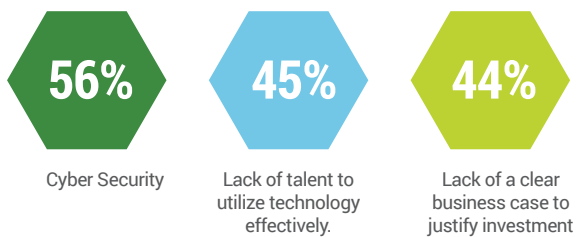
SPENDING

Companies spending on emerging technologies over the next two years.

2% $100 MILLION+
17% $10 MILLION+
53% $1 MILLION+
47% -$1 MILLION
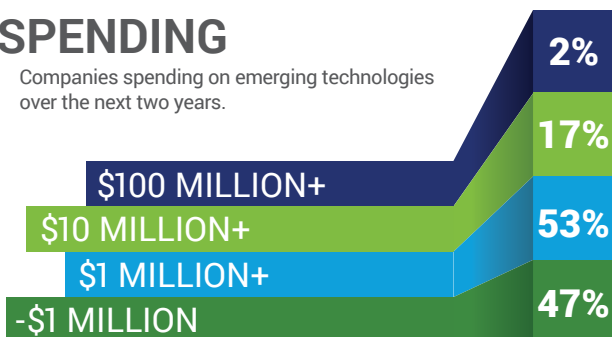
PREPARATION

Actions being taken to prepare for next generation supply chain.

50% Training Workforce to use New Technologies

54% Partnering with Vendors to Understand Benefits

46% Begin Piloting New Technologies

48% Recruiting for Different Skillsets to Align with Future Needs

4
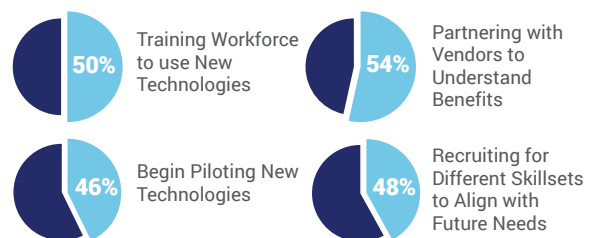
Introduction

> "With a strategic focus and the courage to collaborate, leading firms are utilizing Next-Generation Supply Chain technologies to create digital capabilities that give them the competitive advantage they need to survive and thrive in today's on-demand economy."
>
> **George Prest, CEO of MHI**

As markets demand not only efficiency but agility and flexibility from supply chains, next-generation models are successfully combining automation and digital technologies to drive superior performance. While this digital ecosystem is creating cost savings, innovation and win-win opportunities along supply chains, it is also accelerating the pace of change, creating disruption and raising competitive pressures.

The 2017 MHI Annual Industry Report, developed for the fourth year in collaboration with Deloitte Consulting, reflects the views of 1,100 manufacturing and supply chain industry leaders on this important topic. Survey participants represented a wide range of industries, with the majority (50%) holding executive positions such as CEO, Vice President, General Manager or Department Head. Participating companies ranged in size from small to large, with 47% reporting annual sales in excess of $100 million, and 10% reporting $10 billion or more.

This report provides updates on the eight innovative technologies we predicted would have the most potential to transform supply chains three years ago when this annual report was launched.

We also share evolving trends over the years of the survey and the potential of these trends to disrupt the industry, adoption rates and barriers to adoption. The eight technologies are:

Inventory and network optimization tools - Models and tools to help companies design networks to produce, store and distribute efficiently and effectively to serve customers.

Sensors and automatic identification - Technologies to automatically identify, locate and profile supply chain objects and to capture and communicate associated data and information across the supply chain.

Cloud computing and storage - Use of a network architecture of remote internet servers to host, store, manage and process data and applications rather than a local server or computer.

Robotics and automation - The design and use of computer-controlled machines to automatically perform a series of actions or tasks traditionally performed by humans.

Predictive analytics - The practice of extracting information from existing data sets in order to determine patterns and trends to predict future events or outcomes.

Wearable and mobile technology - Technology devices that can be worn or carried, either as external accessories or as part of clothing, having the capability to exchange data between the devices and a network.

Autonomous vehicles and drones - A computer-guided device that can move about without a human being in control, either on the ground (a vehicle) or in the air (a drone).

3D printing - A group of technologies that can manufacture products through construction of layers from a digital three-dimensional blue print.

This year's survey revealed the emergence of a ninth innovation, the Internet of Things (IoT), that has growing importance in the digital economy. We define the IoT as *"the use of the Internet to connect computing devices embedded in everyday objects, enabling them to send and receive data in real time."*

In addition, this year's report introduces the topic of 'Smart City Logistics' and examines how innovations and technologies are being leveraged to help cities address the growing challenges of congestion, noise and pollution associated with last mile deliveries within their increasing populations.

This report also describes what will be required to increase the adoption rates of the innovations most critical to Next-Generation Supply Chains:

• Robotics and automation
• Sensors and automatic identification/Internet of Things (IoT)
• Wearable and mobile technology
• Autonomous vehicles and drones
• Predictive analytics

These technologies are working together to create next-generation supply chains that are digital, on-demand and always-on. They will soon become the new supply chain reality. A full 80% of survey respondents believe the digital supply chain will be the predominant model within 5 years. Another 16% say it already is.

Survey Highlights

Disruptive Innovation

Survey respondents increasingly believe the nine innovations described previously have the potential to disrupt supply chains or to create competitive advantage if harnessed correctly (see Figure 1). A full 92% of respondents believe at least one of the nine listed technologies could be a source of competitive advantage / disruption in their industry in the next 10 years.

The top technologies respondents say can be a source of either disruption or competitive advantage are:

• Robotics and automation (61%, up from 39% in 2015)

• Predictive analytics (57%, up from 38% in 2015)

• Internet-of-Things (IoT) (55%, new category in 2017)

• Driverless vehicles & drones (54%, up from 30% in 2015)

• Sensors and automatic identification (53%, up from 42% in 2015

Adoption Rates

Cloud computing and storage along with sensors and automatic identification are leading in terms of adoption rates (in-use today), with 50% and 49%, respectively. Over the next two years, the adoption of these technologies is expected to grow to 74% and 71% respectively. The technology predicted to be most adopted within the next two years is Inventory and Network Optimization, forecasted at a 75% adoption rate. Over the same time frame, IoT adoption is expected to reach a 55% adoption rate, followed by robotics and automation at 53% and predictive analytics at 52% (see Figure 2).

Barriers to IoT Adoption

With the current buzz around Industry 4.0 and IoT, the survey uncovered some significant barriers to adoption of these technologies. Over half of respondents (55%) cited cyber security as the greatest barrier, followed by the lack of talent (44%) and the lack of a clear business case to justify investment (44%) (see Figure 3).

Figure 1. 2015-2017 survey results: Trend of innovations being disruptive or a source of competitive advantage

	Disrupt or Competitive Advantage	Support Ongoing Improvements	Little to No impact
Robotics and Automation	61%	27%	12%
Predictive Analytics	57%	32%	11%
Internet-of-Things (IoT)	55%	33%	12%
Driverless Vehicles and Drones	54%	22%	24%
Sensors and Automatic Identification	53%	37%	10%
Inventory and Network Optimization Tools	50%	42%	8%
Wearable and Mobile Technology	44%	35%	21%
3D Printing (Additive Manufacturing)	40%	28%	32%
Cloud Computing and Storage	37%	47%	16%
Blockchain and distributed ledger technologies	31%	41%	28%

■ Disrupt or Competitve Advantage ■ Support Ongoing Improvements ■ Little to No impact

Figure 2. 2017 survey results: Planned adoption of emerging innovations

	In-use today	1-2 years	3-5 years	6+ years
Inventory and Network Optimization	41%	75%	91%	95%
Cloud Computing and Storage	50%	74%	88%	92%
Internet-of-Things (IoT)	24%	55%	81%	92%
Sensors and Automatic Identification	49%	71%	87%	91%
Predictive Analytics	17%	52%	79%	89%
Robotics and Automation	37%	53%	71%	89%
Wearable and Mobile Technology	37%	45%	71%	80%
3D Printing	15%	30%	49%	62%
Driverless Vehicles and Drones	8%	20%	39%	58%

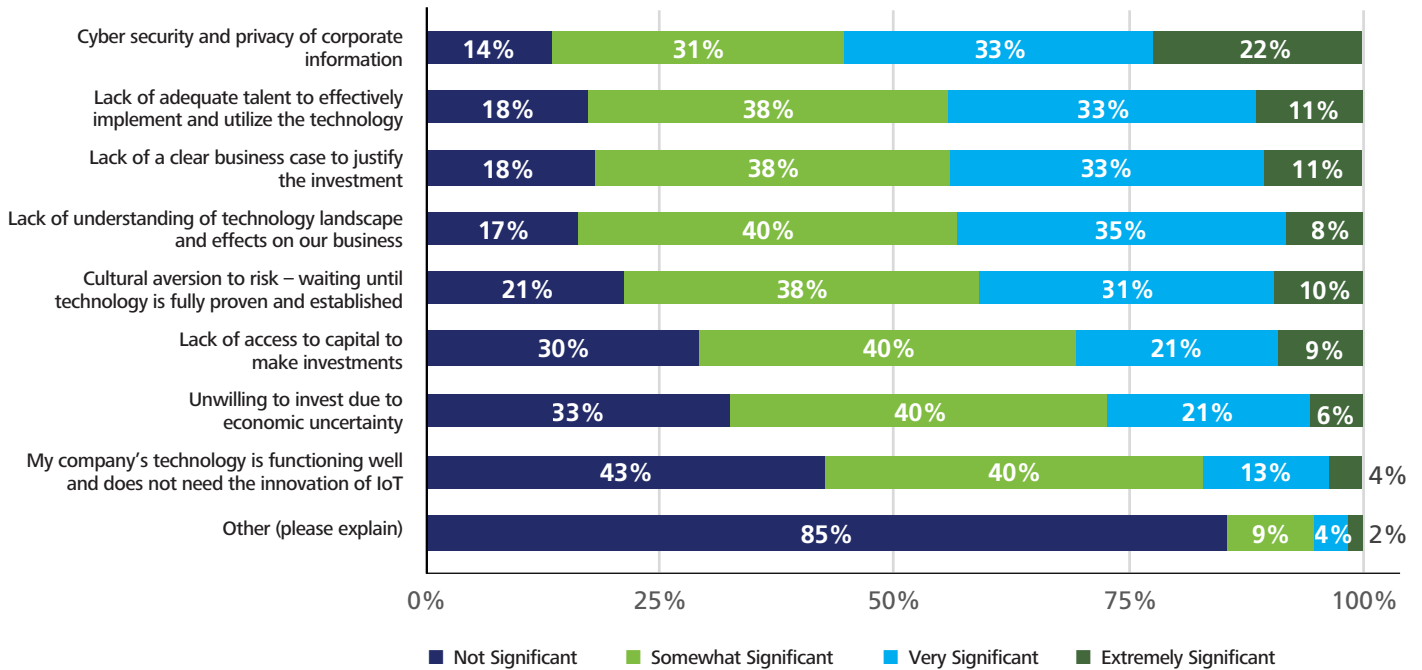## Supply Chain Talent Gap

To implement any of these technologies, firms need access to a skilled supply chain workforce. This has been a theme in all four annual reports, and the talent gap is growing as the adoption of these technologies increases. According to the survey, hiring and retaining a skilled workforce continues to be the biggest obstacle facing supply chain professionals (see Figure 4) with 63% of respondents reporting the issue (up from 58% in 2016). Additionally, 50% say training their workforce to use new technologies is a top priority. Other significant challenges include customer demand for faster response times (55%) and customer demand for lower delivery cost (53%) (see Figure 4).
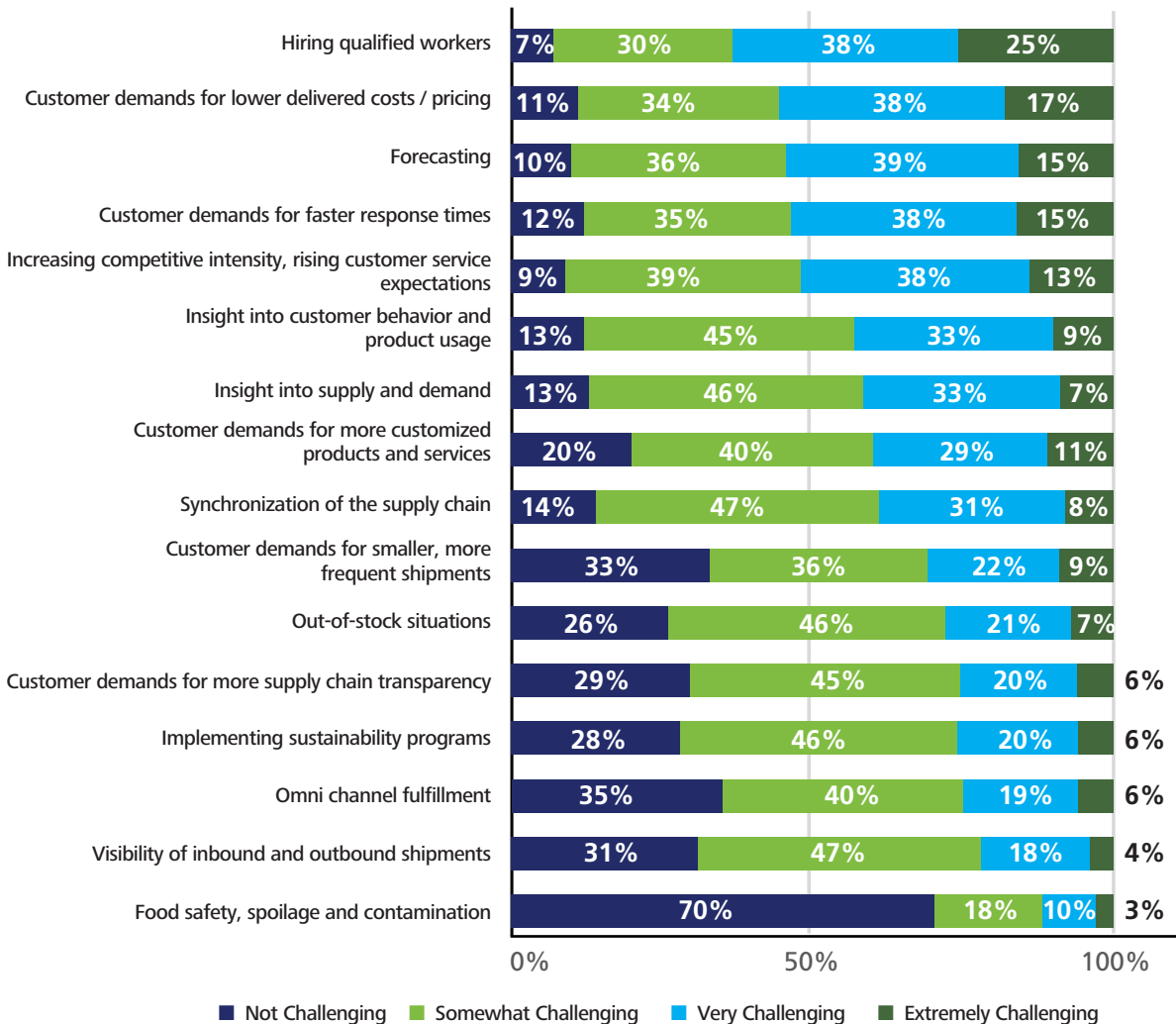
Investments

More manufacturing and supply chain companies are upping their financial commitment to innovation. New technology investments totalling over $1 million have increased from 49% in 2015 to 53% today. Two percent of respondents plan to spend over $100 million.

Figure 3. 2017 survey results: Barriers to adoption

Barrier	Not Significant	Somewhat Significant	Very Significant	Extremely Significant
Cyber security and privacy of corporate information	14%	31%	33%	22%
Lack of adequate talent to effectively implement and utilize the technology	18%	38%	33%	11%
Lack of a clear business case to justify the investment	18%	38%	33%	11%
Lack of understanding of technology landscape and effects on our business	17%	40%	35%	8%
Cultural aversion to risk – waiting until technology is fully proven and established	21%	38%	31%	10%
Lack of access to capital to make investments	30%	40%	21%	9%
Unwilling to invest due to economic uncertainty	33%	40%	21%	6%
My company's technology is functioning well and does not need the innovation of IoT	43%	40%	13%	4%
Other (please explain)	85%	9%	4%	2%

■ Not Significant ■ Somewhat Significant ■ Very Significant ■ Extremely Significant

Figure 4. 2017 survey results: Company challenges

Challenge	Not Challenging	Somewhat Challenging	Very Challenging	Extremely Challenging
Hiring qualified workers	7%	30%	38%	25%
Customer demands for lower delivered costs / pricing	11%	34%	38%	17%
Forecasting	10%	36%	39%	15%
Customer demands for faster response times	12%	35%	38%	15%
Increasing competitive intensity, rising customer service expectations	9%	39%	38%	13%
Insight into customer behavior and product usage	13%	45%	33%	9%
Insight into supply and demand	13%	46%	33%	7%
Customer demands for more customized products and services	20%	40%	29%	11%
Synchronization of the supply chain	14%	47%	31%	8%
Customer demands for smaller, more frequent shipments	33%	36%	22%	9%
Out-of-stock situations	26%	46%	21%	7%
Customer demands for more supply chain transparency	29%	45%	20%	6%
Implementing sustainability programs	28%	46%	20%	6%
Omni channel fulfillment	35%	40%	19%	6%
Visibility of inbound and outbound shipments	31%	47%	18%	4%
Food safety, spoilage and contamination	70%	18%	10%	3%

■ Not Challenging ■ Somewhat Challenging ■ Very Challenging ■ Extremely Challenging

Next-Generation Supply Chains

"As digital capability fuels customer expectations to unprecedented heights, the Next-Generation Supply Chain must be proactive and predictive, with all of its links interconnected and synchronized to the same drum beat of consumer demand."

Scott Sopher, Deloitte Consulting LLP

The Next-Generation Supply Chain is evolving from the more traditional model of a series of linear, individual, dis-synchronized links into a more connected, harmonized network of trading partners. This Next-Generation Supply Chain has three distinct characteristics: Digital, On-Demand and Always-on.

Emergence of the Digital Supply Chain

The digital revolution is upon us, driven by exponential advancements in computing power and memory. More data was created in the past two years than all previous years in history combined[1]. It is now possible to access comprehensive data from every link of the supply chain. Next-Generation Supply Chains will take advantage of this trend and develop new digital capabilities including the strategic placement and use of sensors and artificial intelligence (also known as machine learning and cognitive computing). This newly available data provides the foundation for real-time visibility and sharing of information, filtered through a layer of analytics, and communicated across the entire supply chain for proactive and full-sighted operations.

Cognitive tools such as automation and wearables are bringing this insight-rich information directly to supply chain workers who use it to make necessary adjustments

as they perform their tasks. The physical and digital worlds are converging, transforming traditional, linear supply chains into connected, learning, scalable and nimble supply networks.[2]

The exponential rise of the technologies covered in this report creates a decision tipping point for supply chain leaders: disrupt or be disrupted. A significant majority, 80%, of survey respondents believe the digital supply chain will be the predominant model within the next 5 years (see Figure 5); 16% of these supply chain leaders recognize it is already here. Disruption from this digital era is already evident in how it is transforming industries and changing consumer expectations.

At the same time, machines are augmenting human performance; traditional, linear supply chain nodes are evolving into a set of dynamic networks[2]; and the "Always-On" and on-demand networks can now be more effectively tied to the broader business strategy to become a source of competitive advantage. With an integrated network, companies can compete on differentiating factors, such as speed or service, and apply this differentiator across all the traditional channels of the supply chain (see Figure 5).

Digitizing the supply chain involves a continuous flow of information between the physical and digital worlds. This flow of information between the two worlds is made possible through integrated technologies or capabilities such as the ones covered in this report (see Figure 6).

The creation and collection of these digital transactions can be the key to unlocking innovative solutions to the most complex challenges, creating competitive advantage. The same barrage of information can also cripple organizations by the sheer volume of data generated. In the *By the Numbers* section on page 12, we illustrate a real-world example of the magnitude of information digital supply chains can create.

Harnessing Big Data

Big data has been a business buzz word for the past decade or so, but many companies are still struggling with not only figuring out how to use it, but more immediately, how to collect it without getting overwhelmed by it. A company's first step into this arena is establishing the IT infrastructure to make sure the data is collected in an automated and organized fashion, stored with proper amounts of capacity and cleansed to ensure reliability.

Big data by itself provides nothing other than overhead costs to the business and, unfortunately, this is what many firms are experiencing today in their experimentation with digital information. Insights can be derived from this information, but those insights are captured only by careful thought and planning in order to mine the critical information and discovery of useful patterns in the data. This process is being relegated to machines in increasing numbers because sifting through data is where artificial intelligence and algorithmic processing add the most value, freeing up human capital to focus on other business-critical factors.

Figure 5. 2017 survey results: Timeframe for Next-Generation Supply Chain

4%

16%

80%

16%

64%

- Already here
- Next 5 years
- 6+ years
- Unlikely to ever evolve to this level
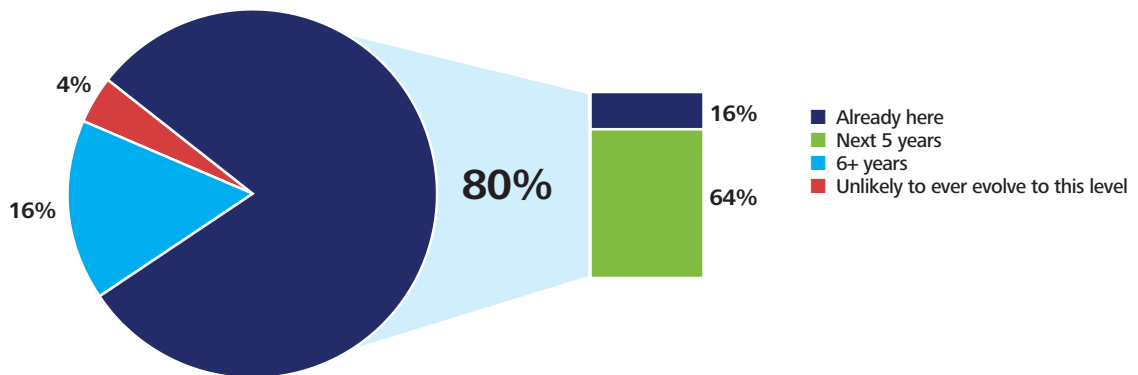
Figure 6. The Rise of the Digital Supply Network[1]
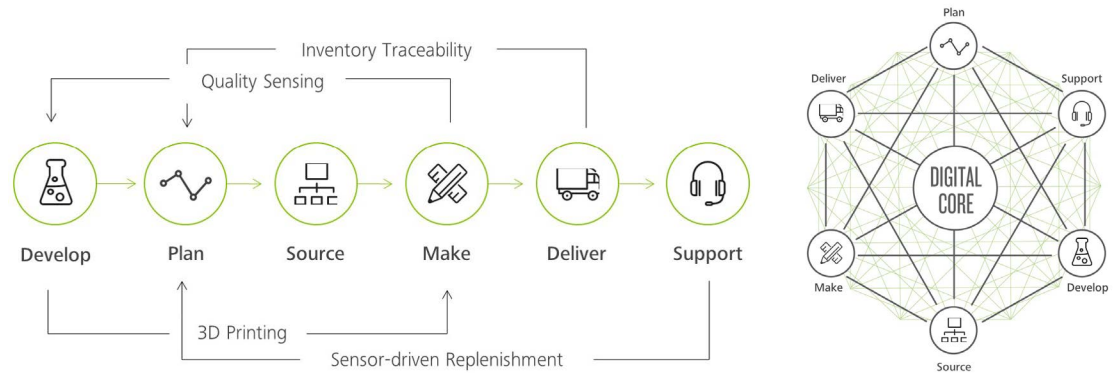
Escalating On-Demand Customer Requirements

The digital revolution is also fundamentally changing the way that consumers behave. According to a report published by Deloitte University Press[2], customers have an increased comfort with technology, and more specifically the technology used to facilitate online transactions, fuelled by high usage of online channels. Users have shorter attention spans, are becoming more demanding and expect more from businesses in terms of short service cycles, lower costs, transparency and corporate responsibility.

Indeed, an astounding array of information regarding their purchases is now at a consumer's fingertips at instantaneous speeds, leading them to expect more from supply chains. Customer expectations for faster, better service are rapidly escalating. Next-day is no longer considered a premium service for which customers are willing to pay. Same day is becoming more prevalent.

The next frontier of supply chain development is on-demand, a level of service that will require next-generation supply chains to provide anywhere, anytime delivery to customers at the time the customer orders and

By the Numbers

Over the past 10 years, nearly every industry has been affected by the trend of digitization driven by exponential gains in computing power. But no industry has been impacted more than Logistics. To illustrate this, one need look no further than the number of Supply Chain transactions generated on Cyber Monday 2016 by one of the nation's largest eTailers. In **1 day**, a reported **426 orders per second**[11] were generated from the website throughout the day. That equates to over 36 million order transactions, an estimated **250 million picking lines** at the distribution centers (DC), **40 million DC package loading scans, 40 million inbound sortation hub scans, 40 million outbound sortation hub scans, 40 million inbound regional sortation facility scans** and **40 million outbound delivery truck scans.** Assuming 200 stops per parcel delivery truck and 300 packages per truck, there were about **122,000 delivery trucks** involved that made **24.5 million stops** generating 24.5 million proof of delivery transactions and **24.5 million shipment confirmation messages.** Carrying this all the way back through the supply chain, one can account for over **1 billion digital transactions** generated for that one day of the year, albeit the busiest day, for only one retailer.

specifies. We have seen this for years in retail with the rise of omni-channel fulfilment, but it is now impacting industries that are not consumer-facing.

This trend will have a trickle-down effect on other industries and the entire value chain. Leading firms are increasingly demanding speed, visibility and transparency from their supply chain partners to meet customer expectations, and it is creating pressure down the supply chain. B2B vendors must evolve as retailers have to provide more and more flexibility and efficiency to support the on-demand model of reducing costs and increased service[3].

This means "on-demand" is not just a challenge for retailers and customer-facing industries, but it is impacting firms regardless of size, industry or position in the value chain.

This year's survey confirmed this trend. Customer demands for faster response times (55%), and rising customer demands for lower delivered costs (53%) are two of the top 5 issues supply chain leaders and professionals find the most challenging.

For supply chain professionals, these trends are pushing against them from all sides as they are asked to deliver product faster, cheaper and in a customized way.

Supply chain organizations are responding to these market challenges by utilizing innovative technologies that allow them to meet or exceed these expectations. Next-generation supply chains will likely be smarter, more flexible and more efficient, thanks to a combination of the innovative technologies covered in this report.

"Always-on Supply Chains"

An astounding array of information on purchases is now at the fingertips of consumers at nearly instantaneous speeds, leading them to expect more. Digital order confirmations, status updates, in-route shipment and delivery vehicle tracking information, on-demand order fulfilment and proof of delivery are a few examples. The net implication for supply chains is a challenge to perform flawlessly, efficiently and transparently if they are to meet these escalating service expectations.

The innovations studied in this report make it possible for supply chains to operate around the clock to outpace the challenges. In essence, they must be "always-on." In last year's report, we defined Always-On supply chains as:

"An integrated set of supply networks characterized by a continuous and high-velocity flow of information and analytics, creating predictive actionable decisions that better serve the customer."

Smart City Logistics

"As part of our Smart City initiative, we put a big emphasis on freight, because it moves directly through our downtown and within the surrounding metropolitan area…It's in the best interests of our region and of companies—both shippers and carriers—who move freight, to do so as efficiently and fluidly as possible."

Chris Gutierrez, President of Kansas City SmartPort, the region's freight-based economic development group covering both the Kansas and Missouri sides of the city

More than half the world's population, nearly 4 billion people, reside in urban areas. That number is projected to double to almost 8 billion within the next 35 years[4]. This pattern of rapidly increasing urbanization is also seen in the U.S., causing city governments to start to tackle the myriad of challenges presented by an increasing concentration of people within a finite area of land. One of the biggest challenges is how to provide for last-mile logistics to serve people within cities.

In the US, the transport of goods currently takes up to 25% of urban road capacity. The trend towards urbanization along with continued dramatic growth of e-commerce and online shopping is driving a dramatic increase in freight deliveries to and within urban areas. This will lead to unsustainable traffic congestion, CO_2 emissions and noise and air pollution levels within urban areas.

Smart City Logistics is the idea that logistics providers can leverage many of the innovations and technology this report has been tracking over the past four years to find solutions to this issue that work for government, businesses, consumers and the environment. A collaborative effort across and between businesses and city planners will be required to arrive at sustainable solutions to this emerging problem.

This topic is included in this report to begin shedding light on this important issue and how next-generation supply chain technology can address this challenge. While 50% of survey respondents are aware of the Smart City Logistics topic (see Figure 7), only 6% say they have begun to collaborate with other companies and cities to utilize and develop supply chain innovations to create new opportunities.

Defining a Smart City

Our definition of a Smart City is an urban area that uses information to design policies and procedures that benefit its citizens. While that data can be gathered through a number of different sources, it is the Internet of Things, with sensors embedded in everything from our phones and cars, to water valves and parking meters that enable analytics capabilities to illuminate policy solutions. While a city could use this combination of data sensing and analytics in stand-alone, one-off projects, a truly Smart City has a strategy for creation, development, and deployment of smart solutions that can work together.

There will most likely never be a perfect Smart City, where every service is driven by analytics connected to an army of sensors because cities will only invest where Smart

City capability intersects with a city's prioritized needs. However, the world is already full of great examples of Smart Cities that use innovative technologies to transform those functions which are most important to people who live there, whether that be traffic management, government transparency or sustainability. Whether it's smart transportation in Singapore or New York City, or environmental management in Barcelona or Paris – these cities are already using the most advanced technology to change the way people interact with the cities they inhabit.

Continuing Pattern of Urbanization

To understand the implications and challenges for Smart Cities, it is important to think of the relative density of urban areas rather than be guided by the classic census bureau classification of what constitutes an urban area. For purposes of this report, we will define a "city" as an urbanized area consisting of more than 50,000 people. By this definition, approximately 65% of the current U.S. population resides in cities that account for just 3.5% of the total land mass[5].

As this trend of increasing concentrations of people within finite areas of land continues (see Figure 8), leaders in the largest cities are beginning to realize they are ill prepared

Figure 7. 2017 survey results: Smart City Logistics awareness

- ■ Aware; begun to collaborate
- ■ Aware; not willing to collaborate
- ■ Aware; begun to plan and invest
- ■ Aware; willing to collaborate
- ■ Not aware
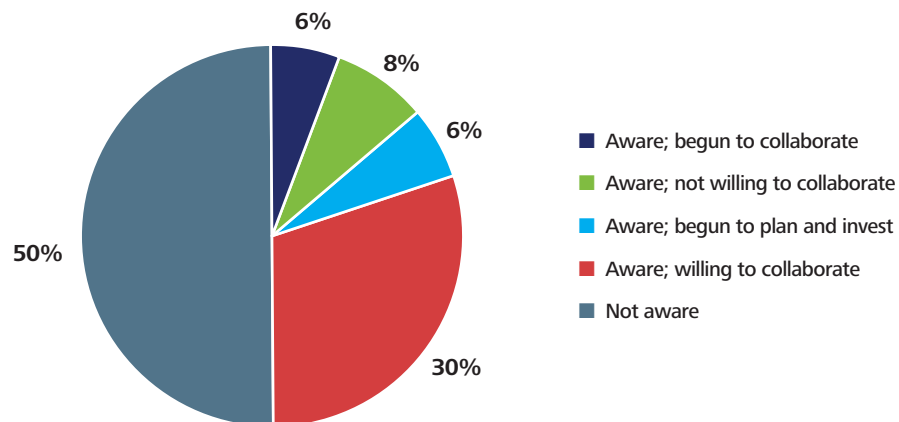
for the profound impacts on city operations and services, from infrastructure all the way to the logistics of how their populace will be served.

At the same time, smaller, second-tier cities are also looking at Smart City solutions to brand themselves as attractive to young workers and the companies who seek to hire them. Salient examples include investments in autonomous transportation in Pittsburg, PA and smart transportation infrastructure in Kansas City, MO.

Implications for Supply Chains

The evolving challenge to supply chains is to understand how innovative technologies can be deployed or implemented in response to an increasingly urban consumer with always-on expectations.

While 50% of survey respondents are aware of the Smart City Logistics topic, only 6% say they have begun to collaborate with other companies and cities to utilize supply chain innovations to develop solutions to address the challenges. We see this as a major opportunity that could impact supply chains over the next ten years.

An Evolution in Last Mile Delivery

This densification of demand will create new models for last-mile distribution, because cities simply cannot tolerate the congestion, noise or pollution a major increase in tractor trailers or package delivery trucks will bring. To avoid these problems, deliveries will have to be smaller and much more frequent, to accommodate accelerating expectations and increased volume. Fortunately, necessity is giving birth to a

Figure 8. Expanding US urbanization: Percent of U.S. populations residing in urban areas

Source: US Census Bureau; Urban area defined as +300,000
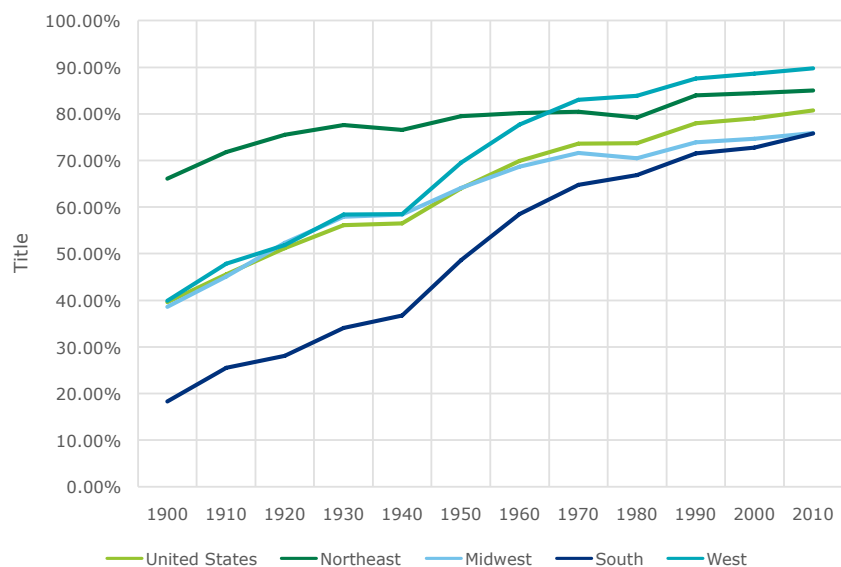
number of new applications for supply chain innovation in the urban context, both in delivery channel and distribution networks.

Some delivery channel innovation is as simple as negotiating permission for off-peak (or dead-of-night) deliveries and temporal shifting of some supply chain activities; more disruptive changes revolve around novel modes of delivery. Much has been written about the disruptive potential of drones and autonomous delivery; the vision of drones whisking parcels through the city scape is both the stuff of science fiction and shockingly plausible. Until governmental regulation can find a way to address concerns over safety and security, however, the airways will remain unclaimed. That being said, the technology is evolving, in both fixed wing drones which drop their payloads via parachute onto rooftop receiving areas, or in suitcase-sized land-based delivery drones utilizing city sidewalks currently in development. As regulatory and technological barriers fall over time, we expect to see more innovation in this space.

Smaller, Urban Distribution Centers

As orders become more frequent and smaller in size, distribution must move closer to customers to cap transportation costs and reduce delivery times. Migrating inward from the large suburban regional distribution centers, supply chain firms are experimenting with smaller distribution center formats within city limits. In many cities, real estate sufficient for distribution activities is being repurposed close to city centers to create smaller, distribution hubs. The traditional spatial constraints of distribution centers is being mitigated with innovations in robotics and automation in pick, pack and sort that make small distribution spaces work. Warehouse execution systems that combine the hardware and software to maximize warehouse efficiency are developing rapidly to meet the needs of urban distribution.

Innovative Technologies

Innovative technologies will be required to address logistics challenges of Smart Cities. The technologies enabling Smart City Logistics innovation are those same solutions we already are seeing in Next-Generation Supply Chains. Both are driven by a combination of automation, sensors, analytics and the IoT, though they encompass many different use cases.

While every Smart City must have IT architecture, how that technology is seen and felt varies depending on what kind of smart solution is in play. For example, whether technology is deployed to dynamically light the path of a pedestrian at night using street lights, count open parking spaces, or listen for gunfire, each situation requires a very specific kind of sensor-array integration technology with associated interfaces. On the other hand, if a city wants to collect information on maintenance needs such as potholes or graffiti, the technology to do that is already in the pockets of its citizens, and the only thing missing is the smartphone app to gather and process the data submitted directly from users.

According to our survey, a variety of Smart City logistics programs (see Figure 9) are currently in the research and planning phases.

Strategies for a Smarter Tomorrow

The life-blood of supply chains and Smart Cities is the collection and distribution of digital information. The information loop from physical to digital and back to physical is paramount to the innovations front and center in the Smart City landscape and the supply chains that will serve them. Sensors, robotics, automation, IoT, drones and wearables will be the primary innovations leading the efforts towards the supply chains and cities of tomorrow.

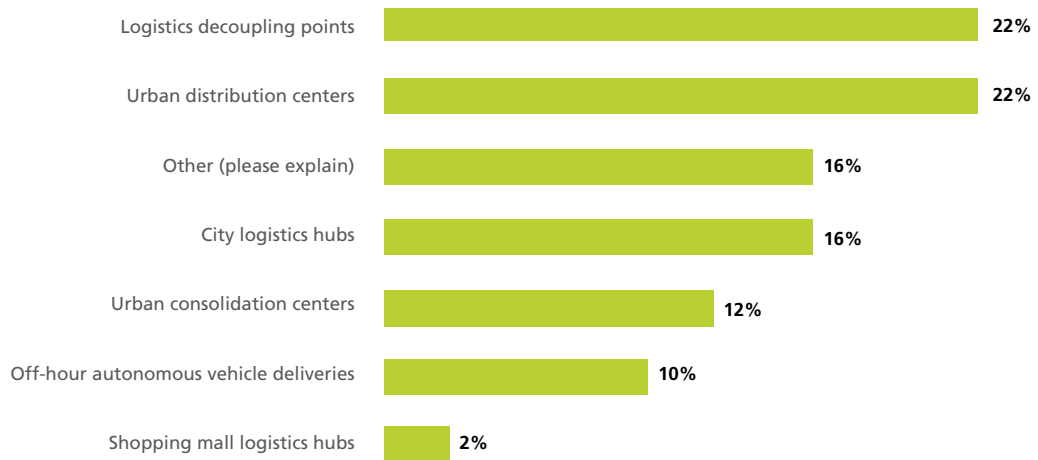The U.S. Department of Transportation's recently conducted Smart City Challenge fielded applications from 78 cities

across America all vying for a $40 million grant to help bring their visions to life. A variety of freight movement and management approaches were proposed to mitigate the anticipated growth of 40 percent in freight volume by 2050. The ideas included:

- Improved urban freight loading and unloading via dynamic curb space reservations—enabled through sensors and other connected technologies—to better time traffic and parking availability

- Implementation of short-range communication devices that connect vehicles to infrastructure, such as road-embedded sensors that detect traffic congestion for dynamic rerouting, and traffic signals that prioritize truck movement along specific freight corridors

- Mobile apps that give truckers real-time information about traffic, routes and parking so they can better determine their route

- Truck platooning, where two or more trucks driving in a row are connected by onboard communications technology that enables them to minimize the distance between each for improved aerodynamics, more efficient fuel usage and a reduction in carbon emissions and pollution

An understanding of today's disruptive technologies is absolutely necessary to develop strategies to thrive in tomorrow's urban environment. As cities develop smart solutions and policies to incorporate new technologies, logistics providers must keep pace to understand what opportunities these new policies represent. The best supply chain leaders, however, will realize the best thinking and solutions will come from collaboration with cities, not just in reaction to their actions.

Figure 9. 2017 survey results: Ongoing planning and research for Smart Cities

Logistics decoupling points	22%
Urban distribution centers	22%
Other (please explain)	16%
City logistics hubs	16%
Urban consolidation centers	12%
Off-hour autonomous vehicle deliveries	10%
Shopping mall logistics hubs	2%

Case Study – UPS Cargo Cruiser

Situation: UPS utilizes trucks and airplanes powered by petroleum-based fuels, but also has a significant global fleet of alternative fuel and advanced technology vehicles, ranging from electric hybrid to natural gas. While reducing carbon emissions is becoming increasingly important, the recent growth in e-commerce is also rapidly changing the profile of the package delivery business, especially in cities, where the trend of urbanization is concentrating more people within smaller areas.

As a result, urban congestion is becoming a serious issue for many of the world's mega-cities. Aligning with its long standing commitment to environmental sustainability, and combined with a growing demand for congestion-limiting operations, UPS is experimenting with a host of innovative technologies and new ways of operating within urban areas.

Case Study: One of the innovations UPS is currently trialing is the eTrike[12]. UPS has successfully tested an electrically-assisted tricycle, called the Cargo Cruiser in the company's Hamburg, Germany fleet to address both air quality and congestion concerns. The eTrike is designed to travel in and around pedestrian areas of the city by operating from a container that is brought into the city center once daily. This is perfectly aligned with Hamburg City's 20-year plan to transform into a greener, healthier, vehicle-free metropolis.

Environmentally friendly with 77 cubic feet of cargo space (more than most mid-sized sedans) and a range of 21 miles with a top speed of 15 miles per hour, UPS' Cargo Cruisers is an economical and efficient way to deliver parcels in an urban environment. And they're not just for narrow European streets. UPS customers in Portland, OR, are now getting used to drivers pedaling around their neighborhoods in a similar model.

The Cargo Cruiser is equipped with a battery-powered electric motor that makes it possible to cover distances, carry substantial loads, and navigate hills and other terrain. The rider still pedals, just like on a conventional tricycle. But in this case the pedaling motion is sensed and then assisted by the electric motor, so that the rider does not feel the load that he or she is pulling.

Result: During the testing phase, UPS evaluated the reliability, design, integration to the city's infrastructure and acceptance of the vehicle. That test was successful, so UPS is now deploying additional eTrikes in other cities in 2017.

eTrikes are helping UPS to achieve its goal to reduce its carbon intensity 20 percent by the end of 2020, while also creating viable options to help facilitate urban last-mile delivery while reducing urban emissions and congestion.

UPS Chairman and CEO David Abney on the Portland-based Cargo Cruiser.

Source: UPS

"At some point, the delivery model of big trucks driving through increasingly congested urban areas to make single, individual deliveries will become unsustainable. Currently we are experimenting with a variety of technologies, operational changes and even new urban distribution centers. Experimentation is key because we know we need multiple solutions to solve for a variety of challenges – from emissions to congestion-related issues."

Alan Amling, VP, Corporate Strategy, UPS Supply Chain Solutions

What leaders should be doing today

- Get involved and stay informed by staying close to industry and supply chain groups that cover Smart City trends. Leaders should identify champions within their companies to be liaisons with city governments to build relationships and take a proactive stance in the formation of new logistics policies powered by Smart Cities.

- Support technology literacy on the front-line by investing in the development of training materials and competency frameworks to ensure every employee has a base level of technological literacy in supply chain innovations. The creation of such a training framework can also be leveraged to disseminate training in the future as the technological landscape of supply chains continues to evolve.

- Understand that the essence of Smart Cities is not formalized sets of technologies or ways of doing business. It is an emerging capability to invent new and local solutions based on the needs of the cities themselves. Supply chains will have to leverage their local knowledge to stay competitive and expand into new markets with eyes wide open to understand the local implications of the Smart City, wherever they may be.

- Collaborate with urban planners, city leaders, educational institutions and leaders from other, potentially competing companies to develop solutions to Smart City logistics challenges.

- Make investments in local educational institutions like vocational schools, high schools, junior colleges and universities. Assist these institutions to design and deliver supply chain and technology-focused curriculum. These institutions and your investment will play a critical role in educating and training the work force that will be required to effectively and efficiently operate the sophisticated supply chains of Smart Cities. In the future, people with the right skills will continue to be the most critical resource in the operation of an enterprise's supply chain.

Innovation Update

> *"Add the rising cost of labor and a labor shortage as the current workforce ages, and supply chain leaders are turning to robots as a solution."*
>
> **Tom Galluzzo, Ph.D., chief executive officer of IAM Robotics**

Survey Trends of the Innovations and Technologies

Four years of conducting the survey gave us an opportunity to compare past and present results to identify and evaluate significant trends of how responses have changed over time. The questions over the past three years have been consistent in probing for perspectives on the eight technologies and innovations identified after the first year's survey. Key insights are emerging from comparisons of results from the past three years.

Disruptive Innovation

Over the last three years, survey respondents increasingly believe the eight innovations previously survey respondents increasingly believe the eight innovations covered have the potential to disrupt supply chains or to create competitive advantage if harnessed correctly (see Figure 10). A full 92% of respondents believe at least one of the nine listed technologies could be a source of competitive advantage / disruption in their industry in the next 10 years.

Actions to Prepare for the Next 10 years

The survey asked what leaders are doing to prepare for market conditions over the next ten years. While workforce training remains important, many are exploring other avenues to improve their supply chains. Showing the largest increases in priority since 2015 are: "Recruiting for different skillsets to align with needs of the future" at 48% in 2017, up from 38% in 2015; "Partnering with vendors to better understand applications and business benefits" at 54%, up from 45%; and "Begin piloting new technologies" at 46%, up from 41% (see Figure 11).

MHI supports collaboration between industry and academic institutions to improve education and training for the skill sets needed to keep up with supply chain innovation and to increase awareness of the importance of manufacturing and supply chain careers. One key resource is MHI's College Industry Council on Material Handling Education (CICMHE), which brings industry, professors and students together to shape in four-year and post graduate university-level programs to meet current business needs. Also, MHI and the Material Handling Education Foundation, Inc. (MHEFI) jointly developed MHI's Career & Technical Education Program, which is helping to build the workforce of tomorrow by developing curriculum and textbook materials for training programs at the high school, vocational-technical school and community college levels.

Barriers to IoT Adoption

Cyber security was identified as a top barrier to IoT adoption, with 55% of respondents in the 2017 (see Figure 12). The 'lack of adequate talent to effectively implement and utilize the technology' was also a top barrier according to 44% of respondents in 2017 compared to 31% in 2015. The 'lack of an understanding of technology landscape and effects on our business' shows the largest percent increase

Figure 10. 2015-2017 survey results: Trend of innovations being disruptive or a source of competitive advantage
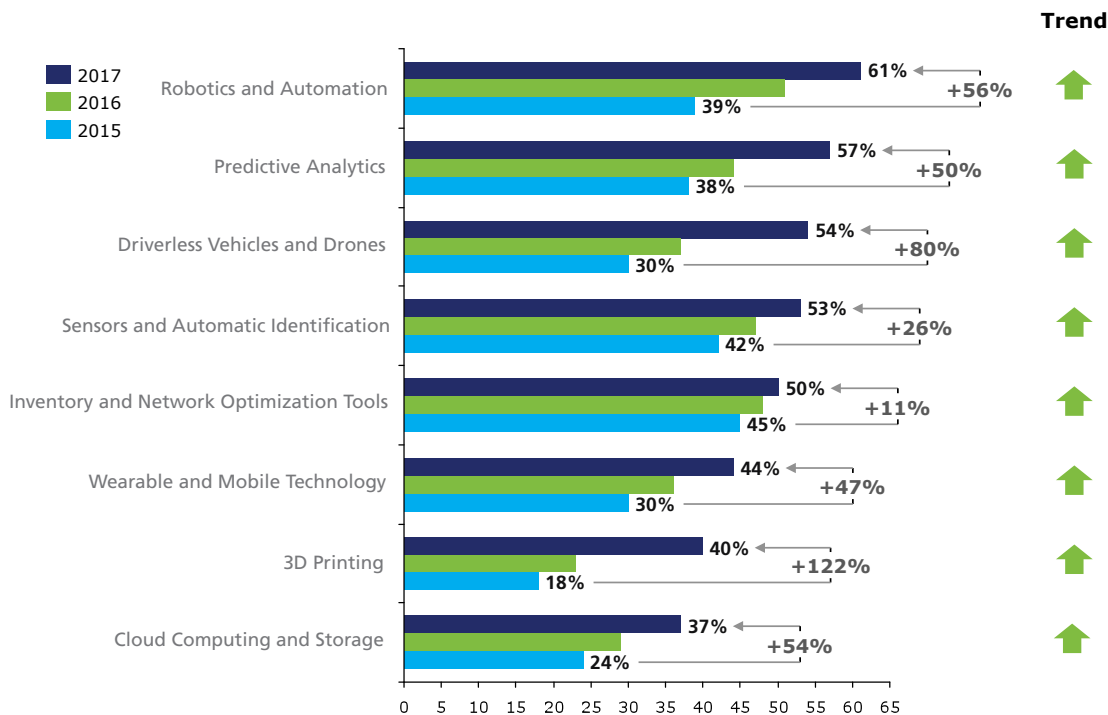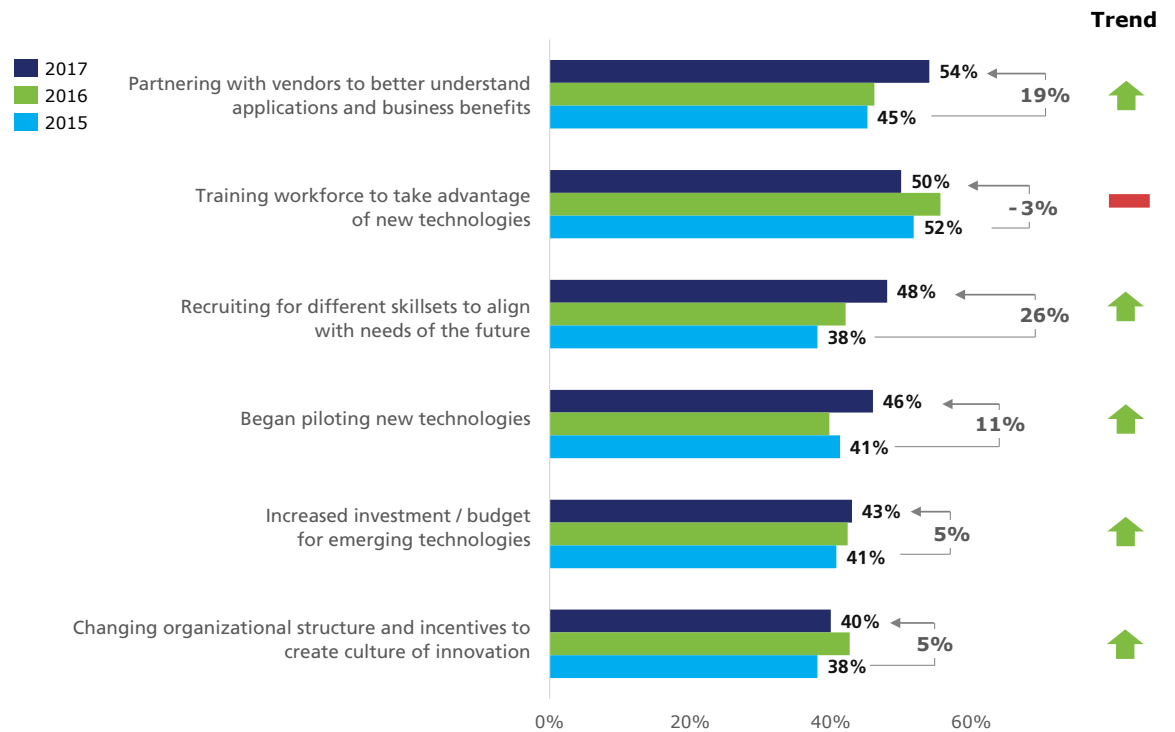
since the 2015 survey (+59%), with 43% in 2017 compared to 27% in 2015.

In order to survive and compete in this new business environment, supply chain leaders will need to put a keen focus on digital security and the development of a skilled workforce. Also, leaders will need to be able to articulate to the C-suite not just the ROI of digital supply chain technologies, but the risks of not adopting.

The next portion of the report will provide more detail and perspective on the art of the possible for the leading innovations driving next-generation supply chains.

Figure 11. 2015-2017 survey results: Trend of actions taken to prepare for supply chain in the next 10 years

Trend

	2017	2016	2015	
Partnering with vendors to better understand applications and business benefits	54%		45%	19% ⬆
Training workforce to take advantage of new technologies	50%		52%	-3% ▬
Recruiting for different skillsets to align with needs of the future	48%		38%	26% ⬆
Began piloting new technologies	46%		41%	11% ⬆
Increased investment / budget for emerging technologies	43%		41%	5% ⬆
Changing organizational structure and incentives to create culture of innovation	40%		38%	5% ⬆

Innovations and Technologies Driving Next-Generation Supply Chains

Robotics and Automation

Next-generation supply chains will utilize robots and automation to perform traditionally manual tasks such as picking, sorting, inspecting, storing, handling and classifying products to improve overall efficiency. Implementation of robotics and automation continues to grow as companies look for ways to remain competitive. According to the survey, adoption of these technologies is currently at 37%. However, the real story is that adoption is predicted to grow to 53% over the next two years and rise to 71% over the next five years.

The spike in this adoption rate is proof that firms recognize that robotics and automation is becoming an important lever to maintain and grow competitive advantage in the new digital, on-demand, always-on supply chain. Additionally, as automation has become smarter, safer, faster and more accurate, it has also become less expensive and more flexible to implement - leading to higher rates of adoption.

Survey respondents also reported that automation is a growing disruptor for their firms, with 61% of respondents (see Figure 13) saying that it is disrupting the industry or providing competitive advantage compared to just 39% in 2015.

Robots are increasingly able to perform "human" traits such as sensing, dexterity, memory and trainability, making automation a good fit for simple and repetitive material handling tasks such as moving products from one area

Figure 12. 2015-2017 survey results: Trend of barriers to IoT adoption

Legend:
- 2017
- 2016
- 2015

Trend

Barrier	2017	2016	2015	Trend
Cyber security and privacy of corporate information	55%			
Lack of adequate talent to effectively implement and utilize the technology	44%		31%	+42% ▲
Lack of a clear business case to justify the investment	44%		37%	+19% ▲
Lack of understanding of technology landscape and effects on our business	43%		27%	+59% ▲
Cultural aversion to risk – waiting until technology is fully proven and established	41%		29%	+41% ▲
Lack of access to capital to make investments	30%		25%	+20% ▲
Unwilling to invest due to economic uncertainty	27%		26%	+4% ▲
My company's technology is functioning well and does not need the innovation	17%		27%	-37% ▼

of a facility to another, picking and packaging, testing or inspecting products and assembling electronics. Automation also brings a level of consistency and repeatability. If an objective of a task is to place a product at a set height parameter of 30 feet, the system will never stock at 31 feet.

Automation is also safer than in the past, with robotic machines now working side-by-side with human workers. This frees up those workers to switch to more advanced roles in programming, maintenance and analytics—roles that require complex thinking, are more rewarding and require greater skill.

When using robotics and automation, 41% of respondents say they are using them in repetitive processes like assembly operations or processing, such as welding or painting (see Figure 14). The percentage is even greater in warehouse and distribution center operations, with 66% of implementers using it for tasks such as loading, picking or receiving.

Investing in Robotics Offers a Competitive Edge

While current adoption of robotics and automation is at 37%, it is predicted to skyrocket to a 71% adoption rate over the next five years. Why? Because supply chain professionals can see that intelligent robots offer a competitive edge.

As customer demand for quicker delivery and multi-channel order fulfillment continues to increase, labor within supply chains will need to become exponentially quicker to keep up, and human labor simply doesn't scale like that.

As automation continues to develop and become more intelligent, it also is becoming more affordable, mitigating the previous cost-of-entry barrier for companies. On top of that, companies can save on labor and increase production, offering an attractive ROI that explains the predicted 71% adoption rate.

Figure 13. 2017 Survey Results: Potential impact of Robotics and Automation

- **39%** Potential to create competitive advantage
- **22%** Potential to disrupt the industry
- **27%** Support ongoing improvements
- **12%** Little to no impact
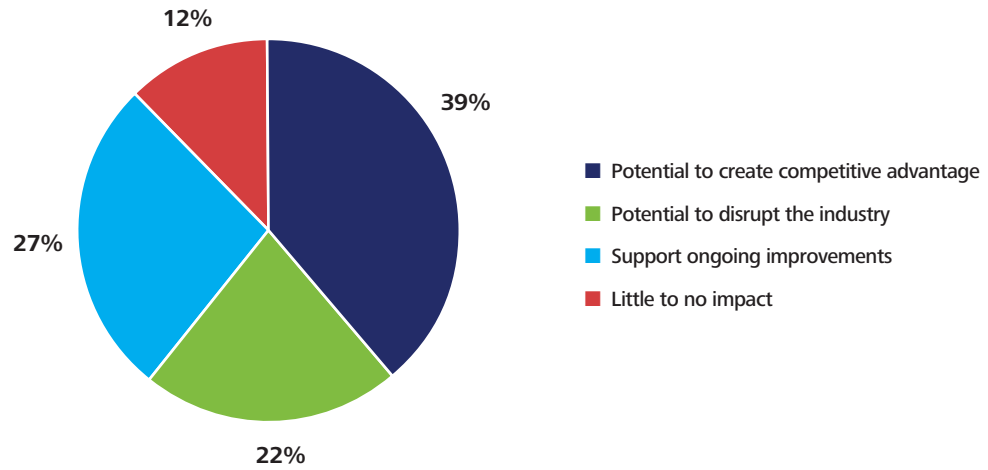
Additionally, the face of robotics and automation is changing. Where traditional automation systems were typically permanently installed and bolted to the warehouse floor, the rise of mobile robots is building greater flexibility into supply chains, matching the Next-Generation Supply Chain model of omni-channel distribution.

Last year's report pointed out that the rise of collaborative robotics was creating visible increases in productivity as the safety barriers and sensors that separated man and machine started to disappear[6]. Robots are continually being developed that are more and more intelligent, allowing them to work alongside humans safely and create a division of labor with humans and robots, each doing what they do best simultaneously to increase productivity.

As robots begin to handle more and more of the repetitive, monotonous tasks, employees can focus on making operational improvements, making jobs in the industry more interesting and more appealing. The growing need for people with technical skills within supply chain and material handling can attract people who may not previously considered jobs in this industry.

Mobile robots also allow companies to invest and convert on a timeline that makes sense for their company and customer base. "An owner can deploy a small number of robots, and then scale up the number of robots as the business grows versus purchasing all at once," says Joe Zoghzoghy, Ph.D., mobile robotics manager for Bastian Solutions[7].

Figure 14. 2017 survey results: How companies are using Robotics and Automation today

Receiving and Put-away	18%
Picking / Packing / Sorting Orders	25%
Loading / Unloading / Stacking	23%
Processing – Welding, painting, cutting, etc.	21%
Assembly operations (multiple products on an assembly line)	20%
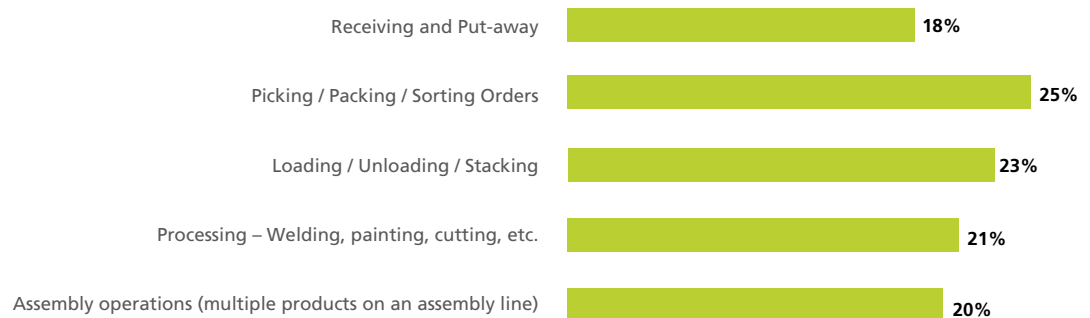
Case Study – One Touch Order Fulfillment at REI

Situation: Outdoor sporting goods retailer, Recreational Equipment, Inc. (REI), responded to customer requests to increase service levels in the Southwest regions to match the same-day and two-day service levels they had established in other parts of the country. They conducted a network optimization initiative, considering environmental impacts as well as cost as key factors and decided to build a new distribution center in Goodyear, AZ with sustainable operations.

The typical REI distribution center had different processes for retail replenishment orders and direct to customer orders. In this case, REI chose to build an operation that would be capable of omni-channel order fulfillment with minimal manual intervention.

Case Study: REI partnered with their material handling systems integrators and equipment suppliers to develop a fully automated, omni-channel, LEED (Leadership in Energy and Environmental Design) Platinum certified distribution center that delivered a large ROI.

The facility also included efficient "pocket sorter" and an OSR Shuttle system. The pocket sorter moves products in bags that are sorted and delivered to workstations for final order processing.

This system provided the facility with the ability to enable picking and order assembly in one-touch - requiring as little interaction with the product as possible.

Pocket sorters deliver products in bags. Since the sorters are automated, they don't need lighting to do their work and motion sensors turn on lighting only when needed, saving on electricity. In addition, LED lights with motion sensors illuminate other parts of the building, so they shut off when human workers are not present.

To achieve net zero energy, REI installed a 2.2-megawatt solar array that produces enough energy to power the entire facility (equivalent to powering 390 homes for one year). The size of the solar array was determined through early energy modeling, ensuring the system would support high automation and a cooling system throughout the building.

Result: The implemented operation enables up to 4,000 unit picks per hour, as compared with 500 units per hour in a manual environment. Inaccurate shipments are virtually non-existent due to the automation employed.

Overall, 97 percent of all materials used in the facility are recycled, meaning that less than 3 percent of materials and waste is sent to landfills. By producing renewable energy, the system will pay itself off in five years and provide REI with 20 years of free energy.
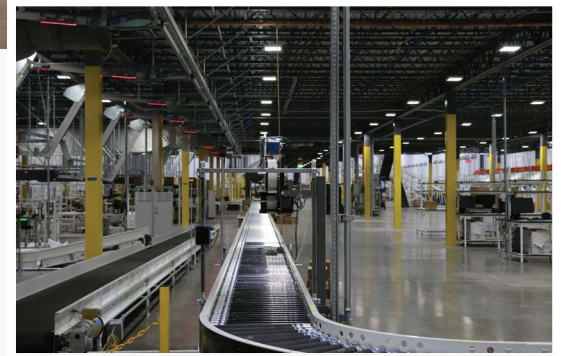
"There are often people that believe that this level of technology doesn't have a positive ROI. It does. We've done the math. It is a function of the productivity and the smaller building that you can build."

Rick Bingle, VP of Supply Chain at REI

What leaders should be doing today

- When thinking about implementing robotics and automation, consider starting with a semi-automated design to learn and understand how far to take robotics. Each company will have different needs and different combinations of robotics, automation, and human capitol should be evaluated to be most effective.

- Be measured when considering robotics and automation. Challenge engineers to be clear in their vision for deploying robotics within an operation. Determine ROI and make sure you develop a clear understanding of where and when automation investments make sense for your business.

- Be informed. Talk to companies using the technology. When working with vendors, ask to speak with their existing customers and tour facilities where the technology has already been implemented. Many companies are very open about sharing their experiences and lessons learned.

- Develop your talent strategy. Begin thinking about which roles may be automated in the next five to 10 years and develop a transition strategy. Think about how roles will evolve and what skill sets will be needed.

- Work with a reputable partner and talk with those in leading associations to help you match supplier capabilities to your specific needs. Working with these partners can even allow you to develop equipment and systems in combinations not seen previously that are specifically beneficial to your operations.

- Model the robotics or automation using simulation technology to "test drive" the solution before implementing it. Simulation modelling software has been available for many years that allows adopters to accurately study, test and visualize the new automation operating in a simulated environment before implementing it. This service is frequently available from the automation vendor or can be contracted from multiple providers.

Innovations and Technologies Driving Next-Generation Supply Chains

Sensors, Automatic Identification and IoT

Sensors Expand Possibilities and Manage Information

Visibility and control are high priorities for those responsible for managing supply chains. Smart sensors provide data on the condition and location of a firm's supplies and products as they are transported across a facility or around the globe. This capability provides the end-to-end visibility and the operational intelligence that Next-Generation Supply Chains demand.

This year's survey respondents reported that 49% of them have sensors and automatic identification in-use today, which is up from 43% in 2015. Another 38% predict that they will adopt the technology within the next five years — taking the adoption rate to 87%.

The data these sensors provide, combined with cloud-based applications connected to the same networks, can be applied to analytic models that uncover supply chain patterns that reveal actionable intelligence.

The potential benefits for supply chains include end-to-end visibility and predictive modeling capabilities that result in optimized agility and performance, reduced risk, improved operational processes, faster delivery times and reduced costs.

Survey respondents are experiencing these benefits, with 53%, up from 42% in 2015, saying that these technologies have potential to create competitive advantage or to disrupting supply chains (see Figure 15). Another 37% say sensors and automatic identification support ongoing supply chain improvements.

Sensors often are implemented as part of or alongside other supply chain technologies such as robots and drones, making them not only versatile, but also supplementing other supply chain technologies covered in this report. Early adoption is becoming an advantage as it makes adjusting to other technologies easier because workers are already familiar with sensing functions.

According to the survey (see Figure 16), firms are using sensors and automatic identification technology for lot tracking and tracing (55%), supply chain monitoring (37%), security (24%), event management (23%). Companies are also using these technologies in point of sale operations, reported at 20%, such as automatic check-out, inventory consolidation, and replenishment, showing a growing

Figure 15. 2017 survey results: Potential impact of Sensors and automatic identification

- ■ Potential to create competitive advantage
- ■ Support ongoing improvements
- ■ Potential to disrupt the industry
- ■ Little to No impact
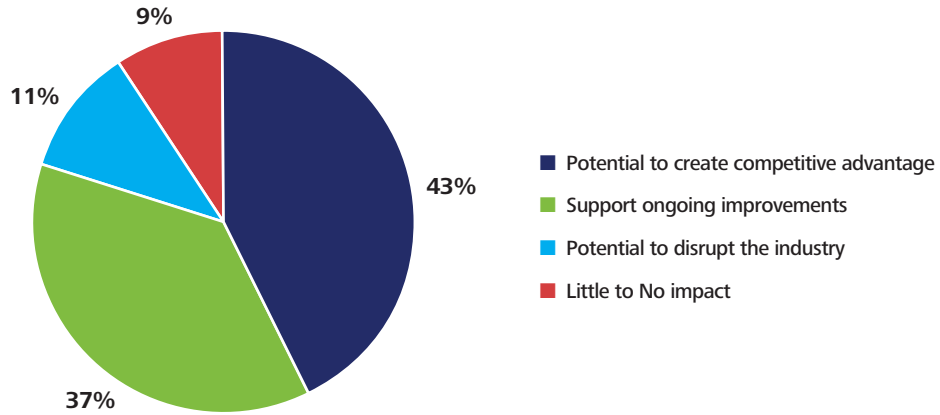
dependence on technology to manage sales and reduce inventory error.

Smart sensors are changing supply chains in some very basic ways. One way the use of sensors is being expanded is by companies who monitor their equipment after it has been sold to customers. Manufacturers can check on equipment remotely and ensure proper working order, leading to fewer maintenance calls and fewer customer complaints[7]. Using sensors can also allow companies to aggregate data to build better products in the future.

Manufacturers can move from simply providing products to providing services associated with managing the life cycle of those products. Sensors also allow for extended networks of equipment that all share an information pool.

Sensors and automatic identification (auto ID) allow information to be collected in ways and at rates that were previously unavailable to supply chain professionals. Visibility and control are high priorities for those responsible for managing supply chains. Timely information about materials movement and status from one link of the chain to the next and on to customers is critical. Technologies

Figure 16. 2017 survey results: How companies are using sensors and automatic identification today (or planning in the next 1-2 years)
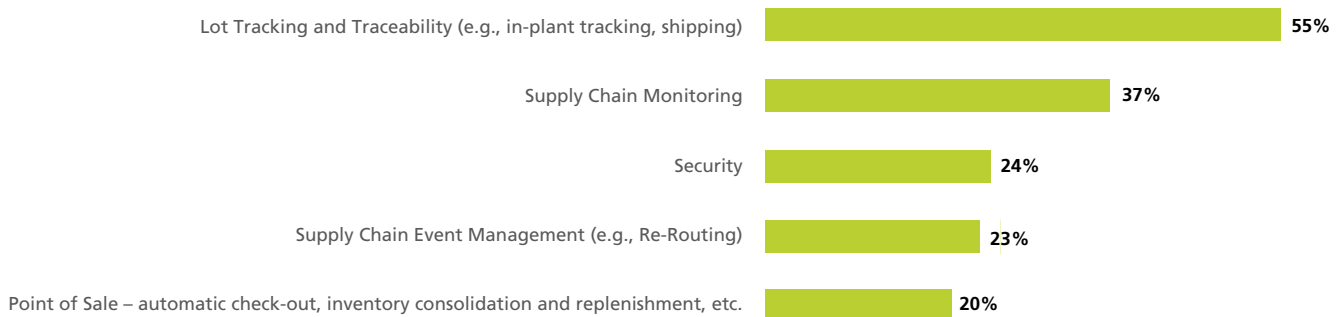
Lot Tracking and Traceability (e.g., in-plant tracking, shipping)	55%
Supply Chain Monitoring	37%
Security	24%
Supply Chain Event Management (e.g., Re-Routing)	23%
Point of Sale – automatic check-out, inventory consolidation and replenishment, etc.	20%

such as barcode readers, radio frequency identification (RFID) tags and readers, point-of-sales systems, imagers and beacons are being used to capture, verify, store and communicate supply chain data, replacing the cumbersome, costly and error-prone manual processes of yesterday.

Auto ID applications give companies information about the precise identity and location of each physical item in the supply chain in an automated and timely manner. This real-time information enables companies to gather other related information about the product in order to assess both its current state and future required actions.

Adopting such technologies provides a major opportunity for a supply chain operation to quickly enhance its tracking and tracing systems, process control and inventory management. The use of sensors expands the reach of these automatic identification applications and has potential to give a company complete visibility to its supply chain by removing a number of traditional supply chain limitations associated with latency and distance.

Internet of Things (IoT) is Foundational

The Internet of Things (IoT) has been added to the list of innovative technologies this year because it is foundational to the application of business process improvement through collaboration with many of the other featured innovations within this report. By definition, it is the interconnectivity of physical devices (smart devices) through a network that ties them all together for transfer of information.

Although the concept for IoT has been around since the 1980s and started to become reality in the 1990s with the commercial emergence of the Internet era, the IoT is just starting to take-off as the number and variety of connected devices has been growing exponentially over the past few years. The IoT is enabled by the combination of the other innovative technologies working together to provide the digital information driving the Next-Generation Supply Chain.

Survey respondents are recognizing the growing importance of IoT, with 55% saying that it has potential to create competitive advantage or to disrupt the industry (Figure 17). Another 33% say that IoT can support ongoing supply chain improvements.

Connected devices are being introduced into all areas of the supply chain from cellular and GPS-based sensors on cargo containers to robotics in warehouse operations. The interconnectivity of these devices is unlocking the potential

Figure 17. 2017 survey results: Potential impact from the Internet of Things (IoT)

- 42% / 33% / 13% / 12%
- ■ Potential to create competitive advantage
- ■ Support ongoing improvements
- ■ Potential to disrupt the industry
- ■ Little to No impact
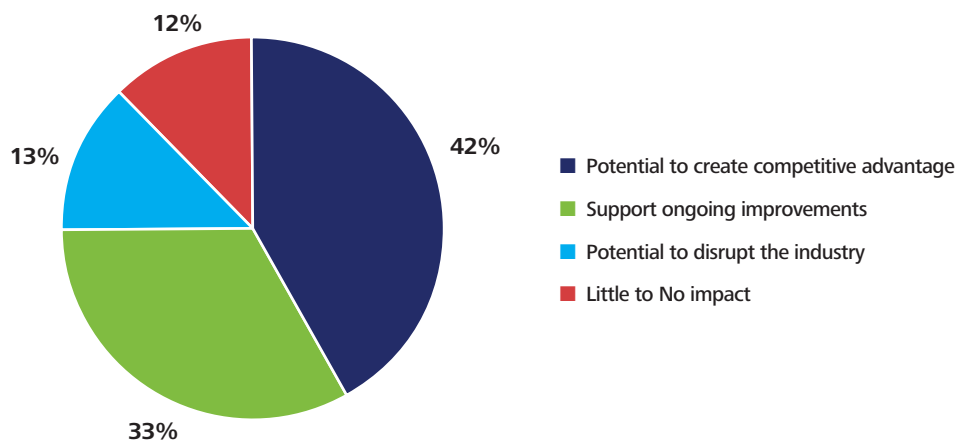
Figure 18. 2017 survey results: How are companies using the Internet of Things today (or planning to use it over the next 1 - 2 years)

Category	Percentage
Real-time analytics	31%
Customer and/or Supplier Collaboration	28%
Customer / market insight	26%
Quality control	25%
Streamlined production	17%
Artificial intelligence (AI) and machine learning	9%
Cold chain temperature and humidity integrity	9%
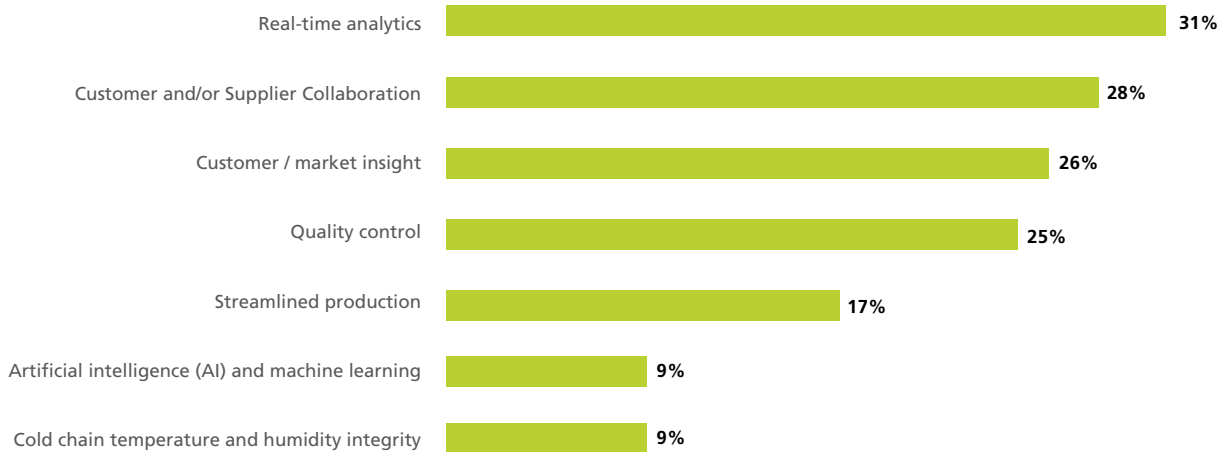
to collect real-time digital information about areas of the supply chain like never before. Sensors for example, are becoming smaller, more sophisticated and less expensive to implement into areas of the supply chain that have typically been manual in nature. Smart devices have been utilized in transportation vehicles for some time now to monitor the equipment conditions for maintenance, but that same technology is now being implemented on railcars to track the bearing conditions and monitor impact reports for the cargo. As the catalog of smart devices continues to grow and infiltrate into all areas of business, the potential benefits produced from the interconnected workings between them will produce great opportunities.

According to the survey (see Figure 18), the top 4 ways that firms are using IoT for are for real-time analytics (31%), customer and/or supplier collaboration (28%), customer/market insight (26%) and quality control (25%). Companies are also using these technologies to streamline production, enable artificial intelligence and machine learning and to support cold chain temperature and humidity integrity.

The Internet of Things is the underlying platform in which the next-generation supply chain will breathe and operate. Through the interconnectivity of the smart devices embedded throughout the supply chain, all of the digital, on-demand and always-on communications are possible. This will also be the case for the future of Smart City Logistics. The smart city urban cores will be completely immersed in the transfer of digital information between devices throughout. Smart sensors placed on final mile, ground drones will be able to communicate with sophisticated software to follow a pre-determined route for delivery, navigate the crowded streets and sidewalks, and adjust based on blockages and detours to reach the ultimate destinations all while providing real-time tracking capabilities for the end consumer. The future for the Next-Generation Supply Chain and Smart Cities is endless in the potential for efficiency and effectiveness through the interconnectivity of smart devices through the IoT.

Case Study – Driverless Vehicles with IoT Technology

Situation: A major US retailer with a product portfolio ranging from jewelry to apparel to tires, struggled to manage operational costs and cycle time increases due to a rapidly increasing mix of non-conveyable items since the introduction of their ecommerce channel. The 1+ million square foot distribution center, once touted as industry leading for its level of automation and conveyors, suddenly faced bottlenecks associated with manual carts used to transport tires, carpet rolls and mattresses through the building. The bottlenecks increased costs and reduced throughput.

Historically, the non-conveyable items represented such an immaterial amount of the business that it was perfectly acceptable to have a person hand-deliver the items from the non-conveyable area to put-away and shipping zones. However, the emergence of the online sales orders not only increased the number of the bulky product picks, but also created demand for more variety of these items. Approximately 30% of the items could not flow through the efficient conveyor system. A study performed by the engineering teams determined that these non-conveyable items were taking 4 to 5 times longer than the standard conveyable items to pick, pack and load onto outbound trucks.

This retailer needed a solution that could address the non-conveyable issues and seamlessly work in harmony with the current infrastructure of warehouse management, inventory and conveyor control systems already in place.

Case Study: The retailer engaged OTTO^{TM} Motors to solve their problem with IoT connected autonomous, self-driving vehicles (SDVs). SDVs are the evolutionary next generation of automatic guided vehicles (AGVs) because they have the intelligence to sense and adapt to their surrounding and reroute as needed to avoid obstacles in their path.

The mobile robots are connected to other modules of automation within the operation and are fully traceable due to the integrated navigation system powered by leading IoT technology. The first generation AGVs only knew where they were within a facility in relation to fixed icons and the sequence they were on along a pre-programmed path, explains Bill Torres of OTTO Motors. SDVs, on the other hand, perform 'Simultaneous Localization and Mapping' (SLAM) in real-time to detect where they are in relation to all of their surroundings, down to the millimeter. The driverless vehicle does not follow fixed program routes.

They are cognizant of all of the viable routes within the facility and make a route optimization plan and then re-route around obstacles. Essentially, the SDV has been given human attributes of localized intelligence and cognizance allowing it to make intelligent decisions about what it sees in real-time, which gives it the benefits of flexibility, adaptability and modularity.

The ultimate solution consisted of a series of OTTO SDVs with cages bolted to the tops of the vehicles' platforms to contain the large, bulky items. The items are transported from their stocking locations to the dock doors for loading onto outbound trailers. Workers are now able to pick an order from "non-con" zones, load it onto an SDV, send it along its way and continue through to their next item to be picked. In the meantime, the OTTO SDV is able to find its way through the ever-changing maze of obstacles along the active warehouse floor and deliver the order to the outbound dock staging area in the appropriate sequential order.

Result: With the implementation of the OTTO SDVs, the retailer has been able to bring their distribution center operations back in line with internal and external expectations with strong financial return on the investment. Benefits from the revamped operations have seen an increase in productivity from an increase in the overall throughput of the facility and a reduction in cycle times. An additional benefit beyond the typical efficiency and speed of throughput is the ability to have live track and trace capability for all of these items as they travel through the distribution center.

"Self-driving vehicles, with their ability to maneuver around people or objects are really collaborative robots, but nobody is talking about it that way."

Bill Torres, Director of Sales, OTTO^{TM} Motors

What leaders should be doing today

- Integrate sensors, automatic identification and IoT within the overarching business case for the emerging Next-Generation Supply Chain as it will be a critical enabler. This technology will provide much of the data needed to connect supply chain partners and provide them with the visibility and insight needed to manage not only risk, but increasingly complex customer service requirements.

- Learn how predictive analytics can provide insight and action prompts to connected supply chain workers through sensors and IoT.

- Stay tuned. The viability of sensor technology is evolving rapidly as the cost is falling. Seek out experts and potential vendors that can share the latest and most relevant information about this technology.

- Begin to identify and refine business processes for digital integration

- Create plan for what data to collect and how to collect it. Then determine how best to organize and use the data.

- Begin training and hiring a workforce with the technical skills to operate in this new environment.

- Establish digitization as a critical enterprise strategy. Require that all functions of the organization include digital initiatives in their strategies and budgets.

Innovations and Technologies Driving Next-Generation Supply Chains

Wearable and Mobile Technology

Wearable and mobile technologies, devices that can be worn or carried, give people convenient and immediate access to information wherever they happen to be working and enables the free flow of information across supply chains.

Mobile technology, including smartphones, tablets and other wireless devices, is now pervasive throughout the world. Wearable technology, including smart watches and glasses, give people ready access to a wide-ranging suite of information regardless of their location and can also collect and display data about the wearer and the surrounding environment.

The relatively low cost of entry to mobile technology allows companies of all sizes to drive up their capabilities. For example, independent truckers can put an app on their phone that gives them digital supply network capabilities, allowing them to participate with and compete with larger companies. Options like digital document signing, mobile updates for proof of delivery, geo-fencing for automatic

appointment confirmation and checkpoint status updates are widely accessible for consumers and reduces reliance on physical documents – a key step in creating the next-generation supply chains.

Just as Uber has disrupted the taxi industry, these mobile solutions will continue to disrupt the trucking industry by providing improved service at lower costs with real-time visibility. This year's survey confirm this, as 44% of respondents reported that wearable and mobile technology has the potential to either disrupt the industry or create competitive advantage. Another 35% say it can support ongoing improvements in their companies (see Figure 19).

The market for wearable and mobile devices is exploding. They are becoming mainstream in both commercial and industrial applications. According to the survey, 22% of respondents say that they are using wearables and mobile technology in their supply chains and adoption is predicted more than double to 45% within the next 1-2 years.

According to the survey (see Figure 20), the top four ways that firms are using wearables and mobile technologies in manufacturing and warehousing are in core processes such

Figure 19. 2017 survey results: Potential impact from Wearables and Mobile Devices

- Potential to create competitive advantage
- Support ongoing improvements
- Potential to disrupt the industry
- Little to no impact
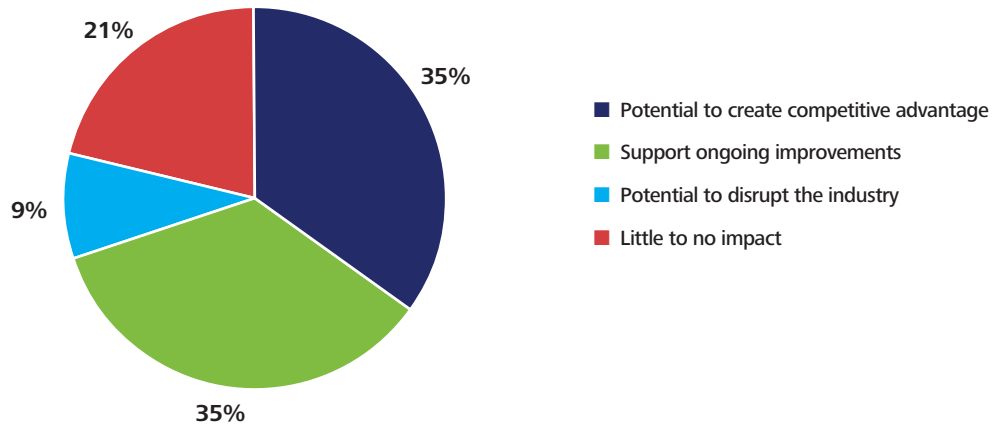
as order picking (27%), receiving (25%), cycle counting (21%) and high-value asset handling and monitoring (15%). Companies are also using these technologies in field service (14%), retail (14%) and sales (11%).

Real-time Visibility

Mobile devices in the hands of supply chain workers can transmit data, like tracking information, to the mobile

devices that are in the hands of consumers in real time. Delivery drivers can give live updates on deliveries and apps with location services allow customers to have real-time updates and tracking of the delivery status. The Next-Generation supply chain is defined by this customer driven need of real-time updates. Always-on supply chains can utilize applications to connect data both within and outside of the company, delivering better quality, faster service, and more cost efficiencies.

Figure 20. 2017 survey results: How companies are using Wearables and Mobile Technologies today (or in the next 1-2 years)

Manufacturing & warehousing: Order picking, value-added processing	27%
Manufacturing & warehousing: Receiving	25%
Manufacturing & warehousing: Routing, trucking, expediting and exception handling	22%
Manufacturing & warehousing: Cycle Counting	21%
Manufacturing & warehousing: High-value asset handling or monitoring	15%
Field services: Installation, repair, maintenance, or monitoring	14%
Sales: Data collection (e.g., orders, sales forecasts)	11%
Retail: Inventory management or replenishment	9%
Retail: Compliance	5%
Other	2%

Mobile devices in the hands of supply chain workers can transmit data, like tracking information, to the mobile devices that are in the hands of consumers in real time.

Smart glasses are increasingly being used to improve efficiencies and effectiveness within distribution operations. They allow workers to free themselves and their hands from stationary terminals and paper documentation. There are also ergonomic and safety advantages in allowing operators to be hands free.

Real-time data can be transmitted and displayed for workers as they are processing items to give updated instructions and decrease number of touches needed on each item. Step-by-step instructions for maintenance and repairs can be transmitted and displayed visually to guide a worker while they are mobile, rather than having to stop and refer to an instructional document.

The benefits of wearable technologies are largely shown in gains of efficiency. By freeing workers hands and allowing them to focus on what they're doing as opposed to scanning and holding both devices and product, workers gain valuable time and have the added benefit of real-time data to work with. This augmented reality creates multiple levels of information sharing and productivity, further pushing supply chains into the customer driven 'always-on' class of the emerging next generation of supply chain.

Business intelligence reports can be viewed on mobile devices, making real-time, business critical insights available exactly in the moment it is needed to make key decisions. As companies move toward next-generation supply chains, wearable and mobile technologies are proving to be a critical factor in pushing forward or being left behind.

Case Study – Order Picking with Smart Glasses

Situation: A third party logistics (3PL) provider has been managing the e-commerce operations for a retail client with highly seasonal demand of sharp increases for the winter holiday. The 3PL faces a number of issues with the irregularity of this spike in demand which included managing the ramp-up of inventory levels and the need for flexible space expansion, but none more so than the challenge of onboarding temporary labor to fulfill pick orders during the final two months of the year to meet the holiday demand peak.

As holiday season approaches, the 3PL will locate a pop-up warehouse space in the general vicinity of the operations and begin to stage additional order volume starting in September through concentrated efforts from their standard team of operators and staff. A month later, the 3PL then begins to hire and train transient staff to support the order picking process through the end of the year. This timeline allows for the management team and supervisors to onboard the warehouse workers with just enough training to learn the order fulfillment process before the tidal wave of demand rolls through Thanksgiving weekend. The 3PL typically finds that not only are managers are challenged to find enough qualified employees for the seasonal peak, but that the overall site sees a significant decrease in operational efficiency and employee productivity during this critical time because of the short onboarding timeline amplified by the complexities associated with the high volumes.

Case Study: The 3PL sought to improve their ability to manage its seasonal demand through empowering the operators, new and experienced, with smart glasses powered with the Skylight software platform by Upskill. With these smart glasses, workers are delivered visual information associated with the picking process right from within their line of sight. Such information includes item locations, item quantity, pick list, "hot" picks, and images of goods, all with intuitive graphics that reduces the human cognitive load. For example, without smart glasses seasonal workers must learn and decode item information and location, for example what "2B-34-189-2" means as seen on handheld scanners.

Prior to introducing the smart glasses, the 3PL considered a couple of other options such as pick-to-voice solutions and pick-to-light systems but found these solutions did not work for seasonal staff who are not native English speakers. Smart glasses provide an interface that transcends language barriers, delivers more system-driven interactive information and visually intuitive content to the operator. In addition, training time for new seasonal staff was greatly reduced.
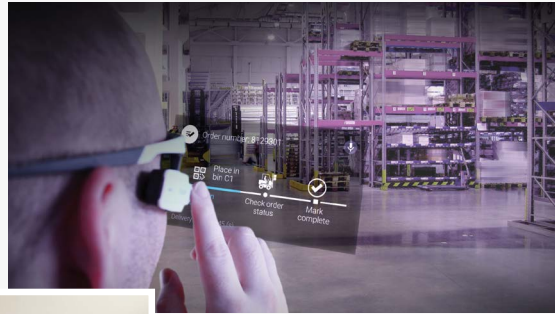
With the wearable technology, warehousing staff receive the visual information needed to complete the next task instead of a codified direction from the screen of the radio frequency scan gun. This enables a much more natural user interface for the workers by providing them with the pick item along with a birds-eye view of the facility layout and where they are in relation to where the next pick is located, resulting in a quicker, more efficient picking process.

The implementation of wearable devices began with the integration of the smart glass platform with the on-premise warehouse management system (WMS). The IT integration efforts took only a few weeks to develop and test before it could be rolled out, very similar in the level of effort and timeline needed to setup new radio frequency equipment for warehouse operations.

Result: The primary benefits from implementing smart glasses for the 3PL's order fulfillment operations was the ability to onboard the seasonal employees at a much faster rate by providing visually intuitive content that allowed them to perform at a level closer to the experienced team members. This allowed the 3PL to wrap up quicker and better respond to seasonal surges in customer demand. Productivity at all levels of operations improved by 12-15% over the previous holiday season and picking errors were drastically reduced. The smart glass order picking operation also benefited the experienced team of operators as they acclimated themselves to the pop-up expansion facilities each holiday season.

"The WMS offers all kinds of information that is not effectively delivered to the warehouse workers. With easy to understand visual information delivered on smart glasses via our Skylight platform, people are better equipped with the information needed to be effective in their job."

Jay Kim, Chief Strategy Officer, Upskill

What leaders should be doing today

- Make sure you have adequate Wi-Fi coverage on the warehouse floor. Many wearables and mobile technology rely on Wi-Fi to deploy information, so companies should ensure their network infrastructure is prepared to accommodate new devices and support needed bandwidth.

- Evaluate cost to productivity ratio of devices and programs. Many mobile devices are targeted toward consumer preferences, and developers could "de-scope" functions not needed for material handling to reduce the price. However, with the development of the Internet of Things, many companies will already have the systems, resources, and knowledge in place to move to mobile and wearable technologies.

- Carefully evaluate the risks of employee participation in wearables programs before investing. Consider incentives and increase benefits from such programs, and plan for safety programs for employees as they adjust to the any new mobile or wearable technology.

- Keep abreast of the latest advancement as the pace of progress is swift in this space. Continue to test the technology. The more familiar workers are with the technology, the easier it will be to drive adoption.

Innovations and Technologies Driving Next-Generation Supply Chains

Driverless Vehicles and Drones

Autonomous vehicles and drones drive themselves from a starting point to a predetermined destination using advanced in-vehicle technologies, cameras and sensors. These vehicles have been used in industrial facilities for decades, but as technology evolves, so do the vehicles and their capabilities.

Today's smarter driverless vehicles and unmanned drones are being used not only for movement of material and product across a facility, but for real-time inventory control, order picking and last mile delivery.

The deployment of this technology is rapidly emerging, with 54% of survey respondents saying that driverless vehicles and drones have the potential to create competitive advantage and disrupt the industry, that is up from 30% in 2015. An additional 22% say that these technologies support ongoing improvements in supply chains (see Figure 21).

While adoption remains low at 8%, 31% report of survey respondents say they will adopt these technologies within the next five years with an additional 19% predicting adoption further into the future (6+ years) (see Figure 22). Given the accelerated pace of change with these technologies, these adoption rates could rise beyond these predictions.

Beyond the Buzz

Major buzz regarding these technologies is currently around last-mile delivery in both urban and rural areas. From flying drone depots to drones being deployed from vans, to ground-based robots, they are seen as potential ways to change how product is delivered to consumers. While full adoption of these technologies may take decades, the value to supply chains will be indispensable.

Today, these vehicles are increasingly being deployed in manufacturing facilities and distribution centers. Companies currently employing drones as inventory management tools are reporting significant increases in accuracy and efficiency.

These drones are more commonly known as unmanned vehicles or aerial robots, "because they're very similar to ground-based autonomous robotic vehicles, except they can move in a third dimension: the Z-axis," explains Eric Ringer, Strategic Projects Engineer at Skyward.

Driverless vehicles and drones offer automation that is flexible and scalable. Companies can purchase the number of robots they need, or can afford, and still have it be an effective tool. Driverless vehicles and drones are also transportable, which means they are more flexible because they are not a static fixed asset, unlike many other forms of automation that have to be installed permanently. They also offer operational flexibility. For example, rather than hardwiring a security camera system or RFID monitoring equipment, companies can deploy a handful of drones equipped with both cameras and sensors to offer a more flexible and adaptable security system.

Driverless vehicles are also experiencing more widespread applications within supply chains. One of the most impactful areas is their growing use in support of logistics
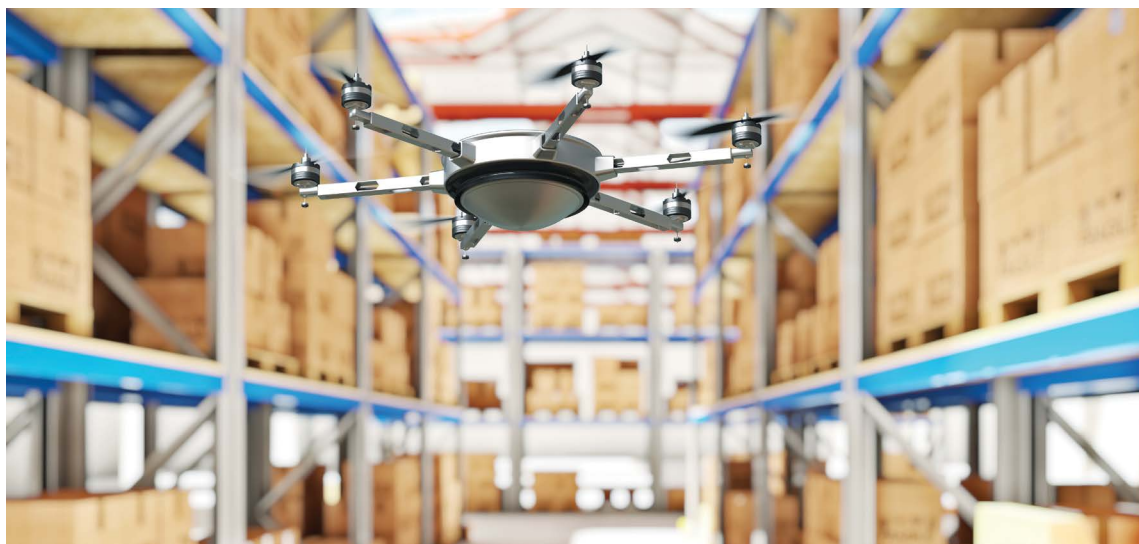
Figure 21. 2017 survey results: Potential impact from Driverless Vehicles and Drones

- ■ Potential to create competitive advantage
- ■ Potential to disrupt the industry
- ■ Support ongoing improvements
- ■ Little to no impact
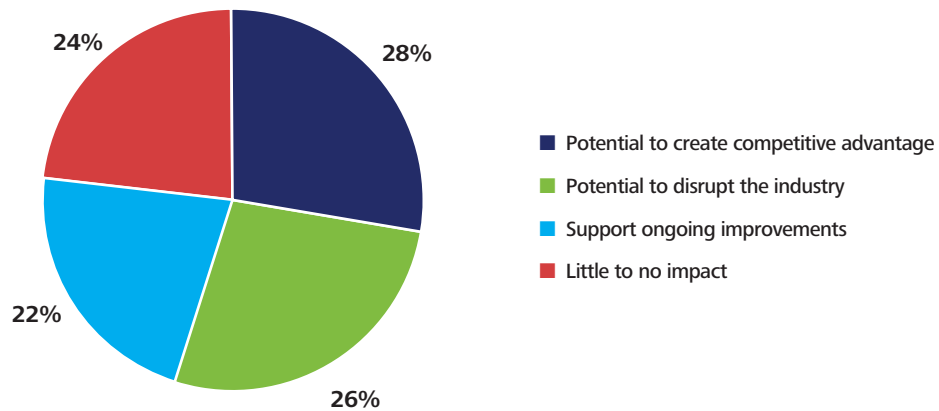
and distribution. For example, in conjunction with planners of smart cities, developers of the technology are exploring the use of caravans of driverless trucks that move during low traffic hours into urban centers within dedicated lanes. Once there, the trucks would be unloaded and sent back outside city limits before the next day.

"The impact of autonomous robotic vehicles and drones is more evolutionary than revolutionary," says John Clark, Director of North American Marketing for MHI Member Egemin Automation, a global AGV manufacturer and supplier. Current drone deployment is focused on connecting product to the Internet of Things, and doing it in a way that is more efficient and more accurate. Clark adds, "It's the intelligence of these technologies, and their connectivity, that makes them game changers for the companies that are willing to invest in them. They give users smarter views of what's happening in their supply

chain from beginning to end. By constantly communicating the information they collect, they create an opportunity to intercede with an alternate plan should a delivery be delayed, for example."[8]

By 2018, 20% of logistics organizations will exploit drones as part of their monitoring, searching and event management activities. What's more, by 2030, vehicles capable of driving autonomously are expected to represent approximately 25% of the passenger vehicle population in mature markets. In fact, many Autonomous Commercial Vehicle (ACV)-related systems are already in use today within the trucking industry. Examples include electronic stability control (ESC), collision avoidance technology, rear- and forward-view camera systems, plus related electronic sensor arrays needed for transmitting data between such systems and a truck's engine, transmission, and brakes.

Figure 22. 2017 survey results: Adoption of driverless vehicles and drones technologies over 6+ years

- ■ In-use today
- ■ 1-2 years
- ■ 3-5 years
- ■ 6+ years
- ■ Unlikely to adopt
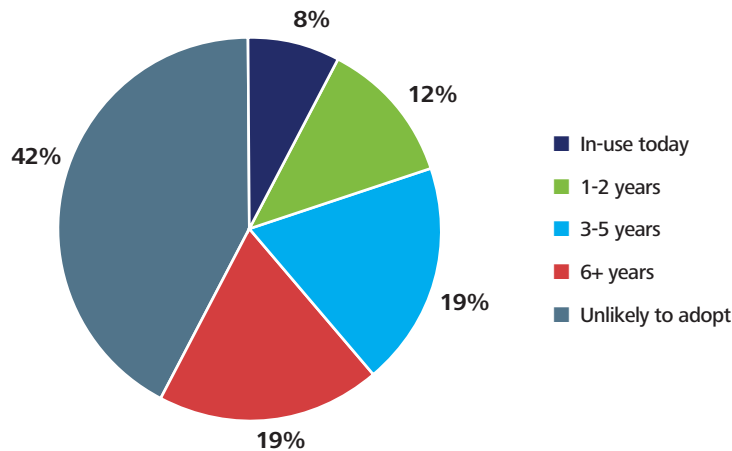
⊕⊕⊕ Case Study – Inventory Accuracy with Drones

Situation: A large retailer faced challenges to manage its more than $250 million of inventory within one of its distribution centers. Even with the full-time efforts of eight cycle counters, they were unable to perform all of the necessary counts to achieve more than 96% inventory accuracy within the 500,000 square foot facility.

Their cycle counting process involves travelling to a designated location, using a radio frequency (RF) scanning device to scan the barcode of the location, counting the units within the location and key entering the quantity of units into the RF device before being directed to the location of the next item on the list. When the cycle count quantity does not match the expected value in the warehouse management system (WMS), an incident is created and escalated for another cycle count to be performed, usually by a supervisor to ensure the accuracy of the report.

Even though the process is connected to the WMS, it is still highly manual and allows for inherent errors associated with the manual completion of tasks. In addition, all cycle counts performed above the second shelf have to involve the use of man-lifts to reach the upper pick locations in order to perform the required tasks. This process not only ties up expensive equipment to perform the cycle counting activities, but also introduces risk of accidents to the operators that are on the lift or nearby.

This retailer was seeking to find a better solution for their cycle counting operations that could improve the accuracy of their inventory and reporting, reduce costs from shrinkage, improve the productivity of their staff and increase the safety for their warehouse employees.

Case Study: The retailer is working with PINC Solutions to deploy a cycle counting drone to automate the process for cycle counting the inventory in their warehouse. The drone is an aerial robot that works autonomously to perform the manual and repetitive tasks that are traditionally carried out by cycle counters on the warehouse floor. But it does more.

The aerial drone can provide video, pictures and historical data for checking each item and how it would have changed over time in order to eliminate the revisiting of the location to verify the count. It will identify the inventory by capturing video and focusing in on an area of interest (i.e., it will extract the image of the label from the video feed and determine how to read it, whether as a barcode or text characters to identify the product).

The video will then be analyzed to perform the cycle count and stored to provide video documentation of the point of interest for records. In the event of a cycle count variance, the record in question can be replayed or observed from a local PC for further review and validation instead of having another physical review of the location.

The solution will not replace human workers to manage the inventory, instead it will enhance their ability to perform their jobs by completing the manual tasks of visiting each and every location to free them up to perform value-additive tasks such as reviewing variance reports and ensuring that the inventory is reported as accurately as possible. Fewer people on the warehouse floor also means less congestion and fewer accidents for the employees.

The primary limitation with this application will be to recognize the abilities of what a drone can and cannot do. For example, the retailer will have to ensure that all locations are organized and able to be counted through imagery, because the drone is only able to see what a cycle counter would see from the front of the location and cannot pick up the items or shuffle the items around to complete the count.

Result: The retailer is piloting the drone solution with expectations to enhance their operations through a number of key performance metrics. They expect to realize an increase in inventory accuracy to over 99.5% and as a result, will have an improvement in their order fill rates and customer satisfaction levels. In addition, overall picking times will decrease without the time consuming variance process when order pickers discover inaccurate item quantities.

Overall cost will also be reduced as a result of more accurate inventory information and reduced variability, which reduces safety stock levels. Finally, shrinkage will be better monitored and controlled and costs associated with incomplete orders will be dramatically reduced.

"The enhanced tools and capabilities allow activities to be done faster, better, cheaper."

Matt Yearling, President and CEO PINC Solutions

What leaders should be doing today

- Explore the possibilities. Self-driving vehicles and drones for supply chains are closer to reality than many people think, and as the technology develops, the variety will only increase. The potential impacts of drone and driverless vehicle use aren't limited to convenience as they can increase efficiency, safety and visibility. These technologies may soon have a major impact on your organization, employees, supply chain and internal operations, so it's important to start preparing now.

- Assess company needs. While drones certainly have disruptive potential, for many firms, proven ground-based robots may be a better solution.

- Look for new cross-industry opportunities that combine transportation-related benefits with other activities. Explore innovations that use drones and other automated vehicles to supplement or improve activities that currently require human interface.

- Stay informed. As technology evolves leaders should remain educated on their use across supply chains and the regulatory restrictions that will be in place to govern their usage.

Innovations and Technologies Driving Next-Generation Supply Chains

Predictive Analytics

Predictive analytics applies statistical modeling and data mining to historical data in order to generate accurate forward projecting views, rather than measure what has already happened. For example, predictive analytics can provide companies with a look into the future and give them opportunities to identify emerging patterns in the marketplace that can lead to highly effective and personalized customer engagement strategies.

For decades, companies have employed a basic form of predictive analytics through forecasting techniques that use sales history as the primary indicator of future market demand. However, with the proliferation of supply chain data, the sources and volume of both leading and lagging indicators allow for much richer analysis and broader applications.

Today, predictive analytics is increasingly used to synthesize insights from the data that digital supply chains provide. Predictive analytics can forecast consumer behaviors and risk, but it is also becoming a way to improve efficiencies in supply chain operations. According to the survey, over 57% of respondents believe predictive analytics will either be a source of competitive advantage or will disrupt the industry (see Figure 23). This is up from just 38% in 2015.

Yet, only 17% of surveyed companies (see Figure 24) report that they are using predictive analytics today. Adoption of predictive analytics, however, is expected to jump to 79% over the next three to five years, and to 89% over the next six plus years. Given this significant expected growth early adopters who compete on analytics will gain a major advantage over the competition.

"Prescriptive analytics provides us with what's the best possible action I can take today in light of what I anticipate happening tomorrow. But what good is it to predict what you cannot act upon?"

Randy V. Bradley, PhD, The University of Tennessee

According to Randy Bradley, PhD, The University of Tennessee, high-performing organizations are five times more likely to be more analytics-driven than intuition-based with respect to decision-making as compared to low-performing organizations. Further, according to an article in the MIT Sloan Management Review, high-performing organizations are twice as likely to use analytics for developing future strategies than are low-performing organizations[9].

While predictive analytics provide much-needed perspective on supply chain operations and organizational performance, the idea of getting started analyzing the huge amount of data generated by digital supply chains can be daunting to the point of paralyzing.

The good news is that as predictive and advanced analytics continue to grow in prevalence, so, too, do the numbers of consultants and solution providers willing and able to help firms develop predictive analytics into a core competency.

Figure 23. 2017 survey results: Potential Impact of Predictive Analytics

- ■ Potential to create competive advantage
- ■ Support ongoing improvements
- ■ Potential to disrupt the industry
- ■ Little to No impact
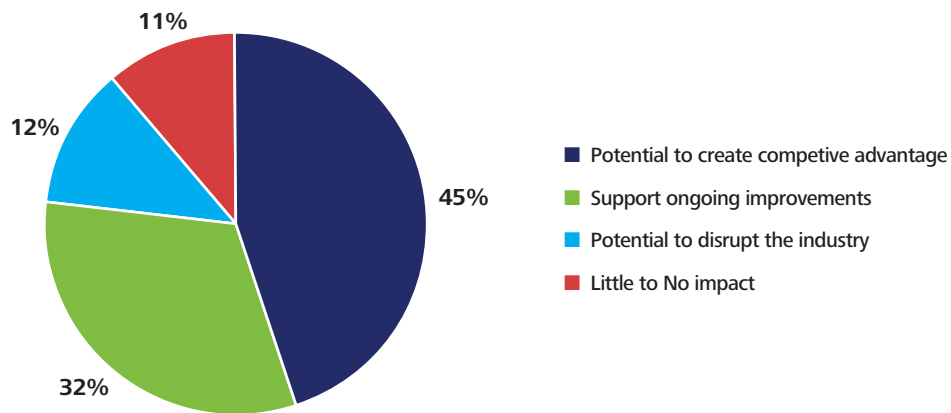
Figure 24. 2017 survey results: Adoption of Predictive Analytics over 6+ years

- ■ In-use today
- ■ 1-2 years
- ■ 3-5 years
- ■ 6+ years
- ■ Unlikely to adopt
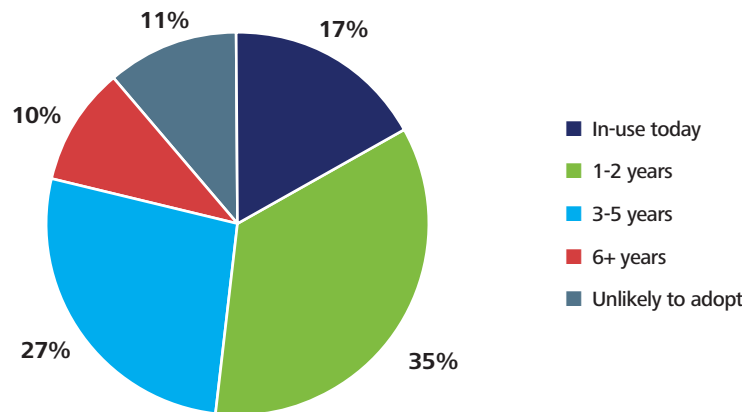
Case Study – Predictive Analytics at The University of Tennessee Medical Center

Situation: The Advanced Orthopedic Center at the University of Tennessee, Medical Center (UTMC), had less than adequate visibility into the appropriate types and level of supplies needed for surgical procedures. Their goal was to move from "hunch-driven" to historical "data-driven" inventory and forecasting decisions. Using their hunch-driven approach, the operating room (OR) doors were open an average of 10.75 minutes per case, and 30% of those door openings were related to supplies that were not readily available in the OR. Such repeated door openings could have potentially increased the risk of surgical site infection and contributed to surgical distractions. Additionally, approximately 70% of the supplies brought into the OR were not needed and had to be returned to inventory.

Leadership saw an opportunity to leverage innovation to minimize the number and potential distraction of multiple door openings into and out of the OR toward their ultimate mission to maximize overall patient safety. Their objective was to develop an ability to track material flow and better predict what supplies the care providers needed for particular procedures.

Case Study: UTMC began implementing "virtual watchers" (RFID scans) to track material flow and generate consumption data that informed material usage. The application integrated with hospital information systems and gathered information about the supply items used, procedures being performed and the physician performing the procedure in the OR. The solution used a standard interface to integrate into multiple databases for inventory, billing and surgical information systems, passing data about the supplies used so they could be properly tracked and charged to the appropriate patient.

The tracking solution provided accurate data for inventory utilization and depletion, which helped the officials proactively determine which supplies would be needed in a particular room, for a particular procedure performed by a particular physician before the patient arrived. The predictive algorithm used historical consumption data and typical procedural information to forecast the right supplies at the right time and right place.
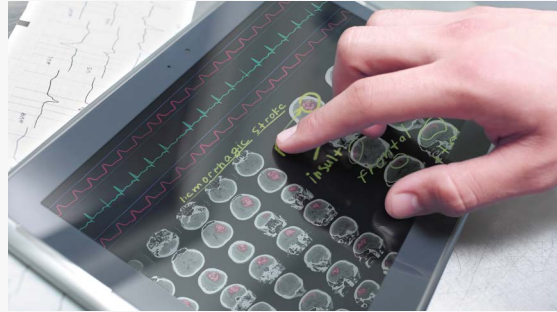
A key challenge faced post implementation was related to information governance - Key processes for data owners and data sharing were developed to mitigate issues.

Results: The medical center developed the ability to 'create the perfect physician preference card' through predicting the supplies for a particular patient procedure, which allowed for a more focused experience to the patient with less risk of exposure to airborne contaminants. Such a physician preference card contains a list of supplies that a surgeon uses on a procedure, guides what supplies are pulled into a surgical case, is often used as the foundation for patient charge sheet and is used for resource forecasting. Forecasting and inventory knowledge became more accurate, allowing waste and expired supply levels to decrease substantially.

Some of the other benefits of tracking the material flow included:

- Reduction in funds tied up in excess inventory
- Reduction of time spent on manual inventory processes
- Reduction of dollars spent on lost product and
- Fewer touches in the supply chain

The pilot implementation of this initiative in less than a third of their procedure rooms led to a savings of several million dollars annually and, more importantly, a significant stride toward the ultimate mission of maximized patient safety.

What leaders should be doing today

- Use a top-down approach to identify and address the biggest business challenges. Many companies make the mistake of first identifying available data before determining how to make it accessible to users. Instead, take a top-down approach, first looking at what drives business performance and then aligning analytics initiatives to those business drivers.

- Become an insight-driven organization by embedding analysis, data, and reasoning into the decision-making process. Position analytics as a core capability across the entire organization, from strategic planners through line workers, providing insight at the point of action.

- Refine your processes as you implement predictive analytics capability. Take a fresh look at all processes that will touch analytics and redesign them with an eye toward shortening the time between analysis and action.

- Acknowledge security challenges and address them proactively.

- Synthesize data to determine optimal tools and techniques. Collect and analyze data for integrity issues and gaps. Layer in external 3rd party data (if applicable). Select optimal quantitative techniques and tools. Visualize data and begin testing hypotheses.

- Create a governance structure and change management plan for on-going analytics initiative. Determine dependent processes and systems for developed analytic solution.

Conclusion

Actions for Supply Chain Leaders

> *"By taking advantage of technology and innovation, Next-Generation Supply Chains will be more efficient, flexible and transparent. This is just what customers are demanding. However, the need for new skill sets to run this new breed of digitized, connected supply chains will only intensify the talent gap as these next-generation models require more technical and analytical expertise."*
>
> **George W. Prest, CEO of MHI.**

The findings from this year's survey indicate that supply chain leaders see advancements in the innovations and technologies we profiled as continued disruptors to the industry. Whether it be robotics, automation, IoT or drones, these leaders understand that the battle for the lion's share of the consumer's dollar will be fought supply chain vs. supply chain. Those organizations that can deliver on rising customer service expectations at efficient cost through competency and innovation in their supply chain operations will be the winners. Additionally, adapting the technologies and supply chain operations described in this report with an eye to the challenges and opportunities provided by Smart Cities will be critical for future success

Next-Generation Supply Chains

Increasing digital capabilities throughout popular culture and the corporate world alike, have fuelled expectations for faster, better service across the entire supply chain. To meet these mounting challenges and provide the step-change improvements to service and efficiency required, supply

chains must transform into next-generation models. The technologies and innovations profiled in this report are key to this imminent transformation.

Foundational Step of the Transformation - Digital

Next-Generation Supply Chains will become more digital and take advantage of advancements in computing power and the growing availability of data from every link. Sensors will be increasingly used in strategic places to provide data that is filtered through an analytics layer and communicated across the entire supply chain.

Instead of a series of linear, individual, dis-synchronized links, the next-generation supply chains will evolve into a more connected, harmonized network of trading partners able to intelligently scale operations. The physical and digital worlds will converge. Cognitive tools including wearables will be used to bring insight-rich information

directly to supply chain workers who will use it to make proactive decisions and adjustments as they perform their tasks.

On-demand and Always-on Expectations

Because an abundance of information is now at the fingertips of consumers at instantaneous speeds, they are expecting more and more from the supply chain in terms of customer service: shorter delivery windows, free shipping, full visibility of order status and more.

Next-generation supply chains will be required to provide anytime, anywhere delivery to customers and will therefore be required to be always-on, digitally connected, with all of its links synchronized. Retail stores, e-commerce sites, inventory control points, distribution and fulfilment centers, upstream suppliers and manufacturers – all will be aligned to the same drum beat of consumer demand in near real time.

Smart City Logistics

The trend towards urbanization along with continued dramatic growth of e-commerce and online shopping is driving a dramatic increase in freight deliveries to and within urban areas. Current fulfilment approaches cannot scale to meet this challenge and would lead to untenable traffic congestion, CO2 emissions and unacceptable noise and air pollution levels within urban areas.

The innovations and technology profiled in this report can be leveraged to develop "Smart City Logistics" solutions to these issues that work for government, businesses, consumers and the environment. A collaborative effort across and between businesses and city planners will be required to arrive at sustainable solutions to this emerging problem.

Actions for Supply Chain Leaders

We are excited to continue to profile and track the innovations and technologies that are transforming the next-generation supply chains and providing breakthrough improvements to service as well as efficiency. To maintain momentum and overcome the significant challenges ahead, supply chain leaders can take these actions:

Look to the future

- Start with a forward looking view of what your supply chain should look like at least five years from now. Work with sales and marketing to understand growth projections by product, channel and region. Understand how product mix change. Consider various scenarios that cover ranges of possibilities and use a leading network modelling tool that will help to model and evaluate your supply chain and support scenario planning.
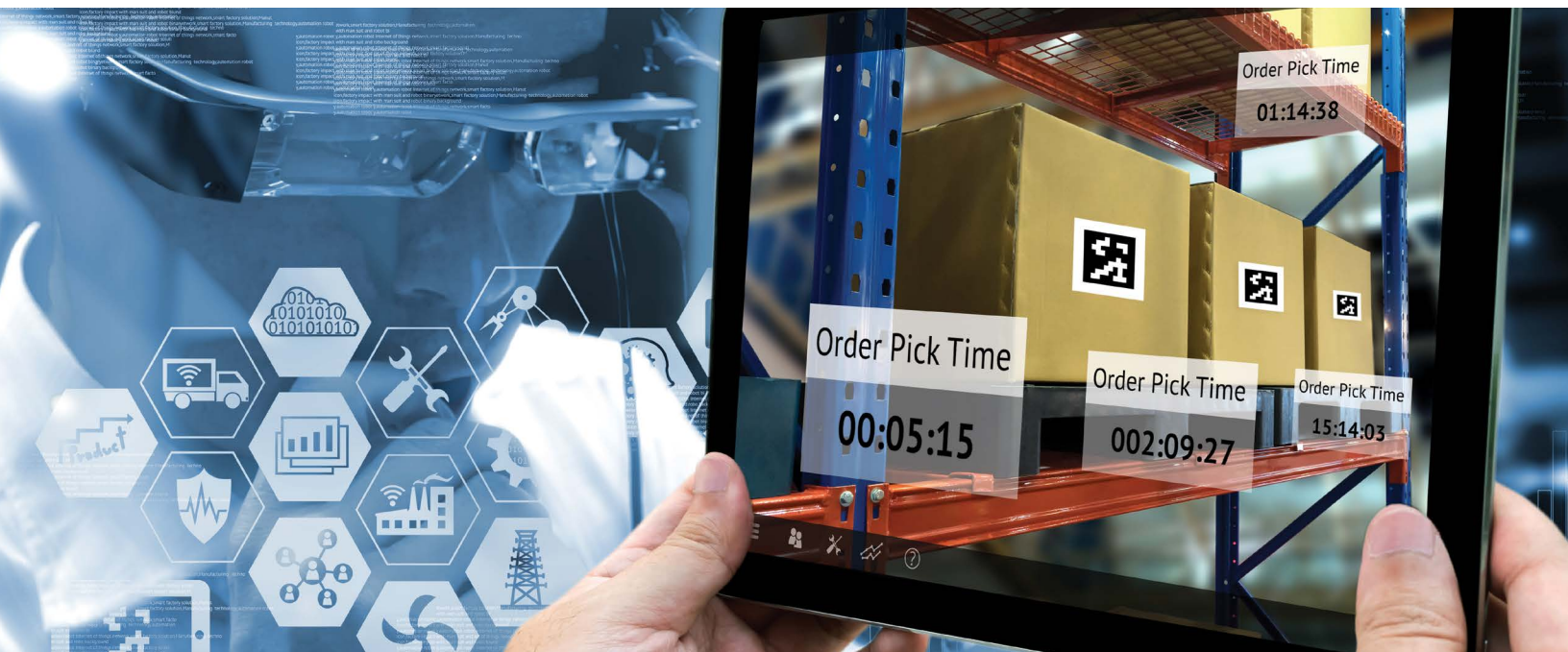
Begin to invest in innovation

- Whether your company is large or small, it is important to begin to invest in initiatives that leverage some or all of these impactful innovations and technologies. Our survey showed a consistent trend of investment across company sizes, with most investing 1-5% of sales revenue. Nearly half of the companies surveyed with sales greater than $10 billion are planning to invest $10 million or more annually, and 30% of these companies are planning to invest at least $50 million annually.

Invest in workforce hiring and training

- The supply chain workforce crisis is real and will only accelerate as new technologies demand a labor pool with increasingly advanced skill sets. MHI has focused on the talent shortage for years and works with the trade to address this critical issue. MHI's College Industry Council on Material Handling Education (CICMHE) and Career & Technical Education Program are key resources.

Today's supply chain leaders should embrace, not fear, the future. The supply chain function offers professionals access to some of the most exciting and innovative technology emerging across the business landscape. Consumers will continue to demand higher levels of service at lower costs. These demands will largely be met from efficiencies and innovation in the supply chain. Hold on! It should be quite a ride.

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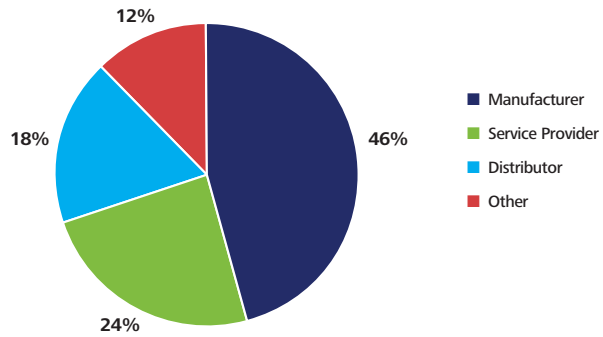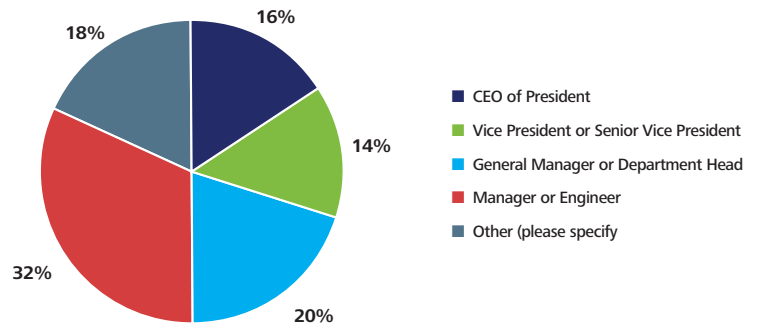
Appendix

About the Report

The 2017 MHI Annual Industry Report is our fourth annual study of emerging disruptive technologies and innovations that are transforming supply chains around the world. The findings are primarily based on an in-depth global survey conducted in late 2016, which involved 1,141 supply chain professionals from a wide range of company types and industries.

Half of participants are executives holding the role of CEO, Vice President, or General Manager or Department Head. Participating companies ranged in size from small to large, with 47% reporting annual sales in excess of $100 million, and 10% reporting $10 billion or more.

Responder's Company Type

- Manufacturer — 46%
- Service Provider — 24%
- Distributor — 18%
- Other — 12%

Responder's Role

- CEO of President — 16%
- Vice President or Senior Vice President — 14%
- General Manager or Department Head — 20%
- Manager or Engineer — 32%
- Other (please specify — 18%

Company Size by Revenue (USD)

- $10 billion and more — 22%
- $1 billion to $10 billion — 21%
- $500 million to $1 billion — 17%
- $100 million to $500 million — 13%
- $50 million to $100 million — 10%
- $10 million to $50 million — 10%
- Less than $10 million — 7%
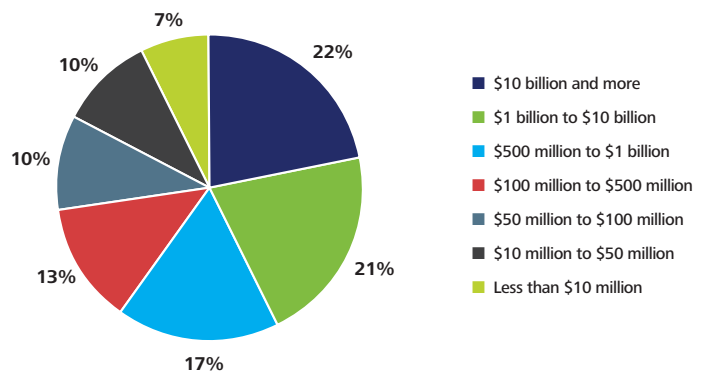
Respondent's Industry

Industry	Percent
Other	18%
Material handling and supply chain equipment	28%
Transportation and warehousing (incl. 3PL and contract)	10%
Consulting and othe rprofessional/technical services	9%
Automotive	8%
Retail	6%
Food and beverage	6%
Wholesale	4%
Technology, telecom and media	4%
Consumer packaged goods, excluding food	4%
Education	2%
Life sciences	1%

Investment In Products And Services Over Next Three Years

Product/Service	Percent
Fork Lift Trucks & Other Mobile & Wheeled Handling Equipment	43%
Racks, Shelving, Storage Equipment & Shop Furniture	42%
Software Systems for Warehousing, Distribution & Logistics	41%
Packaging, Labeling, Shipping, Weighing & Cubing	40%
Automatic Identification & Data Collection/Radio Frequency Identification (RFID)	36%
Information Systems & Controls	35%
Automation Equipment (AGVS, AS/RS & Robotics)	33%
Pallets & Containers	32%
Ergonomic & Safety Equipment	30%
Batteries, Chargers, Motors	29%
Conveyor & Sortation Equipment	29%
Third Party Logistics/Transportation Services	28%
Order Picking and Fulfillment (Pick-to-Light/Pick-to-Voice)	26%
Loading Dock Equipment	25%
Software Systems for Manufacturing	25%
Systems Integrators/Consulting	20%
Overhead Material Handling & Lifting Equipment (Cranes, Hoists, Monorails)	19%
Sustainable Facility Equipment and Energy (HVAC, Lighting, Solar, Wind, Natural Gas)	16%
Mezzanine	14%
Work Positioning Equipments	12%
Power Transmission Equipment	6%
Other (please specify)	4%

Acknowledgements

In memory of Willard P. Heddles, Chairman and CEO, Tiffin Metal Products, Inc.

We would like to acknowledge the hundreds of organizations that participated in our survey. We would also like to thank the MHI Board for their contributions to the survey and conclusions.