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TRANSFORMATION AGE

SHAPING YOUR FUTURE

MHI Roadmap Series

Transformation Age: Shaping Your Future, the third publication in the MHI Roadmap Series, is intended to provide material handling, logistics and supply chain industry professionals insights into trends impacting success in the next 10 to 20 years.

TOOLS

The world needs new vocabulary to convey the continuous state of change characterized by multiple factors morphing at differing, rapid rates. The key is to distinguish among the factors that should be acted on today versus ones to watch for future commercialization and impact.

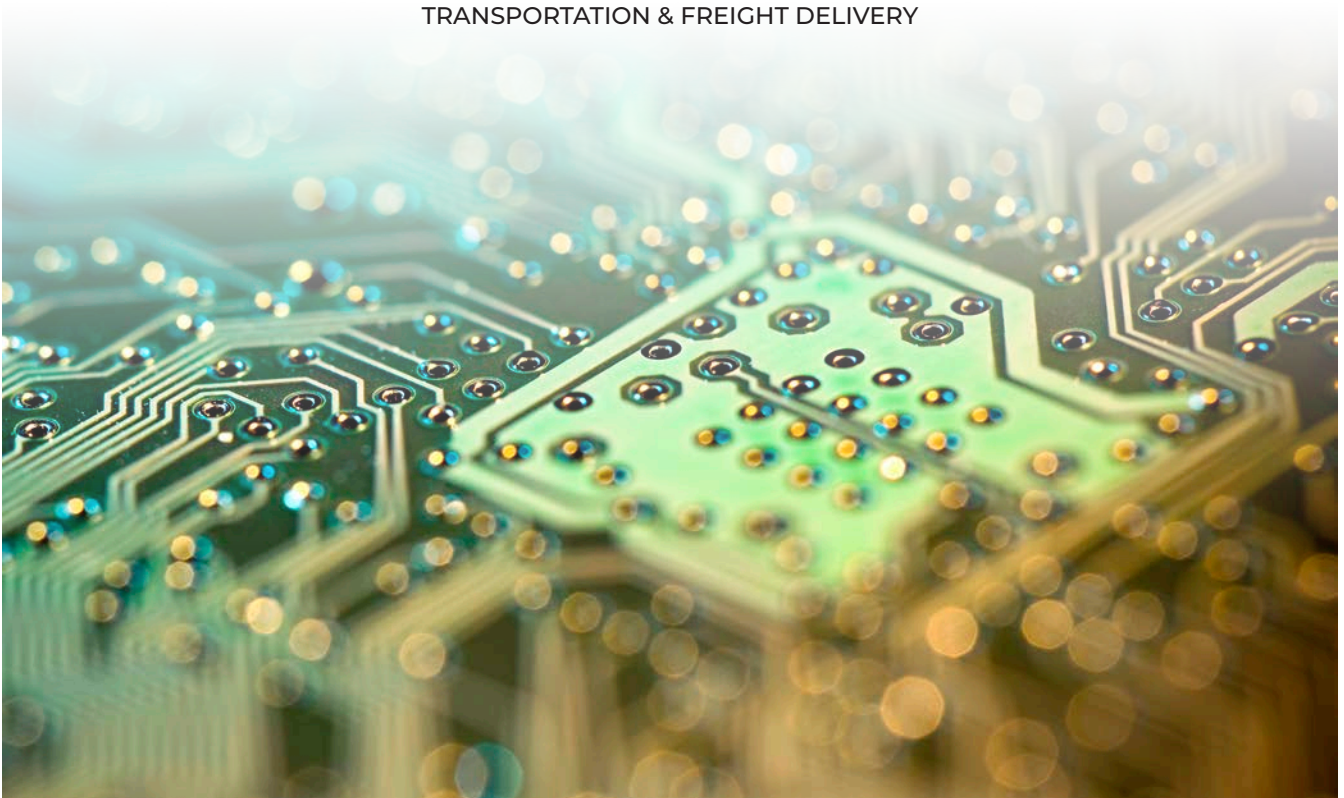
INNOVATION

SMART AUTOMATION & TECHNOLOGY

DATA & DIGITAL DECISIONING TOOLS

PACKAGING & LABELING

TRANSPORTATION & FREIGHT DELIVERY



TOOLS

INNOVATION

The convergence of advances in computing power, technology, digital decisioning tools and change mindsets brings unprecedented opportunity to the material handling and logistics industry. And to our world.

What are you going to do with it?

The world needs new vocabulary to convey the continuous state of change of multiple factors that morph at differing, rapid rates. Even quantum physics doesn't quite capture the conundrum that many are experiencing in this new era.

Success in the Transformation Age requires innovation and transformation for every industry player in some fashion or another. Clarion calls for new and improved manufacturing capabilities, integrated information flows, enhanced delivery channels and accelerated product design headline the list of needs for advanced approaches and tools.

This phase is messy for the material handling and logistics industry and will continue to be so, especially for the next five years. The promotional promises of new concepts outnumber announcements of solutions truly ready for commercialization and impact. Companies trying to embark on an evolutionary path are constrained by facility issues, cultural bias and even their own past success. So why change? Why invest in new tools?

If material handling companies and logistics companies want to be in the race, much less win it over the next five to ten years, investments in new, advanced approaches, mindsets and tools are required. Those that lag might not be around by 2030.

Industry leaders and process managers must gauge the timing and impact of new capabilities both for immediate use as well as for longer-term consideration. Some will have many shades of possibility. Others will morph in utility and effectiveness as customers implement solutions in live applications. Just as multiple versions of consumer products such as the Apple iPhone have been launched over the last decade, so too will various robotics and IoT capabilities emerge over time.

The key is to not be distracted by "hype locusts" as Jason Schenker, Chairman of The Futurist Institute cautions, but rather to distinguish among the factors that should be acted on today versus ones to watch for future commercialization and impact.

Innovation typically occurs in an iterative fashion. Waves of success and failure characterize the process, whether discovery is taking place throughout the industry, across an enterprise, or in a functional department.

INSIGHTS

- DEFINE STRATEGY, THEN TOOLS.
- TEST AND LEARN.
- STRUCTURE PILOTS CAREFULLY.
- CREATE LIFT WITH COMBO OF SMART AUTOMATION, TECHNOLOGY AND DIGITAL TOOLS.
- ADD VALUE WITH PACKAGING INNOVATIONS.
- LEVERAGE ADVANCES IN TRANSPORT AND FREIGHT DELIVERY.

Jason Schenker
Chairman, The Futurist Institute



"The key is to not be distracted by 'hype locusts'..."

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Desired Outcomes

The change environment characterizing the Transformation Age dictates a need for clarification of corporate purpose and a definition of desired outcomes in order to choose how to best move forward with innovation and change related to equipment, tools and processes.

Companies should explore and define which outcomes they are pursuing and what action are tied to each. This strategic planning process helps clarify and direct tactical decisions and execution, and ties those decisions to longer-term corporate objectives.

Desired outcomes for transformation generally fall into three large buckets:

- Improve Operating Efficiency and Productivity
- Develop New Capabilities
- Meet Customer and Market Demands

Actions required to deliver value for each outcome are different and at times overlap. Key to the execution is matching technology, processes, and people to strategies and outcomes. Without such clarity, leaders may be frustrated with the gap between innovative steps and value goal achievement.

This process also helps companies wrestle with strategic change in more manageable steps. For example, purchase of automated sorting equipment with updated maintenance sensors can meet immediate needs for efficiency and productivity improvements and improve scheduling of down-time for maintenance. This use of smart automation checks the box for moving toward strategic improvement without overhauling workforce mindsets and workplace environments. The key is to make sure that investment aligns with the longer term vision for the process and facility.

Implementation of new capabilities for packaging or information flow, usually requiring significant investment of time and resources, provides opportunities for market differentiation and growth. Who knew the refrigerator box would sell more soft drinks? Again, this type of investment should be analyzed in the context of the long-term strategic view of the firm and be compatible with the vision for the broader equipment and technology platforms.

Customer demands will drive the industry in many more ways in the future than in the past. A key question for strategy consideration is whether the demand represents a differentiating opportunity or one that can be satisfied with a collaborative industry approach with no loss of market position for contributing players.

Global Lighthouse Project



COMMITTED TO
IMPROVING THE STATE
OF THE WORLD

44 of the most advanced manufacturing factories in the world are lighting the way as learning beacons

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Test and Learn

The evolutionary nature of the Transformation Age calls for companies – from CEOs to design professionals to factory floor operators – to ask and answer questions about adapting processes and tools to achieve goals for growth, profitability and sustainability. Creating a culture around this approach is a key success factor in fostering innovation and change.

The scientific process of testing and learning, a journey proven to reap rewards for those with patience and vision, is a practice encouraged by industry leaders contemplating strategic initiatives for this decade.

While testing is widely practiced in design activities, the process also reaps benefits in equipment purchases, installation, and implementation, as well as helping improve training and maintenance. Customer touch points can also provide environments for learning by testing messaging, pricing, packaging and promotions.

A powerful benefit of the invest + test + learn strategy is that it can reset the mindset across the workforce – establishing a collaborative culture, and accelerating the acceptance and deployment of new tools and decisioning systems. In the best scenarios, change represents steps toward opportunity.

Pilot Programs

Much has been discussed about the value of pilot programs in transforming company processes and approaches. Consensus among industry experts points to the importance of how such programs are led, structured, measured and monitored.

Companies with experience in utilizing pilots as part of their innovation and transformation initiatives point to a number of key success factors:

- Own and demonstrate innovation and transformation at the top.
- Create a corporate culture of innovation that rewards new ideas.
- Clearly define the desired transformation outcomes of the innovation pilot in terms directly tied to the company's long-term strategy.
- Educate your board of directors and other key stakeholders about the purpose and use of pilot programs.
- Create pilots that involve more than one department or division. Cross-department collaboration results in more ideas and solutions, and increased probability of success.
- Structure pilots to provide rapid success or failure. Learn quickly and adapt.
- Reward employee efforts in the process, not just the results.
- Share learnings broadly within the company to accelerate new ideas and future pilots.
- Fund pilot initiatives adequately.
- Commit to a long-term pilot framework: pilot, learn, adapt, repeat.

Brett Wood
President and CEO, Toyota Material
Handling North America



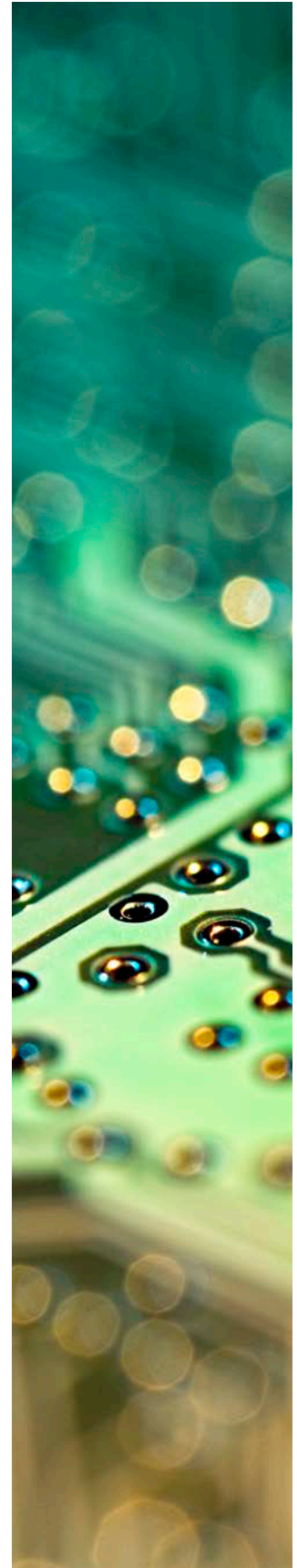
"The key is to invest and test. That philosophy drives our product development."

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Keys to Success

Did you ever wish you had known something before you began a new initiative? Industry leaders and experts have a general consensus on ways to increase the probability of success. Keep these critical success factors in mind as you plan and execute new tools:

- Determine long-term strategy, then tools. For what purpose are you implementing smart automation and digital tools?
- Build for flexibility, scalability, and modular enhancements.
- Identify a long-term software platform: The biggest threat to effective implementation is using multiple devices with different vendor software.
- Invest time in getting everyone on board.
- Talk to others who have implemented solutions you are considering: what lessons did they learn? For example, the pattern of adoption can make a difference.
- Budget for training costs and allocate training time for everyone from equipment operators to information users.
- Acknowledge implementation may be messy at times, with a learning curve for combining machinery + people + environment.



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SMART AUTOMATION & TECHNOLOGY

Opportunities abound for new, smart automation and technology in the material handling and logistics industry.

The next twenty years will see dramatic changes in equipment and processes. Many of the changes will be enhancements to initial product releases, while others will represent step-change technology innovations.

Stepping away from specific equipment and technology choices, innovation in engineering capabilities available today and those expected to be viable over the coming decade will provide new avenues for cost efficiencies, product design, equipment training and customer solutions.

A key factor in identifying the value of new capabilities is to evaluate both their singular contribution as well as the value found at the intersection with multiple other factors.

As an example, new material handling or manufacturing equipment may yield greater volume and precision. But the pairing of that equipment with sensors that feed AI and analytics platforms provides opportunities for information to inform and enable scheduling, maintenance, training, sales and marketing. Adding edge computing resources paired with cloud broadband power creates near real-time information for management decisions. Utilizing AR tools that pair human work with machine intelligence reduces time and improves performance for operations, maintenance and repairs.

The combined lift becomes exponential in benefits and payback.

John Paxton
COO, MHI



“The next decade will see great strides in commercialization of new and advanced tools in the material handling and logistics industry. Every sector, from manufacturing to retail stores will see transformations in the way materials are produced, stored, transported, tracked and sold.”

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Quick Overview of Smart Technologies

A transformative view of industry tools includes a number of known categories, with expectations that the benefits offered within each will expand over time.

SMART TECHNOLOGIES



Cognitive Engineering: Cognitive engineering is a multidisciplinary approach to analysis and design of complex systems and equipment utilizing human factors, psychology, cognitive science, human-technology interaction, and systems engineering. The desired outcome is to provide a wholistic experience enabling a faster, more productive, safer, and at times, more meaningful work environment.



IoT: Incorporation of digital measurement devices with traditional and new equipment provides one of the greatest enhancements to long-standing and emerging companies, allowing rapid capture and transfer of information. Devices incorporated into wearables and mobile devices leverage man + machine information and enable work environments.



5 Senses and More: Many new technologies will emerge with variations based on use of one or more of the 5 human senses- See, Sound, Smell, Touch, and Taste. Human behaviors such as gesturing are being added to man+ machine interfaces.



Neurotechnology Ecosystems: Neurotechnology is where man+ machine meet, interact, and enhance the performance of both.



Augmented Reality and Virtual Reality: Already appearing in both industrial and civic settings, forecasts for the expansion of Augmented Reality (AR) and Virtual Reality (VR) applications suggest these technologies will be prevalent by 2030 and pervasive by 2040.



Robotics: Still in its infancy, robotics is expected to become far more sophisticated in the coming decade, moving from replacement of simple, repetitive human activities to activities humans cannot conduct or even imagine today.



Drones: Great strides have been made in drone equipment, technology, regulation and uses in the last decade, and especially in the timeframe 2018-2020. The coming decade will see much greater use of drones and a wider range of industry applications.

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TOOLS

Cognitive Engineering

Cognitive engineering is a multidisciplinary approach to analysis and design of complex systems and equipment utilizing human factors, psychology, cognitive science, human-technology interaction, and systems engineering. The desired outcome is to provide a wholistic experience enabling a faster, more productive, safer, and at times, more meaningful work environment. This approach characterizes much of the innovative design work underway in the industry, with a growing emphasis on the human-technology interface expected over the coming decade.

Cognitive engineering enables positive man + machine interfaces and process improvements which lead to easier adoption, and safer and more productive equipment and technology uses.

Applications for the workplace include improvements in equipment operation, maintenance, and safety for both human and autonomous operators. Today, cognitive engineering applications paired with telematics (telecommunications + informatics), abound in vehicles, from highway transportation to fork lifts. Advanced features and benefits will continue to multiply.

Wider range applications include shifts in workplace environments to accommodate temperature, lighting, sound and ambiance preferences.

IoT

Incorporation of digital measurement devices with traditional and new equipment provides one of the greatest enhancements to long-standing and emerging companies, allowing rapid capture and transfer of information. Devices incorporated into wearables and mobile devices leverage man + machine information and enable work environments.

Sensor capabilities have grown significantly in recent years, adding a broad range of human senses to engineering-based measurements. Smart wearables that utilize IoT, video, text and visualization capabilities are becoming commonplace in the industry. These IoT tools are leveraging the man + machine interface and creating real financial value. Growth in the use of these tools is expected to rise sharply over the next five years, with continued growth for the remainder of the decade as cost decreases and uses multiply.

Ease of entry makes IoT technology one that companies of all sizes can begin to implement now. Applications for use of IoT are expected to expand dramatically over the next five years, becoming a best practice standard by the end of the decade. IoT interfaces along the supply chain will multiply, feeding accounting, safety, sales, marketing and regulatory information systems. Volume will drive the cost down, enabling more companies to utilize this technology.

Bill Ferrell

Ph.D, PE Fluor Professor of Industrial Engineering Associate Dean of the Graduate School Clemson University



“The variety of ways that humans will interact with the internet as well as the number of implementations are going to increase dramatically and bring efficiencies and new capabilities to the supply chain. Wearables, equipment sensors, smart robotics and more will be useful for operations, maintenance and safety.”

TOOLS

Innovation in use of sensors comes with friction from debate over privacy, bias, data ownership, legal and regulatory compliance, and security. These issues will garner significant attention over the next ten years.

5 Senses and More

Many new technologies will emerge with variations based on use of one or more of the 5 human senses – See, Sound, Smell, Touch, and Taste. Human behaviors such as gesturing are being added to man + machine interfaces.

Vision and voice recognition capabilities are expanding for robotics and worker-centric facilities. Touch and gesture commands are being incorporated into digital screens, assistants and equipment. Sight is key in the AR and VR worlds and smell and taste are already a part of retail experiential strategies.

The primary message here is that smart automation and digital technologies are improving in part because of advancements that humanize the user experience. This trend will continue, in turn creating greater adoption by companies, facilitating higher performance levels and increasing acceptance by workers.

Neurotechnology Ecosystems

Neurotechnology is where man + machine meet, interact, and enhance the performance of both.

Advancements in this brain technology will be an important driver of innovation in intelligent manufacturing and material handling systems over the next 10 years, with significant commercial impact in the decade to follow.

A variety of technologies measure cognitive and affective brain functions and translate the data into meaningful insights and actions for personal, commercial and industrial uses. Hardware and software tools are used to monitor, analyze, visualize and understand brain data for analytical purposes, behavior modulation and modification, or for interfaces with smart devices.

Advances in wearables and other portable devices, telecommunications, AI and computing are converging to provide greater uses and utility for this technology. Other technologies such as Augmented Reality and Virtual Reality will grow as a response to advances in neurotechnology.

Benefits for material handling and logistics environments include workplace wellness, safety, learning and productivity. Neurofeedback on employees' levels of stress and attention can inform workplace management, leading to healthier employees and a safer and more productive workplace.

“Many companies are already leveraging this technology,” says Olivier Oullier, president of EMOTIV a leading provider of portable wireless brain-sensing solutions.

Olivier Oullier
President, Emotiv



Trend Expert

“Technology coupled with responsive, adaptive work environments provides the best working conditions and delivers great workplace wellness, safety, learning and productivity.”

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“These solutions allow a company to measure in real-time some of people’s affective and cognitive states such as stress, attention, and distraction. This information is then used to provide work assistance such as additional training or changes in schedules.

These neuro-tech based solutions also enable someone to mind-control connected objects, software or robotic workstations.”

Controls stemming from brain function, facial expressions and motion enabled machine operation, environmental control and human behavior modulation and modification. These science-based solutions leverage personalized neuroinformatics and machine learning.

In commercial use today, neurotech devices and machine learning algorithms are combined to convert brain waves into digital signals that operate a wide variety of smart equipment. This type of user interface can be used to control virtual and real objects just by thinking, replacing traditional input devices such as keyboards and keypads.

“Use of these technologies provides benefits to both employers and workers,” says Oullier. “We need to stop asking employees to adapt to a fixed work environment and start offering work environments that dynamically adapt to the employees. The end result is a safer and more productive facility and a happier, healthier employee.”

“We need to stop asking employees to adapt to a fixed work environment and start adjusting the work environment to the employee.”

Olivier Oullier, President, Emotiv

An area of great promise for this technology is the provision of useful applications for physically impaired individuals. Through the use of this technology, those traditionally unable to participate in the workforce will find new avenues for employment. Everyday life abilities will also be enhanced, supporting greater independent living, enhanced functionality and a broader scope of activities.

Augmented Reality and Virtual Reality

Already appearing in both industrial and civic settings, forecasts for the expansion of Augmented Reality (AR) and Virtual Reality (VR) applications suggest these technologies will be prevalent by 2030 and pervasive by 2040. 1

Both of these technologies enable collaborative work in real time and experiences beyond present time and location.

Augmented Reality is gaining popularity in material handling equipment operation and maintenance. Glasses enabled with AR informatics and links to service experts reduce time for equipment maintenance. Similar benefits accrue for training.



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Applications include: 3

- Visualizing digital twin images and data within a real-world environment context. This application helps with equipment design, customization, training and operation.
- Quality and performance monitoring, utilizing past and present images for comparison.
- Remote assistance allowing the technician and expert to work collaboratively, sharing a view of the live equipment as well as maintenance and repair data and instructions.
- Monitoring real-time health of equipment or products from close range or distance without having to traverse the factory or distribution center floor.

With acceptance growing and equipment costs dropping, use of these technologies will greatly expand over the decade. 2

Growth in Smart Cities that incorporate AR technology tools will in turn spur industrial and retail applications.

The integration of AR and VR technologies with neurotechnology systems represents a next step advance that will emerge in this decade. This integration will spur the use of both AR, VR and neurotechnology systems.

Robotics

Still in its infancy, robotics is expected to become far more sophisticated in the coming decade, moving from replacement of simple, repetitive human activities to activities humans cannot conduct or even imagine today.

A key to imagining the future of this field is to remember that advancements in AI, Edge computing, quantum computing, semiconductors, material components, batteries, electric vehicles, industrial and urban infrastructure, and telecommunications will impact the pace of change and the breadth of applications.

Industry experience with robotics over the past five years varies dramatically. At the same time, the field has moved forward with innovations, making practical applications more effective, flexible and varied.

Robotics provides stationary and mobile capabilities for transforming material handling work environments. Improvements in flexibility, safety and guidance systems promise broader adoption in the next five years.

Melonee Wise
CEO, Fetch Robotics



Trend Expert

“Robots have very different applications. For example, there are robots that weld cars, some go under the ocean, others are used to deliver toothpaste inside a hotel. It’s not one thing.”

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Nuances in robotic applications now include on-demand automation of activities and data collection, providing enhanced flexibility and safety of implementation and ongoing usage. Without the need for fixed guidance infrastructure, installation is quicker and uses are more flexible in industrial environments. This change has the potential to spur adoption significantly.

Robotics for material handling are not reserved for industrial settings. Innovation in commercial and home environments will incorporate AMRs and other robotics in the coming decade. 4 Needs for moving heavy loads, from office supplies to groceries and gardening mulch will be addressed with small-scale, portable robotic equipment and devices.

Key success factors related to implementation of robotics include (1) mapping out detailed process steps to be performed with robotics prior to purchase, (2) reaching buy-in and support of the workforce, (3) investing in time and resources for operator training as well as training for others working in the shared environment, (4) investing in programming resources to ensure robotics benefits are fully realized.

Drones

Great strides have been made in drone equipment, technology, regulation and uses in the last decade, and especially in the timeframe 2018-2020. The coming decade will see much greater use of drones and a wider range of industry applications.

Competitive differentiation opportunities exist along the supply chain for movement of goods and people, monitoring, mapping, surveillance, and other services utilizing proprietary drones as well as drone services.

The 2019 drone market forecast by Drone Industry Insights calls for the drone market to hit \$43 billion by 2024, representing a compound growth rate of 20.5% and tripling the market value compared to 2018. 5 The forecast anticipates Services to continue as the leading segment in the drone industry with Software growing at the fastest rate.

End-to-end solution providers are expected to continue to lead market R&D and growth.

The Energy industry leads in use of drones and the forecast states that leadership position is expected to continue through at least 2024. Agriculture and construction follow, but Transportation and Warehousing companies are the fastest growing users and are expected to take over the second rank by 2025. Most notably, Kay Wackwitz, CEO and founder of Drone Industry Insights, says "...the drone market will grow much larger than initially expected and predicted..." 6

While a lot of growth and innovation will occur in this industry, with short-term benefits accruing to the material handling and logistics industry as well as others, much work remains to address issues pertaining to public acceptance, regulations, safety and infrastructure. Progress will be rapid, but mitigated by these factors.

The drone industry is now bifurcated into two categories of drones: those with existing commercial use, and others with great promise, such as eVTOLs, but require significant investment in R&D before broad adoption and usage is expected. The material handling and logistics industry will benefit from both types by 2030.

Kay Wackwitz
CEO and Founder, Drone Industry Insights



"The drone market will continue to grow much larger than initially expected and predicted."

TOOLS

Understanding the various types and uses of drones will be important in building competitive transport strategies for the next several decades. Each type is built for a specific purpose, including flight length, load weight, and environmental factors such as whether or not a runway is available.

Purpose

Counter Drones

Used for surveillance, detection and deterrence.

Delivery Drones

Commercial, industrial and private/public partnership drones used for transporting goods.

Passenger Drones

Commercial and private drones used for human transport.

Styles

Piloting

Piloted/manned and unpiloted/unmanned

Energy

- Electric
- Hydrogen/Fuel Cell
- Gasoline or Kerosene/Combustion Engine/Turbine and Generator

Configuration

Vertical Takeoff and Landing (VTOL)
Conventional Takeoff and Landing (CTOL)

Automation and Autonomy

Partial Automation to Fully Autonomous



Millie Radovic
Market Analyst
Drone Industry Insights



“The disruptive power of delivery and passenger drones is the first step in the radical reshaping of both the aviation industry and the way we move in urban environments.”

Data: Drone Industry Insights. Graphic by Burchette & Associates

Development and growth in drones will be dependent and intertwined with the evolution of the broader topic of [Urban Air Mobility](#). National infrastructure, Smart Cities, transportation technologies, regulations, public acceptance and smart automation will all play a role in the future of drones.

Sources

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TOOLS

DATA & DIGITAL DECISIONING TOOLS

Data and digital decisioning tools are bringing step-change advancements to material handling and logistics. In the next five years, digital technologies could well produce the greatest changes to the industry – and to the world – ever experienced and ever imagined.

The enormity of the impact will be evolutionary, creating lasting changes to the way data is obtained, stored, analyzed and used. In turn, the resulting informatics capabilities will impact everything from material and product design to marketing and logistics scheduling.

Advancements in these technologies will continue throughout this decade and well into the next. Every aspect of material handling and logistics will be impacted and every industry sector can benefit.

Quick Overview of Data and Digital Decisioning Tools



Infonomics: Infonomics - or the economics of information - is the discipline of managing and accounting for information. Approached with the same rigor as other business assets, companies have the opportunity to derive and optimize the value of their proprietary information.



Digital Twins: The digital virtual world can mirror reality in actionable ways.



Standardized Platforms and Protocols: Adaptation of smart technology and digital tools by material handling and logistics companies would be greatly enhanced by greater standardization of industry technology protocols and software platforms. Many firms cite this issue as an obstacle in their transformation initiatives.



Computing Power: By 2030, innovations in compute technology and processes will greatly enable speed, memory and capacity of computers and machines. Capabilities announced in the last two decades will gain traction and existing solutions will be enhanced far beyond current state offerings.



Quantum Computing: Up until now, mankind has been constrained in using technology to solve problems by the limits of computing power, memory and speed of computers and machines. With advances in quantum computing, and growing opportunities for commercially available applications, the challenge becomes one of imagining the issues to solve.



5G Broadband and Beyond: Coming into 2020, fewer than 30 cities in the United States have 5G broadband service, and even those do not have complete coverage across their city limits. Customers who do have the service will experience faster speeds and lower latency, translating to improved abilities for data capture and use.



Blockchain: It's all about truth and certainty - and having the information to certify that truth.



AI: By 2030, innovations in compute technology and processes will greatly enable speed, memory and capacity of computers and machines. Capabilities announced in the last two decades will gain traction and existing solutions will be enhanced far beyond current state offerings.

“5 Reasons Not to Delay Your Digital Transformation,” by Lawrence White for World Economic Forum



A worker on a Audi assembly line in Hungary.
image: REUTERS/Laszio Balogh

TOOLS

Infonomics

Infonomics – or the economics of information – is the discipline of managing and accounting for information. Approached with the same rigor as other business assets, companies have the opportunity to derive and optimize the value of their proprietary information.

This process examines the production and consumption of data and the transfer of money to produce, sell or obtain information.

Data and information will drive the next two decades as never before. Sales cycles, inventory controls, marketing initiatives, risk management, production cycles, transportation schedules... every facet of the supply chain... will be data driven. By 2030, leaders in material handling and logistics will be those who generate business value from their data.

Beyond immediate important internal uses, industry players will have myriad opportunities to leverage their proprietary data for financial gain. Debates surrounding data and information ownership and privacy will increase, signaling the need for greater clarification in communication surrounding data privileges and underscoring the value of secure digital information technologies such as Block Chain.

Accounting practices do not yet recognize data as a formal company asset, but that too may change as more companies and brands find financial value in leveraging information about products, markets and customers.

Digital Twins

The digital virtual world can mirror reality in actionable ways.

Other definitions extend the concept to include processes and people. ²

Gartner defines a digital twin as a software design pattern that represents a physical object with the objective of understanding the asset's state, responding to changes, improving business operations and adding value. ¹

A screen displaying graphic representations and data on the unique and integrated operations of equipment in a manufacturing facility provides a digital twin of the actual equipment operation. This type of digital twin is useful because it allows a facility operator to see the information in an aggregated form that is actionable. The same application is useful in a distribution center to view products and environmental conditions.

Training via internet screens or AR technology can utilize digital twins to provide the workforce with realistic simulations.

Uses of digital twinning also includes predictive twins, which model the future state and behavior of a device based on historical data from other devices. ² This predictive tool promises to further extend the value of twinning and IoT.

Use of digital twinning is expected to expand in the coming decade as more and more of life on Earth is conducted via digital means.

Naras Eechambadi,
President and Founder, Quaero



Trend Expert

**Data is Great, but What You Do with
it is Where the Value Lies.**

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Standardized Platforms and Protocols vs. Equipment Based Software

Industrial Platforms and Protocols

Adaptation of smart technology and digital tools by material handling and logistics companies would be greatly enhanced by greater standardization of industry technology protocols and software platforms. Many firms cite this issue as an obstacle in their transformation initiatives.

This issue often inhibits companies' ability to integrate processes across equipment manufacturers and impedes valuable data flow.

Much talk about the need for standardized industrial software platforms has yet to produce a meaningful breakthrough to resolve this issue. The firm or venture that cracks this design will become the enabler of rapid transformation for many industry companies.

Home Product Platforms and Protocols

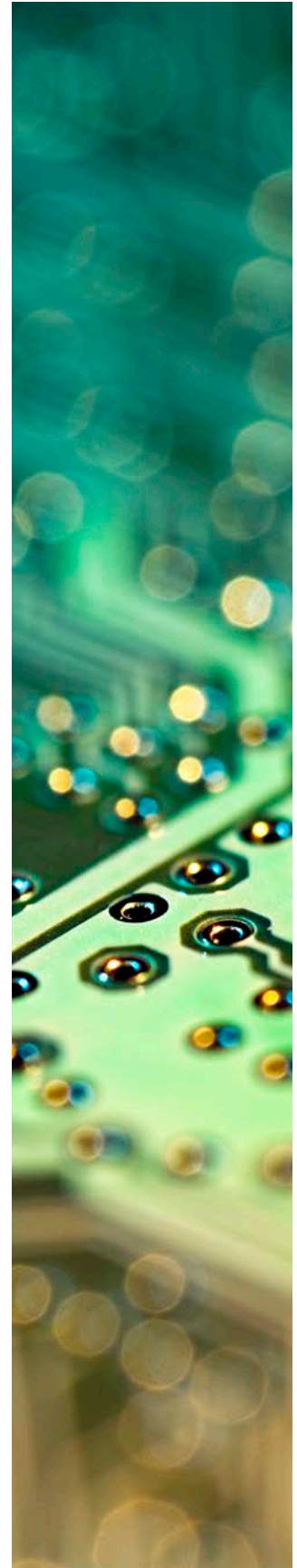
In the consumer products world, a new working group was announced in December 2019 by Amazon, Apple, Google and the Zigbee Alliance to “develop and promote the adoption of a new, royalty-free connectivity standard to increase compatibility among smart home products, with security as a fundamental design tenet.” 3

This collaborative venture aims to tackle the challenge of standardizing in-home protocols.

Apple notes in the project announcement, “The goal of the Connected Home over IP project is to simplify development for manufacturers and increase compatibility for consumers. The project is built around a shared belief that smart home devices should be secure, reliable, and seamless to use. By building upon Internet Protocol (IP), the project aims to enable communication across smart home devices, mobile apps, and cloud services and to define a specific set of IP-based networking technologies for device certification.”

This industry working group, dubbed “Project Connected Home over IP,” already includes a variety of Zigbee Alliance board member companies and welcomes other device manufacturers, silicon providers, and other developers from across the smart home industry to participate in and contribute to the standard.

If you'd like to get involved or receive updates visit connectedhomeip.com.



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AI

The use and effectiveness of AI has increased significantly in the past 3-5 years. The impact will grow exponentially in the coming decade, affecting every industry, business, and nation. Most individuals will be impacted in some way, whether they are aware of it or not.

Ponder these stats from the "AI Index 2019 Annual Report": 4

- In a year and a half, the time required to train a large image classification system on cloud infrastructure has fallen from about three hours in October 2017 to about 88 seconds in July, 2019. During the same period, the cost to train such a system has fallen similarly.
- Prior to 2012, AI results closely tracked Moore's Law, with compute doubling every two years. Post-2012, compute has been doubling every 3.4 months.
- In the five months since being launched in May 2019, the T5 Team at Google almost reached human baseline in the language-based AI SuperGLUE competition with a score of 88.9. Human baseline is 89.8. Industry bets are the team will exceed a score of 90 by May 2020.

The combination of AI and smart technology is the brain behind the use of IoT smart sensors, edge computing, cloud technology, 5G and next generation broadband, satellite communication systems, and more.

Best practices around AI uses will evolve over the next decade. The most frequently identified societal considerations relative to AI, as reported in the "AI Index Annual Report 2019," include fairness, interpretability and explainability. Standards around ownership and usage of data will continue to be key points of discussion and debate within the industry as this technology evolves and more uses and users are added.

Key areas of AI usage today include data analytics, semantic segmentation, image classification, image generation and temporal activity localization. Development of production and activity benchmarks and innovative machine learning algorithms continue to advance the technology in each of these areas.

Material handling and logistics fields of robotics, IoT, product design, packaging and transportation will continue to benefit from AI embedded solutions. Improvements in computing capabilities will enable larger data sets to be used, which in turn will improve machine learning and machine teaching capabilities.

Next steps in advancing this technology depend on improvements in algorithms used to serve specific needs. For example, to improve AI applications in robotics, improvements are needed across cognitive functions of vision, natural language, spatial relationships and task-specific knowledge.

"AI in Shipping: Areas to watch in 2020," by Alexander Love for Ship Technology



TOOLS

Computing Power

By 2030, innovations in compute technology and processes will greatly enable speed, memory and capacity of computers and machines. Capabilities announced in the last two decades will gain traction and existing solutions will be enhanced far beyond current state offerings.

Integration across platforms, devices and processes will enable AI and IoT in commercial, industrial, consumer and military applications. Compute processes will be integrated in new ways for technology underpinning a wide array of capabilities from EV guidance systems and Smart Cities to those in complex industrial manufacturing.

“Computers were the fundamental driver of digital progress until now. Going forward, machine learning will be the fundamental driver,” says Pablos Holman, inventor and founder of Komposite. 5

He cautions, “But we need to always keep in mind, technology is just a tool, and like a hammer we can use it to smash a head or build a house. We need to become possibilistists and think about how the future could be better.”

Going forward machine learning will be the fundamental driver.

Pablos Holman, Inventor and Founder, Komposite

Technology advances as well as greater integration across the computing spectrum will allow meaningful collaboration among people and processes and enable faster decision cycles, while at the same time dictating greater requirements for information sharing throughout supply chains and business and personal processes.

Compute Technologies to Watch

3D Computing

MIT researchers announced a 3D chip fabrication method in 2017 that uses carbon nanotubes and resistive random access memory (RRAM) cells. 6 Commercialization followed when Intel launched a 3D silicon chip in 2018. Scaling chip production has already begun, impacting product design across many industry sectors.

The advancement from 2D to 3D is significant, allowing far more chips to be placed on a motherboard, and notably, enabling greater integrated chip functions and an increase in information pathways. The resulting increase in power and speed in a small space promises to advance infinite IoT applications powering large equipment, modular systems, portable devices and wearables.

Pablos Holman
Inventor and Founder, Komposite



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TOOLS

DNA Computing

DNA computing is a branch of biomolecular computing that uses DNA as a carrier of information for arithmetic and logic operations. Still in its early stages, DNA computing is being explored by leading technology companies such as Microsoft and attracting attention from a world community of scientists.

“As incredible as it sounds, DNA can be used for computing, says Stephen McBride, editor of RiskHedge Report and contributing author to Forbes. “One pound of DNA has the capacity to store more information than all the computers ever built.” 7

This approach has important implications for information recording and archival data storage in molecular form.

In their nature.com article on digital data storage using DNA, Luis Ceze, Jeff Navala and Karin Strauss note, “Molecular data storage is an attractive alternative for dense and durable information storage, which is sorely needed to deal with the growing gap between information production and the ability to store data. DNA is a clear example of effective archival data storage in molecular form.” 8

The researchers point out a number of benefits of this data storage tool. High density storage in the magnitude of six times that of other approaches available today will become increasingly important as more and more data is generated through a variety of smart technologies. This high density characteristic promotes long-term preservation of data in molecules at low energy costs. The ease of replicating DNA enables copying large amounts of data faster and at lower costs.

DNA also offers advantages for long-term archival storage. As the researchers note, “DNA is time tested by nature, with DNA sequences having been read from fossils thousand of years old.”

When kept away from lights and humidity and at reasonable temperatures, DNA can last for centuries to millenia. An interesting point made by the researchers is that DNA has been time tested by nature, with DNA sequences having been read from fossils thousands of years old.

Researchers and data scientists agree that this digital tool is one to watch over the coming decade. Not only will storage capabilities be improved, but other technologies that feed and use the data will be advanced as well.

Edge Computing

Answers lie at the edge. Costs savings and digital efficiencies are to be found there too.

There is much to discover at the edge, onsite or near an industrial or commercial activity. Smart Cities will benefit as well. So will consumer experience.

While cloud computing brings great memory and bandwidth for managing large amounts of data, there is great distance between most cloud platforms and their data sources. This distance introduces latencies that reduce the timeliness, and at times the usefulness, of information gleaned from algorithms in the cloud.

Edge computing provides the geographic proximity to functional IoT sensors, and, more importantly, proximity to decision makers who may need to act expediently to the information gleaned from monitors and analytics.

“Molecular Digital Data Storage Using DNA,” by Luis Ceze, Jeff Navala and Karin Strauss



“Cisco Alums Reunite: Prem Jain’s Pensando Spins into the Edge-Computing Conversation,” by Mark Albertson for Silicon Angle



TOOLS

Already in commercial use, edge computing is providing impact on data security, speed, reliability, and scalability. Powerful, timely data collection is driving data analytics, developed and honed in cloud environments, that provide in-the-moment actionable results.

Many of the benefits of edge computing are achieved when paired with the power of cloud computing. For example, algorithms in the cloud can be used to analyze and test data streams to optimize manufacturing production or inventory controls. The updated analytics can be delivered to the edge on a daily or hourly basis to modify operations. The same approach can be used to optimize vehicle traffic management or local weather forecasting.

Consumer experiences can also be modified with edge computing – in this case sometimes referred to as “ambient computing.” Suggestions for additional items or recipes can be served up to a shopper in a grocery store, a blouse suggestion for a shopper buying slacks, or athletic socks to someone purchasing running shoes. The suggestions are based on algorithms developed and enhanced in the cloud, with the application to specific shopping experiences enhanced at the edge.

Much of the impact of IoT and AI will be delivered through edge technology. Over the next several years, edge computing will quickly become ubiquitous, with tremendous impact over the decade.

Exascale Computing

Think big. Think fast. Really fast. 10¹⁸ fast. Quintillion calculations per second.

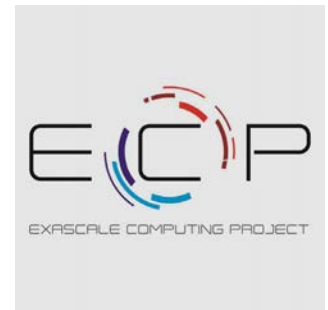
That’s 5 times faster than the world’s largest supercomputer can deliver today.

And the U.S. is on it.

The United States embarked on a 7-year project in 2016, known as the “Exascale Computing Project,” to develop the hardware, software and protocols to bring this capability to reality by 2021. The project promises to have a “profound impact on life in the coming decades.”⁹

The project is being conducted as a collaborative effort of two US Department of Energy (DOE) organizations the Office of Science (DOE-SC) and the National Nuclear Security Administration (NNSA), to advance the country’s efforts in scientific discovery, energy assurance, economic competitiveness, and national security.

The mission of this strategic initiative is to deliver applications, system software, hardware technologies and architectures to establish “an enduring national HPC (High Performance Computing) ecosystem along with HPC workforce development.”



“...Exascale super computers will more realistically simulate the processes involved in precision medicine, regional climate, additive manufacturing, the conversion of plants to biofuels, the relationship between energy and water use, the unseen physics in materials discovery and design, the fundamental forces of the universe, and much more.”

exascaleproject.org

TOOLS

World-wide competition for development of exascale technologies pits the U.S. project against initiatives in China, Taiwan, European Union, Japan and India.

Along the way to reaching their end goal, Exascale Computing Project teams are developing capabilities that in and of themselves bring added value to improving current computing applications. Announcements are posted frequently on exascaleproject.org.

A 2020 Research and Markets report cites MindCommerce as seeing the advent of hybrid systems that will utilize both quantum and classical CPUs on the same computing platform. 10

Research and Markets is high on this technology, writing in their report, "These next generation computing systems will provide the best of both worlds – high speed general purpose computing combined with use case specific ultra-performance for certain tasks that will remain outside the range of binary computation for the foreseeable future." 10

Quantum Computing

If only we could imagine...

Up until now, mankind has been constrained in using technology to solve problems by the limits of computing power, memory and speed of computers and machines. With advances in quantum computing, and growing opportunities for commercially available applications, the challenge becomes one of imagining the issues to solve.

Quantum computing is based on quantum bits referred to as qubits. Each qubit doubles the computing power of a linear bit. That increase in computing power represents enormous potential.

In a sense, quantum computing isn't better than traditional methods – it's different. The class of problems it can solve is different from those served well by approaches broadly embraced today.

The nature of quantum computing isn't just about speed. Quantum computers enable complex modeling and simulation functions of large data sets. These capabilities are escalating AI, molecular modeling, cryptography, financial modeling, weather forecasting and particle physics.

On the flip side, cybersecurity experts warn that encryption strategies must be adapted to counter quantum-based attacks. 11

Already in use in well-funded scientific and technology design environments, quantum computing is being developed, tested and used by hundreds of organizations worldwide. 12

Implications for the material handling and logistics industry include escalation of development of autonomous vehicles and robotics, development of new materials for use in industrial environments, and advances in augmented reality and virtual reality applications.



TOOLS

Over the next decade, discovery and innovation in quantum computing, programming and problem solving will lead to novel creations and solutions for commercialization and impact.

If we can only imagine....

5G Broadband and Beyond

Coming into 2020, fewer than 30 cities in the United States have 5G broadband service, and even those do not have complete coverage across their city limits. Customers who do have the service will experience faster speeds and lower latency, translating to improved abilities for data capture and use.

Seemingly instant downloads and connections will improve manufacturing processes, business interactions, and customer experiences, whether virtual or real. Collaborative product design, freight transportation and delivery, Smart Cities, equipment maintenance, machine learning, virtual education and training tools, autonomous vehicle management, robotics execution and drone surveillance will become more powerful, customizable and effective.

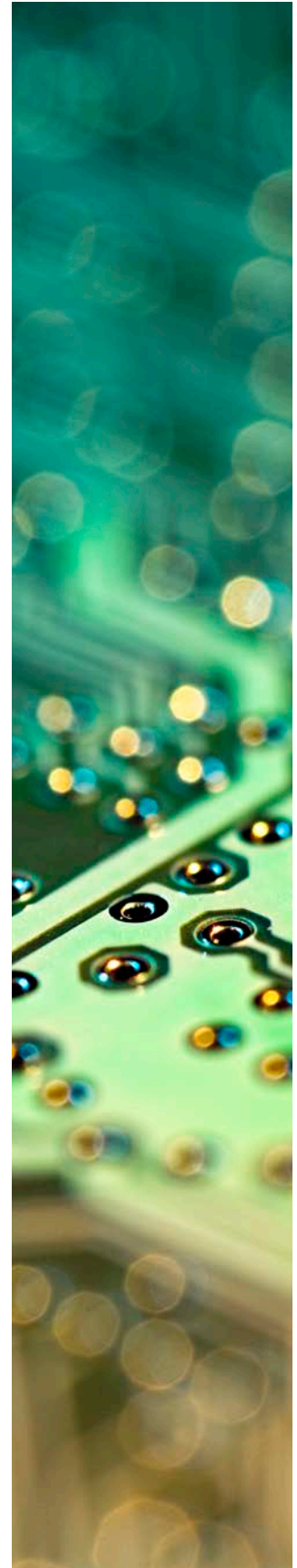
While 5G is being rolled out, the next generation – 6G, or by whatever name the next iteration is known – is already being researched and developed by engineers and labs around the world. This next generation network is predicted to be available by 2030, but may be a reality even sooner.^{13, 14} The key expectations are for even greater bandwidth, and that any issues encountered with 5G will be addressed with this next network technology. During this decade, advances in other areas of technology may provide new avenues for communication technology that enhance 6G in ways not even imagined today.

An issue getting attention in the telecom industry today is the state of current fixed infrastructure – the cables, fibers and switches – and the gap between the fixed side and the quickly evolving mobile side. Most of the advancements in recent years have been on the mobile side. Fixed networks don't have the capacity to handle the larger and faster data sets of 5G, much less what comes beyond that. The result will be delayed signals at switches and routers.

Work on future infrastructure capabilities is necessary, according to Richard Li, chief scientist of future networks at Huawei and the chairman of the United Nations' International Telecommunication Union (ITU) 2030 focus group. He offered that assessment in, "Now's the Time to Think About What Comes After 5G," an article in the IEEE Signal Processing newsletter.¹⁵

Article author, Yang Li, cites Li's opinion that "The next generation, 6G, will likely bring applications with even higher throughput requirements. Li says autonomous vehicles, massive machine-type communications, tactile Internet, and holographic communications are all on the table for the coming years. But the current fixed side won't be able to withstand the coming surge."

"Fixed networks that will be able to support the 6G networks. That is the key," says Li



TOOLS

Blockchain

It's all about truth and certainty – and having the information to certify that truth.

Blockchain is a distributed ledger technology that provides a way to create a secure and permanent digital record of an asset's origin, characteristics, and ownership as well as its pathway across the supply chain.

The technology provides a digital framework through which information is documented, verified and shared.

This digital tool enables public information sharing in support of verifiable sourcing, security, safety, financial transactions and compliance. The benefits to individuals and businesses promise to drive a whole new standard for transactional relationships over this decade

The benefits to individuals and businesses promise to drive a whole new standard for transactional relationships over this decade.

The potential is enormous and the benefits will accrue to companies of all sizes as well as consumers and members of the workforce.

Leanne Kemp, CEO and founder of Everledger, one of the world's leaders in blockchain technology, says blockchain "fosters trust, transparency and accountability throughout the network." She notes, "These are important factors in building relationships among businesses and their stakeholders, no matter their size or location."

Kemp points to parallels with the growth of other technologies, including the evolution of the world wide web, now connecting businesses and people all over the world via the http protocol, and the emergence of a standard secure platform using the smtp protocol. She sees the adoption of blockchain as the next step in advancing technology protocols for transactions and relationships whether the participants are down the block or around the world from each other.

Kemp's vision for blockchain is that the technology will become the global standard for securely sharing data. "This tool has the potential to become the worldwide distributed technology that brings value to every participant in the supply chain, from the origin of a raw material to the end consumer," notes Kemp.

"60% of CIOs expect some level of adoption of blockchain technologies in the next three years."

"This tool has the potential to become the worldwide distributed technology that brings value to every participant in the supply chain, from the origin of a raw material to the end consumer."

Leanne Kemp, CEO, Everledger

Others agree. A September 2019 Gartner publication reports the "business impact of blockchain will be transformational across most industries within five to ten years." David Furlonger, distinguished research vice-president at Gartner, says "60% of CIOs expect some level of adoption of blockchain technologies in the next three years." 16

Leanne Kemp
CEO and Founder, Everledger



Trend Expert

Blockchain Fosters Greater Transparency and Stronger Worldwide Relationships

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More from Leanne Kemp:

How the OECD can release the power of blockchain

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A key to gaining full value from adoption of blockchain is to understand its components.

In an October 2019 article, "[The Four Phases of the Gartner Blockchain Spectrum](#)," Gartner contributor Kasey Panetta describes blockchain as containing five elements: distribution, encryption, immutability, tokenization and decentralization. She writes, "When combined, these elements enable organizations to take advantage of the true benefit of blockchain, which is allowing two or more parties who don't know each other to safely interact in a digital environment and exchange new forms of value and assets." 17

Blockchain industry experts agree that convergence of advancements in multiple technologies such as AI, IoT and self-sovereign identity (SSI) will fuel blockchain adoption and expand its use exponentially over the next 10 years.

The strategic signals here point to something even bigger – to evolution in business models, not just technology adoption.

The strategic signals here point to something even bigger – to evolution in business models, not just technology adoption.

As Panetta notes, "Blockchain-enhanced solutions will lead to business model changes as autonomous agents gain the ability to commercially interact and operate independently of a human."

The time is right to begin exploring and evaluating blockchain solutions. Adoption of key aspects now will prepare businesses for more widespread adoption and help identify future break-out opportunities for market success.

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TOOLS

PACKAGING & LABELING

Over the last decade, packaging and labeling have shifted from being commodity elements to value-added products and solutions that serve key expectations from industrial, commercial and consumer customers.

The experience of package shipping, unloading, opening and disposal are now differentiators in product and service delivery.

Innovation and growth in these solutions will escalate over the next 10 years. This growth will come with added pressures to meet demands related to shipping characteristics, smart automation, competitive costs, customer preferences and product value.

A number of factors are driving this growth and shaping sector innovation, including e-commerce, digitization, sustainability, margin pressures and customer preferences for convenience, customization, safety and security.

Packaging and labeling have the potential to provide value to customers in many ways, especially cost savings, preventing waste and adding value.

New technologies in automation, AI and blockchain are creating opportunities for the packaging sector, which in turn are serving myriad needs of customers and logistics partners.

Whether you are in the packaging business or a user of packaging and labeling, these solutions can be leveraged for brand building, customer satisfaction and loyalty, safety, security, logistics, tracking, sustainability and convenience.

[In an interview with McKinsey consultant Shekhar Varanasi](#), Ted Doheny, CEO of Sealed Air, describes packaging as being at the convergence of disruptive technologies. ¹

“That’s because everything is put in a package,” Doheny says. How does a package communicate with people who want to know what is inside, when it was filled, how much it weighs, whether it was stolen, and whether the contents are nearing their expiration.”

He encourages companies to think about the interface between packaging and technologies such as blockchain. “Packaging companies can use digital tools that note exactly when something went into a package. We can own that information and share it with customers, so they can trace the inputs and track the package. By providing that information, blockchain helps us add value.”

Smart automation dictates the need for packaging to be addressed in different ways than those used in the past with a human workforce. Doheny says, “A robot hand might not be as soft as a human hand. So what packaging is required? We may have to design for both robots and humans.”

More retail packaged goods brands will emerge as leaders in sustainability, responding to customer demands and driving packaging and labeling innovations. Greater integration of this philosophy into design, sourcing, production, shipping and merchandising practices will mark this decade for significant progress in positive supply chain value.



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One such brand, General Mills, published their strategic imperative in 2019, pledging to reduce greenhouse gas emissions, sustainably source fiber packaging, utilize 100% recyclable packaging by design and achieve zero waste landfill impact, all before or by 2030. 2

Their efforts include active research, sourcing, development, and use of new materials that are from renewable sources and are recyclable. Both in-house and collaborative initiatives contribute to this ongoing commitment.

These types of efforts, whether pursued in-house or collaboratively with industry partners, represent significant corporate focus, resources and commitment, and a shift from a project mentality to a long-term strategic business model.

Future Trends in Packaging and Labeling

A broad variety of market demands, material innovations and business factors will impact and enable packaging and labeling over the coming decade.

Primary Packaging Packaging for direct shipments of products without a secondary protective outer layer will grow. This solution reduces weight, eliminates unboxing and dealing with packing materials, and reduces waste. 	Safety and Security Information on date and time of shipment, temperature and moisture while in route and locations of shipping points will become standard information. 	Delivery Coding New delivery modes will need enhanced labeling to support autonomous freight delivery. 
Customer Unboxing The customer experience in unboxing the contents and either disposing or reusing the packaging will be a growing and critical user experience factor. 	Sustainability Greater adoption of sustainable materials and practices will reduce use of plastics, reduce landfill impact and increase recycling of materials. Sustainability will become a must have and not a trade-off option. 	Reusable Packaging Costs savings and sustainability with repetitive use. 
Freshness Food delivery is growing and so is the demand for keeping food fresh and appealing. Innovations in materials, material coatings and packaging design will emerge. 	E-Commerce Packaging Increased requirements for strength and flexibility, improvements in consumer's unboxing experience, and facilitation of easy, efficient returns. 	Materials Light-weight, flexible, protective materials. Able to withstand rough handling along supply chain. Edible materials. Additive features to package contents. Sustainable materials will grow in importance. 

General Mills Sustainability Pledge



As responsible stewards of natural resources, we aim to reduce our environmental impact across each product's full life cycle. Several key strategies drive our work to reduce the impact of packaging production and waste.

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Easy to Pack

Time and cost savings; ease of workforce training and machine programming and handling.



Simplify Returns

Packaging reusable for returns provides value in the customer experience and increases likelihood of accurate and safe return delivery.



Integrated Production

Solutions will become more localized, close to or integrated in-house at brand owners.



Increase in Convenience

Easy open and resealable closures, portability, one-hand use, and single-portion packs will grow in consumer and commercial goods.



Sustainable Convenience

Consumers have strong preferences for sustainable solutions in convenience options. These are no longer trade-offs.



Personalization/Customization

This goes well beyond monograms and names. Personalization relates to size, repeat shipping cycles, color, texture and shape.



Price Pressure

Margins will continue to be under pressure even as greater value is delivered.



Graphic: Burchette & Associates

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TOOLS

TRANSPORTATION & FREIGHT DELIVERY

Movement of materials is one of the key aspects of logistics, and one that represents a significant cost factor. Significant shifts in transportation and freight delivery occurred in the first decade of this century, paving the road for further progress in the future. From electric delivery trucks to warehouse drones and many modes in between, transport will be transformed through technology and engineering to optimize capabilities throughout the supply chain.

In looking ahead to 2030, transportation experts believe 4 factors will drive changes in commercial transportation and freight delivery:

The first is a tipping point for electric vehicles (EVs), with improved battery capabilities and expanded domestic charging infrastructure.

Second is the use of drones to facilitate short-distance ferrying of light-weight goods in and around manufacturing, warehouse and distribution facilities and for specialized freight delivery to consumers and businesses.

Third is the emergence of new, integrated urban freight delivery strategies to execute the last mile with special focus on the last fifty feet of delivery.

Fourth is technology and material advances in marine vessels and associated freight handling and storage capabilities.

A look at each of these factors reveals the potential impact of each as well as some opportunities for multi-modal approaches.

Electric Vehicles (EVs)

Industry leaders and transportation experts forecast strong adoption of EVs in multiple commercial classes over this decade, paralleling growth in consumer-driven EVs. 1 Adoption timeframes and cost impacts will differ among light, medium and heavy-weight commercial vehicles.

Municipal and private bus fleets will continue EV adoption as part of cost savings and sustainability initiatives.

Electric van and truck sales are expected to accelerate over the decade with growth continuing out to 2040.

Long-haul heavy-duty trucks will be more difficult to electrify, thereby utilizing more natural gas and hydrogen fuel cells.

The move to smaller freight vehicles will accommodate growing urbanization, e-commerce and city restrictions, further fueling the rapid rise in EVs.



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Increased adoption of drones will be driven by advances in automation for data processing and mission execution, reports Millie Radovic, industry analyst at Drone Industry Insights. 6 Radovic notes, “Actionable data is next to a powerful and reliable drone probably the most important driver of the drone industry...the faster, the more accurate, and the easier the images can be evaluated, the better.” Additionally, she notes AI technologies will allow processing of thousands of images without a human in the loop.

Key trends in packaging, such as eliminating secondary packaging, and use of lower-weight materials will converge with advances in drone equipment and standards and further facilitate innovation in deliveries. Sensors will add capabilities and useful information as well.

Today, commercial drone deliveries are handled by both outsourced specialty firms and in-house staff. Drone Industry Insights expects the use of full service end-to-end solution providers to grow, providing rapid competition to non-drone approaches. 7

For more information on drones, go to the [Smart Automation & Technology](#) section of the Tools chapter or the [Market Influencers](#) chapter of this report.

Urban Freight Delivery

Much academic and private research is underway to address the realities of freight delivery. The questions are not easy to answer; new technologies and capabilities, converging with an explosion in delivery demand, require new thinking and approaches to optimize freight delivery strategies and leverage innovations in industry equipment.

In the U.S., as in much of the world, progress in material handling and logistics finds itself at odds with current infrastructure settings in urban areas. Throughout the last century, cities have removed alleys meant as delivery corridors; most remaining alleys are limited by narrow space dimensions. Developers have built out commercial districts and work-stay-play venues without adequate delivery parking and dock access. Skyscrapers, condos and apartment buildings have added miles of floors for deliveries.

Research by the University of Washington’s Urban Freight Lab (UFL), an innovative partnership of private industry, academic researchers and public transportation practitioners, indicates “if cities do not redesign the way they manage increasing numbers of commercial vehicles unloading goods in streets and alleys and into buildings, we will reach total gridlock.” 8

This “final 50 feet,” a term coined by UFL researchers and described by the lab as a key to customer satisfaction, is “both the most expensive and most time-consuming part of the delivery process,” they say. 8

Anne Goodchild, director of the UW Supply Chain, Transportation & Logistics Center and founder of the UFL, cites 4 areas of great potential for optimizing the final 50 feet. She stresses the need for public-private collaboration to effectively address these urban freight delivery needs:

“Global Drone Outlook 2020,” Drone Industry Insights



Anne Goodchild
 Director, UW Supply Chain,
 Transportation & Logistics Center,
 Founder, UFL



University of Washington, Urban Freight Lab

The University of Washington’s Supply Chain, Transportation & Logistics Center houses the vibrant Urban Freight Lab (UFL), an innovative partnership that brings together private industry, academic researchers and public transportation practitioners to solve freight problems common to private and public spaces.

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Industry professionals and city staffs need to work together to address delivery-related parking. For example digital platforms can provide delivery trucks with an automated way to locate parking spots for designated times, and one day even reserve spaces as needed.

Public policy can impact new development, ensuring curb parking space and transportation lanes are not hijacked for delivery activities, and delivery and loading docks are located where delivery vehicles will not obstruct other traffic.

Multi-tenant buildings can include innovative delivery mechanisms such as commercial and personal locker systems so deliveries can be made and picked up from a central location. While this is easier to implement in new construction, existing facilities can be modified to support this strategy.

Utilization of emerging technologies for robots and drones can provide new avenues for time and cost-efficient delivery strategies while also providing methods that reduce the toll on human labor.

Goodchild notes that, historically, the transportation and freight industry used to think of transport approaches as common solutions that needed to be implemented in the same or similar manner across the board. “Not so today,” she says. “We are increasingly seeing that we must have highly differentiated approaches that match specific environments, especially in the last mile.” She adds, “What works in New York City doesn’t work in Kansas City, and what works in dense urban spaces isn’t applicable in rural areas.”

In addition to geographic differences, various delivery sectors have specific needs as well. Goodchild says, “Think of delivery vehicles for small packages versus vans with heavier cargo that require equipment like a hand truck or jack to assist the delivery person. How does that cargo get lifted up a flight of stairs? That is the type of question we have to solve for the last mile and the last fifty feet of delivery.

“In solving for these different environments, we will see a lot of experimentation with different types of solutions from electric cargo bikes to bots like the Amazon Scout that moves along sidewalks at a walking pace,” notes Goodchild. “We will also see more mixed mode approaches such as a truck delivery using a drone to transport goods to a landing area on top of a building.”

Delivery services are also growing in type and complexity for suburban residential settings. Food and gift delivery tops the list of what comes to mind for most people, but a growing affinity for home delivery of everything from toothpaste to dog food is occurring across all age groups.

Michael Kay, associate professor of industrial engineering at North Carolina State University, believes consumer trends favoring home delivery services for food as well as house and garden supplies will drive adoption of new delivery equipment systems.

“Home delivery stations will provide secure receipt and pick-up of everything from dinner to garden mulch.”

Michael Kay, Associate Professor of Industrial Engineering, North Carolina State University

“Home delivery stations will provide secure receipt and pick-up of everything from dinner to garden mulch,” says Kay. He expects these systems will create new demand in the coming decade for innovative new construction as well as home renovations. “Consumer garage space, less relevant as consumers reduce vehicle ownership, will be prime locations for home locker systems,” says Kay.

Urban Freight Lab Members

Boeing HorizonX
Building Owners and Managers Association (BOMA) – Seattle King County
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Michael Kay

Associate Professor of Industrial Engineering, Interim Director of Operations Research Graduate Program, Associate Director of Graduate Programs in ISE Department, North Carolina State University



Home Delivery Logistics using Driverless Delivery Vehicles

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7 Hot Trends That Will Change the Future of the Food Delivery Industry

The Final 50 Feet Research Program: Optimizing the Last Leg of the Urban Goods Delivery System



Maritime Shipping

Maritime shipping is experiencing significant transformation, driven principally by the expansion of world trade, changing customer needs, the pursuit of operational efficiencies and a desire to protect the environment. Advancements in technology, engineering and business solutions are rapidly enhancing and enabling commerce at sea.

Over the last decade, significant investments have been made to upgrade ports on every coast of the United States. These enhancements are continuing and will provide greater channel depth, improved navigability and enhanced freight management.

Automation of loading and cargo discharge processes, channel deepening, widening of port access, expansion of berth slots, and improvements to drayage will allow American ports to receive larger ships and speed processing times and length of stays in port.

These investments appear to be paying off. Gary Frantz reports in DC Velocity that “many U.S. ports processed record or near-record freight volumes through the first part of 2019, building on a 2018 that set a high-water mark for import and export ocean cargo.”⁹

Competition for bigger vessels and larger cargo discharges is fueling hundreds of millions of dollars in investments by multiple ports, especially those on the East Coast. These improvements will enable simultaneous entry by multiple big vessels and faster cargo handling between ships and trucks or rail. That’s good news for supply chain players everywhere.

Enhancements in related infrastructure will include road and rail line improvements and construction of inter-modal facilities to support extended supply chain transport and logistics. Container yard expansions, construction of specialized storage facilities, smart automation, digital capabilities, and upgrades in cranes and robotic equipment are planned as well.

Significant economic development opportunities are tied to these enhancements, promising lucrative benefits to port states and other markets along connecting transportation corridors.

ARO 2020: US East Coast ports vie for rising cargo volumes



TOOLS

Strategic Imperatives

A subsequent report, Global Marine Technology Trends 2030 (GMTT 2030) by Lloyd's Register, QinetiQ and the University of Southampton, examines how technologies will impact maritime shipping, naval operations and the ocean space sector out to 2030. 10

The stage is set for continued growth and modernization of U.S. ports out to 2030. But is the vision for these improvements transformational and setting the stage for use of future smart technologies?

And what about capabilities to interface with new and planned maritime communication networks and smart ship systems?

Will the U.S. workforce be prepared for the new digital capabilities required for port operations in the future?

The Global Marine Trends 2030 report places maritime shipping in a global supply chain context: "The ocean is the highway for international trade, with 90% being seaborne." 10 This statistic underscores the importance of vision, strategy and investment in the future of this critical pathway in the supply chain.

As in other areas of the supply chain, avenues for progress stem from advances in smart automation, technology, digital tools, new materials, communication systems and sustainable processes. Innovation in marine environments, logistics and operations will contribute to improvements of shore-based activities, and the combination of advances in both realms will lead to transformative change that will benefit life around the globe. Positive impacts on the new space economy are possible as well.

Challenges and Opportunities

The commercial shipping industry has hurdles to clear in navigating this evolutionary phase.

A report focused on marine technologies, The Global Marine Technology Trends Report 2030 (GMTT 2030), 11 paints a picture of great need and opportunity in maritime shipping around the world. The report points out that today the shipping industry is in its infancy in technology applications compared with automotive, aerospace and consumer electronics industries – so the scope of the opportunity is huge.

The report examines how technologies will impact maritime shipping, naval operations and the ocean space sector out to 2030.

For the commercial shipping sector, the report identifies two technology arenas that will shape operations in 2030.

- The first arena includes technologies for propulsion and powering, ship building and smart ship – their term for ships with enhanced digital technology
- The second includes sensors, robotics, big data analytics, advanced materials and communications.

The researchers point out these technologies are not isolated, but rather are connected to each other to create advanced capabilities and benefits.

TechnoMax Ships

Ships incorporating these technologies will be known as TechnoMax Ships. Others that have only some improvements will be known as Pre-TechnoMax Ships. These two classes of ships will be important distinctions in the marine industry for chartering, contracting, bonuses and cargo handling.

Global Marine Technology Trends 2030

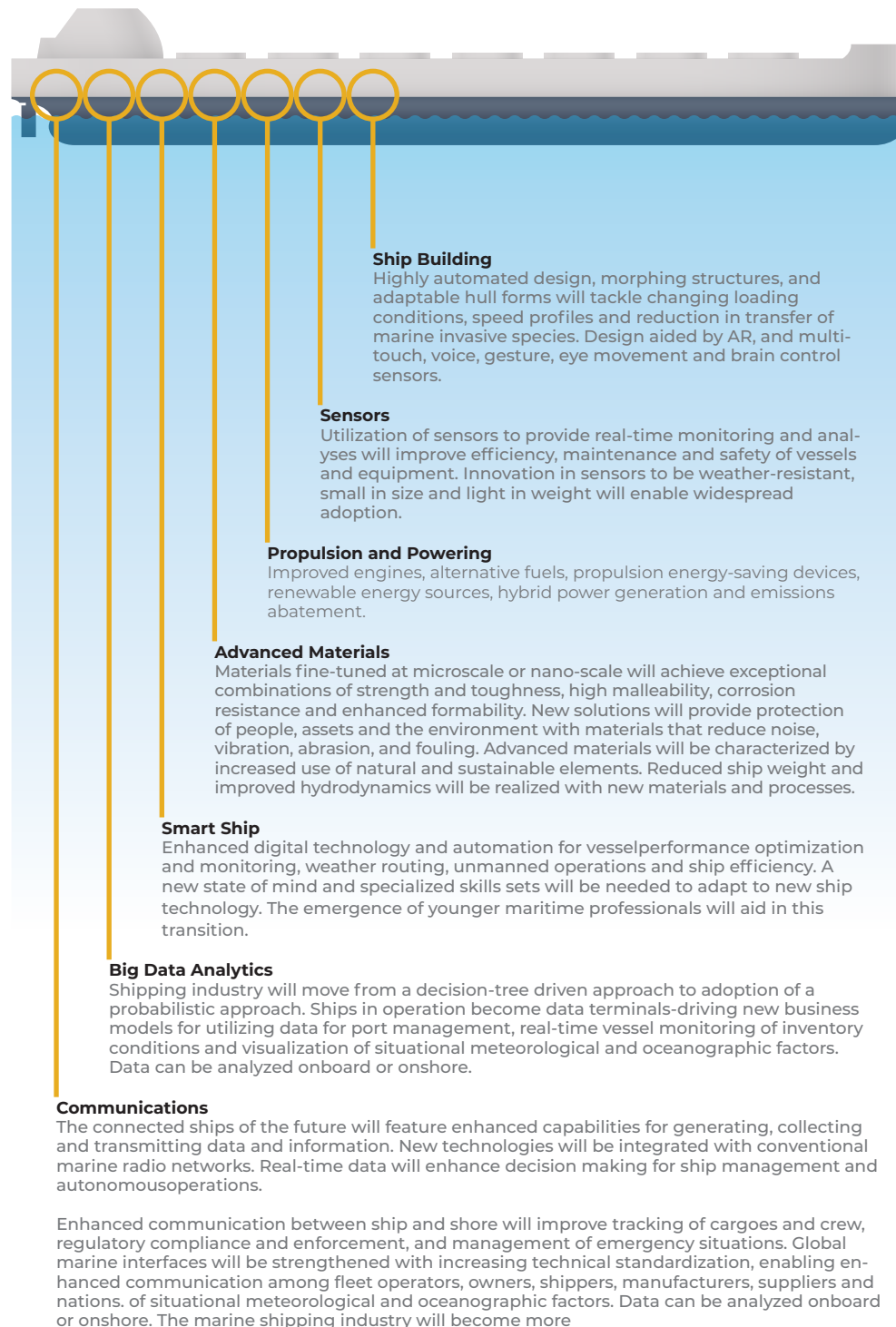


"These ships will be smarter, data driven, greener, with flexible powering options, fully connected wirelessly onboard, digitally connected through global satellites." GMTT 2030

TOOLS

Beyond operational advancements, perhaps the greatest value gains from TechnoMax Ships will come from enhancements to communications networks and the actionable data that will be available on a real-time basis.

Smart Shipping



TOOLS

The challenges involved in successful implementation of these technologies are not small. Success depends on a favorable regulatory framework, technical standardization on a worldwide scale, cooperation among marine stakeholders and significant re-skilling and training of crew and management.

As with much of the material handling industry, a shortage of skilled workers is a continuing challenge. The GMTT 2030 report sizes the hurdle: “There are over 104,000 ocean-going merchant ships. The shortage of highly-qualified sea-going staff is an increasing concern, especially as ships become more complex due to environmental requirements.”

The report casts a long-term vision for the man + machine relationship in maritime shipping that is centered around critical thinking and technical skills: “Smart shipping is not necessarily about removing people from ships, but about better connecting ships and their crews with specialized onshore resources.”

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Commercial shipping and the workforce that powers the industry will change significantly and benefit greatly over the decade as technology, digital tools and innovative processes are embraced and incorporated into many aspects of the sector.

2030 and Beyond

Overall, marine shipping will look very different in 2030 than it does today. Operations will be smarter, digitally enabled and data-driven. Ships and their processes will be greener and more flexible to accommodate dynamic conditions. Onshore resources and onboard management will be transparent and improved for the safety of crew, cargo and the environment.

Tools for the Future

The future is bright.

The material handling, logistics and supply chain industry will gain tremendous opportunity in the coming decade with the realization and commercialization of innovations in smart automation, technology, digital decisioning tools, packaging and transportation solutions.

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Report Credits

The “Transformation Age, Shaping Your Future” report site offers information and dialogue on long-term industry trends for the material handling and logistics industry. As such, the information contained within serves as an invitation to engage in thought and discussion about key factors that are expected to drive, fuel and impact various aspects of life, commerce and industry in the coming decade.

Much of this information was gleaned from in-depth interviews with industry leaders and trend experts. Other data was obtained from secondary research of published material on specific topics. The combination provides insights into those forces that will impact the industry and, more importantly, the implications for action needed now and in the future by company leaders and their teams.

We wish to express thanks to all who gave their time and shared their experience, expertise and opinions for this report.

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