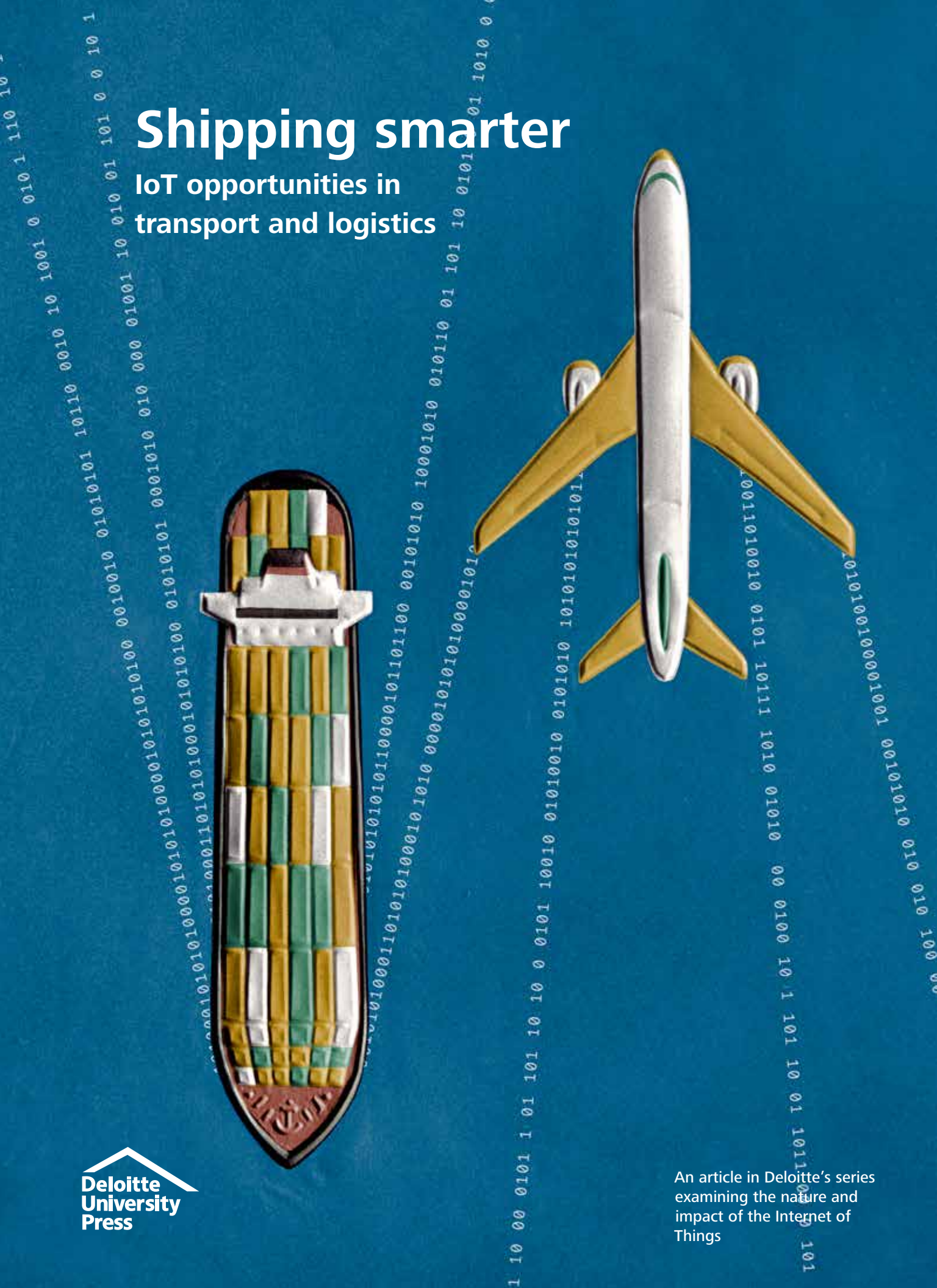
Shipping smarter

IoT opportunities in transport and logistics



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An article in Deloitte's series examining the nature and impact of the Internet of Things

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Introduction

MANY industries and business sectors are struggling to grasp the possibilities of data-driven technology, but companies in transport and logistics (T&L) are way ahead. By their very nature, the logistics providers that move objects by air, sea, rail, and ground have widely distributed networks and rely on rapid information about those networks to make decisions. As a result, they were quick to see the benefits of new sensor and connection technology, placing them at the forefront of the transition to a connected world.[1]

Companies in this sector have embraced the suite of data-driven technologies dubbed the Internet of Things (IoT) in diverse settings, from maritime and aviation freight to warehousing to package delivery. Specific applications include the real-time tracking of shipments, warehouse-capacity optimization, predictive asset maintenance, route optimization, improved last-mile delivery, and more. In fact, many logistics providers (companies that package, transport, and store goods) have seen logistics users (companies with goods that need to be moved) adopt their innovations within their own supply chains.[2]

But there's much more to come. As IoT applications and capabilities expand, so do opportunities for T&L providers. Through a rapidly increasing number of connected devices, embedded sensors, and analytics technologies, companies in the sector can enjoy unprecedented visibility into almost every aspect of their business, from operations to finance, enabling new sources of value creation.[3] This visibility, in turn, will allow T&L providers to more intelligently exploit their rich and complex data asset base, leading to more efficient use of transport infrastructure, better engagement with customers, and more informed decision making.

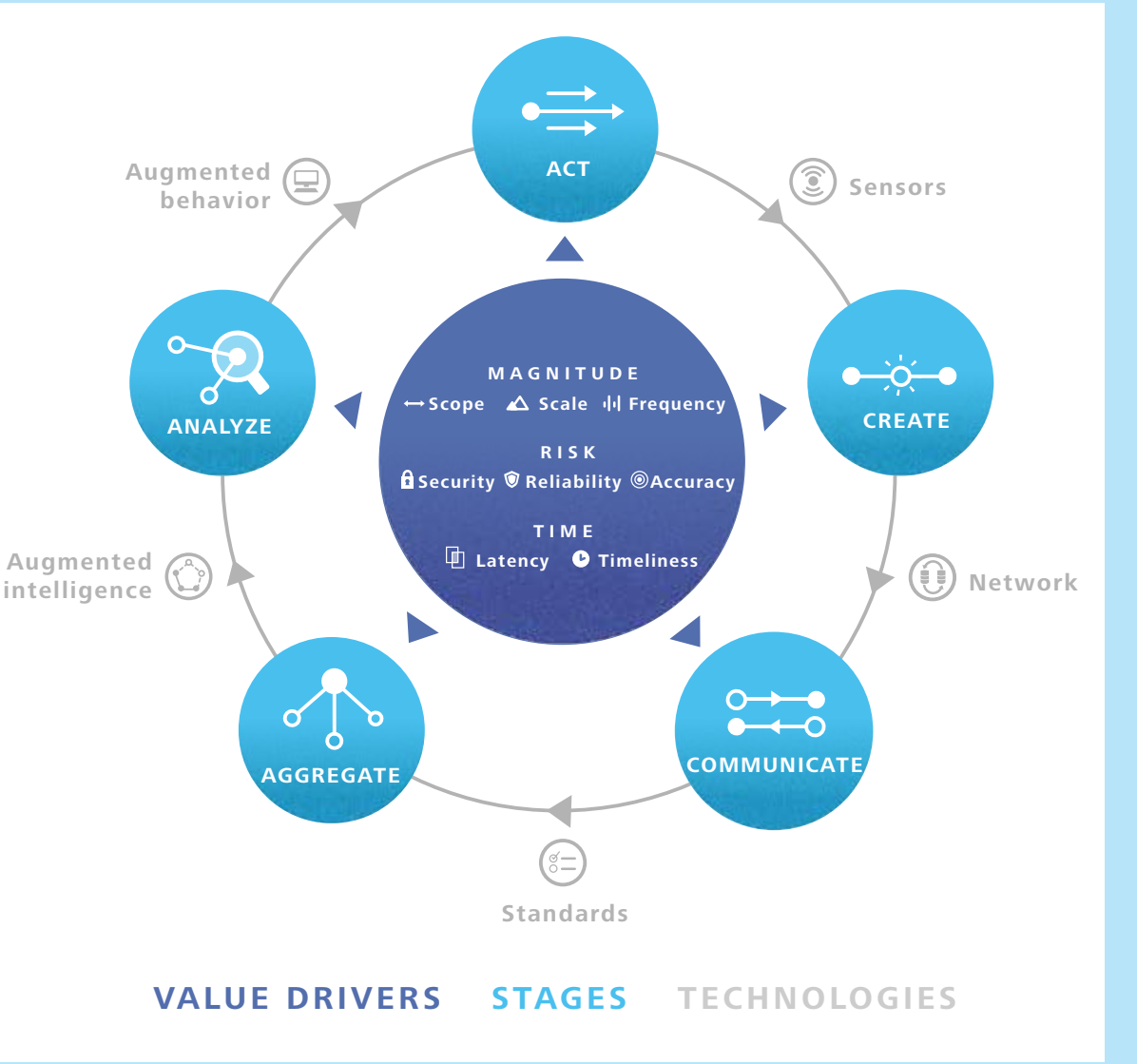
Of course, T&L companies aiming to further incorporate IoT technology face real challenges, both technical and strategic. To find their place in the IoT domain, we believe organizations first need to envision, broadly, what business problems IoT applications might solve for them and their customers. This end-state vision should also address the IoT's implications for these companies' strategic position and ecosystem relationships.

Envisioning this end state begins with understanding how the IoT creates value. The technology is about the creation, communication, aggregation, analysis, and use of information from real-world objects by real-world objects. Therefore, the value created by the IoT is governed by the flow of information through a system. The Information Value Loop (see inset) models this information flow, providing

a framework for companies to view their current and potential IoT use. As T&L companies seek to realize the benefits and overcome the challenges raised by this new phase in the evolution of the IoT, the loop can prove a valuable tool in defining a company's place in its ecosystem and how it can capture at least its fair share of value. In short, the value loop can help companies understand *where to play and how to win*.[4]

THE INFORMATION VALUE LOOP

The suite of technologies that enables the Internet of Things promises to turn most any object into a source of information about that object. This creates both a new way to differentiate products and services and a new source of value that can be managed in its own right. Realizing the IoT's full potential motivates a framework that captures the series and sequence of activities by which organizations create value from information: the Information Value Loop.



For information to complete the loop and create value, it passes through the loop's *stages*, each enabled by specific *technologies*. An *act* is monitored by a *sensor* that *creates* information, that information passes through a *network* so that it can be *communicated*, and *standards*—be they technical, legal, regulatory, or social—allow that information to be *aggregated* across time and space. *Augmented intelligence* is a generic term meant to capture all manner of analytical support, collectively used to *analyze* information. The loop is completed via *augmented behavior* technologies that either enable automated autonomous action or shape human decisions in a manner leading to improved action.

Getting information around the Value Loop allows an organization to create value; how much value is created is a function of the *value drivers*, which capture the characteristics of the information that makes its way around the value loop. The drivers of information value can be captured and sorted into the three categories: *magnitude, risk,* and *time*.

How tech moves logistics

TRANSPORT and logistics are fundamentally about moving things from one place to another. Therefore, the main service components of T&L can be categorized into the things that move and the things that do the moving—the "demand" and "supply" sides of logistics. The supply side includes warehouses, where goods are stored and forwarded; a transport network (roads/tunnels/sea/air); and the vehicles/vessels/crafts that are used to move goods from suppliers to warehouses and, ultimately, the customer. The capacity, efficiency, manageability, reliability, and, of course, cost with which T&L companies can provide these are the key drivers of value on the supply side. Naturally, the common supply-side IoT applications currently focus on improving these drivers and reducing cost (table 1). Some common examples include capacity sensing, planning and reporting, routing optimization, energy-efficiency management, and proactive fault/problem detection and resolution.[5]

The demand side, on the other hand, includes goods to be transported and the customers expecting the goods. The value to customers is determined by the time, security, traceability, and condition of their cargo. Similarly, current IoT use cases focus on

Table 1. Common applications of IoT for logistics supply (warehouses, trucks, planes, etc.)

Capacity sensing	Planning & reporting	Route optimization	Energy management	Fault detection & resolution
Systems that can detect and communicate open spaces in a warehouse, port, or parking lot	Systems that can detect and analyze events such as traffic accidents within a delivery network, allowing for more accurate delivery dates	Tools that can map the shortest or most fuel-efficient route for delivery vehicles, for example	Tools that monitor and enable decision making about the use of fuel, lighting, and heating/cooling within vehicle fleets and facilities	Systems that can monitor fleets of vehicles, aircraft, or ships for faults and maintenance needs, improving uptime for the fleet

improving those factors and include environment monitoring, threat detection and prevention, and real-time traceability down to unit level (table 2).

These examples highlight the IoT's potential to improve parameters within the key T&L service components and add value for both businesses and their customers. Together, these applications largely focus on cutting costs or increasing efficiency. Since those are common business needs, it is natural that IoT technology should address them. However, applications are also able to meet other business needs, from shaping the environment to creating new revenue. For example, some companies are already exploring new pay-as-you-go business models thanks to the improved visibility and real-time control that IoT applications can provide.[6] Rather than simply seeing this technology as an extension of current technology, T&L companies should consider pursuing initiatives that address their key business needs as IoT ecosystems evolve and mature further.

Table 2. Common applications of IoT for logistics demand (customers, packages, containers, etc.)

Environment monitoring & management	Threat detection & prevention	Real-time traceability
Systems that can monitor and adjust the temperature at which a package is maintained	Tools that can help detect unauthorized openings of shipping containers, helping to prevent and reduce theft	Systems that can track and track not just vehicles or shipments but individual items

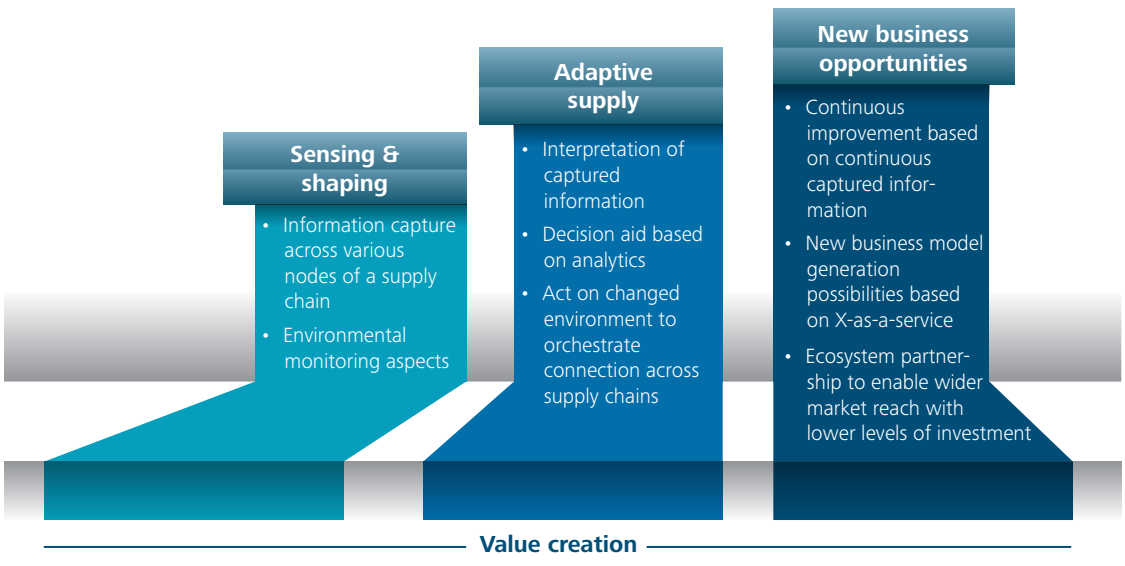
Business needs drive IoT applications

DEPLOYING and expanding IoT capabilities requires more than just technological breakthroughs—making a system work requires not only an understanding of the industry dynamics but also a strategic approach to the Information Value Loop.

Thus far, T&L companies have implemented IoT technologies mostly as track-and-trace applications, intending to decrease network complexity. For example, GPS asset tagging can be used to optimize routes by plotting the real-time locations of trucks and deliveries and using analytics to draw the shortest or most fuel-efficient route between them. Similarly, GPS tagging of shipping containers and other demand-side goods can help manage the flow of those goods through transit nodes. Together, these applications allow for faster movement through the network with fewer transitions. New applications retain a focus on networks but also aim to make better use of the information captured to create new value and even new revenue. As yet, few companies and IoT applications have moved toward fully capturing the technology's value-creation potential.

The potential for value creation corresponds well with the scope of an IoT application (figure 2). Business needs such as sensing

Figure 2. T&L IoT framework



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the environment require little new value creation and, as a result, can be accomplished with relatively narrow-scope IoT applications. Similarly, to adapt an entire supply chain or distribution network to change requires more value creation and a wider scope of IoT application. Finally, to enable new business models and generate new revenue requires integrating customers into a product ecosystem, the widest of all IoT applications.

Currently, the highest concentration of use cases can be found within the sensing and shaping category, such as applications offering track-and-trace.[7] Such applications are simplified by the fact that they must exist on the supply side of logistics, which can be owned entirely by the T&L company. Therefore, such applications can be accomplished with relatively few hurdles or changes to existing business practices. By contrast, few companies—in any industry, not only T&L—have thus far adopted IoT applications that achieve ecosystem scope. In T&L, the difficulty encountered in moving to these higher-value, larger-scope applications can be captured by the fact that they must incorporate both demand- and supply-side logistics capabilities.

However, not every company has to move immediately to create an IoT ecosystem with its customers. Rather, to move toward more advanced applications delivering increased value, T&L providers should attempt to identify bottlenecks that currently limit the flow of information through the use of the Value Loop.

Enabling the Value Loop for demand sensing and shaping

NATURALLY, T&L companies started small with the IoT, and most applications currently implemented have comparatively narrow scope and limited risks. Even so, they have generated tangible benefits—in fact, the range and complexity of modern logistical operations are nearly beyond the capability of analog spreadsheets or rosters to manage.

Take for example, Amsterdam Airport Schiphol, Europe's fifth-largest airport. To maintain tight schedules, flight operations demand to-the-minute coordination between aircraft, ground crew, and a range of equipment. Baggage and cargo must then be offloaded, transported, and loaded again across the 10.7 square-mile airport.[8] With more than 5,000 baggage carts moving goods around the airport, keeping track of this fleet—its availability, utilization, and maintenance periods—has proven difficult. The carts can be anywhere on the airport, in use or in maintenance, and in order to operate smoothly, ground crews need to be aware of each cart's location and status at all times.

Tracking non-motorized support equipment at airport terminals, large plants, and other logistic service companies is a clearly identifiable challenge within the Value Loop: The limiting factor is the ability to *communicate*. Without the ability to communicate their location, ground equipment, especially the small, unpowered baggage carts stored near the terminals, were incredibly difficult to locate when needed.[9] This posed a challenge for airports and similarly dispersed logistical applications that required low-power transmission of data about equipment across a wide area, over a long period of time, and in a crowded radio-frequency environment. It simply would not do if a baggage cart were lost because its transmitter was out of range, a battery died, or, worst of all, caused a mishap because it interfered with an aircraft's communications or navigation.

Schiphol found a solution to these issues in the GSETrack system.[10] GSETrack monitors and tracks baggage carts and all other non-motorized ground support equipment (GSE) by sending and receiving valuable information such as real-time location, usage, and equipment data without the need for large investments in hardware and software.

The transmitters used are energy-efficient, last three to five years, and can be recharged. They are able to communicate with each other, establishing their own independent network—one in which every piece of equipment has a transmitter that becomes a node that communicates only with the other nodes.[11] Without a hierarchical IoT-based structure, the system simply routes data from node to node until the information reaches a gateway to the Internet or a user's terminal.

As the nodes are short-range, communicating only with others around them, they use very little power. Moreover, because they're using each other to form a network, expensive network and communication equipment is unnecessary. This also helps to solve the challenges around interference and distributed locations. By communicating with any and all nodes within range, it does not matter to a cart if it is moved. The transmitter requires no new programming—it will simply locate nearby nodes and communicate with those. Similarly, the low power requirements limit the level of radio frequency interference. While this particular solution is being developed for the aviation environment, these "mesh networks" are finding new possible applications elsewhere in the T&L industry.[12]

With the technical issues overcome and the *communicate* bottleneck alleviated, Schiphol could quickly begin to enjoy the value of the new efficiencies created, recouping some of the billions that mishandled baggage costs the air transit industry each year ($2.4 billion in the United States alone).[13] The IoT system has enhanced, rather than forced changes to, existing processes and procedures. Although they create more value, broader, supply-chain-wide applications do not benefit from the same ease of implementation.

Enabling a responsive and adaptive supply chain

WHILE Schiphol was forced to address a range of technical issues in order to more efficiently track ground equipment at the airport, it was still largely a problem within one organization: The airport administration could mandate the technology to be used, and all of the equipment was confined within the bounds of the airport. Moving beyond the bounds of simple tracking on the demand side of logistics to adaptation on the supply side requires a wider scope, integrating multiple external suppliers and distributors throughout the supply chain.

This situation can be seen in stark contrast within a shipping port, where many companies and multiple modes of logistical transport jostle for space in a small area. Every large shipping port has problems aligning different stakeholders in order to optimize the port's utilization. Moreover, the expected turnover of containers in ports continues to increase dramatically. For instance, the port of Hamburg projects that the number of containers passing the port will grow from 9 million in 2013 to 25 million in 2025.[14] Since traffic increases accordingly while space remains limited, it is of great importance for large harbors to maximize utilization and minimize the idle time of every link in the system.

However, with multiple companies operating various different types of equipment, each with unique data requirements, integrating all of those data can be a challenge—not to mention the fact that many of the port's users are competing firms reluctant to share information with competitors. In terms of the Information Value Loop, the bottleneck in this instance lies in the difficulty of *aggregating* information, due to the number of disparate parties involved. Without proper data aggregation, it is much more difficult for a system to analyze and redistribute data about the port to the relevant stakeholders so that they may make better, more efficient use of the available supply of logistics (cranes, trucks, and warehouse space).

The port of Hamburg addressed this problem by connecting all participants in the port using a single data system.[15] By doing so, port managers were able to collect and aggregate information about all traffic inside the port area on closed bridges, possible congestion at the terminals, available parking space in truck parks, and more. The aggregation enables the system to share information with all stakeholders, so that they can make better decisions about how to load, unload, and route cargo through the port. To deal with companies' unease about sharing information with competitors, the system gathers all information in

the port but shares only what's relevant to each stakeholder. In this way, the Hamburg port was able to improve turnover of goods and traffic, reduce idle time throughout its supply chain, and control traffic. By doing so, it has benefited all stakeholders, among them the freight shipping companies, carriers, railway companies, customs, and of course the port itself.

While the port of Hamburg was able to overcome significant challenges and integrate data from diverse stakeholders, those stakeholders were all engaged directly in the logistics activities of the port. To take the next step and generate new revenue from new business models, IoT solutions must expand even further and encompass new customers.

Enabling new business opportunities

MAXIMIZING the value generated through IoT applications ultimately means being able to identify and take advantage of new business models within the ecosystem. It means establishing a mechanism of continuous improvement, reinvesting the captured information through the optimized value loop into new ways of generating value.

Such an endeavor would be of major scope and complexity, integrating not only logistics firms and suppliers and distributors in their supply chains but also customers and possible business partners. To date, again, few companies in any industry discovered how the IoT can create novel business models or new revenue, but logistics companies may be uniquely well positioned to quickly adopt just such models. Using the IoT to create new revenue requires applications that not only include the company's operations but also integrate its customers into a product ecosystem. Logistics companies traditionally have close ties to customers, which can come to rely on them for core business functions.[16] Therefore, logistics companies can rely on those ties to more quickly introduce customers to a potential IoT application offering new benefits for which they are willing to pay. In fact, where other industries are struggling to progress beyond the "killer app" and discover how IoT technology can generate revenue, several logistics providers have already begun to do so.

DHL is one of those cases to date, in terms of aiming for a wide IoT ecosystem optimization, as the company foresees improvements to both logistics and the transportation network providing fresh revenue streams as new business models emerge.[17]

DHL has begun the integration between warehousing, logistics, and transportation systems. The company then is able to analyze the data capture at each step to enable smart inventory management, predictive asset maintenance, and advanced supply-chain risk management.

However, incorporating IoT applications for value creation and new revenue requires looking at providing value across the ecosystem—for example, maintaining detailed information about specific product requirements including temperature, humidity, handling care, source, and destination; with up-to-the-minute data, DHL would be able to instantly redesign clients' supply chains in ways currently unavailable. Understanding customer needs for temperature-controlled shipment and the availability of refrigerated trucks and aircraft could allow them to create customized shipping routes for each specific package. Naturally, such individually optimized routes would warrant premium pricing, creating new revenue opportunities for the company as well as value for customers.

Similarly, customers themselves may want to know the information that IoT applications put at a logistics provider's fingertips. Pharmaceutical companies, for example, surely would find valuable information on drug shipments' chain of custody and status for reassurance that they have not been damaged, tampered with, or exceeded a safe temperature range. By offering this information to customers as a service, DHL is creating new opportunities to work with shippers as a guarantor of their supply chains, and generating even more new possibilities for revenue. The company has also taken this concept a step further, with Resilience360, a supply-chain risk-monitoring tool offered to customers. This tool takes advantage of current knowledge of postal strikes, road closures, natural disasters, and other events that a worldwide fleet gathers, and allows customers to see their supply chain's impact in real time.[18] They can even use the tool to adjust the timing or mode of shipments to minimize the disruption from world events.

Therein lies the chief challenge: Many solutions in the T&L sector are hermetic and far from being designed as open platforms for collaboration. Systems that track supply-side availability are disconnected from those that deal with customers on the demand side. To realize new business models and new revenues, supply- and demand-side systems need to work together to smoothly process information. This integration underscores the need for stronger partnerships and is an area that will require special attention. Innovative IoT solutions require cross-industry partnerships, and the success of any given initiative may depend heavily on the choice of partner.

Recommendations to ship smarter, not harder

TRANSPORTATION and logistics industry players may have different goals and ambitions for IoT technology. Depending on their business strengths and strategic focus, the scope of the solution that is needed can vary widely. As scope varies, so do the difficulty of implementation and the potential benefit from IoT applications. However, since the IoT can impact not only a company's industry position but also its ability to partner with different companies and industries and its ability to use and capitalize on future technologies, executives must closely examine these choices within the context of a company's strategy. In other words, given the significant investments needed in technology and partnering, and in an industry with relatively small margins, each T&L company should have a clear value case in mind when planning its IoT direction and strategy.

So while the IoT has revolutionized technology and how work gets done, the fundamentals of business strategy remain constant. As with any strategy, companies must define a goal, choose the business need that the goal will address, develop a solution, and build an action plan to implement that solution. To borrow an analogy from sports, a football team must decide which code to play (association football, rugby, Australian rules, or American football), then decide on which field to play it, then assemble a roster of the right players in the right positions, and finally develop a specific game plan.

Define goals: From all of this article's examples, we can see that the T&L industry is at the forefront in terms of IoT value generation, with many companies going far beyond track-and-trace possibilities to combine GPS with sensors for temperature, exposure to light, humidity, and barometric pressure. These companies have not just realized that new business-model possibilities are a real differentiator from competitors—they have understood that value generation based on collected information is becoming a T&L industry standard for their customers: The market is beginning to demand a strategic positioning related to the IoT.

That seemingly daunting task may be made simpler by the application of a few rules of thumb. First, before even considering the technical aspects of IoT technology, a company should use its strategy to understand goals for any new application. Do executives wish to simply improve the efficiency of existing operations by better sensing the current state of processes? Do they wish to respond more rapidly and adapt to changes in supply? Or do they seek new business opportunities to generate new revenue?

Choose the business need: Answers to those questions help determine where within a company IoT technology might be deployed. To begin with, should the company pursue

IoT applications that address only supply-side capabilities, or must the demand side be integrated as well? Then, if the question is which operations are candidates, which interaction could best benefit from the IoT? If a goal is improved sensing to increase efficiency, a company need only focus on supply-side capabilities. Then, analyzing those capabilities with an eye to the processes with the most variance can help identify areas where IoT applications may have the largest impact. On the other hand, if new revenue is the goal, the equation should involve demand-side customer relationships. With a specific business need in mind, the Information Value Loop can help to model the flow of information through that process or operation. This will help identify bottlenecks where an IoT application is likely to have the most benefit and where a company should focus attention.

Develop a solution: With a myriad of software and hardware options in the marketplace, as well as full-service providers, developing a clear view of the components needed for a particular IoT architecture can be difficult. However, the bottleneck and value drivers found by analyzing a company's business need using the Value Loop can help guide these decisions. They can help understand when to choose a hot data storage application that can provide near-real-time data, and when longer latency but more powerful analytics are required. Similar thinking may also help a company identify where external help is necessary and who suitable partners may be. This process will likely help ensure an integrated IoT solution with desired end-to-end capabilities.

The good news for T&L companies that are still contemplating how to build their IoT capabilities is that new technology is rapidly improving the conditions for value capture, with innovation reaching the market almost weekly. These innovations are driven by the advent of IoT applications focusing on size, operability, security, and low power consumption in order to improve mobility and a wide range of functionalities. The next generation of IoT devices will also include embedded data-analytics capabilities, as evidenced by recently launched products that combine processors, memory, and radios onto a single tiny chip.[19]

This means that, regardless of the strategy or business need a T&L company needs to tackle, the necessary IoT technologies will likely be widely available.

Build an action plan: We believe that creating a plan that anticipates and adapts to changes is critical—beyond the natural variation in any industry, the rate of change in IoT technology is tremendous. Without a flexible implementation plan, the most cutting-edge solution today can often quickly become a liability. For example, IoT implementations that seek to adapt the supply chain or generate new revenue will almost certainly force changes to existing business processes. Creating a plan to revise these processes and train workers as appropriate is one key to capturing the most value from any IoT application.

Like any team, a T&L company must work hard if it desires success—though playing the wrong sport on the wrong field can be a surefire way to fail no matter how hard a team works. The planning process and recommendations above can help T&L companies determine where to play and find the right strategy to win, ensuring that IoT technology is a valuable part of every T&L game plan.

Endnotes

1. Some companies even began laying the widespread foundations for IoT implementation as early as 2004, when large retailers and the Department of Defense mandated that their shippers and suppliers use RFID tags on inbound shipments.
2. This development of many supply-chain tools such as electronic data interchanges originated from pure logistics providers such as the military and ports. For information on how companies in all industries can apply similar techniques to improve their own supply chains, see Joe Mariani, Evan Quasney, and Michael E. Raynor, "Forging links into loops: The Internet of Things' potential to recast supply chain management," *Deloitte Review* 17, July 27, 2015, http://dupress.com/articles/internet-of-things-supply-chain-management/, accessed July 29, 2015.
3. Jonathan Koomey, "The computing trend that will change everything," *MIT Technology Review*, April 9, 2012, www.technologyreview.com/news/427444/the-computing-trend-that-will-change-everything/, accessed July 21, 2015.
4. For more information on how the Information Value Loop can be used to craft an IoT strategy for every industry, see Michael E. Raynor and Mark J. Cotteleer, "The more things change: Value creation, value capture, and the Internet of Things," *Deloitte Review* 17, July 27, 2015, http://dupress.com/articles/value-creation-value-capture-internet-of-things/, accessed July 29, 2015.
5. You can visualize these applications through the phases of a package delivery: A carrier needs to know its fleet's current demand and capacity, plan and distribute packages accordingly, route planes and trucks efficiently, maintain the trucks and planes, and do this all while reducing the costs to fuel vehicles and heat/cool facilities.
6. While pay-as-you-go models may be relatively new to logistics since routes and destinations are largely planned ahead of time, they are not new to transportation. Car rental companies such as Car2Go and Zipcar offer pay-as-you-go plans, as do insurers such as Metromile; pay-as-you-go bicycles can be found on the street corners of cities such as New York, Chicago, and Washington, DC.
7. Independent studies of technology applications to multi-modal transport in the EU have determined similar results. Perego et al. find that while wireless tech has low penetration in the logistics industry, order tracking and vehicle location monitoring are the most common applications. Similarly, out of 33 EU Framework Program projects, at least 20 are best categorized as Sense & Shape, using our terminology.
   Alessandro Perego et al., "ICT for logistics and freight transportation: A literature review and research agenda," International Journal of Physical Distribution and Logistics Management 41, no. 5 (2011): pp. 457-83; Irina Harris, Yingli Wang, and Haiyang Wang, "ICT in multimodal transport and technological trends: Unleashing potential for the future," International Journal of Production Economics 159 (January 2015): pp. 88-103.
8. BBC News, "At a glance: Heathrow's rivals," November 22, 2007, http://news.bbc.co.uk/2/hi/uk_news/7107652.stm, accessed July 22, 2015.
9. Rhea Wessel, "Munich Airport says RFID improves dolly management," *RFID Journal*, October 21, 2009, www.rfidjournal.com/articles/view?5316/, accessed July 22, 2015.
10. Telecom Paper, "Undagrid starts track-and-trace system for Schiphol," May 26, 2014, www.telecompaper.com/news/undagrid-starts-track-and-trace-system-for-schiphol--1015885, accessed July 22, 2015.
11. EIT Digital, "Undagrid wins the Internet of Things Idea Challenge 2014," November 26, 2014, www.eitdigital.eu/news-events/news/article/undagrid-wins-the-internet-of-things-idea-challenge-2014/, accessed July 22, 2015.

12. Much of the research and initial employment of mesh networks are coming from the military, where especially complex mobile ad hoc networks are beginning to see use. For more information on how these mesh-networks operations and other potential applications, see Joe Mariani, Brett Loubert, and Brian Williams, *Continuing the march: The past, present, and future of the IoT in the military*, Deloitte University Press, August 6, 2015, http://dupress.com/articles/internet-of-things-iot-in-military-defense-industry/.
13. SITA, *Air transport industry insights: The baggage report 2015*, www.sita.aero/resources/type/surveys-reports/baggage-report-2015, accessed July 21, 2015.
14. SAP Technology, "T-Systems and Hamburg Port Authority: Building smarter port logistics with SAP HANA Cloud Platform," May 16, 2013, https://youtu.be/Zv46j2WZ3jU, accessed July 21, 2015.
15. Ibid.
16. For example, this is the case in third-party logistics, a description of which can be found in Jean-Paul Rodrigue and Markus Hesse, "Chapter 5.4: Logistics and freight distribution," *Geography of Transport Systems* (New York: Routledge, 2013), https://people.hofstra.edu/geotrans/eng/ch5en/conc5en/ch5c4en.html, accessed July 22, 2015.
17. James Macaulay, Lauren Buckalew, and Gina Chung, *Internet of Things in Logistics: A collaborative report by DHL and Cisco on implications and use cases for the logistics industry*, 2015, www.dhl.com/content/dam/Local_Images/g0/New_aboutus/innovation/DHLTrendReport_Internet_of_things.pdf, accessed July 22, 2015.
18. Ibid.
19. RTT News, "Freescale semiconductor unveils world's smallest SCM for Internet of Things," June 23, 2015, www.nasdaq.com/article/freescale-semiconductor-unveils-worlds-smallest-scm-for-internet-of-things-20150623-00009, accessed July 22, 2015.

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