MATERIAL HANDLING & LOGISTICS U.S. ROADMAP 2.0

powered by MHI

APRIL 2017

FROM THE WRITING TEAM

As we finalize Roadmap 2.0, the weather in March of 2017 is quite unpredictable for all of us.

From Boston to Atlanta, several days of unseasonably warm weather turn into unseasonable cold and even snow much further south than usual. Right now the final days of winter are all about change.

In fact, that's the story of the *Material Handling & Logistics U.S. Roadmap 2.0*. Change. Lots of it at breakneck speed. And, you're living it.

This report is intended to help you anticipate what may be coming next. All of your answers are not in these pages. But many of the key developments and dynamics that will affect your supply chain on the road to 2030 are featured.

You are going to have to pay attention to technology, consumers, workforce and logistics infrastructure. All will have an impact on your supply chains and how they work going forward.

The temptation is to focus on what needs to be done today. Do a little planning, but don't spend much time on next year or years to come.

If that's all you do going forward, you will be buried. We are all well past the days when you could compartmentalize todays from tomorrows. Everything is just moving too quickly and is too interconnected.

That said, put *Roadmap 2.0* to work for you and your staff. It doesn't have all the answers, but we hope it's a strong starting point.

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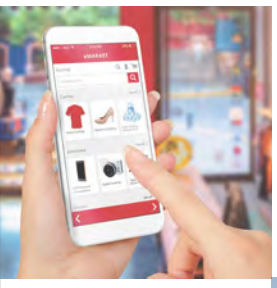
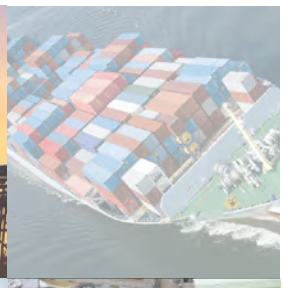
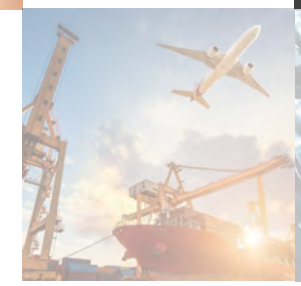
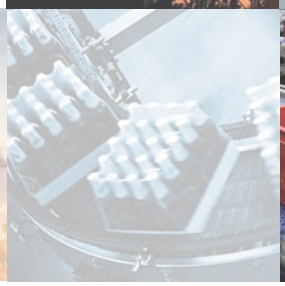
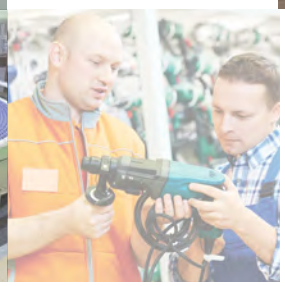






Oh, how quickly the world is changing. And the supply chain right along with it.






UNBELIEVABLE AND SURREAL

The story of material handling, logistics and supply chain 2017 – 2030

The first Material Handling & Logistics U.S. Roadmap was published in early 2014.[1]

Up front, the *Roadmap* identifies key supply chain disruptors. Then, it identifies core competencies to counter the disruptors (see page 9 for the full list). Ultimately, it is a baseline for the industry.

But in a short time, most will agree the rate of change has accelerated, prompting this *2.0* update just three years later.

Where did all this change come from? Thomas Friedman, columnist for *The New York Times*, offers some answers in his 2016 book, *Thank You For Being Late*. Coincidentally, he started research on his book just after the *Roadmap* was originally published.

The pace of adoption of technology is unprecedented. The amount of cross-border bandwidth that is used has grown 45 times larger since 2005.

He attributes the rapid rate of change across the globe to three forces. They are technology, globalization and climate change. And powering these three forces are three core developments—the introduction of smart phones, expanded bandwidth and unprecedented connectivity through the cloud. They make our rate of change possible.

The pace of adoption of these technologies is unprecedented, too. McKinsey & Company says "The amount of cross-border bandwidth that is used has grown 45 times larger since 2005. It is projected to increase by an additional nine times over the next five years as flows of information, searches, communication, video, transactions and intracompany traffic continue to surge."[2]

The upshot of it all is unprecedented interconnectedness. By the way, the sub-title of Friedman's book is "An Optimist's Guide To Thriving In The Age of Accelerations."

Accelerations, indeed. Consider three events in 2016. All have the potential to significantly change supply chains worldwide. None are a focus of *Roadmap 2.0.* This publication is not about government policies, funding, treaties, tariffs, regulations, politics or international law.

Instead, these three events are noted because they underscore the breadth of potential fundamental change in supply chains in the very near future. And, none of these three were on the supply chain radar as recently as 24 months ago.

One is the U.S. presidential election. Yes, we all knew it was coming, but the Trump surprise was just that. Now, tariffs, trade agreements and re-shoring of manufacturing have a prominence they didn't previously. The potential implications for supply chains are enormous.

Then there's the matter of Brexit. After more than 20 years, the essence of the European Union (globalization) is under siege by Britain's announced withdrawal. Another big surprise.

What it means to trade (read supply chains) is uncertain, to say the least. Furthermore, populist movements in other countries are advocating the same route.

Finally, don't overlook what's happening in the South China Sea, where China has built and militarily fortified artificial islands. Territorial claims could well challenge and change international shipping lanes.

These three alone could be summed up in two words: unbelievable and surreal. The former is the simple title of a future book by Katy Tur, who covered the presidential election for NBC News. The latter is Merriam-Webster's word of the year for 2016.

Actually, unbelievable and surreal aptly describe our daily rate of change across the board. In the two-and-a-half years Friedman spent writing his book, he checked back with his technology experts at least twice if not three times. He needed to be sure his information was still current. And that, too, is the case in material handling, logistics and supply chain.

This is the world we live in. Most of us are gasping to keep up.

Roadmap 2.0 is focused on four key forces in the supply chain: Technology, Consumers, Workforce and Logistics Infrastructure.

As we stand in 2017 and look forward to 2030, these four will directly impact both the rate of change and what changes in supply chains.

The supply chain has lots of dots. The challenge is to connect them and move ahead at or close to the current rate of change: Not an easy task.

Just as the original *Roadmap* was a high-level look, so is 2.0. It does not get down to street level and is not intended to cover everything changing in the supply chain.

Similarly, 2.0 is not prescriptive. Instead, it is a look forward that tries to capture what is changing within the four forces and the importance of these shifts to the future of the supply chain.

Finally, 2.0 extends the *Material Handling & Logistics U.S. Roadmap* horizon from 2025 to 2030.

What's changed lately

Soon after publication of the original *Roadmap*, Lee Scott commented on it. He built his reputation at Walmart on supply chain prowess, before rising to become CEO.

He said, "I am glad that I am retired and not responsible for meeting those 2025 expectations."

While Scott was thinking out to 2025, we can look at some of what has changed lately, several years before 2020, let alone 2025.

- Manufacturing output has returned to pre-recession levels with 1.5 million fewer workers.
- In just 18 months, Accenture automated 17,000 tasks, saving 20 million hours of work for its employees.
- Artificial intelligence is starting to reshape work in the supply chain.
- Blockchain is no longer just for BitCoin or fintech. Walmart is testing it in the supply chain to add structure to its processes.
- In the fall of 2016, fast-fashion leader Zara went from a winter coat concept to delivering it to stores in just 25 days. Eleven of those days were spent manufacturing 18,000 coats.
- Gap has just reduced its concept-to-store time from 10 months to 8 months.
- There is a shift among retailers from inventory stock to inventory flow. The shift to flow is possible because of interconnectedness, bandwidth and technology.
- Warehouses are much more sophisticated and likely in the not too distant future to rely on robotic automation.
- Brick-and-mortar stores are now viewed as small distribution centers to react to Amazon. At the end of 2016, Target shipped orders from 1,000 stores, up from 460 just a year earlier.
- Amazon accounted for 28% of all e-commerce at the end of 2016.
- In the 2016 holiday season, Amazon accounted for nearly 40% of all retail e-commerce. Its closest competitor was Best Buy at 4%. Walmart was almost 3%.

It really is harder now to get a job because employers are demanding that people have better skills than previously required.

- Amazon and others are building alternative shipping/delivery systems to UPS, FedEx and USPS.
- Drones were considered a sure thing for package deliveries when Jeff Bezos talked about them on *60 Minutes* in December 2013. Now that prognostication is not so certain.
- The e-commerce retail cost structure is still challenged by free shipping. Now, returns have become a major challenge to e-commerce success.
- The final mile is ever more complex. Even Dunkin' Donuts feels it, launching curbside pickup for coffee.
- The gig economy, sharing economy and on-demand economy are all here now. Some people say the three are the same thing.
- Some businesses no longer need assets or employees.
- Uber is front and center. It lost $2.1 billion through the first three quarters of 2016. And that's without assets or employees.
- The Board of Directors of Ford considered autonomous vehicles frivolous in 2012. By the end of 2016, Ford expected to have in the near future the largest fleet of autonomous test vehicles among automakers.
- California declared Uber's self-driving cars illegal in 2016. So Uber moved its testing to another state.
- It really is harder now to get a job because employers are demanding that people have better skills than previously required. This includes the ability to adapt to new technologies and use soft skills.

From the 2014 *Roadmap*

DISRUPTORS

E-commerce

Relentless competition

Mass personalization

Mobile and wearable computing

Robotics and automation

Internet of Things

Urbanization

Big Data

Workforce

Sustainability

CORE COMPETENCIES

Total supply chain visibility

Standardization

Internet of Things (IoT)

Planning and optimization

e-commerce

Collaboration

Urban logistics

Technology and automation

Sustainability

Workforce

It's not easy because, in many ways, material handling, logistics and supply chain are dealing with an inherent handicap.

- Amazon only needs two days to train its seasonal warehouse workers. Touch screens and robots help a lot.

Granted, this is only a partial list. But the breadth, speed and degree of change here makes your head hurt.

That said, it's very easy to get caught up in the heat of the moment.

Futurists talk about what's possible. As Cisco, Merck and other leaders know, these changes are challenging to implement and make work on a day-to-day basis. And then something else new comes along. Will it ever end?

In fact, McKinsey says business has generally realized much less than half of its digital potential. That's the spread between the rate of challenge (what can change) and the rate of change (what has already changed).

We are talking about fundamental and far-reaching shifts in how the supply chain works between now and 2030. And while not everyone will be at the forefront, there is a lot at stake for all.

What does all this mean?

The supply chain has lots of dots. The challenge is to connect them and move ahead at or close to the current rate of change: Not an easy task.

It's not easy because, in many ways, material handling, logistics and supply chain are dealing with an inherent handicap. They have all been around for thousands of years. But the modern codification of them is still relatively new. Supply chain professionals are not as well established as lawyers or accountants. As a result, the industry and profession are still becoming.

Here's a short timeline. Industry associations such as MHI were founded only 70 years ago, some more recently. The term "supply chain" was seen on a broad scale for the first time in 1982 when it debuted in the *Financial Times*. It wasn't until a very few years ago that supply chain became sufficiently well recognized that it became a prominent academic major at the University of Tennessee, for instance.

In other words, there is still a massive opportunity for maturing. Nothing wrong with that. It is just where things sit today. But that very fact is also a notable factor in the industry's and profession's ability to adapt to the rate of change. Fortunately, that maturation is going forward. Rapidly.

Steven Melnyk wrote about it in *Supply Chain Management Review*.[3] He is a professor of operations and supply chain management at Michigan State University.

While the title of the piece talks about the need for supply chain professionals to become strategic (see Workforce section), it just as

importantly details the drivers of change behind the need for this shift. Melnyk calls it "the new supply chain." And while he never says the article is a mini-*Roadmap* to 2030, it is.

Ten of his drivers of change on this road are:

- uncertainty and change,
- increasing rate of technological advances,
- customer-driven complexity,
- new competitive pressures,
- new methods of dealing with customers,
- low cost is no longer enough,
- customer demand for greater supply chain visibility,
- robust not optimal systems,
- outside/in not inside/out perspective, and
- a future focus.

Just as the first *Roadmap* identified 10 disruptors and 10 core competencies, these are 10 core drivers of change fundamental to this update. You will find them throughout *Roadmap 2.0*, both explicit and inferred.

The original disruptors and core competencies have not gone away. They are all still very much at work in material handling, logistics and supply chain. But Melnyk's 10 drivers are an updated addition to what also requires attention going forward.

The supply chain landscape is both quite different and much the same as in 2014. But the feeling is notably changed.

***Roadmap 2.0* is an attempt to offer a range of data points to complement your experience and help you prepare for 2030.**

For instance, many more are now comfortable talking about various technologies from the Internet of Things to data analytics. You may have even met a data scientist recently.

As we all know, "the tyranny of now" is endemic to the supply chain. Many would say the supply chain process is now part of the customer experience. That's despite the fact that few customers know much, if anything, about the supply chain or how it works.

During the workshops held to collect information for *Roadmap 2.0*, one of the participants expressed the rate of change this way. "Warehousing has changed so much in the past 5 years that I have to be careful not to hire experienced people who do not recognize the shifts."

At another workshop, there was discussion about how permanent a material handling system should be in a warehouse. A proposal was made that all equipment should be leased for five years and then replaced with an updated system. That doesn't happen today, but no one said the idea was a bad one. It could well be standard practice by 2030.

What would have been an acceptable solution before may not work now. And what is working today may well become history fairly quickly as we hurtle to 2030.

Roadmap 2.0 is an attempt to offer these and other data points to complement your experience and help you prepare for 2030. Ignoring any of what is changing is not a viable option for anyone. Many futures depend on readiness. ■

TECHNOLOGY

No place is the rate of change faster than among the technologies that drive supply chain, logistics and material handling. And that will be the case through 2030.

To begin, there is more competitive technology than ever out there, and it is constantly evolving. Rapidly. Take drones, which received attention in the original *Roadmap.*

Those were the days of human-piloted drones. Now that people have come to accept the concept of these small flying copters, that technology is old school.

Leading edge today is drones with enough on-board artificial intelligence to require no human intervention to accomplish a specified mission. According to the television news show *60 Minutes*, such autonomy, in defense drones in particular, is the most important development since the nuclear bomb. And, who is to think that autonomous drones as a technology can't migrate to the supply chain by 2030, if not sooner.

Then, there's the significantly heightened degree of interconnectedness described by Thomas Friedman in *Thank You For Being Late*. Interconnectedness is possible because of a range of technologies from the cloud to the smart phone. It has completely changed the supply chain landscape from placing orders, filling orders, tracking orders and delivering orders. Most call that supply chain visibility, also from the original *Roadmap*.

At the same time, some of these improvements and other trends have dramatically increased congestion within the four walls of facilities, *and* outside as highways, rail, sea and air delivery become clogged (see Logistics Infrastructure section). The overall effect is intensified competition across the supply chain as its different functions battle just to accomplish their individual missions.

The future role of technology is undeniable. In a *Fortune* survey of 500 CEOs in 2016, 75% of them identified cloud computing, mobile computing and the Internet of Things as "very important" or "extremely important" to their future businesses.[4] They went on to say "digitization has become their destiny."

That said, there are inescapable and profound concerns about these technology trends. They range from ordinary security of data and physical items to causing massive unemployment by eliminating jobs to combinations of technologies that could be wrongly used to significantly damage humanity.

75% of CEOs surveyed identified cloud computing, mobile computing and the Internet of Things as "very important" or "extremely important."

For context, this dichotomy of the consequence of technology—paradigm-changing improvement to initiating the downfall of humanity—has been a concern for centuries. Moveable type is an example. So is the cotton gin. Don't forget the computer.

But just as others before us managed technology and adapted it for the good of man, we must now do the same. What if 40 years

from now artificial intelligence made all human work obsolete? Is that good or not so good?

In the original *Roadmap*, technology was identified as both a disruptor of the supply chain and a core competency required to counter disruptions. It was not alone in its dual nature—e-commerce and workforce are two others. All are still having an impact.

Moving forward to 2030, technology trends, acting individually or together with related trends, will inevitably challenge and change many paradigms in the supply chain.

Consider just two. The ability to provide central control over a very large portion of the supply chain would have far-reaching implications. Not only would the movement of goods be much better coordinated, but congestion both within and outside the four walls could be much reduced. Not to mention a shortening of response times in order fulfillment.

Second, predictive analytics based on data collected and stored in the cloud could fundamentally change the supply chain. From anywhere in the world, analytics would affect interactions directly with the consumer all the way to anticipating who will order what. By doing just that, companies would be able to produce and pick those orders during less-than-peak periods, effectively increasing capacity.

The exact path technology will take in the future is not known. However, understanding trends, knowing how to look at developments to see opportunities, and developing capabilities that take advantage of these opportunities will be central to future success regardless of how technology evolves in the supply chain.

The relative importance of technology in the supply chain

This section of *Roadmap 2.0* is focused on the impact of technology on material handling, logistics and supply chain between now and 2030. The three other sections on consumer, workforce and logistics infrastructure focus on the impact each of those will have.

Along the way, people wondered which of the four will have more impact on the supply chain between now and 2030.

It was generally agreed that logistics infrastructure is clearly the big picture of moving goods. It's very influential. But it also tends to be embedded and slow to change. Much of logistics infrastructure is legacy and unlikely to change radically between now and 2030. So while it has the potential to have the most impact, that just isn't the case today. And that scenario is unlikely to change significantly by 2030.

Workforce is another contender because these people do the work in the supply chain. No small task. But workforce has its own rhythm and changes over a longer period of time like infrastructure. Furthermore, we are now at a

Technology trends will inevitably challenge and change many paradigms in the supply chain.

point where the technologies of automation must now be considered part of the workforce.

That leaves technology and consumer. We live in a time when the consumer is king. It is a powerful force. Consumers today are the commonly recognized centerpiece of commerce and expect what they want when they want it. Keywords here are "instant gratification" and "on their terms."

We also live in a time when consumers don't necessarily know what they want. Only because of technology do consumers live in the world they do at any point in time.

Similarly, technology will directly impact the rate of change in logistics infrastructure as well as the workforce, not the other way around.

Furthermore, something fundamental has changed since 2007, just ask Friedman. In his book, he cited all the technology breakthroughs that occurred that year. It's staggering. They have made our current interconnectedness possible. If they had not all appeared at about the same time, the rate of change in our world would not be the same. Clearly, it would have been slower.

So, as powerful as the consumer is, technology is most likely to be the strongest driver of change today and for the foreseeable future in the supply chain.

Viewing technology's impact

Exactly how will technology impact the creation and movement of goods between now and 2030? In general terms, technology will:

Technology is most likely to be the strongest driver of change today and for the foreseeable future in the supply chain.

- create new markets (technology push),
- meet needs in existing markets or of internal customers (demand pull),
- enable change to the way business is done, and
- improve the workplace.

We'll start with technology push.

In early 2007, people carried flip phones in their pocket or purse, had a desktop computer at the office, and lugged a rather heavy and bulky laptop in their briefcase. Things then changed dramatically with the introduction of the iPhone on Jan. 9, 2007. This new technology simply changed the notion of a phone. Not only did it create a new market, think about the breadth of impact it has had on so many aspects of life.

People typically went to brick-and-mortar stores when they needed something. Some ordered online and waited a week for delivery. Then, a number of technologies were merged to allow Amazon to offer Prime. Online shopping with two-day free delivery has now evolved into purchasing an item on our phone and expecting free, two-day … or same-day … or two-hour delivery. And, we can't live without it.

In other words, technology push is when technology creates new markets and services for companies to exploit, grow and thrive. Opportunities are created when unanticipated technology-induced disruptions occur.

Disruptive technologies can also be developed for a specific need or combination of needs. This

is demand pull. Specific needs can be articulated by an external customer or in response to a trend in customer behavior.

For example, UPS created the UPS Access Point network in response to scarce personal time during normal working hours. The network improves access to their delivery services by allowing customers to drop off and retrieve packages around the clock at delivery lockers.

The potential of the network doesn't have to stop there. These lockers could become part of a system integrated with drones and small autonomous vehicles for last-mile delivery. That would keep e-commerce retailers on the leading edge in competition for ever-shorter order fulfillment lead times.

There are instances when technology helps workers by improving the safety of certain dangerous and repetitive jobs that can cause injury.

In other cases, technological innovations have been developed for internal customers with a common motivation to increase productivity and efficiency in current operations. This doesn't require much explanation. Consider packages moving along high-speed conveyors using bar code or radio frequency identification or vision systems to sort with near perfect accuracy.

A valid discussion is certainly taking place regarding the displacement of certain jobs by technology (see Workforce section). But the point here is that the use of technology can and does improve productivity in mundane as well as unexpected ways.

Technology that facilitates doing business differently and new business interactions can both push and pull. This was so frequently mentioned by *Roadmap 2.0* workshop participants that it is worth a separate mention here.

Consider advances in communications and mobile computing. They have facilitated collaboration and competition in ways that were never imagined and are growing at a rapid pace. Neither of these capabilities is new, but the technologies have been enhanced to be easier to implement and use.

Uber is an example of executing the old business of a taxi in a new way enabled by advances in technology. This same technology and Uber's dramatic success over a rather short time period are now spawning attempts to replicate it in trucking and shared warehousing.

Vertical collaboration in logistics is another example. Retailers and suppliers share information in vendor-managed inventory. This is a direct result of technology facilitating a new way to control inventory.

Here, technology is a catalyst for fundamental changes in the way business is conducted. And while most think of e-commerce only in the business-to-consumer (B2C) world, this is an example of equal importance in the business-to-business (B2B) world, too.

Finally, there are instances in which technology helps workers by improving the safety of certain dangerous and repetitive jobs that can cause injury. Sometimes humans are replaced by automation and sometimes robots assist humans. These types of advances are making the workplace safer. They are also expanding

the opportunities for humans who have physical limitations to perform tasks that were previously beyond them.

Technology trends to 2030

During the *Roadmap 2.0* workshops, three trends dominated the technology discussions. They are:

1. Increasing scope, deployment and sophistication of the integrated system of cloud computing, connectivity, sensors and the Internet of Things;
2. Broad use of advanced artificial intelligence, particularly when deployed in the cloud, will scale so resources can be applied to address problems with huge computing requirements; and
3. Rising importance of security and risk in both the physical and cyber domains as the availability and usage of data escalates.

Cloud computing

Cloud computing is the game changer. It provides scalable resources for computing and data storage available from everywhere that facilitates centralized control of systems, analysis of massive data sets, solving huge problems, and making systems increasingly smart.

Interconnectedness is what cloud computing is all about. It integrates not just data but the Internet, mobile devices, remote communication, sensors and devices throughout the supply chain. The result is a basic structure that resembles the one used by humans in decision-making and control.

Human control involves the brain receiving information from the senses (sight, touch, sound, taste and smell). It processes this information to reach a decision and sends the desired action/control to voice or manual manipulation using the nervous system.

In the developing cyber system, ubiquitous sensors send information to the cloud using the Internet in (near) real time. Cloud computing allows algorithms to perform the analytical functions and send the desired data back to devices over the Internet. This overall structure is not new, but the increased speed and scalability changes everything.

This combination of technologies is now frequently referred to as cyber physical systems. They are the "integration of computation, networking and physical processes. Embedded computers and networks monitor and control the physical processes, with feedback loops where physical processes affect computations and vice versa."[5] The idea has captured the imaginations of many with scientists and engineers from industry, academia and government currently working in this area.

An important aspect of cloud computing is that it delivers computing resources—from data centers and warehouses to software applications—on an as-needed basis over the Internet. Importantly,

In the developing cyber system, ubiquitous sensors send information to the cloud using the Internet in (near) real time.

these are scalable to meet demand at any moment. If the need is to transfer a small amount of data every few minutes or solve a complex optimization problem with millions of variables and constraints, the resources are made available.

The growth in cloud computing is impressive. Forbes reported that worldwide spending on public cloud services will grow from $70 billion in 2015 to more than $141 billion in 2019; and public cloud infrastructure spending in that same period will grow from $38 billion to $173 billion.[6]

The usage numbers are equally impressive. A RightScale survey of 1,060 IT professionals in January 2016 indicates that 95% noted they were using cloud resources, both public and private clouds.[7]

The cloud is putting game-changing computing resources at the fingertips of businesses all over the world where it would have been unimaginable just a few years back.

Now, the cloud is most valuable to material handling, logistics and supply chain when the information can be effectively collected and deployed to a huge number of end points at high rates of speed. This is indeed rapidly happening.

The number of connected devices in 2016 is a 25% increase over 2015.[8] Meanwhile the number of smart phones worldwide in 2016 increased 12% over 2015.[9]

The development of the necessary supporting systems for cloud computing to significantly impact the supply chain is happening just as quickly. In 2016, it was reported that the average global connection speed was more than 4.5Mbps, a 20% increase over 2015 speeds.[10]

The surge in cloud computing is being aided by a parallel rise in the Internet of Things (IoT). It probably will become the ultimate power user of the cloud.

IoT is a network of physical objects that have embedded sensors that communicate directly with the Internet and each other as well as the cloud, making the data widely available. From soda machines to roadways and from pacemakers to autonomous vehicles, devices all over the world produce and send unimaginable amounts of data across the Internet that can be used by controllers of various types to make decisions and control activity.

For many, this is old news as many companies are engaged with the IoT. However, the exact breadth of use is still being defined. A Gartner

IDC estimated 2015 IoT spending worldwide at almost $700 billion with an estimated nearly $1.3 trillion projected in 2019.

press release in November 2016 indicated that 6.4 billion devices connected to the Internet were used last year. That's a 30% increase over 2015.[11] A report by Statistia placed the number at 22.9 billion for 2016.[12]

There is an equally wide range of estimates on spending related to the IoT. However, the vast majority suggests spending exceeds $200 billion in the United States.[13]

IDC estimated 2015 spending worldwide at almost $700 billion with an estimated nearly $1.3 trillion projected in 2019.

IDC also noted that, currently, about 40% of the worldwide total is spent in the Asia/Pacific region and that the manufacturing and transportation verticals were the largest spenders. Regardless of which number is more correct, all forecasts are for dramatic growth over the next decade—and all the numbers are huge.

And the story is getting more complicated. The IoT also shares the spotlight with the Industrial Internet of Things (IIoT) and Industry 4.0.

At a high level, it seems that the terms IIoT and Industry 4.0 are used to describe the same general idea. However, they were developed quite differently and that might make a difference when they are discussed.[14] Industrie 4.0 is the name given to a German strategic initiative that is firmly rooted in the German government and academia. Outside of Germany it is known as Industry 4.0.

It refers to the fourth industrial revolution where centralized control of manufacturing and production will be facilitated by intelligent devices and a network that drives industrial production.[15] The vision is comprehensive and widespread; hence, it not only contains ideas about applications but notions of protocols and standardization as well.

The origin of IIoT might be rooted in GE's Industrial Internet or Cisco's Internet of Everything or even somewhere else. But IIoT is used to describe the same growth of the IoT technology applied to an industrial setting.

Potentially important is that the IIoT term was born and lives in the free market business setting. It is not government sponsored or driven. This difference might or might not be important because Industry 4.0 and IIoT are focused on the same technology that will clearly be critical for all industry in the future.

With the growth and evolution of the cloud, communications and sensors, it seems that fully embracing the IoT-related elements will be necessary in the next decade. This will offer opportunities in all four forms to advance technology's impact—push, pull, new ways to do business and improving the workplace.

For example, just the use of sensors and the accompanying predictive analytics creates opportunities to improve efficiency by predicting impending failures and can be the source of new markets and products.[16, 17] It seems likely that understanding, embracing and integrating

the IoT into operations will be required for survival in the next decade.

The potential of the IoT is not limited to helping machines work more effectively. It will do the same for managers, providing them with needed information to manage in real time.

It is hard to imagine that prolific use of data isn't in the future of successful companies. That places a premium on acquiring capabilities to collect and analyze data along with an active and flexible risk management strategy for data security and privacy.

Companies must embrace the need to continually update their IT backbone as technology changes.

What are some keys to capitalizing on all this moving data rather than being victimized? There are at least two aspects to this answer.

One exploits centralized decision making as the segments of the supply chain become more closely tied together. A seamless and efficient flow of goods will result from integrated control of inbound raw materials, material handling within the factory, production, flow of outbound finished goods to warehouses, and warehouse operations.

This makes possible a significantly wider range of personalization. Technology provides an alternative vision to mass production and even mass customization on the way to 2030. It also reduces inventory and shortens total cycle times even as lot sizes of one come to dominate.

In the not too distant future, you will be able to order a personalized product by describing what you want linguistically, not selecting from permissible options. An artificial intelligence agent in the cloud will design the product including structural properties to meet safety guidelines if needed.

It will then send the design to a 3-D printer for production, and then orchestrate delivery using autonomous vehicles. That purple bicycle with pink flames that will perfectly fit your child who is 4 feet 10 inches and 85 pounds will soon be available at a cost not much higher than stock bicycles today and with next-day delivery.

To take advantage of this shift, companies must embrace the need to continually update their IT backbone as the technology changes. They will need to actively assess which advances are opportunities. It is imperative to continually review the state of technology through the lenses of its impact on push, pull, new ways to do business, and/or improving the workplace.

Roadmap 2.0 workshop participants also projected a strong need to overcome several potential negatives of technology in general and cloud computing in particular. These include:

- data security,
- regulatory issues that suppress technology's advancement,
- integration of new technology with legacy systems,
- technology glitches and risk management, and
- an appropriate balance within each company to not become over-dependent on technology.

The most far-reaching challenge, however, might be adjusting to and managing paradigm changes. Clearly, the impact of this trend has the potential to change the tasks and required skills from the executive suite to the shop floor.

Artificial intelligence

The second trend is the continued advance of software and algorithms that allow systems to perform tasks historically done by humans: artificial intelligence. Now, AI is certainly not new with books on the topic dating back to 1950. Courses have been taught at universities for decades. Nevertheless, it's impressive to watch IBM's Watson win Jeopardy, and to use Google Translate to read a menu in Paris. But, how does this transform the supply chain?

AI is getting much more sophisticated and its capabilities and reach are expanding due to new technical developments and cloud computing. This leads to a much more human-like cyber system of cloud, communications, sensors and devices. "Robotics, autonomous vehicles and "machine-learning" systems will lead to self-thinking supply chains."[18]

This revolution is underway, but the pace of change is going to explode in the near future. For example, many companies are using AI to anticipate the demands of customers, both end-users and upstream supply chain partners. This allows a warehouse, for example, to link specific customer patterns to operations. Certain orders that have yet to be received can be anticipated and pre-picked at a time that is convenient for the warehouse.

Capitalizing on an evolving IT backbone, AI could make route planning dynamic to speed vehicles to their destinations. This requires instantaneous processing of real-time traffic information, data from vehicles in an area, and embedded infrastructure sensors.

It is not possible to mention AI without noting the ability of self-driving delivery vehicles to successfully navigate roads in different parts of the world. Daimler successfully navigated a 9-mile test of a self-driving truck on a highway in the fall of 2015. Just a year later, a semi loaded with beer made its own autonomous run in North America. While there are obstacles to widespread implementation, the impact is clear and profound for both long-haul and final-mile deliveries.

On the shop floor, AI could facilitate the close coupling of the design and manufacturing processes to reduce the total cycle time. Gestures and voice become valid inputs as design software and physical prototypes will become passé.[19]

Designs will be directly transferred to production including additive manufacturing. The shortened production cycle time can be a huge opportunity in a market where personalization is a given.

While the potential tasks that AI could perform—especially if cloud computing, communications

AI is getting much more sophisticated and its capabilities and reach are expanding due to new technical developments and cloud computing.

technology, and the deployment of sensors continues at the anticipated rate—is almost limitless, there is an ominous side of AI.

An Infosec Institute report echoed a University of Oxford survey that AI "seems to be possessing huge potential to deliberately work towards extinction of the human race. Though, synthetic biology and nanotechnology along with AI could possibly be an answer to many existing problems however if used in wrong way it could probably be the worst tool against humanity."[20]

Developing robust, reliable and value-added uses for the massive amounts of data is a huge opportunity.

This same concern has been expressed by others.

Elon Musk says, "If I were to guess what our biggest existential threat is, it's probably that. So we need to be very careful with artificial intelligence. With artificial intelligence, we are summoning the demon."

Bill Gates says, "I am in the camp that is concerned about super intelligence. First the machines will do a lot of jobs for us and not be super intelligent. That should be positive if we manage it well. A few decades after that, though, the intelligence is strong enough to be a concern. I agree with Elon Musk and some others on this and don't understand why some people are not concerned."

The development of AI and its deployment within a fast and highly interconnected system of cloud computing and ubiquitous sensors is an unarguable trend. The fact that this type of system has the potential to change paradigms surrounding supply chain and logistics is impossible to ignore.

But there is also a real and very dark side to this trend that clouds the more distant future. In the short term, it seems likely that these systems will develop and be deployed to improve productivity and meet demands more effectively and efficiently. However, it also seems likely that the path forward is going to encounter strong and measured opposition that will slow the pace and even stall progress.

Using data despite risk

Developing robust, reliable and value-added uses for the massive amounts of data is a huge opportunity, and, simultaneously, a tremendous challenge. As with the IoT, the possibilities to exploit this are nearly limitless.

Current products are pulling technology by providing specific places where new and innovative software can use the data to improve processes.

At GE Minds + Machine 2012, it was reported that Jeff Immelt postulated, "the marriage of Big Data analysis and industrial engineering promised a nearly unimaginable range of improvements."[17]

Brian Carpizo, who works for Uptake (a company that bills itself as performing "analytics for the Industrial Internet") says companies could "use data mining techniques when processing signals streaming from machine sensors to detect machine degradation and predict impending failures." Whether data is used to improve internal operations or to sell to customers to minimize or eliminate unplanned downtime, advances in this data network allow

previously unanswered questions to be addressed realistically and in real time.

In this same spirit, the *Roadmap 2.0* participants identified a number of important but difficult to answer questions about end-to-end supply chain visibility. They specifically noted supply chain transparency. In a nutshell, this is all about much-improved tracking of freight movement, traceability and cyber security.

There is no question that possessing the capability to effectively leverage Big Data with analytics will be a required capability and very soon.

As everyone knows, there is another side of Big Data. Effective use can require rather sophisticated technology because the ramifications of data hacks are enormous, highly visible and alarming.

In a 2015 survey about technology in the home, 71% of the respondents were very or somewhat concerned about their information being stolen. Another survey of 5,000 worldwide enterprises found that 85% are deploying IoT devices but only 10% felt they could prevent them from being hacked.[21]

In the *DHL 2016 Logistics Trend Radar*, the first megatrend reported is growing security awareness. In fact, DHL says the combination of highly visible data breaches and "tightened security regulations that require high levels of supply chain transparency" are slowing the adoption and implementation of cloud and AI-related technologies.

In some ways, the conundrum is classic risk-reward with a choice. Use this huge data stream with so much potential and assume the risk, or go very slowly using data and risk losing market share. The difference would appear to be the magnitude of the risk associated with being hacked and the lack of obvious risk-management strategies.

DHL is not alone in making the link that it did. *Roadmap 2.0* workshop participants cited cyber security as the leading impediment to the adoption of various supply chain technologies. They also cited physical security as a major risk.

There was also a minority opinion worth noting among younger workshop participants. They simply have a different view of the human-computer interactions that lead to a different position on data security and risk.

The younger generations have made the use of technology such as smart phones integral to their daily lives. They view the risks associated with

breaches differently than older generations. As we move to 2030 and the younger generations take on more corporate responsibility, it will be interesting to see if they continue to be more risk tolerant, especially in regard to adoption of new technologies.

Changing landscape of supply chain

It is important to note that these and other supply chain technologies are not being plugged into static facilities and transportation modes. Not only is manufacturing changing, but so is distribution, within the four walls and outside.

Moving to 2030, demand pull will be a powerful force as segments of the supply chain require new capabilities to cope with their changing conditions. Consider these four:

1. Based on variables from the range of goods processed to expected delivery cycles, different types of distribution centers and technologies will be required.
2. Rapidly expanding requirements to handle single-piece flow further upstream in the supply chain will require a shift in technologies including 3-D printing.
3. Technology interacting with humans in DCs and the shop floor.
4. Transportation.

Different types of facilities/DCs/ fulfillment centers

The conflicting demands of short order fulfillment lead times in urban areas with competitive, low prices is a trend that suggests there will need to be several different types of facilities in the future.

Even looking out past a decade, it is hard to imagine that there will not be large facilities in more rural areas that are used to transfer freight along major arteries. These facilities will continue to be horizontally focused. They will have a large footprint because of location where land is reasonably inexpensive and use conventional material flow with the latest technology including conveyors, sorters and related handling equipment.

The focus will be on efficiency and one would expect many technologies will be developed in a pull mode. Automation will continue to increase within the facilities and the IoT will continue to expand its role and evolve in sophistication because of the cloud computing/ AI/communications/sensor development.

Meanwhile, physical interfaces between segments of the supply chain will be developed, allowing autonomous trucks to arrive at a facility, dock, unload quickly, load quickly, and then depart 24/7/365 with minimal human intervention. Systems of automation/robotics and humans will continue to evolve so that high-speed material flow within the facility is highly efficient and IIoT is the enabler.

On the other hand, facilities in urban areas will likely need transformative technology much more pervasively. The number of individual packages that will need to be delivered to customers is going to continue to grow much faster over the next decade.

For instance, inbound raw materials for additive manufacturing cells in urban areas is going to grow dramatically. Even with the proliferation of aggregating concepts like Amazon Lockers, the number of locations is also going to grow dramatically and the acceptable time for delivery will continue to shrink (at least for some fraction of the deliveries).

How will the various new technologies support single pieces as well as free shipping and returns?

Congestion in urban areas is also going to get worse, challenging traditional delivery. Land for traditional, horizontal facilities will become prohibitively expensive or prohibited by zoning boards, so the facilities to support urban logistics will change dramatically.

One answer identified in the 2014 *Roadmap* is going vertical, and that is true today as well. This option requires major technology innovation in material handling and storage to accommodate the necessary speed for order fulfillment.

To go vertical, the interface with vehicles that deliver the packages will likely look much different from current designs. The vehicles themselves will be different and operate differently, likely including drones and autonomous vehicles.

Meanwhile, distribution strategies will change because available land is limited. One example of a non-traditional idea is Amazon's patent for an airborne fulfillment center suspended below a blimp that uses drones for deliveries.[22]

Regardless of the specific facility design and operations strategy, inventory accuracy will continue to increase in importance as multi-channel fulfillment continues to grow and the available space for inventory shrinks.

Single-piece unit loads

Another trend is more the result of many factors but is already driving some technology innovations. Quite simply, it appears that the unit load as a single piece is gaining prominence in the supply chain.

It wasn't terribly long ago that pallet loads dominated and single pieces were mostly handled at the very end of the supply chain. However, e-commerce has pushed single pieces upstream. The push for shorter order lead times and personalization are moving single-piece handling still further upstream.

This is not without a cost. In companies across the country, chief financial officers are telling supply chain chiefs that their handling and distribution costs are out of line. The supply chain chiefs point to the shift from pallet loads to single pieces and the inherent additional handling and distribution costs. CFOs are not universally accepting the premise. After all, the company's existing cost structure supports a profit and additional costs must be eliminated to support profit growth.

The question moving forward is how will the various new technologies support single pieces as well as free shipping and returns? Returns in particular were a major concern of *Roadmap 2.0* workshop participants.

Embedded in this trend is 3-D printing or additive manufacturing, which was discussed in the 2014 *Roadmap*. It is part of nearly every look at the future of logistics including the most recent one by DHL, but its role in 2030 is unclear.[23]

Almost certainly, 3-D printing will be more widely used to produce individual parts by 2030. The opportunities for supply chain would seem to center on how this technology scales in terms of the types of products it can produce competitively.

Conceptually, 3-D printing creates a batch size of one and, as long as capacity permits, there is no need for a finished goods inventory. Everything is made to order, so all items are highly personalized. With printers located near customers, the required logistics is reduced to regularly providing inbound raw materials and final-mile delivery of individual items.

Amazon has even patented the notion of mobile 3-D printing. The concept calls not for delivery of a part but arrival of a small truck with a 3-D printer that would produce at the point of delivery.

There is no question that this is going to impact logistics by 2030, the question is to what degree. It is possible the technology does not evolve much and additive manufacturing is used in specific application domains. Or, it might be possible for logistics firms to become a new type of manufacturer with an investment in 3-D printers.

Technology interacting with humans

The last capability area within the four walls embraces broad and exciting ways that technology can interact with humans. First, there are wearables. The second are devices that allow humans to physically perform tasks that they are unable to do otherwise.

As with most of the technologies discussed, none are new. But they are in their infancy either in scalability or scope of impact or both. The key, then, is for companies to identify the elements that enhance their specific situation, acquire the capability and leverage this to their best advantage.

Wearables are quite familiar today because of personal use devices like Google Glass, Fitbit and GoPro. What might not be as familiar are warehouses where pickers wear smart glasses equipped with voice recognition and scanning assist.

The functions that wearables can deliver today are pretty astounding and the surface is just being scratched.

Wearables make it possible to provide skilled mechanics with detailed drawings and videos of tasks that they have never performed in real time. This can be done along with visual recognition to guide a repair procedure. The end result is significant time savings alongside elevated results.

Or, consider the advantage of providing real-time information to newer employees as they settle into their job. This capability will be crucial for many companies to acquire and integrate into their normal operation, and it will need to be done soon.

There is also an exciting growth in devices to improve human performance. Robotics are being developed that work beside humans to make jobs easier. They can also allow people with physical limitations to perform jobs they were not previously able to do. These types of advances are expanding the available workforce and providing opportunities to people who did not have them previously.

Additionally, developing exoskeletons for use in logistics is growing. In this context, exoskeletons are wearables such as a powered arm or suit

that enhances physical capability such as lifting capacity. Already, the European Union is funding six projects targeted at preventing back injuries and assisting people with mobility impairments. One of the projects has produced a functional prototype that was demonstrated in 2016.[24]

Technologies aimed at providing cognitive and physical assistance will surely be of tremendous value to most companies and they promise to deliver great value to all adopters.

Outside the four walls—transportation

The term autonomous is currently applied to a very wide range of vehicles. It is clear that the march toward self-driving vehicles without a human interface will be reality within the next decade. In the interim, it seems quite likely that autonomous vehicles with different levels of human interaction and for different applications are more imminent.

For example, some expect that it will not be long before autonomous trucks for long hauls will be on the road. Initially they will have safety drivers to move containers between storage and/or transfer centers. With successful testing on streets in traffic having already been completed to show the proof of concept, the pace will certainly accelerate.

For example, Ford has promised a car for ride sharing that operates in a defined, mapped area before 2021.[25] They interface with facilities on each end of a route.

Trucks moving freight will be developed but, in the interim, it is easy to visualize humans along for the ride. They will be on board with a cyber system that includes AI with communications and sensors driving the truck between the facilities. Direct communications between vehicles will be part of the mix, too.

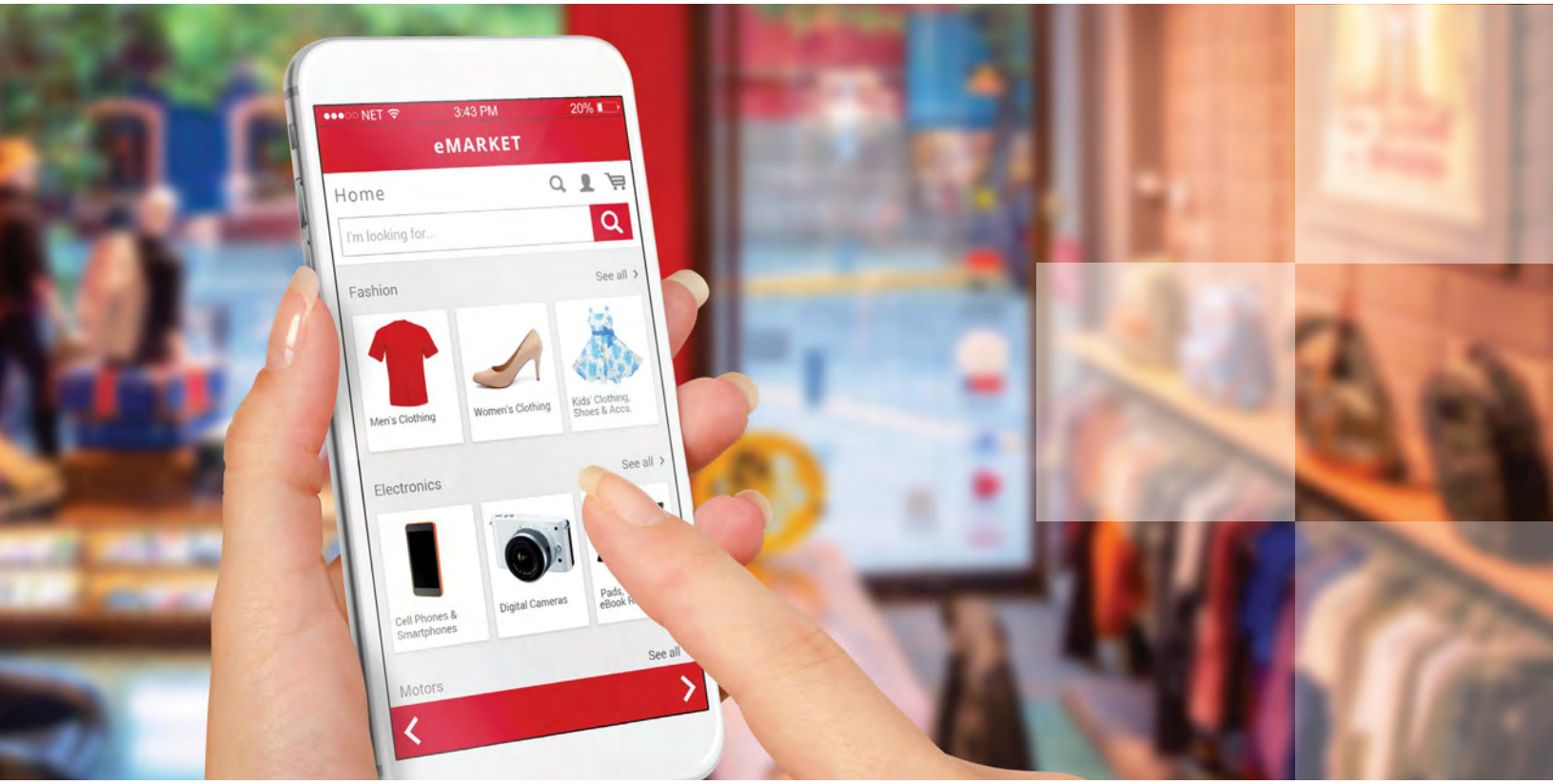
More dramatic changes are likely to be seen in the transportation associated with final-mile delivery. A September 2016 McKinsey report suggests that autonomous ground vehicles (including drones) will account for 80% of final-mile deliveries within 10 years. They project traditional human-based deliveries will account for the remaining 20% because of a special circumstance like high drop factors.[26]

It is worth reiterating what was said at the start of this section. The exact path technology will take in material handling, logistics and supply chain between now and 2030 is not known. However, understanding trends, knowing how to look at developments to see opportunities, and developing capabilities that take advantage of these opportunities will be central to future success regardless of how technology actually evolves. ■

Understanding trends, knowing how to look at developments to see opportunities, and developing capabilities that take advantage of these opportunities will be central to future success.

CONSUMERS

The consumer is king. In fact, millions of consumers are kings. All at the same time.



Often thought of as monolithic, the consumer is anything but. There are, of course, the five demographic groupings by birth dates (see boxes in this section). Each has its own characteristics, attitudes and outlooks that influence their broad consumption habits and patterns. And then there's the matter of individual preferences.

While most think only about personal consumers here, there is also the matter of business consumers. Buying habits, patterns and practices of the two are converging. It hasn't always been that way.

On the personal consumption side, consider the buying habits of a typical middle-aged couple living in rural America and a Millennial couple living in a city. In 2017, the former is more likely to visit a brick-and-mortar store and drive a fair distance to get there. The latter visits brick-and-mortar, too, but is more oriented to online buying. Furthermore, the Millennials are more likely to compare prices on their mobile devices before deciding what and where they will buy.

They both order goods online. The middle-aged rural couple is typically satisfied with longer delivery times than the Millennials. The tyranny of now is much more prevalent among city-based Millennials.

Between now and 2030, the business-to-consumer (B2C) mix and their buying patterns will shift considerably. For instance, Millennials will be well into adulthood with the oldest at middle age. The generation behind them, often called iGen or Gen Z, has not all been born as *Roadmap 2.0* is published. By 2030, they will range in age from teenagers to 30-year-olds. So not only will the mix of consumers be different but so will the pressures they exert on the supply chain.

Much of consumers' patterns are the direct result of the Internet and globalization. Both have disrupted the supply chain and will continue to do so to 2030 and beyond. Tom Friedman's book *Thank You for Being Late* makes that clear.

The Internet provides interconnectedness. Globalization moves interconnectedness to a grand international scale. The result is less expensive commerce that allows millions of

Between now and 2030, the business-to-consumer (B2C) mix and their buying patterns will shift considerably.

consumers to buy from large business entities as easily as from small merchants. A commercial logistics infrastructure capable of efficient distribution of long-tail inventory turns orders into deliveries.

It is more than Amazon, and Taobau in China, Rakuten in Japan, Otto in Europe or Ulmart in Russia. Thousands of small sites exist across the Web, each catering to specific niches of product to a broader audience of consumers. U.S.-based holiday shoppers in 2016 ordered thousands of products directly from Internet retailers located in Japan, Korea, Ireland, United Kingdom, Germany, Australia and China, to name a few countries. These e-commerce sites rely on inexpensive parcel shipping and automated foreign exchange through Visa, Mastercard and PayPal.

The combination of e-commerce and relentless global competition provides consumers more options to buy than ever before, a trend that will continue. As it is, this trend has already given consumers more options to research what they want and buy than they had just three years ago.

Together, the Internet and globalization made possible the concept of the demand-driven supply chain in the past decade. And, they are changing it as this is being written.

Just as important, this is not confined to the B2C world. It's also about business-to-business (B2B) consumers.

The B2B store now is available on the desktop computer, on a tablet or cell phone in the hand of an employee.

Profiles of the five consumer generations

Looking forward to 2030, five different generations will impact consumer wants, needs and behaviors. And between now and then, the impact of each of those generations will change.

Not everyone agrees on the lines of demarcation between generations. That underscores the fact that generational science is not always so scientific. For *Roadmap 2.0*, here are the breakouts:

- Silent Generation – born at the end of the Great Depression and through the end of World War II;
- Baby Boomers – born after World War II until the early 1960s;
- Generation X – born late 1960s to early 1980s;
- Millenials (sometimes known as Generation Y) – born mid-1980s until 2000;
- iGen (also known as GenZ) born after 2000.

At the front end, the Silent Generation fades out of the consumer mainstream during the next decade. As a result, this group has the least impact on future consumer trends. Meanwhile, the roles of the other generations evolve as they pass through various life milestones. See the boxes in this section on the key characteristics affecting the consumer behavior of the other generations.

In the past, the purchasing process took more time, working through purchasing managers, sales meetings and pricing negotiations.

Just like consumers buying for themselves, family and friends, B2B consumers can research and buy a product any time based on an immediate need or problem. And, they do it anywhere—from the comfort of their couch, an airplane seat, or standing on the shop floor of a factory.

As a result, the traditional procurement department staffed with managers buying for business is a fading concept. Corporate downsizing, e-commerce platforms, third-party procurement advisors, and the growth of tiny enterprises are all shifting the landscape. The department's supply closet previously replenished by procurement is increasingly a Web page with negotiated prices and desk delivery.

In the past, the purchasing process took more time, working through purchasing managers, sales meetings and pricing negotiations. That process is changing at an increasing pace, too.

This trend is in place but not yet universal by any means. It will be. Relentless competition opens new opportunities for e-commerce vendors to leverage their logistics assets into new markets.

More than just paper and pens are bought in B2B. Employees buy computers, printers, hardware, casters, pallet rack, cameras, software, food, cleaning supplies, furniture and much more from their desks and mobile devices, not from stores.

Amazon Dash Buttons, tied to a Prime Account, are one example of B2C triggered replenishment. In B2B, wholesale distributors, looking for ways to automate the reorder function with small resellers to build dependent relationships, will create an automated vendor-managed inventory platform for smaller companies. Sales once based on traditional relationship-based selling will become automated through software robots.

Between now and 2030, the combination of forces in the B2C and B2B arenas will streamline more than just order placement. They will significantly change how the supply chain works. Personalization, predictive data, inventory flow, omni-channel, returns and final-mile delivery meld and combine to create a unified customer-focused service.

Consensus at the *Roadmap 2.0* workshops was that the consumer will strongly influence the degree of disruption, rate of change and operational speed of the supply chain. This will amplify between now and 2030. The tyranny of now will only become more domineering, causing a relentless re-engineering of how material handling, logistics and the supply chain will work going forward.

Consumers as supply chain disruptors

Some say the consumer is the ultimate disruptor to commerce and the supply chain between now

and 2030. At the workshops for *Roadmap 2.0*, participants clearly identified the consumer as the dominant force going forward. We do live in a consumer-driven society where nothing is more prized or expected than a good consumer experience.

But then there is technology. Much of how consumers operate today is the result of technology that makes their wants and needs possible.

In 2000, smart phones and social media didn't exist. But both are now central to the consumer experience. It's worth noting that consumers didn't know they wanted/needed social media or smart phones before they appeared on the scene. Innovative systematic business leaders created the tools, and the consumers pushed those tools into obvious and unforeseen applications. This goes back to the push-and-pull discussion in the Technology section.

This is also a bit of a chicken and egg dilemma. There is no question the consumer is a prominent force in the supply chain now and going forward. But as the Technology section explains, consumers don't determine their own destiny. Technology plays a major role and is often the determiner of the consumer decision-making, buying and delivery process.

What do consumers want?

So what is driving all this upheaval of consumers, their behaviors and how the various components of the supply chain will work?

To try and get that answer, we typically oversimplify consumers. We all do it. "At the end of the day, they want to buy the stuff, and they want it fast. Now they just want it faster," says Lauren Freedman of digital-commerce agency Astound Commerce.[27]

And, she's right. But there's more to B2C and B2B consumer behavior today and on the road to 2030. Other contributing factors include demographics, technology enablement, life style and expectations, to name a few prominent ones. All directly influence desires, needs, wants and behavior of consumers. How all those factors interact will make the road more than interesting.

Boomers and Gen X change what they consume

Both groups push the notion of retirement aside, choosing to continue to work to maintain income or to stay active. Their employment may change, moving to more knowledge-based work as their age and experience continue to create needed value.

Their employment and wealth creation continues to fuel consumption; however, what they consume changes. By 2025, consumption focuses on lifestyle, staying active and connected to their family and community. Life maintenance increases importance as they consume more health and medical care services. Boomers and Gen X use health and social club services for community connection and general fitness. The oldest, desiring freedom and lower costs, consume more in-home assisted care, choosing to be in their own homes, or living with their children and grandchildren.

To begin, this is a need vs. want dynamic. Consumers need food, shelter and security. They want ease, trust and variety. When consumers look to fill a need, they think beyond the outcome, the choice of means to fulfilling the need becoming the decision point. This is beyond the "I need a hole, not a drill," statement. The consumer's decision is three dimensional, balancing the effort needed to buy, the cost of the buy and the quality of the experience as much as product quality.

No longer accepted by many consumers is the old saying of: "You can have it fast, good or cheap; chose any two." Consumers want all three, and businesses will find ways to deliver.

This fast-moving trend finds consumers wanting more dimensions of value as well as innovation by manufacturers, distributors and retailers. Where consumers always consider the price of an item, they increasingly place more value on the time and effort needed to complete a purchase. The fast, good or cheap model is insufficient for the consumer of the future if not the consumer of today. They will place more value on quality, the status of the purchase and the effort of the physical procurement.

One-size-fits-all no longer applies to consumers, and they want options that decrease effort and time to select and buy the product. Each individual consumer is different, and the relentless options presented by competition provide a personalization opportunity to sellers.

Price rules only when all other options are the same. Free shipping rules when all other options, including price, are the same. However, consumers are not always looking for free shipping or the lowest price if the paid shipping option creates a different value proposition of greater selection, higher quality or uniqueness.

One-size-fits-all no longer applies to consumers, and they want options that decrease effort and time to select and buy the product.

At first, consumers bought free shipping membership programs such as Amazon Prime only for the free shipping. As innovative as Prime is, Amazon was forced to continue to build value to maintain or increase membership while increasing the program price. And as it did so, the bar was raised and consumers came to expect the new status quo as entry level for future programs from Amazon and others.

It is also important to point out that retailers cannot underestimate the importance of consumer expectations. If that happens, the retailer will be the loser. Consumers are very firm about what they don't want at any given time. And, they will win out here. That is the tyranny of rising consumer expectations.

Critical decision points for consumers

Consumers are always asking four questions to determine the suitability of offerings under consideration. They are:

1. Do they have what I want/need?
2. How much is it?
3. When can I get it?
4. How do I get it?

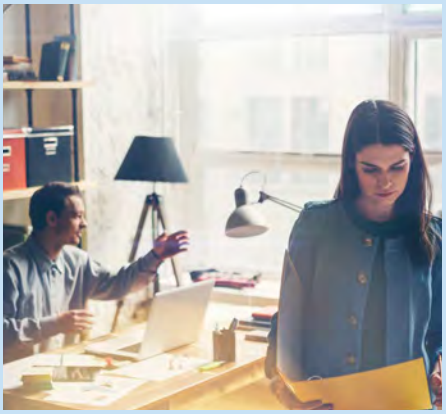
These are not new questions and they will not change in the future. They do define the consumer's context of the ability, desire,

resources and timing (ADRT), building the consumer's decision path to purchase.

At this point, however, no single question is known to be the dominant dealmaker or deal breaker today for consumers. As data analytics advance between now and 2030, that dynamic will likely change, at least in regard to individual products or certain categories of products.

There is a fifth question: Do I trust you? This is a bonus question that consumers ask in an interconnected and impersonal Web-enabled world. And, they should be asking it.

The two factions of Millennials



By 2025, all Millennials are fully in prime earning and consumption years.

Unlike earlier generations, Millennials split into two distinct factions—those who became working adults before 2010 and those who became working adults after 2010. Similar to the cultural effect of the Great Depression and World War II, the Great Recession divides the behavior and attitudes of Millennials.

Generally, Millennials entering the workforce before 2008 delayed marriage and children longer than past generations. This group held onto their jobs (for the most part) as corporations unloaded higher-paid Boomers and under-qualified Gen X workers. They married but delayed having children to build up financial and employment security.

These Millennials borrowed less to attend college, partly because of lower tuitions and higher financial support from their parents. Of those who did go to college, more graduated with science or business degrees than liberal arts degrees, making the process of finding employment less of a challenge.

The second half of Millennials, graduating after the economic downturn, represents a larger portion of the generation due to a spike in birthrate and the timing of the Great Recession. These Millennials graduated into a tight job market looking for technical education. Millennials with technical, science and business degrees found employment in their fields. Those with liberal arts degrees found a job market with little demand for liberal arts degrees.

The attitude difference between these groups is noticeable. The early group identifies more with Gen X and often does not consider themselves as Millennial. Neither is the case with later Millennials.

Early Millenials also push off the notion that they display entitlement. This split is important because it influences the consumption pattern of each group.

Early Millennials delayed major life events, like marriage and children, partly because of the challenges of debt and earning power. One significant trend reflects how more Millennial women joined the workforce, focused on building careers.

This translates to home buying and other consumption. Early Millennials purchased homes and related durable goods as singles, not waiting to make a home purchase until they married. They tend to buy smaller homes located inside of urban markets or condominiums.

By 2025, all Millennials are fully in prime earning and consumption years, becoming the dominant generation of consumers. Demographers expect Millennials to settle down and have children like the other generations. However, it will be about five years later than was typical for Gen X or Boomers.

Do you have what I want/need?

One promise of the Internet is that consumers can find exactly what they want. Sometimes.

Consumers certainly can find more options to purchase products. Massive online sites like Amazon promise everything and offer a standard of order fulfillment service that sets the bar for the industry.

Consumers' use of shopping and pricing services, like mobile price check applications, continues to grow.

The explosion of options in every merchandise category has created paradox-of-choice fatigue among consumers. We all tire of endless options that have no apparent difference in value or utility.

For some consumers, an unfulfilled promise of simplicity exists with e-commerce. Extensive search and filtering features in Web shopping sites are not enough. Consumers report frustration with the inability to find what they are looking for or find it in stock.

Some e-commerce sites provide marketplace solutions. Here, the site provides a shopping and revenue collection platform for sellers that are different business entities than the host site.

These marketplaces create the most consumer complaints about item information. Consumers encounter problems with fulfillment accuracy, stock status, packaging and damage at a higher rate from marketplace sellers than the host site itself. This is an opportunity for handling improvements in order fulfillment.

Traditional brick-and-mortar retail faces a two-dimensional capacity problem—not enough space for a wide breadth of offerings and the ability to carry a depth of stock to satisfy demand. Traditional retailers turn to omni-channel solutions, combining display space with e-commerce capacity. This setup offers consumers the option of e-commerce fulfillment to the customer's home (sometimes offered free) for items not in stock.

Clearly, great opportunities exist to improve the supply chain starting with this first of key questions: do you have what I want/need?

How much is it?

Cost remains an important factor in the purchase decision. However, initial cost is a decreasing factor. Savvy consumers look at acquisition costs, including shipping and the cost of returns.

Many surveys show that the more the consumer can see the landed cost of an item while making a buying decision, the more likely the consumer will be to complete the purchase.

The higher the price tag on a product, the more likely the consumer researched the buying options from a computer or tablet or smart phone. Consumers' use of shopping and pricing services, like mobile price check applications, continues to grow. However, the marginal utility of these services is dropping for consumers as sellers use these same services for competitive and dynamic pricing decisions.

As broadband Internet access improves and more consumers use mobile devices for shopping research, these tools drive the importance of initial cost as sellers fight to be competitive in price. Clearly, initial cost is important, but other factors guide the consumer's decision.

When can I get it?

This one has supply chain written all over it and is critical to consumer's decision process.

Consumers make buying decisions based on when they can take possession or delivery of the goods based on their convenience and schedule. Amazon Prime's standard ground service changed U.S. consumer expectations of the meaning of fast delivery. Today, more U.S. consumers consider two-day the standard of performance for delivery. Still, for many consumers, three- to five-day shipping can be an acceptable standard.

Same-day, or even next-hour delivery, skew to urban areas and higher-value items. A consumer's perceived need of now service is typically product based. Pizza and other delivered meals are an example. So is auto parts delivery to service providers with a standard two-hour dash delivery.

In the future, other maintenance, repair and operations (MRO) organizations' needs will develop rapid-delivery programs for appliance repair, for instance. Here, consumers want to reduce the time they go without the use of the appliance.

Of greater concern is the ability to direct the exact time of delivery to the place they want it. Consumers want to direct when they take delivery based on where they want to use the product, and the relative security of the delivery from theft. Going forward, there are sure to be other parameters that will require delivery at a specific time and place.

How do I get it?

Going to the market is a human habit stretching back over two millennia. Modern retail consumption is much more recent.

In the late 19th century, consumers in the western United States had three options: go to the store in town, buy from the traveling peddler, or use the new concept of mail order. Mail order became e-commerce, but e-commerce is more than just a replacement for mail order.

Mail order faced the same returns issues that e-commerce faces today. Sears built a successful business based on a satisfaction-guaranteed policy creating a trust relationship with the consumer. The major e-commerce companies today provide performance-related satisfaction guarantees for delivery performance, a trend that will continue to grow.

Self-selection continues to matter to those consumers who care about the specific products, where quality, fit or finish matters to that specific consumer. Consumers continue to purchase goods in traditional retail locations where they value the ability to touch, smell, try on and then select the products. In grocery, produce, specialty bakery and meats will continue to be consumer selected, and in retail, so will high-value clothing.

Convenience becomes a driving factor for consumers when they trade the ability to select and inspect for the convenience of fast pick up or delivery. Standardized consumer products allow for more online selection with physical pickup. Grocery retailers provide Web selection

Sears built a successful business based on a satisfaction-guaranteed policy creating a trust relationship with the consumer.

iGen enters the picture

Looking forward to the next generation of consumers, a number of key markers separate the Millennials from iGen. This generation is still being born. But the leading edge of this generation is old enough now to be the next market for marketers and generational researchers to study and research. There is enough information to deduce many of the conditions that shape behavior of this group.

Projected to be 82 million strong, iGen accounts for 29% of the total population in 2025, outnumbering Millennials by more than 3 million. As they grow through the teen years, iGen becomes a dominating force behind the Millennials, shifting the mean age of the population lower as Boomers and Gen X age.

iGen grows through native born and immigrants, children born outside the United States that immigrate into the United States, and as the American born children of illegal immigrants.

The most ethnically diverse generation in the country, iGen will drive greater levels of ethnic and social diversity in the workforce and as consumers. Through Internet-delivered video, iGen watches and participates in diverse culture.

Generational experts call for fewer than 20% of iGen to marry in their 20s, an extension of Millennials and a strong contrast to Boomers where 42% married by 30.

Born after 2000, iGen does not remember the events of Sept. 11, 2001. Their lives of higher attention to security and lockdowns in school, terrorism and shootings guide their thinking of what security is.

This is the first generation of ubiquitous computing. Born into homes with computers, laptops in schools, tablets, and smart phones, iGen is dependent on technology for education, entertainment and work. To iGen, getting a smart phone is more important than a driver's license. Where other generations consider technology trends as novel, iGen takes them in stride.

The early wave of iGen is now starting to develop their consumer and living behaviors, so predictions of those behaviors are ephemeral, for now.

iGen accounts for 29% of the total population in 2025.

This generation, because of education and ability, levers technology as consumers more than any other generation. Combine that with a lack of transportation to traditional retail and the commercial offerings of the Internet, it is no surprise that iGen uses technology to research what to buy before making the buy. iGen is the most comfortable of all generations researching for better bargains using smart phones, even when standing in front of the salesperson in the retail store. iGen expects wireless in every store, restaurant and waiting area.

While media is part of the information barrage for all but the Silent Generation, iGen grows up in a media saturated world where data and information are available from endless sources, with much of that information wrapped in a coating of advertising. iGen does not remember where marketing is not part of their media consumption where brands appear in movies and television shows. It is natural for advertisements to appear in news feeds or in the apps they use on tablets and smart phones.

Far more important, iGen can't remember a time before social media. More than any other generation, iGen believes social media affects how people see them.

and curb-side pickup. Final-mile delivery figures prominently here.

Rural and suburban consumers turn to e-commerce delivery of normal consumer staples for a combination of convenience and economy, where the drive to the local shopping center could be more than 30 miles each way. This growing trend creates new challenges for parcel carriers as residential package delivery volumes grow. However, the trend should build to a tipping point where the delivery volume to these isolated communities becomes large enough.

Parcel delivery upstarts created competition for the major parcel players, helping create economy of scale for e-commerce companies to use in rate negotiations. The relationship between Amazon and the U.S. Postal Service is yet another example of how delivery is a vital competitive weapon in the consumer supply chain. Meanwhile, Amazon is evaluating other options for delivery of its shipments including a fleet of planes and delivery trucks.

Delivery is an expected service for large items. Furniture, appliances and other large items traditionally use delivery service as a sales component.

More important, the removal of packaging and the old item is a value-add that consumers want. It's a service that more consumers see as having value. This service did not exist a decade ago, and it will increase in demand as consumers look to recycle their old flat screen televisions and large appliances.

Consumers are increasingly concerned about the proper recycling of their discards, asking more about the disposition of the discard in the buying process. This concern about the full life cycle of the item will continue to increase as part of the younger generation's concerns about the environment. These trends create opportunity for final-mile logistics providers to create differentiating services to all retailers.

The bonus question: Do I trust you?

Consumers always question the motives of the seller. While the consumer understands that the seller wants to make a profit, consumers want a fair deal from the transaction.

Consumers typically start with zero trust in any seller, and only after asking their buying questions does their trust level go up. Product brands engender trust, as do stores, not to mention the people working in the store.

As peer-to-peer marketplace platforms developed, trust created significant resistance to growth. To address the issue, sites developed mechanisms for consumers to rate the performance of the seller in each transaction. These ranking systems help build consumer trust in the platform itself and for each of the participating sellers.

Now ubiquitous in any e-commerce site, consumers can rank a product or the seller's service. Some platforms allow sellers to rank consumers.

Consumers typically start with zero trust in any seller, and only after asking their buying questions does their trust level go up.

Younger consumers increasingly trust the feedback of other consumers over the value of the protection provided by government and private consumer protection administrations. Today this is important in the sharing economy, as 64% of consumers polled say they trust peer regulation over government.[28]

As more e-commerce platforms create marketplaces for third-party commercial sellers, they incorporate more customer feedback mechanisms, actively polling consumers for feedback on performance, packaging and quality.

Mobile applications let consumers rapidly research the experience of other users through social media. Consumers quickly and easily report their dissatisfaction with a product or service on YouTube, Facebook or Twitter.

Consumers report higher trust in sellers that openly communicate the transaction process before, during and after the transaction. Surveys say that while many consumers assume a process up front, a defined process increases trust. When consumers must work with an assumed process, they tend to have less satisfaction and complain about service more. Consumers expect sellers to execute a documented process as described and provide as painless as possible a return or remediation process when things go wrong.

Consumer research indicates that in-process seller communication, such as order confirmation, shipping notices, tracking information, and follow-up survey requests, build trust. All of these steps to build consumer trust require information integration between the seller and logistics providers.

Consumers challenge the supply chain

But who exactly will people buy from in 2030? That's the leading question.

We all assume the current e-commerce market share of 14% of all consumer purchases to continue upward. Recent history moved e-commerce ahead at a 10%+ annual rate.

During the 2016 holiday season, Amazon had nearly a 40% share of e-commerce sales.

Meanwhile, Amazon's revenues expanded from $3 billion in 2000 to more than $90 billion at the end of 2016. That's 28% of all e-commerce in the United States.

During the 2016 holiday season, Amazon had nearly a 40% share of e-commerce sales. Its closest retail e-commerce competitor for the season was Best Buy with less than 4%. Target, Walmart and Macy's each were less than 3%.[29]

The 2016 holiday shopping season proved to be a negative for many of the leading department stores in the United States. Several of those long-time, brick-and-mortar names are on deathwatch by financial analysts.

There are currently about 1,100 malls in the United States. That number is on its way to about 700 in a few years, according to retail analyst Jan Kniffen, CEO of J. Rogers Kniffen Worldwide Enterprises.[30]

Exactly how all this will pan out in coming years is unknowable at this point. But retailers are clearly not sitting still. They are actively changing their material handling, logistics and supply chain tactics and strategies to deal with ever-changing consumer demands.

Clearly, it will no longer be enough to have inventory available that can be picked and shipped to a pre-set schedule. The new emphasis, already coming into play, will be on inventory flow, moving from its source to the consumer in one constant movement.

Retailers have just started to shift away from inventory stock to inventory flow. This was evident in late 2016 and will only build to 2030. The idea is to move inventory to consumers at a moment's notice rather than just have inventory availability.

As part of this, brick-and-mortar stores are now looked on as small direct-to-consumer distribution centers. At the end of 2016, Target shipped orders from 1,000 stores, up from 460 just a year earlier.[31]

This idea of stores as DCs is also part of omni-channel strategy, which has continued to take on greater importance since its debut in 2013. Omni-channel is all about making the channel—store, Internet, mail order, phone—of no consequence or concern to the consumer.

Omni-channel will continue to be a journey for consumers and retailers in the years ahead. Consumers will expect to be accommodated, and retailers will need to re-organize their order fulfillment and returns operations. Omni-channel is a critical paradigm shift for meeting consumer demand and has been anything but straightforward or easy for retailers.

There will be added pressure to make omni-channel work if Kniffen's projection on malls is correct. Fewer malls means fewer stores to be part of omni-channel operations.

Then, there's the matter of free shipping for e-commerce. Most of the participants in the *Roadmap 2.0* workshops expect it to be a temporary phase. Others see it as central to the e-commerce value proposition. Time will tell, and it will have an impact on the total cost part of buying.

As the free shipping battle continues, the developing problem is product returns. Managing returns can be more trouble than it is worth. There are times when Amazon says "don't bother returning" and simply issues a credit. Not all companies do that. Dealing with returns and the costs will have an impact on operations within the four walls going forward.

The B2B supply chain is going through its own changes to accommodate its consumers. The Internet, mobile devices and corporate credit cards are replacing large corporate purchasing departments. It is no longer a novelty to make a buying decision and place an order while standing in the middle of a factory floor. Meanwhile, such unencumbered access is changing and will continue to change how goods distributors manage in distribution centers not to mention delivery to the consumer. There will be parallels here to B2C operations.

In the end for both B2C and B2B, it's all about having inventory where the consumer wants it when he or she wants it. That is and will be the greatest challenge in solving the consumer riddle

The Internet, mobile devices and corporate credit cards are replacing large corporate purchasing departments.

for the supply chain in coming years.

It will be a matter of having the right inventory, making it available and shipping it to consumers on a delivery schedule that meets their specific needs. They may want/need it in the next hour or the next week. But the supplier of the inventory must be able to accommodate both situations with equal agility.

As we move to 2030, it will become increasingly important to deliver the goods not just to a location but to that location within a specific time frame. Too early or too late may well mean there is no one to take delivery, canceling the sale.

Going back to the Technology section, the availability of data and systems to manage it will help with managing this process all the way to anticipating an order before it is placed. The days of traditional forecasting are becoming obsolete in theory but more importantly in practice. Predictive data will replace it as demand-based point-of-sale replaces account-based point-of-sale.

At the same time, the age when manufacturers develop, design, build and market products in mass to consumers is fading. Mass customization took hold initially but is being displaced rapidly by personalization on a grand scale. Predictive analytics is not going to reverse that, but it will probably help with managing the personalization process.

Unfortunately, there's no extra time built into the supply cycle for personalization. Most consumers are not about to say, "take an extra couple of days to personalize my order."

And just as product personalization will dominate by 2030, personalized logistics will, too.

In turn, consumer demands/expectations will make distribution centers look different, too. Omni-channel is part of this, but there will be other shifts on the road to 2030.

Finished inventory on shelves and racks will be displaced (but certainly not entirely eliminated) by components and pieces that come together in a finished product with final assembly. But the trend of final assembly in the distribution center won't stop there. With 3-D printing, raw materials, not parts, become the inventory, waiting for the order before additive manufacturing takes place, creating a finished product that is immediately shipped to the consumer. It's just another example of the move to inventory flow from inventory stock.

This shift cannot be underestimated. Amazon in 2017 is seen as a leader in meeting consumer desires. But it still relies on the existing stock model. According to participants in the *Roadmap 2.0* workshops, even Amazon will have to move to a form of make-to-stock. It has already started with on-demand book printing.

And just as product personalization will dominate by 2030, personalized logistics will, too. The ability to deliver to specific location at a specific time becomes personalized services. This moving-target delivery method is risky, if the delivery misses the target, the recipient may not be there and won't be returning to that location again. The current leading concept of Uberization is clearly only scratching the surface here in 2017. Final-mile delivery will be one of the largest challenges moving to 2030.

Welcome to the rapidly changing world of consumers and the supply chain. ■

WORKFORCE

As a formal profession, supply chain is barely three decades old. Yes, material handling and logistics have been practiced for a very long time. But the term supply chain first reached a broad audience in 1982 in the *Financial Times*.

Being a newcomer relative to other professions is a double-edged sword for the supply chain workforce as it moves toward 2030.

On one hand, relative youth allows considerable flexibility and agility to accommodate changes in responsibilities and interests. Quite simply, there's more than one way to run a supply chain. And, what is considered to be a supply chain professional's responsibilities expands annually.

On the other hand, such relative inexperience means the profession is still earning recognition central to the success in industries from heavy manufacturing to high-end fashion retailing.

Before the 1980s, supply chain activities were generally regarded as necessary evils that supported other, more important business functions such as marketing. Furthermore, supply chain was traditionally seen in one dimension—as a cost to minimize whenever possible—if it was noticed at all.

Today, many C-suites and company boards recognize that effective supply chain management is, by itself, a competitive advantage. Industry leaders now promote the bottom-line value of fast, accurate, sustainable and cost-effective supply chains, logistics and material handling as *Roadmap 2.0* is published. This will become even more pronounced with time.

All of that is positive for the supply chain workforce. But it raises two questions:

1. What will industry demand differently from these professionals in 2030, and

2. What will the supply chain workforce demand differently from industry?

By 2030, the workforce will have different attitudes, expectations and concerns.

The answers to both are very much in flux because the work and how it gets done will change noticeably in two major ways.

First is the matter of simple demographics. By 2030, Boomers will be fairly uncommon in the workforce. Millennials will be entering middle age. The oldest of Gen Z will be early in their careers. It will be a unique workforce with its own attitudes, expectations and concerns.

The other is the work people will no longer have to do given the relentless surge of technology. It's all about getting more work done in a shorter period of time to respond to the tyranny of now to satisfy the rising impatience of consumers.

Many current material handling and logistics jobs likely won't exist by 2030. Consider the threat to freight forwarders of today.

In 2017, digitization exists, to varying degrees, in freight forwarding. That includes portal Web

sites that could automate much of the human effort required today. By 2030, there is every reason to expect that digitization will not only rule, but artificial intelligence (AI, the holy grail of automation) will carry the workload.

Freight forwarders are not alone. Automation has already had an impact on jobs. Manufacturing output in the U.S. returned to pre-recession levels at the end of 2016. However, 1.5 million fewer human workers are needed.[32] In other words, automation is already a significant portion of the supply chain workforce as *Roadmap 2.0* is published.

The supply of new workers will be unable to keep up with the mass exodus of aging workers.

Here are some other notable shifts expected to impact the supply chain workforce going forward.

- The supply of new workers will be unable to keep up with the mass exodus of aging workers, resulting in a growing vacuum of qualified workers in all functional material handling, logistics and supply chain roles.
- In 2015, the Millennials surpassed Generation X as the largest portion of the human workforce.[33]
- The U.S. labor force participation rate has continued to slide to its lowest levels since the 1970s, although it has been hovering near 63%.[34]
- Both the U.S. unemployment rate and underemployment rate have declined moderately, hovering near 5% and 13%, respectively.[35]
- Job growth in supply chain-related professions has remained strong, even as overall job growth has slowed in the United States.[36]
- Despite declining unemployment and underemployment, it has become harder for available workers to be hired for supply chain jobs because employers demand more qualified people with different and better skills.
- The gig economy, comprised of a growing on-demand workforce, has continued to take hold. As contract employment continues to grow, the percentage of contingent workers (temporary and freelance independent contractors) has surpassed 40% of the U.S. workforce.
- Collaborative labor sharing and crowdsourcing of these contingent workers through social media platforms and peer-to-peer networks of people will continue to increase.
- Use of automation continues to expand as it becomes more reliable and readily available. Here are some examples:
  - In December 2016, Amazon made its first commercial delivery by Amazon Prime Air drone (profiled in the first *Roadmap*), the first step in its initiative to employ thousands of drones for its deliveries.[37]
  - Autonomous vehicles, including floor- and ground-based vehicles, which might be more practical than drones in certain applications, have become more mainstream across the supply chain. In October 2016, Uber's autonomous vehicle-based delivery startup, Otto, made its first commercial delivery in Colorado after a 120-mile trip.[38]
  - Professional-services giant Accenture has reported automating 17,000 of its internal tasks, saving 20 million hours of work annually for its employees.[39]

The key question across the entire supply chain workforce is: What will be the rate of adoption of labor-saving and people-replacing technologies and practices? The short answer is: No one knows.

A report from the McKinsey Global Institute in January 2017 says, "activities most susceptible to automation are physical ones in highly structured and predictable environments." In *Harnessing automation for a future that works*, McKinsey says these activities account for 51% of work in the U.S. economy. Furthermore, manufacturing is one of several industries and activities in this sweet spot for automation.

Making Millennials the leaders of the future

It is easy to make the case that attracting and engaging the Millennial workforce between now and 2030 is essential to supply chain success. The question is: How do companies get these workers in the door and groom them to be leaders in a few short years? Here are some recommendations:

When reasonable, avoid centralized command and control, and repetitive physical tasks.

- Maintain a corporate culture with a sense of purpose, where Millennials feel appreciated and believe their work can make a positive impact on the community and the world.
- Encourage a sensible work-life balance so Millennials can achieve their goal of an integrated life rather than compartmentalizing their career, social network and community.
- Provide collaborative and informal workspaces that incorporate technology, social connectivity, participation on teams and gamification. When practical, use technology to facilitate virtual work, such as telecommuting.
- When reasonable, avoid centralized command and control, and repetitive physical tasks. Instead, give Millennials a variety of mentally stimulating work, flexible schedules, and more freedom and empowerment to do their jobs creatively.
- Promote positive reinforcement with appreciation, recognition and meaningful incentives (but not necessarily money) for a job well done.
- Don't coddle Millennials, but do provide effective on-the-job coaching to help them improve their skills.
- Expose them to new opportunities on the job and give them a chance to receive crosstraining and learn new skills.
- Offer clear advancement tracks from entry-level positions to executive management roles, and show Millennials how they can pursue them.

If businesses are intentional about creating company cultures in which Millennials can thrive, there is little doubt that the Millennials will be productive and valued members of their workforce in 2030.

McKinsey did not offer a firm timeline for this shift.

Then, there is the matter of how many new jobs will be created as automation expands. For instance, material handling automation will certainly expand. But that equipment must be serviced by a technician workforce that today is rapidly evolving. And, those technicians will not be alone in the world of new occupations that are not well established today.

In early February of 2017, *The Wall Street Journal Logistics Report* said that in the past year, 106,000 jobs had been added in transportation and warehousing. This followed on the heels of Amazon announcing that it would add 100,000 warehousing jobs in the near future.

Clearly, the trajectory of supply chain jobs is up in the air. But don't bet against automation of many forms having an impact on the workforce going forward.

The supply chain workforce of 2030

What we do know is that supply chains will work differently in 2030. However, the workforce categories are expected to remain much the same as today's white- grey- and blue-collar workers.

White-collar (engineering and management) workers with university-level supply chain and logistics related degrees plan, engineer and manage complex supply chain operations.

Grey-collar (technical) workers install, configure and maintain the equipment and automation ubiquitous in supply chain operations.

Blue-collar (operational) workers ensure the right products are efficiently made, accurately shipped and delivered to customers in a timely manner.

For this reason, *Roadmap 2.0* workshop participants generally agreed that demand for grey-collar workers could well exceed the demand for blue- and white-collar workers as 2030 approaches.

Three main trends changing the supply chain workforce now will continue in coming years. First, the growth in the pool of qualified workers for many jobs is unable to keep pace with demand for these people. Second, the demographics of available human workers are evolving. And third, the continuous development of practical new technologies and the improvement of existing ones are changing how work gets done, as well as how quickly and accurately it can be done. (See the Technology section.) Participants in the *Roadmap 2.0* workshops agreed that these three trends are unlikely to abate anytime soon.

While organic population growth by birth remains high in other parts of the world, particularly Africa and the Middle East, it remains flat in North America. The fertility rate in the United States has averaged less than two children per

The continuous development of practical new technologies and the improvement of existing ones are changing how work gets done.

woman since the mid-1970s. However, an average fertility rate of 2.1 children per woman is required to sustain population levels without immigration.[40] In spite of these flat birth statistics, the U.S. population has continued to grow moderately through immigration in recent years.

Greater workforce diversity will include more women, ethnic minorities, immigrants from various cultures, speakers of different languages, and people with disabilities. That diversity is already here at some operations. A distribution facility in New England today employs more than 1,000 workers who speak 15 different primary languages, the most common of which is Mandarin Chinese.

In addition, the blend of generations comprising the human workforce continues to evolve from Boomers moving into retirement to iGen (also known as Gen Z) with many still to be born. Millennials will be the heart of the workforce in 2030.

This highly diverse human workforce will require different skill sets than today. Blue-, grey-, and white-collar workers will all perform their jobs using new methods, tools and technologies, including many not widely used today. Some do not even exist yet. New types and methods of education and training are essential going forward.

Automation is already widespread in the supply chain, complementing human workers. This trend is sure to advance, ensuring that automation is just as much a part of the future workforce as people. In fact, at the *Roadmap 2.0* workshops, the breakout discussions about workforce quickly turned into discussions of technology and automation.

Companies are often forced to apply a scarcity mentality to match jobs to available qualified human workers.

The consensus among the *Roadmap 2.0* workshop participants was that robots and other forms of industrial automation will do work that humans can and cannot do. The non-human workforce (mechanical automation as well as software and related technologies) will complement and displace the human workforce in many supply chain jobs. These technologies can do those jobs better, faster, more efficiently and more cost-effectively than humans. As a result, fewer people will have careers doing repetitive or burdensome tasks. More people will have careers building, installing, programming and maintaining the non-human workforce.

Companies are often forced to apply a scarcity mentality to match jobs to available qualified human workers. However, they can apply an abundance mentality when exploring jobs for non-human workers. The non-human workforce is theoretically limitless, yet it requires limited ongoing investment (payroll, benefits, vacation and sick leave, training) and works overtime and holidays with no additional pay.

Automation will extend beyond mechanization, software and robotics to machine learning and self-improvement. The impact of these newer technologies will soon be widely seen in the supply chain. In the year 2030, AI will aid the workforce on an ever-increasing scale. The Internet of Things (IoT, a key topic of the first *Roadmap*), which continues to explode across the world, will serve as the sensory network for all types of supply chain automation.

Expect teams of industrial robots in many variations—manipulators, autonomous vehicles, drones, and, yes, even humanoid robots—throughout manufacturing, warehousing and distribution. They will perform a range of autonomous work, including loading and unloading, handling, assembly, inspection and quality control, order picking and delivery.

Three key workforce challenges

Three major workforce challenges face supply chain professionals on the road to 2030:

1. Finding people,
2. Improving the skills of people, and
3. Managing and retaining qualified people.

Finding people

Today, demand for people at all levels exceeds supply. Simply finding enough people to do the necessary work is a losing numbers game for the time being. That may come more into balance with expanded use of technology. But none of the workshop participants could identify an arrival date for that tipping point, if it arrives at all.

Meanwhile, the U.S. Department of Labor, as well as other government agencies and private research firms, periodically publishes reports summarizing: the number of people actively looking for work (the unemployed); those working less than they would like (underemployed); and those who have quit looking altogether.

Connecting with and recruiting these people remains a challenge.

The supply chain profession is young, poorly understood and often lacks visibility. Furthermore, industry practitioners lament that careers in the material handling and logistics have a public-relations problem, or worse, a stigma.

Just ask a group of parents to raise their hands if they want their children to work in a warehouse, manufacturing plant or distribution center. Few hands go up. The reality is, without greater visibility and an improved image, supply chain jobs face an uphill battle. The key here is to change the conversation from jobs to careers.

To find enough people for supply chain operations, the profession should adopt four key capabilities:

1. A thorough understanding of the changing labor market,
2. Alignment of work with workers (rather than vice versa),
3. A commitment to the flexible workforce, and
4. An improved image and greater visibility for material handling and logistics.

Understanding the labor market

There is no question that the changing workforce demographics require companies to explore and recruit more broadly than ever.

To begin, supply chain managers should reach beyond the mainstream labor market and recruit

Without greater visibility and an improved image, supply chain jobs face an uphill battle.

Worth Noting: The Implications of Automation

About 41% of the U.S. workforce worked in agriculture in 1900. By 2000, only about 2% did.

Philosophers debate whether automation is the cause of the changing human workforce or the result of it. Regardless of the answer, an overwhelming consensus has emerged among futurists, economists, scientists, engineers and sociologists that the non-human workforce is expanding rapidly and will continue to do so. This consensus was echoed by the material handling and logistics thought leaders who participated in the *Roadmap 2.0* workshops.

There are several reasons for this trend. One way or the other, industry must enlarge its workforce to satisfy the demand for low-cost workers between now and 2030. For tasks well suited to it, automation (hardware and software) is more efficient and productive than human workers. It offers better memory, quality, dependability and consistency than human workers do. Furthermore, the supply of automated workers is virtually unlimited. Automation will likely continue to become less costly, while wages and benefits for human workers will increase over time.

That said, no one expects automation to entirely replace the human workforce by 2030. In some cases, automation will continue to be too costly. In other cases, it will not be seen as an acceptable alternative. But whenever possible, all or part of the workforce that does predictable, repetitive, menial, unskilled physical work will be replaced with a non-human workforce.

What will this automation invasion mean for human workers? In a 2016 TED Talk, David Autor, professor of economics at MIT, explained that the adoption of automation hasn't historically resulted in a net loss of jobs for the human workforce. Instead, it resulted in a displacement of workers from old jobs to new ones.

About 41% of the U.S. workforce worked in agriculture in 1900. By 2000, only about 2% did. These workers were displaced from jobs in agriculture to jobs elsewhere, including manufacturing and distribution. As another example, the number of bank tellers has quadrupled since the introduction of the ATM in the mid-1970s. Tellers are still cashing checks, of course, but they're also performing a variety of other functions for bank customers.

It is widely anticipated that the material handling and logistics industry will rapidly experience a similar displacement, and the trend will affect white- and grey-collar workers as well as blue-collar workers. Automation will increasingly perform the repetitive, predictable work. It will displace human workers who will then perform other jobs that require more creativity, administration and oversight. As a result, supply chain automation will create many new careers for the human workforce. Technicians who service automated material handling equipment is a prime example.

Since neither automating everything nor avoiding automation altogether will be practical, the material handling and logistics workforce of 2030 will be comprised of humans and automation working together. The need for human workers and the need for automation will not be mutually exclusive but intertwined. The industry must strike the right balance between the human and non-human workforce. The non-human workforce will require flexible human workers who can adapt to it, complement it and support it. It's a good thing that human workers increasingly desire more flexibility and less repetition in their jobs.

workers from marginalized demographic groups: older people and retirees, recently discharged military veterans, people with disabilities, people of different cultures, legal immigrants, and people with criminal records who have paid their debt to society.

Within reason, companies should look for ways to give workers what they really want from their jobs. People in each demographic group have their own attributes and preferences. All increasingly want loyalty, fair pay, more options and more flexibility on the job.

Businesses should thoroughly study population trends and the availability of the local workforce when selecting a location for a supply chain facility or office. For example, continued urbanization is likely to result in a growing availability of workers in and near urban areas.

Those companies interested in legal immigrants should offer classes on practical life skills. Basic classes in subjects such as practical English, financial management, and citizenship, for example, could well draw more of these workers to the organization and help them assimilate more quickly.

Alignment of work with workers

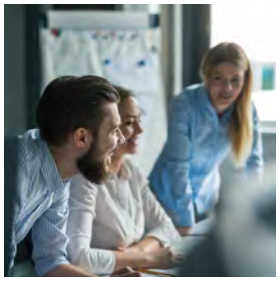
The question remains whether the future will bring a shortage of the right jobs or a shortage of the right workers. The ability of companies to find the workers best suited to these jobs will depend on the number of qualified workers available, not just the total number of available workers.

As the demand for people exceeds the supply going forward, the traditional human resources practices of standardizing job titles, job descriptions and the work itself will become less effective. It's already happened. Businesses must match work to available workers on a case-by-case basis.

Work creation should take precedence over job creation to ensure a sensible allocation of labor between the human and non-human elements of the workforce. That requires companies to determine what people can do that the non-human workforce cannot do and delegate work accordingly.

Human resources departments should understand the unique functional attributes of each job candidate rather than focus on the candidate's industry experience. Then, they should discover all the potential productive jobs the candidate can do to support the mission of the business.

Companies should make reasonable accommodations to adapt jobs to workers with special needs. For example, older people and people with disabilities might cope with limited speed, mobility, dexterity, stamina and technical proficiency. However, they might offer greater accuracy and quality, a more responsible work ethic and a greater enthusiasm for their work.



Within reason, companies should look for ways to give workers what they really want from their jobs.

Commitment to the flexible workforce

People want to work for companies that offer flexibility in how and when they work. Many companies will have to relax unnecessarily rigid organizational structures and work shifts while adopting hiring policies that accommodate a variety of work arrangements.

This may well require a shift away from 40-hour workweeks of five, 8-hour shifts (or even four, 10-hour shifts) to more flexible and virtual hours, shifts and workweeks. Employee timekeeping and payroll systems need to accommodate flexible hours, shifts, workweeks and physical working locations as well as the variable, non-standardized functions that human workers perform.

Employers should embrace and encourage telecommuting for those workers who do not require a physical presence on the job.

Employers should embrace and encourage telecommuting for those workers who do not require a physical presence on the job. They should evaluate remote employees based on their results, not their physical presence, and take advantage of readily available technology to facilitate virtual collaboration and communication.

The supply chain is likely to become less predictable in the coming years due to more demanding consumers and a faster pace of change in technology, not to mention more employment regulations. Consequently, more companies will choose to limit long-term employment commitments that are affected by employment regulations, benefits and taxes.

Conventional, full-time workers may morph into more contract or part-time workers, especially as the gig economy expands. But there must be a thorough understanding of the nuances of U.S. employment laws when hiring on-demand independent contractors (1099 workers) instead of traditional, permanent employees (W-2 workers). These two types of workers are not legally interchangeable, and the U.S. government has specific definitions and regulations for employing independent contractors.[41]

An improved image and greater visibility for the profession

As the benefits of efficient supply chain management become recognized at top corporate levels, people in general are largely unaware of the rewards offered by supply chain careers. Worse, many young people and others outside of the profession perceive that a supply chain career means performing tedious, demeaning and seasonal dirty jobs. They aren't interested in any of that. If material handling, logistics and supply chain managers are to be successful in finding enough qualified workers and competing for talent in the coming decades, these perceptions must change.

The members of the supply chain ecosystem should organize an effective campaign to eliminate the misinformation and the stigma associated with this profession. Through the use of appealing methods, channels and media, the industry should creatively and clearly articulate to the labor marketplace what the supply chain profession really is and why it is a desirable vocation. For example, UPS' successful "We Love Logistics" ad campaign was very effective.

As a part of this, companies need to establish clearly defined career paths, getting away from the one-dimensional idea of a job.

Improving skills of people

Finding people is only half the battle. If they are unskilled or have the wrong skills, there is a mismatch. What good is a pool of available workers if these workers don't have the qualifications and skills to get the work done accurately and productively? A workforce that is unskilled, unwilling or otherwise unfit to do the work required will not make supply chains work.

Managers want new hires at all levels to be trained and ready to do productive work on Day 1 of their employment. Participants in the *Roadmap 2.0* workshops were not proponents of extensive company training. Many remarked that training an inexperienced and unskilled worker is costly and time consuming, regardless of the person's role. Plus, they expressed concerns that workers trained at their company's expense are more likely to look for a more desirable job elsewhere.

To improve worker qualifications, the material handling industry must adopt three key capabilities:

1. More effective education and training,
2. Tighter collaboration with academia, and
3. Clearly articulated functional skills required of workers.

More effective education and training

Looking ahead to 2030, each worker category (blue-, grey-, or white-collar) will require different levels and types of education and skill sets as well as different certifications and credentials.

There is an expectation that people must arrive from academia with the necessary skills to hit the ground running. That puts an onus on educational institutions to more precisely train its students for the supply chain workplace. And, there is the problem. It can't be done as companies would like. In fact, several conditions must be addressed just to set a baseline.

This starts with the disconnect between industry and academia. Primary and secondary schools should ensure that every student is exposed to and is comfortable with rapidly advancing technology. That puts an emphasis on science, technology, engineering and math (STEM) education. Students need a basic proficiency with the latest mainstream computing devices and exposure to various forms of automation.

Primary and secondary schools should also begin exposing students to careers in material handling, logistics and supply chain. Secondary schools should return vocational education to their classrooms to equip graduates for work in the technical, electrical and mechanical trades.

Trade schools, technical schools and community colleges should offer more two-year degrees in various specialties related to technology and automation. There is also an unfilled need for more training and certificates in material handling, logistics and supply chain. Grey-collar workers will be in high demand to help satisfy the material handling and logistics

There is an expectation that people must arrive from academia with the necessary skills to hit the ground running.

industry's growing need to install, manage and maintain automation and related equipment and technologies.

Four-year colleges and universities should establish more supply chain programs. They should also offer more undergraduate and postgraduate engineering and management degrees concentrating in supply chain related disciplines.

Tighter collaboration with academia

Educational institutions and companies tend to operate independently from each other because they are charged with serving different purposes. To develop a more qualified supply chain workforce, that wall must be replaced with effective collaboration.

An initial step is to actively align and synchronize these efforts. Educational institutions should treat companies as customers, and businesses should treat educational institutions as suppliers. As a result, graduates will be better prepared earlier to meet the demands of supply chain careers.

Educational institutions should invite more practitioners into their classrooms to expose students to real-world supply chain operations and challenges. Conversely, businesses should involve more students in their operations by offering more co-op positions, internships, and externships (working on campus for an off-site company). Businesses should also sponsor more student projects to give students exposure to real-world supply chain operations and challenges.

While recruiting new workers, businesses should describe the transferable functional skills they require from the perspective of the worker, not the employer.

Clearly articulated functional skills

Roadmap 2.0 workshop participants agreed that the supply chain industry of the future needs fewer human workers to perform repetitive tasks better suited to the non-human workforce. They also expect a strong demand for people with skills that complement automation and technology. To reach a broader population of potential workers and hire them into supply chain jobs, the industry must clearly articulate those hard and soft functional skills.

Many of these skills are transferrable from other industries and companies. While recruiting new workers, businesses should describe the transferable functional skills they require from the perspective of the worker, not the employer.

In addition to the necessary hard functional skills, businesses should prioritize the recruitment of workers with soft skills. These include verbal and written communication skills, people skills, flexibility, agility, critical thinking and creativity.

Retaining workers for the long term

Retaining workers is just as important now as it will be in the future. Companies face two types of competition to retain people—other companies and the workers themselves. To boost employee retention, businesses must develop the following three important capabilities:

1. Company cultures that allow supply chain professionals to thrive,

2. Effective training methods for the workforce of tomorrow, and

3. More appropriate methods of performance evaluation.

Company cultures that allow workers to thrive

Studies show that the American worker is fundamentally disengaged, and the trend is not improving. According to the Gallup organization, employee disengagement has lingered around 70% in recent years.[42] To keep Millennial workers actively engaged, employers must understand what they really want and what motivates them (see box, p. 49). Then, they must create work environments that bring out the best in them. But the changes can't stop here.

Businesses need to embrace the attributes of Millennials (as well as their successors, iGen and whoever comes next). This requires breaking down cultural barriers left by previous generations and creating work environments that suit younger generations.

All should acknowledge that the opportunities available to business and the demands of customers will continue to change often and quickly. Consequently, worker displacement will be frustrating but a reality. Management and workers should embrace necessary and reasonable changes and work together to identify new productive roles for displaced workers.

It's time to eliminate barriers between business functions and adopt a more holistic organizational structure. Rather than working in isolated silos, cross-functional teams of workers need to collaborate effectively, think critically and creatively, focus on the big picture, solve problems, and achieve the strategic goals of the business.

Companies should gamify job activities. Research has shown that gamification significantly improves worker engagement and performance. Furthermore, Millennials and other young workers respond better to more mentally stimulating activities.[43] Gamification can also help to institutionalize standard operating procedures and track how well workers follow them.

Effective training methods for the workforce of tomorrow

Educating and training workers to keep pace with accelerating changes in consumer demands and technology will be no easy task. As a result, companies must prioritize ongoing training if they want their workers to remain productive.

Managers of the material handling and logistics workforce should administer a hybrid of three primary types of training: In-person or virtual classroom training (approximately 10%), one-on-one mentoring and coaching (approximately 20%), and on-the-job training (approximately 70%). *Roadmap 2.0* workshop participants agreed that this ideal blend of training is likely to produce the best results.

To simplify and institutionalize training and ensure consistent outcomes, companies should standardize processes rather than jobs. They should develop and adopt a playbook of clearly defined standard operating procedures (SOPs) that outline the most effective ways to carry out all routine business practices and contingency plans. This playbook also reduces the need to depend on anecdotal knowledge and the institutional knowledge of more experienced workers.

Cross-training is essential. Flexibility and variety of work are not only desired by the Millennial workforce, but also make them more well-

rounded and potentially better suited for a variety of roles.

As with the work activities themselves, businesses should take advantage of gamification to improve the effectiveness of training programs.

The other members of the greater material handling and logistics ecosystem (schools, industry organizations, suppliers) should support businesses by expanding continuing education programs and certifications that facilitate training.

Managers should emphasize that worker training is not a one-time activity, but an important ongoing process.

Managers should emphasize that worker training is not a one-time activity, but an important ongoing process. As a policy, companies should establish and administer programs that continually train and retrain every worker to consistently improve everyone's knowledge and skills.

Continuing education, certification and advanced degrees should be promoted at every organizational level—executives, managers and front-line workers. Tuition reimbursement for successful program completion is an added bonus.

More appropriate approaches to performance evaluation

The one-size-fits-all concept needs to be abandoned. Instead of treating workers as commodities, supply chain managers should treat them as investments. Defined job descriptions and wage classifications should give way to accurate assessments of the value of each worker's contribution to the mission of the business.

Management should deploy useful technologies to track the performance of workers and provide meaningful and objective feedback more often. Examples include visual dashboards and wearable devices that collect appropriate worker data and display individual and team performance. Additional technologies are likely to be available for this purpose before 2030.

As non-human workers perform much of the repetitive work in the future, supply chain managers will find it more difficult and less effective to standardize blue-collar jobs using time and motion studies. The average blue-collar worker will be harder to define and measure. Standard deviations will be larger, making engineered labor standards less useful for many jobs.

For those blue-collar jobs that are not so repetitive, and therefore cannot easily be standardized, managers should find ways to evaluate workers fairly and objectively. Managers need to use reasonable expectancies and objectives that are appropriate for more variable work.

That said, managers will still need to evaluate workers and measure their performance. In turn, workers want meaningful feedback on their job performance.

The final question to workshop participants was: *Will these workforce issues be resolved?* A minority said they had to be. Others said not a chance. Still others expected current workforce issues to morph into new issues. Time will tell exactly what those will be in 2030. ■

LOGISTICS INFRASTRUCTURE

To the untrained eye at a distance, logistics infrastructure does not appear likely to change much in the years ahead. Some ask: How many Panama Canal scale projects are out there after all?

But get closer. Fundamental change is afoot from the physical movement of goods to the digitization of information about them. By 2030, these changes will transform large segments of air, sea, rail and highway logistics.

To begin, globalization is a point of contention as *Roadmap 2.0* publishes in early 2017.

On the one hand, the United States and the United Kingdom apparently want less globalization and more nationalism. On the other hand, China's leader says his country will become the leader in globalization. This is a complete flip from the past 20+ years for all three countries.

Where the politics of this will be in 2030 is anyone's guess. But the business side of this discussion is already moving production closer to the point of consumption. Re- and near-shoring is underway. It's all about business decisions using cost analysis, logistics assessments and related considerations. General Electric's Jeff Immelt[44] calls for shorter, more nimble and responsive supply networks to replace today's long supply chains.

Meanwhile, digital flows will become as important as physical flows of goods. Industrial and individual consumers not only want immediate delivery but delivery to a specific location at a specific time. Along the way, they demand full transparency regarding the location and status of their shipments. To make that happen requires seamless integration of data along with the physical and operational integration of all elements including manufacturing, distribution and transport. That is a fundamental shift in logistics infrastructure.

Participants in the *Roadmap 2.0* workshops, along with many others, expect emerging technologies to strongly impact this shift. Additive manufacturing increases regional product flow for semi-finished and finished goods. Extensive Internet of Things (IoT) systems, connecting more than 20 billion devices[45], improve the flow of goods and processing of information beyond traditionally siloed manufacturing, distribution and transportation systems. Data analytics facilitates dynamic routing of shipments to minimize the impact of disruptions and delays.

Keeping all that data safe is an ongoing concern as logistics professionals enhance cybersecurity to protect goods and move them to their intended destinations as scheduled.

Industrial and individual consumers not only want immediate delivery but delivery to a specific location at a specific time.

By 2030, expect semi- and fully autonomous vehicles to be part of the mix for road, rail, air and water deliveries.

To be competitive on the future logistics landscape, large-scale distribution and fulfillment centers will require data-driven networks of smaller centers strategically located closer to the consumer, especially in urban areas. Part of the answer here is a new fleet of delivery vehicles.

By 2030, expect semi- and fully autonomous vehicles to be part of the mix for road, rail, air and water deliveries. These trucks, cars, planes, ships and other vehicles, controlled by artificial intelligence, will greatly influence the design of the future physical infrastructure.

And as we all know, America's infrastructure is in dire need of attention and dollars. We are at an interesting nexus of needing to upgrade what we have just as new technologies change how logistics operates.

However, there is certain to be tension and operational conflict as the new vehicles and systems operate on infrastructure designed for previous vehicle and system technologies. Remember, logistics infrastructure plans are typically made in 40-year increments.

This will be particularly noticed at publicly funded logistics links and nodes that have not reached the end of their design lives. New infrastructure designed to accommodate digital flows will engage a far different funding landscape, leveraging private and user funding far more than in the past.

Meanwhile, policy makers will move their focus to innovative statutes, rules and regulations that reflect the technological changes and shifts in service operations. Private infrastructure investments will be more commonplace as traditional, public funding sources are challenged to meet the needs.

Even education is part of the logistics infrastructure conversation on the road to 2030. Adoption of advanced technologies requires closer collaboration between education and industry.

As noted by IBM CEO Ginny Rometty, the "new collar" jobs don't require a four-year degree[46] to design and implement education and training programs that prepare new and current employees. Traditional educational programs—whether four- or two-year colleges—will be increasingly supplemented by high-intensity, hybrid courses. These prepare new and employed managers and staff for new assignments or different careers in increasingly digitally driven careers. More details are in the Workforce section.

The logistics infrastructure backbone

At the highest level, logistics infrastructure consists of links and nodes in the network that allows freight traffic to flow.

The links include not only physical links such as roads, bridges, rail lines, water routes, air routes and pipeline corridors, but communication corridors, too. The nodes comprise: road interchanges and intersections, rail yards, intermodal terminals, ports and airports. Also included are distribution centers, manufacturing

facilities and major freight collection and commerce-generating centers such as major shopping centers and the like.

The world's logistics infrastructure incorporates a mix of hard and soft assets and systems to move and handle freight. Hard assets range from road haulage and inland water transport to pipelines and distribution centers. Components of these hard assets include rail yards, canals, air routes, terminals and material handling equipment. In other words, it includes assets within the four walls of buildings and the facilities themselves as well those assets that move goods between facilities.

Soft assets include communications, shipment management and border controls. The components here range from switching systems to warehouse software as well as customs and security.

Much of the logistics infrastructure in the United States is in various levels of disrepair.

Integration of the movement of goods is increasingly dependent on the free flow of a huge volume of data. Generation of and access to the data is becoming as important if not more important as the hard assets that actually move the shipments.

The integration of data and the movement of goods is typically a multi-step process. Often, shipments are moved across two or more transport modes. For instance, goods fabricated in Asia for a consumer in Europe move by road to a port, then by ocean or air transport to a port or airport, and then by truck to a distribution center.

It is worth noting that both public and private funding cover the cost of the logistics infrastructure. Railroads, for instance, are privately funded and operated. Air cargo services, generally privately owned, typically use publicly funded facilities. Pipelines are completely private. On the soft asset side, private funding and operation pays for communications and shipment management. Customs is publicly funded and receives supplemental user fees.

Logistics infrastructure and prosperity

The fifth edition of The World Bank's Logistics Performance Index and its Indicators notes that "logistics performance both in international trade and domestically is central to the economic growth and competitiveness of countries." Firms engaged in moving and handling shipments provide predictable deliveries at a reasonable cost. The reliability of this promise is of prime concern. Public officials and policy makers increasingly see the "need to implement coherent and consistent policies to foster seamless and sustainable supply chain operations as an engine of growth."[47]

As one of the *Roadmap 2.0* workshop participants put it, "investment in our existing infrastructure, including maintenance and innovation, enables our way of life."

That said, much of the logistics infrastructure in the United States is in various levels of disrepair. It consistently receives a "D" grade from American Society of Civil Engineers (ASEC). That grade reflects the general state of repair of existing structures and the available capacity of the system to meet the needs for the movement of goods in the United States. The ASEC's last report, published in 2013[48], pointed out to a lack of investment creating barriers to

the economic operation and well-being of the country.

Only five of the 16 infrastructure categories achieved a passing grade. Within the transportation sectors, ports, railroads and bridges had a passing grade. Aviation assets, inland waterways, roads, levees and dams were failing.

The report card estimates the nation's investment to at least bring the asset categories to a passing grade would total $3.6 trillion by 2020. Such an investment is difficult to afford if the only sources of funds are traditional public sources. The alternative is widespread use of other funding mechanisms including public-private partnerships and design-build-lease-operate agreements. The adoption of the increased use of non-traditional funding and operating programs requires changes in policy and associated rules and regulations.

The state of the logistics infrastructure is mentioned here only because it could play a major role in how it all changes on the road to 2030. Exactly how that will play out is a political decision beyond the scope of *Roadmap 2.0*. But, logistics infrastructure disrepair is the elephant in the room.

Leading factors in logistics

Four key factors figure prominently in the logistics infrastructure agenda looking to 2030. These are consumers, urbanization, infrastructure integration and advanced technologies. All are intertwined.

Although important, regulations and funding are not the focus of *Roadmap 2.0*. Instead, the focus is on the actual movement of goods and information about them, not the decision-making process involving politics, policy and related mechanisms.

The intent here is not to identify every conceivable change expected. Instead, we will highlight several leading opportunities in logistics infrastructure.

To begin, there's the consumer. Full details on the impact of the consumer on the overall supply chain are in that section of *Roadmap 2.0*. Here, the focus is on the direct impact of consumer desires and behavior on logistics infrastructure.

Consumers want much more than just immediate delivery. They also want delivery to a specific location at a set time. This forces the merger of information corridors along with the physical movement corridors.

Freight flow planning models, in their infancy in the public sector in 2017, will come into their own to identify the flow of freight across all modes. Those models provide the foundation for land use and transportation planners alike to create concepts and final designs for efficient movement of goods. Freight flow planning is independent of other traffic planning.

Consumers want much more than just immediate delivery. They also want delivery to a specific location at a set time.

The development, design and construction process, especially where public and private transport operations and facilities merge, requires closer coordination at local, state and national levels by 2030. The objective is to coordinate efforts for capacity usage optimization. Especially important here are the intersections of various modes. This includes the intersection of intermodal rail yards with ports and highways not to mention distribution and manufacturing centers.

The need is to streamline a growing percentage of freight flows as a percentage of all traffic.

Planners and developers will be measured and compensated not just on what they build, but on the integration of it all. In the United States, the interaction between the public and private members of the state and local Freight Advisory Committees, mandated in the 2015 "Fixing America's Surface Transportation" Act, improves understanding of the interplay between users, their operations and those who design and build infrastructure. In fact, the act now requires state departments of transportation to report their progress.

The world's population continues to move to urban areas at a rate of about 75 million each year[49]. That creates infrastructure design, construction and operational challenges.

A major concern is the reduced percentage of land devoted to transport needs.

Many developing world urban centers will have an estimated 5% of total land for transport compared to developed cities such as Manhattan at 36%. Urban congestion will have a ripple effect through the supply and logistics chains in the Unites States and around the world.

Solutions focus on localized manufacturing using technologies such as additive manufacturing to small and often autonomous delivery vehicles. Expect a combination of kiosks and lockers, whether in stand-alone units or in existing storefronts or apartment complexes, to co-exist with traditional delivery services.

Final-mile delivery continues to be a challenge. Innovative, zero-emissions delivery alternatives such as those created by UPS in Hamburg, Germany[50] and Portland, Ore., figure prominently. The drive for operational sustainability and efficiency over shorter distances between manufacturing and distribution locations and consumers facilitates the adoption of these new technologies and vehicles. In addition to traditional and non-traditional wheeled vehicles, look for drones in remote areas and difficult terrain. Electrically powered pick-up and delivery vehicles will reflect corporate attention to sustainability and environmental sensitivity.

The need is to streamline a growing percentage of freight flows as a percentage of all traffic. Changing dynamics of the freight flows caused by e-commerce and/or the increased use of semi- and fully-autonomous vehicles must be considered. The latter require more attention from departments of transportation all the way down to maintenance of lane markings and other visual cues used to navigate on roads and highways.

There are great potential benefits to the broad use of autonomous vehicles in the logistics infrastructure. KPMG predicts that adoption of self-driving cars and trucks could reduce the number of accidents by 80%. Accidents

could become so rare that stand-alone vehicle insurance could be totally eliminated[51].

Cost savings would be considerable just by eliminating the cost of accidents including vehicle removal and repair. Further cost reductions result from elimination of the loss of productive capacity and the need for spare vehicles and equipment. Trucking companies could use these savings to upgrade equipment, and develop and implement new systems.

The adoption of new technologies creates pressures on policy makers at all levels to alter, amend or even formulate new policies and associated rules and regulations. Among the many issues they face are:

- Establishing a new environment for assessing liability issues arising from accidents involving semi- and fully-autonomous vehicles;
- New design criteria for roads, bridges and other infrastructure elements that are used by the semi- and fully-autonomous vehicles;
- Accommodation of communications systems and sensors used by the semi- and fully-autonomous vehicles, and;
- Protection of the data flowing between and to/from the semi- and fully-autonomous vehicles. This will involve the creation of standard protocols and restricting access to commercially sensitive information.

On an even grander stage is Hyperloop technology. As *Roadmap 2.0* publishes, Hyperloop enters its test phase on a 7-mile circuit in Nevada. By 2030, the concept is expected to be operational for freight transport.

The initial systems are likely closed-loop networks, potentially between ports and distribution clusters. A number of factors including funding, lack of alternatives and lower technological, political and social barriers to entry will determine where these closed loops appear. Initial test speeds of 300 miles per hour will increase to at least 500 miles per hour when the technology enters commercial use.[52]

The rise of autonomous vehicles will affect the infrastructure of distribution and manufacturing. At the dock, automated robots load and unload all types of vehicles including trucks, trailers, rail cars and ships.

Inside the facilities, operating and management systems will meet supplier and customer demand for continuous real-time shipment and/or stock keeping unit (SKU) location information. The design of these highly automated facilities changes as the level of human workers declines or are restricted to certain spaces. Charging stations for mobile equipment will become more important and prevalent than washrooms and break rooms for staff. Put away and picking systems currently tailored to human needs and speeds will change to reflect the capabilities

The rise of autonomous vehicles will affect the infrastructure of distribution and manufacturing.

Recognition of how the physical infrastructure supports the cyber infrastructure will increase in importance.

of robotic systems. Rack systems 100 feet or more in height would allow large facilities to be located in denser locations closer to the end customer.

The importance of cyber and physical security

All of what has been discussed so far is at risk if cyber and physical security are not front and center continuously. When the first edition of the *Roadmap* was published, cybersecurity was not included. Try to talk about logistics infrastructure (or even visiting your local retailer) without including cybersecurity in 2017. It was a major concern at all workshops for this report.

In fact, some expect the current lines between cyber and physical security to blur by 2030. In the business environment of 2030, information may well be as valuable as or more valuable than product, so security considerations and planning must be holistic. The major data highways are just as important to commerce and security as the Interstate highway system.

Recognition of how the physical infrastructure supports the cyber infrastructure will increase in importance. Many of the physical assets of data and communications networks interconnect for operational efficiency. Planning for future physical assets should consider potential synergies from integrating information infrastructure into their design and networks.

Safe, secure physical and data connectivity is critical for efficient and reliable freight movement. This is perhaps most apparent in the vast U.S. transportation infrastructure. At the foundation of our national security infrastructure, the energy grid and communications networks that support transportation and logistics remain a key focus for security and risk management interests.

In what former Assistant Secretary of the Air Force William C. Anderson calls “the new battle space,” this U.S. domestic infrastructure remains vulnerable and is a major national risk.

Similar to the conventional battlefield, scale is not a panacea. Securing every asset, installation, or network is impossible. Recognizing that these critical needs far exceed the resources available to secure them means resilience in many forms remains a key driver in planning for transportation infrastructure going forward.

At the federal level, security of the nation’s transportation infrastructure is the purview of the Department of Homeland Security (DHS) and the Federal Department of Transportation. These agencies work closely with state, regional, local authorities and experts to better understand the nuances and specific risks facing key installations. Identifying key areas of infrastructure, both physical and virtual, is an ongoing process. As the full spectrum of infrastructure continues to expand, the leading practices of 2030 for managing

The high visibility of artificial intelligence in autonomous vehicles will strongly influence public perception of the technologies.

security risk feature a robust on-going effort to grow "response, recovery, and coordination capabilities to support whole community resilience."

Programs like CTPAT (Customs-Trade Partnership Against Terrorism) will proliferate throughout the global supply chain. But standardization and organization of these efforts ensures they are relevant and effective security and risk prevention measures. These sectors have already adapted to higher screening thresholds. This includes the Transportation Security Administration's (TSA) Certified Cargo Screening Program (CCSP) policy for 100% screening on inbound air cargo.

Across the logistics and transportation sectors, advances in data visualization make business intelligence potentially accessible to every stakeholder. This connectivity increases security oversight. Together with operational benefits realized, this development ushers in cultural changes guiding how companies view (and share) key metrics or performance indicators.

Data security will remain a limiting factor in the application of data visualization and business intelligence. A lack of prudence protecting consumer or supplier information is a significant risk for companies across the supply chain. This is a relevant trend in both manufacturing and service-related sectors mirrored by growth in consumer demand for supply chain visibility.

As use of open-source platforms or crowd-sourced data grows, so, too, will the democratization of data and analytics. Combined with the maturation of the sharing-economy concept, a cultural shift is underway in how data is collected, shared and interpreted at the meta-level.

As security concerns continue to be relevant for infrastructure, scrutiny of people and goods through screening and data collection must not impede or violate civil liberties. This will be an important balance to achieve, and by 2030 seems increasingly subject to policy-makers' agendas. Regional politics, more important as regional influence grows in the logistics landscape, will influence growth and innovation. And, it may very well provide examples of abuses and systemic impacts with negative social outcomes.

Technologies to watch

Clearly several emerging technologies are critical to the future of U.S. logistics infrastructure. It's all about developing a smarter infrastructure that optimizes all transportation modes said participants in the *Roadmap 2.0* workshops.

Technologies covered here are: artificial intelligence, additive manufacturing, autonomous vehicles, communications and data flow, data analytics and supply chain visibility. The focus is on their importance to logistics infrastructure and augments what is in the Technology section.

Artificial intelligence

Artificial intelligence (AI) figures prominently in everyday planning, analysis and operations.

Take autonomous vehicles. The high visibility and positive developments demonstrated by AI here will strongly influence public perception of the technology. Trust in AI will evolve from familiarity through improvement to widespread application of it in transportation ahead of other sectors.[53]

Transportation applications for AI provide a valuable testing ground for developing more accurate and robust algorithms. That spurs AI penetration into other sectors. Affordability of AI systems is not expected to be an issue.

By 2030, integrated application of AI in federal, state and local risk assessment portfolios improves risk management for supply chain stakeholders. U.S. Transportation Research Board advisor Kristen Sanford Bernhardt describes the "increasing ability to model complex systems" as the significant promise of AI and advanced computing.[54] Together with the influence of data analytics, leveraging technology including AI into the design of transportation and logistics installations will also increase efficiency and safety for humans involved[55].

Along with AI, the connectivity required by the logistics infrastructure will be amplified by the Internet of Things (IoT), Big Data proliferation and decentralized analytics, including agent-based modeling and simulation. These and other technologies leveraging AI shape everything from final-mile routing to long-term infrastructure planning. AI improves real-time vehicle routing for driven and autonomous fleets, providing the shortest or most-efficient route minimizing the carbon footprint of transportation.

Elsewhere, AI teamed with online freight booking, visibility and real-time data will significantly pressure third-party logistics providers to adapt and deliver different value . Freight forwarding will likely change significantly due to AI.[56] Recommendation engines will expand into business-to-business procurement spaces, too.

AI will increase decentralization of decision-making. However, the importance of coherent data analytics will drive consolidations in corporate structures[57]. Conversely, AI and developments in cloud and distributed computing enable decentralized decision-making and learning in the production, distribution and delivery arenas.[58] The human impact of AI will also be significant.

People-free warehouses could be a reality at least on some scale. Advanced optics (or IoT feeds) and robotic handling technologies paired with a responsive, AI-driven resupply function improve performance through machine learning and algorithm refinement.[59] While displacing some people, AI will create new roles for people managing AI[60].

Along with AI, the connectivity required by the logistics infrastructure will be amplified by the Internet of Things.

Additive manufacturing

Commercially viable since the 1980s, the declining cost of additive manufacturing (also known as 3-D printing) has made this technology a potential game changer to the logistics infrastructure.[61] Leveraged properly, the technology reduces inventory and working capital for firms as it provides responsiveness

Increased use of autonomous vehicles, especially passenger vehicles, allows higher operating speeds without the risk of accidents.

and flexibility to offset demand unpredictability or forecasting error.[62] Additive manufacturing also minimizes downtime due to equipment failure. It prints a replacement part on the spot, eliminating the need to deliver a part over the road.

At the extreme, the array of technologies related to additive manufacturing empowers the consumer with personalized products. This product and service design capability provides manufacturers with a stronger value proposition for consumers. Additive manufacturing allows product designers to leave that last bit of creativity, innovation or vanity to the customer. Technical improvements in the capabilities of 3-D printed materials spread the use of this technology.

In the aerospace industry, additive manufacturing efficiencies reduce costs associated with transportation for parts, adding a positive environmental impact. Boeing, an industry leader in the use of additive manufacturing, has proven 3-D printed parts can reduce complexity in manufacturing, and improve overall performance with lighter 3-D parts.[63] Boeing's efforts led to an expansion of manufacturers integrating additive manufacturing into their sourcing and design activities. This, in itself, minimizes demands on the logistics infrastructure.

Additive manufacturing will continue to impact the supply chain by reducing the time-to-market for product development.[64] It shrinks the design and prototyping cycle. By 2030, the ability to bring products to market faster is sure to be more important than ever. Swarm programming or coordinated collaborative manufacturing by multiple 3-D printers using different materials will increase production speed and complexity.[65] This opens the door to new, more efficient transportation schemes to deliver products.

Autonomous vehicles

As soon as 2026, some expect that 90% of new vehicles will be autonomous[66]. As was mentioned earlier, this will impact traffic flows and time on the road for deliveries.

Increased use of autonomous vehicles, especially passenger vehicles, allows higher operating speeds without the risk of accidents. This facilitates rapid transfer of goods and delivery to dense urban areas as well as rural areas, minimizing the need for a network of smaller distribution centers.

Meanwhile, the sharing economy stands to impact logistics infrastructure. As more automobiles are shared rather than owned, the need for wasteful street or parking lot capacity will significantly shrink. This, in turn, will effectively free up road capacity without costly additions. In addition, parking for delivery vehicles will be more available, facilitating the faster flow of goods.

Sidelining driver-controlled vehicles will reduce if not eliminate the need for traffic signals. Intersecting, merging and diverting vehicles negotiate spacing, acceleration, deceleration and speeds. This reduces delays and enhances the movement of road haulage.

Researchers at the Swiss Institute of Technology, the Italian National Research Council and Massachusetts Institute of Technology have developed a slot-based approach to facilitate the movement of autonomous vehicles at intersections[67]. This allows autonomous vehicles to operate alongside non-autonomous vehicles and contribute to faster and smoother traffic flow on roads and highways. This, in turn, increases the productive capacity of the road system and reduces operating costs for freight transport.

By 2030, self-driving cars will likely be lighter as the safety factor associated with large/heavy vehicles is eliminated due to lower accident rates. Lighter vehicle costs translate into lower fuel consumption rates. In addition, the costs of all vehicle construction decrease. These two cost savings translate into improved margins for transport companies.

The size of fleets, including Uber-like ones, will decline as efficiencies improve, too. As an example, studies by the Organisation for Economic Co-Operation and Development (OECD) and the University of Utah predict that taxi systems composed of autonomous vehicles could be one-tenth the size of traditional car taxi systems. Similar efficiencies emerge for delivery fleets and longer-haul road transport as the need for rest periods declines.

Communications and data flows

Together with resources, labor and capital, logistics giant DHL recognizes information as the "fourth production factor and essential to competitive differentiation.[68] Moving to 2030, data flow across the supply chain will become increasingly automatic, while related analysis and decision-making decentralizes.

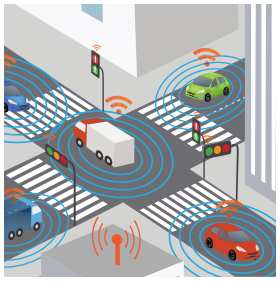
By taking advantage of data analytics along with cloud or distributed computing, decisions can be made closer to the end user or relevant situation. The physical infrastructure required to sustain data flow in capacity and bandwidth will be a vital area for investment.

Fiber, wire, broadcast, and satellite connectivity will dominate data flow in 2030. But the physical transportation of data remains relevant as it provides security and speed of delivery for massive amounts of data. This will benefit trucking and rail sectors as the Amazon petabyte-scale data transport "Snowmobile" concept proves viable in the broader marketplace.[69]

As the use of high-speed delivery services increases, consumers expect continuous access to the specific location of their shipments. Simple nodal-based tracking and tracking systems will fade away.

In addition, such data will become valuable information for transport system planners and operators. With it, they can respond in real time to shifting traffic volumes and re-deploy vehicles as needed.

For example, real-time identification of slower speeds due to some incident informs drivers and/or autonomous vehicles of the delays and



By 2030, self-driving cars will likely be lighter as the safety factor associated with large/heavy vehicles is eliminated due to lower accident rates.

suggests alternate routes. This data can later be used by planners and developers to identify locations for review and identify possible solutions.

Data analytics

Data analytics (converting Big Data into usable information) in transportation and logistics is expected by 2030 to mature beyond operational improvement and network optimization.[70] The application of analytics to an ever-growing array of data inputs deepens the capabilities of forecasting. It also identifies new market opportunities and helps firms better understand risk.[71]

By 2030, data-driven decision-making will be standard in the logistics infrastructure.

The IT and human resource investments companies make to remain relevant in this new paradigm are no longer optional. Fortunately, the cost of storage and the infrastructure needed to maintain robust analytics practices is in decline. Open-source platform development, leveraging the cloud and growing commercial collaboration further reduce barriers.

By 2030, data-driven decision-making will be standard in the logistics infrastructure. Risk mitigation practices will improve, enhancing the chain-of-custody tracking for regulations, security, product recalls and complex reverse logistics. These capabilities are especially important in the food and life-science supply chains, but offer opportunity for every sector[72].

Meanwhile, open source and distributed ledger software continue to grow beyond niche applications such as financial transactions into the realm of full supply chain visibility.[73] Block chain and other distributed ledger systems will be fully deployed by 2030 in supply chain management for major retail, life-sciences, advanced manufacturing and more.[74] Major investment in this developing market by major consulting firms indicates the potential for these kinds of platforms.[75]

Crowdsourcing of data remains a vital source for firms seeking to better understand consumer patterns, the operational environment, traffic and congestion, activity trends and potential risk. The development of advanced analytics and data management around crowdsourced applications strengthen the business case to include data from diverse and raw sources.

Data science skill sets needed in the workplace are becoming more available in college and university curriculum. To supplement this trend, by 2030, many companies will invest directly in the data science and analytical skills of their employees. Academic collaboration with industry on training and research will become commonplace.

Supply chain visibility

Consumer interest in product supply chain sustainability and social impact will also have an impact on the logistics infrastructure. Providing supply chain visibility to consumers, or collaboratively to supply chain partners, is a standard business practice come 2030.

Understanding the consumer's demand for responsible sourcing and manufacturing practices also provides insight into segments where price elasticity allows for a premium margin. As an example, pioneer firms enabling local and regional food sourcing offer food retailers both brand fodder and a higher price point.

As distribution (and potentially manufacturing) becomes more locally oriented in dense urban areas, the local, tangible social and environmental impacts of production and transportation are sure to increase in these areas. Visibility of these impacts will also be an important community consideration and relevant to policy makers at state, regional and local levels.

As of 2030, supply chain performance metrics will be based on collection and analysis of vast amounts of data generated by the shipments themselves, the vehicles transporting them and the infrastructure network. Individual company control towers will integrate data from smart transport corridors and vehicles to provide continuous visibility of shipments.

The regionalism of supply chains will enhance reaction times and the ability, employing artificial intelligent based management systems, to re-route vehicles to avoid or minimize delays and disruptions. These AI systems not only manage routine events, but generate alerts and options for exceptions and non-routine events.

The power of collaboration

The sharing economy is often lauded for the innovation of efficiency, but these values are not revolutionary or foreign to supply chain and material handling professionals. They are evident at every level of freight consolidations and are a vital element of profitability for many third-party logistics providers and freight forwarders.

Active collaboration and information sharing between suppliers and manufacturers is a core practice of successful supply chain management. These collaborations rely heavily on information to identify synergies. *Roadmap 2.0* workshop participants emphasized the importance of coopetition on the road to 2030.

Coordination and data analytics must be paired with new infrastructure designs or expanded use of combined unaccompanied combined transport—a significant possibility with a rise in autonomous freight vehicles.

With improvements in supply chain transparency bolstered by the proliferation of IoT and visibility technologies, more effective logistics infrastructure collaboration enables robust information sharing at a scale previously unimaginable. Standardization of data characteristics expedites adoption and efficiency. Cultural shifts toward sharing will usher in an explosion of collaboration across all modes of transportation and freight. However, security of information remains a primary concern. Long-term success depends on developing systems for information exchange without security breach.

The opportunities that data analytics provide for potential collaboration between transportation modes are also a key to successful final-mile logistics.

Standardization of data characteristics expedites adoption and efficiency.

While these practices help supply chain and material handling professionals to better manage the changing landscape, they also reduce congestion on our current infrastructure. Along with a more holistic use of our transportation and logistics infrastructure, including rail, canals and inland waterways, logistics infrastructure efficiencies will rise to the challenges of 2030. ■

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WHERE DO WE GO FROM HERE?

We asked this same question at the back of the first *Roadmap.* And honestly, the answer is much the same this time, except it is three years later.

As was said up front, *Roadmap 2.0* does not prescribe solutions or pretend to cover every contingency out there. It can't do either.

It is, instead, a high-level look at where we are and what, at the time of publication, appears to be possible going forward. Don't worry. Those possibilities are about to change. The interplay between technology, consumers, workforce and logistics infrastructure ensures that.

As you now know, this is not a prescriptive report. But it does draw a lightly featured map for future developments and challenges in material handling, logistics and supply chain. It is also worth noting that across the workshops there was considerable disagreement on what the future holds. There was plenty of agreement, too. The fact is there are lots of ways to build supply chains into the next decade.

We all know supply chains will look notably different in 2030 than they do today. Many of the same dynamics may be in place, but how they interact will surely be different.

Being able to cope with those differences will change what is considered supply chain, how it all works, and the tools at your disposal. As was said three years ago, it is our hope that the *Roadmap* "will serve as a catalyst that sparks the imagination of those developing tomorrow's" supply chains.

So, where do we go from here? It's up to you. Good luck on your journey to 2030. ■

It is our hope that *Roadmap 2.0* "will serve as a catalyst that sparks the imagination of those developing tomorrow's" supply chains.

MATERIAL HANDLING & LOGISTICS U.S. ROADMAP 2.0

powered by MHI

HOW *ROADMAP 2.0* CAME TOGETHER

The original *Material Handling & Logistics U.S. Roadmap* was released in January 2014. During the next two years, people across the supply chain read, examined, dissected and discussed what it all meant to them.

The answers varied, depending on where people sat in material handling, logistics and supply chain.

What everyone could readily agree on, however, was that the rate of change was incredibly rapid and the *Roadmap* needed to be updated sooner rather than later.

That update was done in 2016. Just as the first time around, workshops were held around the country. This time they were in Atlanta, Ga.; Trenton, N.J.; Ontario, Calif.; Tucson, Ariz.; and Chicago (see next page for a full list of participants). Nearly 200 people attended. These thought leaders came from the key stakeholders in the supply chain—practitioners, equipment and software suppliers, academia, associations and government.

Clearly, *Roadmap 2.0* was a broad industry effort. And while MHI led the effort, it was only possible because of support from other industry associations and media/publication partners (see list page 78).

Their workshops focused on four categories—technology, consumers, workforce and logistics infrastructure. At each workshop, people were asked how they expected these four areas to impact material handling, logistics and supply chain between 2016 and 2030. Their input was then combined by the authors of *Roadmap 2.0*, along with their own research, to create this report.

The body of Roadmap 2.0 was posted at www.mhlRoadmap.org and www.mhi.org for public comment. Those comments were incorporated in this final report released at ProMat 2017 in April 2017.

It should be noted that MHI, as it did the first time, entirely underwrote the effort. The material handling, logistics and supply chain industry thanks MHI for its continued generosity five years into this initiative. ■

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ROADMAP 2.0

OPEN COMMUNITY OF THOUGHT LEADERS

***Roadmap 2.0* content is based on input from nearly 200 strategic thinkers—70% of whom did not participate in the development of the first *Roadmap*.**

They include material handling and logistics practitioners, equipment and software suppliers, academics, as well as associations and government representatives.

They include material handling and logistics practitioners, equipment and software suppliers, academics, as well as associations and government representatives. These thinkers participated in one of five roundtable events held August through November 2016, dividing into 69 different discussion topic breakout sessions.

Attendees contributed their insights on recent and anticipated developments. These face-to-face, full group and breakout sessions were hosted in Atlanta, Ga.; Trenton, N.J.; Ontario, Calif.; Tucson, Ariz.; and Chicago.

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  www.naiopnj.org
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