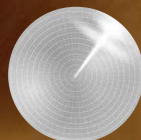


# INTERNET OF THINGS IN LOGISTICS

A COLLABORATIVE REPORT BY DHL AND CISCO ON  
IMPLICATIONS AND USE CASES FOR THE LOGISTICS INDUSTRY



## PREFACE

We at DHL and Cisco are excited to share this new trend report with readers from the logistics industry on a topic that fires the imaginations of both our companies: the Internet of Things (IoT).

IoT presents a unique technology transition that is impacting all our lives and will have huge implications for the business of logistics. As we move from 15 billion connected devices today to some 50 billion by 2020, and embed sensor technology and analytics throughout our organizations, companies will enjoy unprecedented visibility into operations, enabling new sources of value. This visibility, in turn, will transform how logistics providers make decisions, including about how goods are stored, monitored, routed, serviced, and delivered to customers, as well as operational health and safety practices.

Furthermore, the proliferation of IoT for our homes, work environments, cities and even ourselves (with the emergence of wearable technologies and biomedical sensors) creates opportunities for new business models in logistics. We believe there is hidden value yet to be realized.

This trend report aims to deepen readers' understanding of IoT, covering three main issues:

- What is the Internet of Things, and why is it a big deal?
- What are some of the leading practices and applications of IoT that are generating value across sectors?
- What are some of the key use cases for IoT in the logistics industry specifically, and what will be their implications?

DHL and Cisco share a belief in the potential of IoT to revolutionize business processes across the entire value chain, and particularly the experiences of our customers. In our collaboration, we will explore a few of the many innovations presented by IoT, and their application to the logistics industry. We hope you find the journey illuminating.

Yours sincerely,



A handwritten signature in black ink that reads "James Macaulay".

**James Macaulay**  
Cisco Consulting Services



A handwritten signature in black ink that reads "Markus Kückelhaus".

**Dr. Markus Kückelhaus**  
DHL Trend Research

<b>Preface</b> .....	<b>1</b>
<b>1 Understanding the Internet of Things</b> .....	<b>3</b>
1.1 Introduction: Connecting the Unconnected .....	3
1.2 The Internet of Everything vs. IoT .....	5
1.3 IoT Impacts on Logistics .....	7
<b>2 IoT Best Practices</b> .....	<b>8</b>
2.1 Operational Efficiency .....	8
2.2 Safety and Security .....	10
2.3 Customer Experience .....	12
2.4 New Business Models .....	13
<b>3 IoT in Logistics</b> .....	<b>14</b>
3.1 Use Cases – Warehousing Operations .....	14
3.2 Use Cases – Freight Transportation .....	18
3.3 Use Cases – Last-mile Delivery .....	21
3.4 Success Factors for IoT in Logistics .....	25
<b>Outlook</b> .....	<b>26</b>
<b>Sources</b> .....	<b>27</b>

# 1 UNDERSTANDING THE INTERNET OF THINGS

## 1.1 Introduction: Connecting the Unconnected

In today's society, the Internet is often considered a "given" due to its ubiquitous presence and accelerating influence on the ways in which we live, work, and communicate with one another. But how did the Internet get so large so quickly, and what role will it play in the future?

The Internet has undergone numerous stages of development, dating back to the founding days of ARPANET, the first TCP/IP network from which today's Internet evolved. Throughout these stages, the Internet has fundamentally been about connecting computers. These computers, of course, continue to evolve in parallel with the build-out of the Internet, with significant developments in PCs, laptops, tablets, smartphones, and more. Regardless of the many different form factors and computing architectures, the Internet essentially revolved around connecting these devices whose sole reason to exist was to send, receive, process, and in most cases store information. Until relatively recently, the Internet has been composed entirely of computers connected to one another over the network.

Today this is no longer the case. We have entered a unique period in the life of the Internet — the Internet of Things (IoT). IoT is not an entirely new concept, having originated in the early 2000s with the work of MIT's AutoID Lab.<sup>1</sup> While definitions vary, perhaps

the simplest way to think of IoT is to consider it as the networked connection of physical objects.

With the advent of IoT, Internet connections now extend to physical objects that are not computers in the classic sense and, in fact, serve a multiplicity of other purposes (see Figure 1). A shoe, for example, is designed to cushion the foot while walking or running. A street light illuminates a road or sidewalk. A forklift is used to move pallets or other heavy items. None of these have traditionally been connected to the Internet — they did not send, receive, process or store information. Nonetheless, there is information latent in all of these items and their use. When we connect the unconnected — when we light up "dark assets" — vast amounts of information emerge, along with potential new insights and business value.

A connected shoe can tell its owner (or a researcher, or a manufacturer) the number of footfalls in a given period of time, or the force with which the foot strikes the ground. A connected street light can sense the presence of cars, and provide information to drivers or city officials for route planning and to optimize the flow of traffic. A connected forklift can alert a warehouse manager to an impending mechanical problem or safety risk, or be used to create greater location intelligence of inventory in the warehouse.



**Figure 1:** The Connected Home and Consumer

<sup>1</sup><http://newsoffice.mit.edu/2012/auto-id-cloud-of-things-big-data>



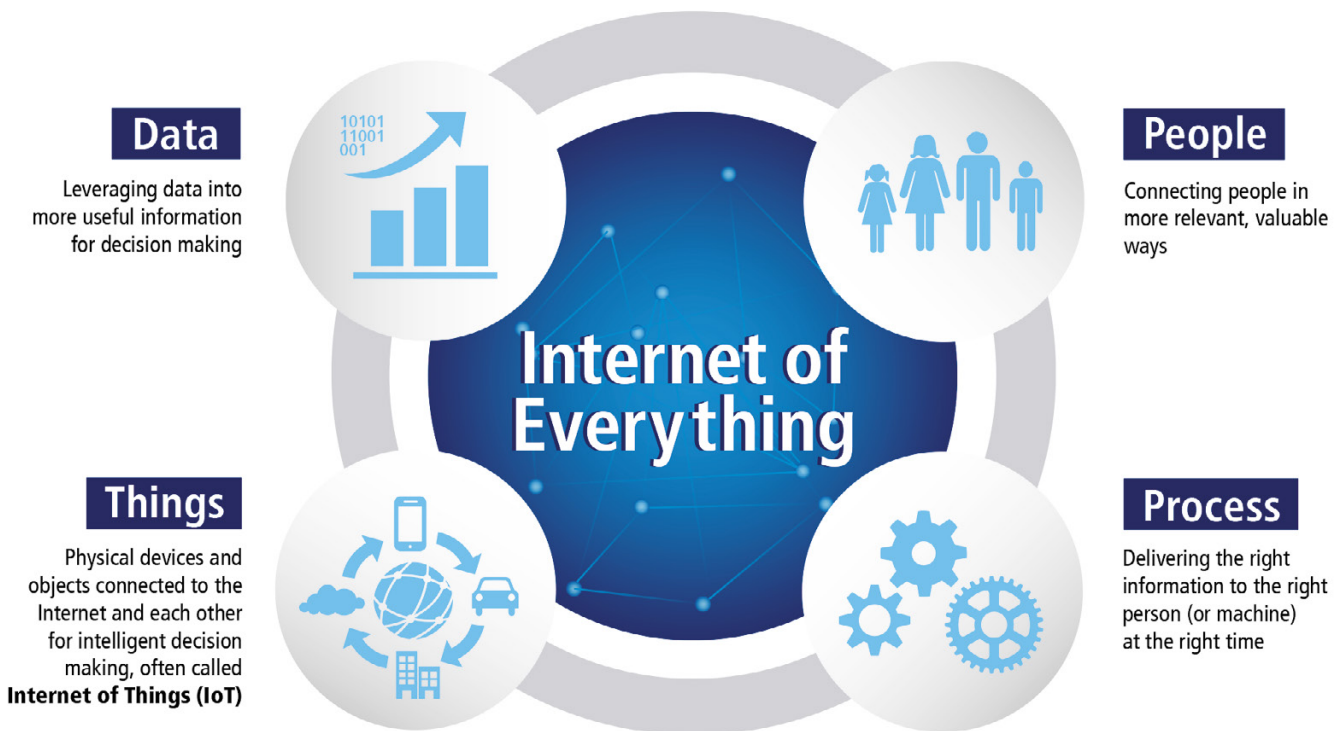
To light up such dark assets, IoT encompasses a diverse array of different technologies including wireless local (e.g., Bluetooth, RFID, Zigbee, Wi-Fi), mesh network, and wide area connections (e.g., 3G, LTE), as well as wired connections. Increasingly, IoT represents the convergence of information technology (IT) and so-called “operational technology” (OT). OT is characterized by more specialized, and historically proprietary, industrial network protocols and applications that are common in settings such as plant floors, energy grids, and the like.

Of course, IoT also includes more consumer-oriented devices, embedded technologies, and apps. An important element of this is the incorporation of controllers and actuators (Arduino is a well-known example), so that an action taken in the *digital world*, such as a user clicking a link in an application, can result in a corresponding action in the *physical world* (e.g., an alarm sounds, a lever flips, an assembly line comes to a halt).

However, we are only at the beginning of the IoT revolution. So far, less than one percent of all physical objects that could be connected to the Internet are currently connected. In numbers, that means of the roughly 1.5 trillion items on earth that could benefit from an IP address, just under 15 billion are connected to the Internet today.<sup>2</sup> The average consumer in a developed nation is surrounded by dozens of connectable items. These include com-

puters, consumer electronics, and communication devices (e.g., smartphones); appliances; physical materials in the home (e.g., thermostat, plumbing); clothing and wearable devices; vehicles and much more. By 2020, Cisco estimates there will be more than 50 billion devices connected to the Internet. By that time, computers (including PCs, tablets, and smartphones) will represent just 17 percent of all Internet connections; the other 83 percent will result from IoT, including wearables and smart-home devices.<sup>3</sup>

While this may seem like a low rate of current penetration, IoT deployments have skyrocketed in recent years. According to Zebra Technologies, in a study conducted with Forrester Research, enterprise IoT deployments have grown by 333 percent since 2012. According to the survey, 65 percent of respondents had deployed IoT technologies in the enterprise in 2014, compared to only 15 percent in 2012.<sup>4</sup> Although technical and public policy issues persist, many factors contribute to the accelerating deployment of IoT capabilities. These include progress toward common IP-led standards; the introduction of IPv6 (which resolves the constraint on the number of available IP addresses for connected devices); the proliferation of wireless connectivity; improved battery life; device “ruggedization” and new form factors; open innovation models such as Kickstarter and Indiegogo, as well as the so-called “maker” movement; and the declining costs of technology, following Moore’s Law.



**Figure 2:** IoE, the Networked Connection of People, Process, Data, and Things<sup>5</sup>

<sup>2</sup> <http://blogs.cisco.com/news/cisco-connections-counter>

<sup>3</sup> Strategy Analytics, “Connected World: The Internet of Things and Connected Devices in 2020,” 9 October 2014.

<sup>4</sup> “IoT in the Enterprise Up Three-Fold, Study Finds,” Network World, November 24, 2014

<sup>5</sup> Cisco Consulting Services, 2014

## 1.2 The Internet of Everything vs. IoT

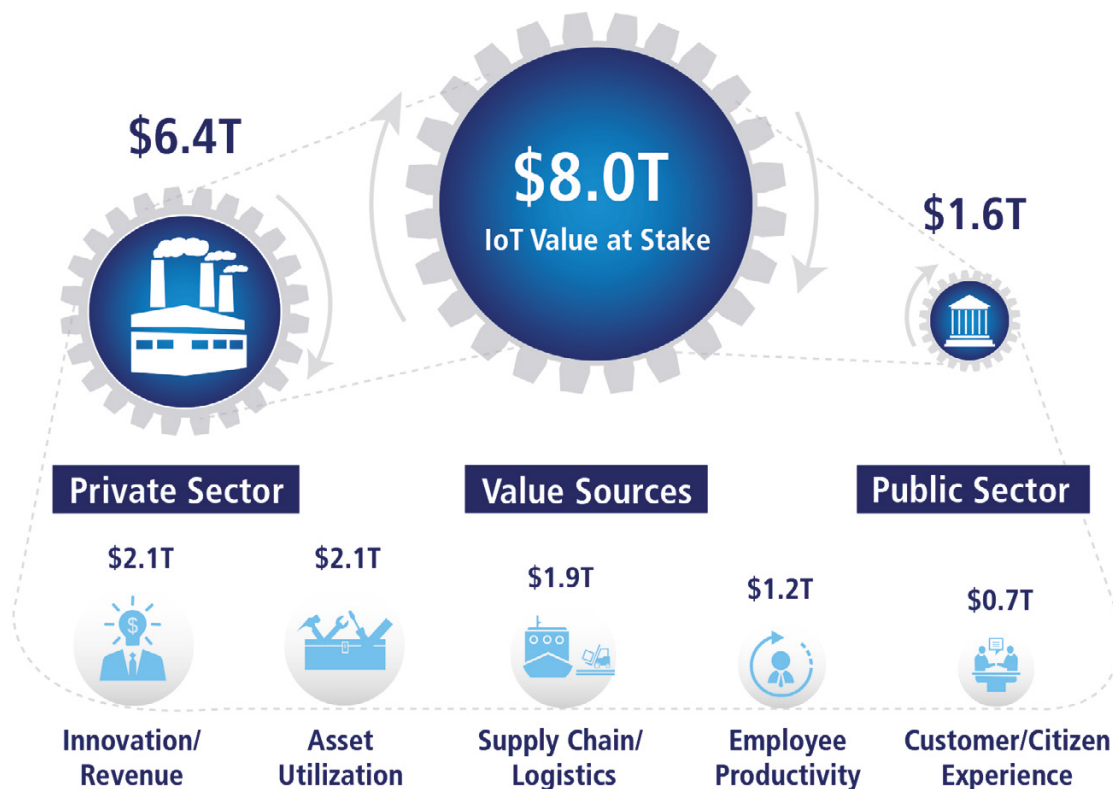
As critical as IoT is in connecting the unconnected, it is only part of the story. Along with physical objects, people and intangible “things” must also be connected in new and better ways. IoT is a vital enabler of certain types of connection that together make up what Cisco refers to as the “Internet of Everything” (IoE). IoE connections can be machine-to-machine (M2M); machine-to-person (M2P); or person-to-person (P2P). IoE includes not just the networked connection of physical objects, but also includes the links between people, process, and data (see Figure 2). IoT is most often equated to M2M connections but, as noted, definitions of IoT are nearly as diverse as its applications. Nevertheless, most observers agree that IoT implies value beyond just the physical or logical interconnection of objects.<sup>6</sup>

Why is the distinction between IoT and IoE important? While IoT is one of IoE’s key technology enablers, so too are cloud and big data, P2P video/social collaboration, mobility (including location-based services), and security. Together, they create the opportunity for unprecedented innovation and organizational transformation. IoE is dissimilar from IoT in that it is not of itself a single technology transition, but rather a larger platform for digital disruption comprised of multiple technologies. In this sense, IoT is a subset of IoE.

Current calculations estimate that IoE represents \$19 trillion in “Value at Stake” globally over the next decade.<sup>7</sup> Value at Stake can be understood as the new net profits created as a result of IoE (i.e., from markets that could not have existed before), as well as the migration of profits from losers to winners as a result of IoE-led market dynamics.

IoT by itself will generate \$8 trillion worldwide in Value at Stake over the next decade (see Figure 3) which accounts for more than 42 percent of IoE’s overall Value at Stake. This value will come from five primary drivers: innovation and revenue; asset utilization; supply chain and logistics; employee productivity improvements; and enhanced customer and citizen experience. Supply chain and logistics alone are estimated to provide \$1.9 trillion in value, which is a promising indication of the untapped potential and profits to gain from utilizing IoT in the logistics industry.

The Value at Stake calculations stem from a bottom-up economic analysis conducted by Cisco on dozens of IoT use cases, both public and private sector. Each use case represents a business capability and resulting economic value brought about by connecting the unconnected.



**Figure 3: IoT Value at Stake<sup>8</sup>**

<sup>6</sup> Machina Research, “What’s the Difference Between M2M and IoT?” September 2014. See also IDC, “The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things,” April 2014

<sup>7</sup> [http://internetofeverything.cisco.com/sites/default/files/docs/en/ieo\\_vas\\_public\\_sector\\_top\\_10%20insights\\_121313final.pdf](http://internetofeverything.cisco.com/sites/default/files/docs/en/ieo_vas_public_sector_top_10%20insights_121313final.pdf)

<sup>8</sup> Cisco Consulting Services



“ The Internet of Things will revolutionize decision making – we know that. By connecting the previously unconnected, we create incredible potential for businesses to improve the speed and accuracy of decision making through the analysis and application of digital information. It enables dramatically

faster cycle times, highly dynamic processes, adaptive customer experiences and, through the ecosystem of people and technology, the potential for breakthrough performance gains. ”

**Edzard Overbeek, Senior Vice President, Cisco Services**

But what does connecting the unconnected entail? An example of a city government is instructive. For many municipalities, smart parking is the “killer app”: parking is a source of important government revenues, but also a cause of process “friction” that yields inefficiency and citizen dissatisfaction. Beyond frustrated drivers, this friction has important implications. It is estimated that as much as 30 percent of all urban traffic is the result of drivers looking for parking.<sup>10</sup> Parking in unauthorized spaces has reached epidemic proportions in many major urban centers, with approximately one third of all parking occurring outside designated (pay or free) spaces.<sup>11</sup> This adds to congestion and undermines city revenues. On a global scale, inefficient parking also contributes to billions of dollars in lost citizen productivity and millions of tons of greenhouse gases.

So how does smart parking create value for cities? It begins with connecting previously “dark” assets in new and better ways, in this case by placing sensors on parking meters and spaces (see Figure 4). This creates new data and intelligence about those assets — which spaces are available, where they are located, how much it costs to park. The resulting insights provide the basis for process innovation, including new services (e.g., “space finder” apps) and new sources of monetization (e.g., dynamic pricing based on availability). Ultimately, this delivers the most important impact: benefit both to city employees and citizens. With smart parking, traffic wardens and city planners can be more productive, and drivers can enjoy greater convenience. Case examples of smart parking include Barcelona, Dubai, Nice, San Mateo County (California), and Santander.

This example illustrates that there is more to IoT than merely connecting assets. Connecting “things” is a means to an end. IoT creates value through the data that can be captured from connected assets and the resulting insights that will drive business and operational transformation.

Thus the use of analytics and complementary business applications (e.g., data visualization) is crucial if organizations are to capture and make sense of the data generated from connected devices. As IDC puts it, “The IoT is innately analytical and integrated.”<sup>9</sup> An illustration of this is a network of motion sensors combined with IP cameras and video analytics capabilities – together this system delivers insights beyond the basic detection of motion (e.g., it can intelligently identify an unauthorized human form from a branch blowing in the wind as responsible for tripping a sensor).



**Figure 4:** IoE-enabled Smart Parking<sup>12</sup>

<sup>9</sup> <http://www.streetline.com/2013/10/streetline-and-cisco-expand-collaboration/>

<sup>10</sup> [http://web.mit.edu/11.951/oldstuff/albacete/Other\\_Documents/Europe%20Transport%20Conference/traffic\\_engineering\\_an/the\\_time\\_looking\\_f1580.pdf](http://web.mit.edu/11.951/oldstuff/albacete/Other_Documents/Europe%20Transport%20Conference/traffic_engineering_an/the_time_looking_f1580.pdf)

<sup>11</sup> IDC, “IDC’s Worldwide Internet of Things (IoT) Taxonomy,” October 2013

<sup>12</sup> Cisco Consulting Services

### 1.3 IoT Impacts on Logistics

IoT promises far-reaching payoffs for logistics operators and their business customers and end consumers. These benefits extend across the entire logistics value chain, including warehousing operations, freight transportation, and last-mile delivery. And they impact areas such as operational efficiency, safety and security, customer experience, and new business models. With IoT, we can begin to tackle difficult operational and business questions in exciting new ways.

As shown in Figure 5, applying IoT to logistics operations promises a substantial impact. We can monitor the status of assets, parcels, and people in real time throughout the value chain. We can measure how these assets are performing, and effect change in what they are currently doing (and what they will do next). We can automate business processes to eliminate manual interventions, improve quality and predictability, and lower costs. We can optimize how people, systems, and assets work together, and coordinate their activities. And ultimately, we can apply analytics to the entire value chain to identify wider improvement opportunities and best practices.

In essence, IoT in the world of logistics will be about “sensing and sense making” (see Figure 6). “Sensing” is the monitoring of different assets within a supply chain through different technologies and mediums; “sense making” is concerned with handling vast amounts of data sets that are generated as a result, and then turning this data into insights that drive new solutions.



**Figure 5:** IoT-enabled Capabilities<sup>15</sup>

But is this the right time to leverage IoT in logistics? Today, we see optimal conditions for IoT to take off in the industry. There is a clear technology push through the rise of mobile computing, consumerization of IT, 5G networks, and big data analytics, as well as a pull from customers who are increasingly demanding IoT-based solutions. Combined, these factors are enabling logistics providers to adopt IoT at an accelerating rate.

### IoT is “SENSING & SENSE MAKING” in the world of logistics

#### Technology push

- Mobile computing growing steadily with more mobile phones expected in 2020 than people in the world
- Due to the consumerization of IT, sensor technology has become more mature and affordable to be used for industry purposes in logistics
- With the move towards 5G, wireless communication will reach a new level of maturity connecting everything anytime
- Cloud computing and big data technologies will enable new data-based services

IoT in Logistics

#### Need for logistics solutions

- High need for transparency and integrity control (right products, at the right time, place, quantity, condition and at the right cost) along the supply chain
- End consumers are asking for detailed shipment tracking to have transparency in real time
- Business customers are asking for integrity control especially for sensitive goods
- Logistics companies need transparency of networks and assets being used for ongoing optimization of efficiency and network utilization

**Figure 6:** Convergence of Technology and Logistics Trends

<sup>15</sup> Cisco Consulting Services, 2015



## 2 IOT BEST PRACTICES

As with most technology transitions, it is helpful to look at IoT in a broader context, and to consider some of the best practices from other industries. This can inform and inspire the use of IoT in logistics. We have selected a number of innovative IoT examples, clustered into four functional categories; each provides individuals or companies with significant benefits.

### 2.1 Operational Efficiency

#### 2.1.1 Traffic and Fleet Management

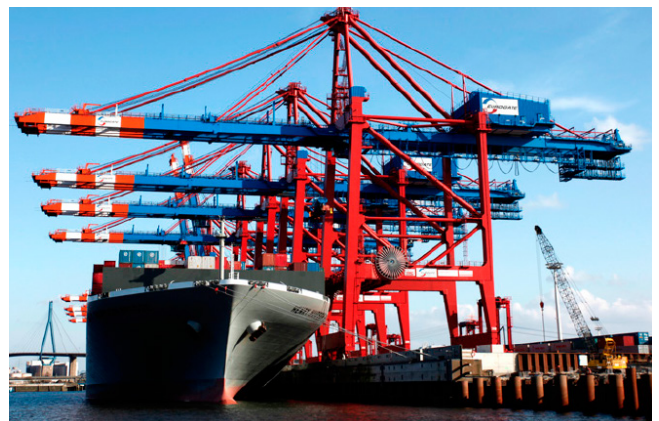
Optimizing asset utilization to drive greater operational efficiency is at the very heart of IoT value; according to Cisco's calculations, it accounts for roughly 25 percent of the total Value at Stake from IoT. Vehicles are among the assets most ripe for improved efficiency, especially in terms of traffic and fleet management. In-vehicle telematics and vehicle-infrastructure integration have been vanguard applications in the use of sensor data. And automotive manufacturers and transportation operators have invested substantially in connected vehicles, including "recovery" systems, such as LoJack, and in-vehicle driver services, such as General Motors' OnStar. With IoT, traffic and fleet management applications herald a new wave of efficiency gains.

One example is the Seoul City Transportation Information Center (TOPIS), which evolved from a bus management system created in 2004. It is now responsible for providing efficient public transportation services through managing and gathering information on all public transportation in Seoul, excluding traffic signals. The TOPIS Center gathers data from streets, buses, taxis, and citizens using GPS devices, loop detectors, road sensors, video, and citizen reports. This data enables a scientific approach to transportation-management policy. Travelers have access to bus arrival times 24 hours a day, enabling them to schedule their routes and choose which buses to ride. The system has increased transit efficiency, reduced traffic, improved uptake of transport services through clear communication to the public, and raised customer satisfaction.<sup>16</sup>

Fleet management is crucial at the Port of Hamburg, which is the second busiest port in Europe. Its "smartPORT" initiative has raised efficiency and prepared the port for additional growth.



The overall goal is to maintain, modernize, and improve the Hamburg Port Authority's IT infrastructure to support efficient operations and economic development, while minimizing the impact of traffic on local citizens. An IoT-based approach coordinates all aspects of harbor operations impacting ship, rail, and road traffic. So far, the Hamburg Port Authority has installed more than 300 roadway sensors to monitor traffic in the port area and to track wear on bridges. Digital signs and mobile apps give drivers traffic and parking information. Sensors also extend to waterways (using radar and automatic identification systems to coordinate ship traffic), and a solution that integrates roadway traffic data to help manage traffic disruptions that may occur when ship traffic requires bridge closures around the port area.<sup>17</sup>



<sup>16</sup> [http://internetofeverything.cisco.com/sites/default/files/pdfs/Korea\\_TOPIS\\_Jurisdiction\\_Profile\\_final.pdf](http://internetofeverything.cisco.com/sites/default/files/pdfs/Korea_TOPIS_Jurisdiction_Profile_final.pdf)

<sup>17</sup> [http://internetofeverything.cisco.com/sites/default/files/pdfs/Hamburg\\_Jurisdiction\\_Profile\\_final.pdf](http://internetofeverything.cisco.com/sites/default/files/pdfs/Hamburg_Jurisdiction_Profile_final.pdf)



## 2.1.2 Resource and Energy Monitoring

Operational efficiency is not exclusively about lowering costs. IoT sensors are ideally suited to tracking all kinds of resources, including petroleum and natural gas, electricity, and water. And IoT technology has strong potential to enable greater environmental sustainability. IoT can reduce waste, prevent disasters, and be a critical component of the smart energy grid of the future. Utility organizations, municipalities, oil and gas companies, and consumers themselves are among the many entities and individuals tapping into IoT capabilities to optimize their use of resources.

Hagihon, Israel's largest municipal water utility company, is leading the way in using smart devices to improve water-system management, maintenance, and revenue collection in the Jerusalem area. In a semi-arid climate, Hagihon has reduced water loss while preserving the company's bottom line.

The company replaced a traditional, labor-intensive work model with a smart-technology solution, implementing a mix of both high- and low-tech strategies, and cultivating several key technological partnerships, to increase efficiency and profitability. Pump and in-ground sensors allow easy tracking of water pressure and flow. A supervisory control and data acquisition (SCADA) system controls functions based on sensor data analysis. A geographical information system (GIS) provides a real-time map of current conditions. Fixed acoustic sensors, combined with mobile, cloud, and GPS technology, can pinpoint water leaks underground, while ERP and mobile apps support field technician productivity. This impressive leak detection system has resulted in a significant decrease in overall water loss, and has increased profitability. The system has also improved labor efficiency, with sensors taking data collection that was previously conducted manually. This has generated substantial cost savings.



Other compelling examples of IoT enabling improved management of water and electricity resources include Water for People, a non-governmental organization dedicated to promoting clean water in the developing world through IoT, and the City of Oslo, Norway, with its world-leading smart street-lighting program.

## 2.1.3 Connected Production Floor

As was the case with in-vehicle telematics, sensor-enabled applications have been commonplace in the field of industrial automation and manufacturing process control for many years. ABB, Bosch, GE, and Rockwell Automation are just some of the organizations that have invested heavily in this area. Most production floors were historically managed by operational technology that was “closed” — that is, running on proprietary network protocols and legacy management applications. With IoT, all these systems are now migrating to open IP standards, resulting in increased scalability, interoperability, uptime, manageability, and security.

IoT enables managers to understand what is occurring at a given moment in a factory environment — the performance of machines, ambient conditions, energy consumption, status of inventory, or the flow of materials. Preventative maintenance is a key use case of IoT, and this is particularly critical in a production-floor setting. Sensors can alert managers (or machines) that a physical asset in the factory is exceeding acceptable levels of vibration or temperature, is malfunctioning, or is otherwise prone to fail. This has major implications in terms of overall equipment effectiveness (OEE), a key metric of manufacturing productivity, and has positive ripple effects throughout the supply chain.

Continental Tire provides a good example of a connected production floor. The company was experiencing production delays due



to misplaced components for tire manufacturing in its enormous plant environments, relying on grid lines painted on the floor and handwritten notes to locate “carriers” (carts) holding sheets of rubber and other tire components. Now, Wi-Fi sensors are placed on carriers and integrated with an inventory management system, so that employees can view individual carrier locations on their mobile devices. These appear as icons superimposed on a map of the facility. As a result, Continental has increased production efficiency, and cut wasted component costs.<sup>18</sup>

## 2.2 Safety and Security

### 2.2.1 Equipment and Employee Monitoring

Monitoring of equipment and people to increase safety and security is another main value proposition of IoT. Union Pacific, the largest railroad in the United States, uses IoT to predict equipment failures and reduce derailment risks. By placing acoustic and visual sensors on tracks to monitor the integrity of train wheels, the company has been able to reduce bearing-related derailments, which can result in costly delays and up to \$40 million in damages per incident. By applying analytics to sensor data, Union Pacific can predict not just imminent problems but also potentially dangerous developments well in advance. Over 20 million temperature readings per day are sent to the Union Pacific data center; on average, three railcars per day are identified as exceeding a safe threshold of some kind. Train operators can be informed of potential hazards within five minutes of detecting anomalies in bearings or tracks.<sup>19</sup>

In the case of Dundee Precious Metals (DPM), equipment monitoring and employee safety go hand in hand. DPM is a Canadian mining company that operates Europe’s largest goldmine (located

in Bulgaria). For the company, IoT is about information-enabling a mine. Mining is not generally seen as an information-heavy industry — the process of mining is much the same today as it has been for the better part of the past century. Although there may be hundreds of personnel underground at any given time, not a lot of information typically comes out of a mine. Reports tend to be paper-based and issued after miners and supervisors come off shift every eight hours. This creates all kinds of inefficiency in terms of how the mine is run, and operating “blind” can compromise worker safety.



DPM is using IoT to connect its end-to-end mine operation, including vehicles, mobile devices, cameras, programmable logic controllers (PLCs) on conveyer systems, lights, fans, power, and more. Supervisors can track equipment and miner movements throughout the mine. The mine’s blasting system is integrated with location-tracking applications to ensure the blast site is cleared of personnel and equipment. The result is greater safety for miners and increased mine production — from half a million tons to two million tons per year.<sup>20</sup>



<sup>18</sup> <http://www.aeroscout.com/files/RFID-Journal-AeroScout-and-Continental-Tires-04-25-2012.pdf?1>

<sup>19</sup> <http://blogs.wsj.com/cio/2012/03/30/union-pacific-using-predictive-software-to-reduce-train-derailments/>

<sup>20</sup> <https://www.youtube.com/watch?v=5GxJLU57hQQ>

## 2.2.2 Health Monitoring

Using IoT to monitor people extends beyond preventing industrial accidents to improving the wellness of the population in general. The consumer trend of using wearable technologies to enable the “quantified self” has increased dramatically in recent years, exemplified by devices from Apple, Fitbit, Jawbone, Pebble, and Sony. The number of personal health and fitness trackers (including smart watches) in use is expected to approach 50 million in 2015, and the figure is set to double in the next two years.<sup>21</sup>



Healthcare organizations are moving beyond the activity-measuring capabilities of consumer-oriented wearables, which generally track factors such as hours of sleep, steps taken, or calories burned. Some are leveraging IoT for an array of different and more complicated wellness monitoring applications. For example, Novartis and Google are developing a smart contact lens to measure blood glucose levels for diabetes patients.<sup>22</sup>

But one of the biggest areas of value for IoT, in terms of both health and financial outcomes, is chronic disease management. Monitoring patients — their blood pressure, their compliance with medication instructions, the care they receive within the walls of a hospital or senior living facility — is perhaps the core application of IoT in healthcare. Products such as so-called Proteus “smart pills”, which feature tiny sensors embedded in the tablets swallowed by patients, illustrate how IoT-enabled biomedical device miniaturization can give doctors and scientists greater insights into disease.<sup>23</sup>

IoT can reduce the potential for medical error among caregivers, provide an opportunity to intervene in emergencies, help medical professionals and patients take a more longitudinal approach to care, and, in the aggregate, shape research and health policy.

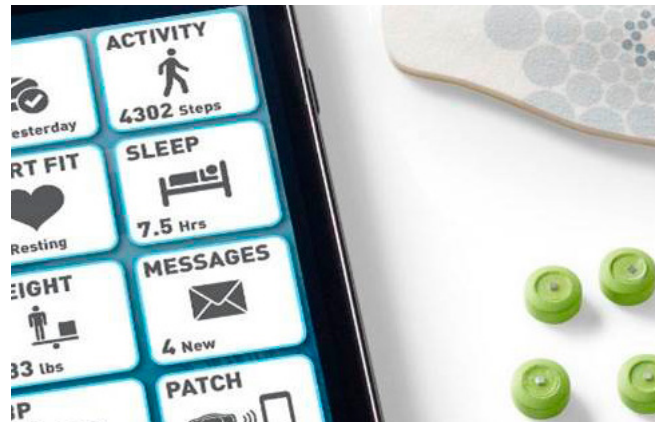


Figure 7: Smart Healthcare Using Proteus Smart Pills<sup>23</sup>

## 2.2.3 Physical Security

IoT also introduces many improvements in physical security. An example in the consumer world is SmartThings, which began as a Kickstarter-funded innovation and was acquired by Samsung in 2014. Through its portfolio of smart home-security solutions, SmartThings enables consumers to lock and unlock doors in their home from anywhere using a mobile app; capture images or trigger alarms when sensors detect motion; and receive alerts if doors or windows are unexpectedly opened. These kinds of intrusion-detection capabilities serve as next-generation burglar alarms, but SmartThings also secures other “things”: sensors attached to a child’s clothing or a pet’s collar, for example, can be configured to alert the user if they have strayed from the premises.<sup>24</sup> The August Smart Lock,<sup>25</sup> another popular consumer application of IoT, allows users to provide access to their house to trusted parties remotely, using a smartphone app and an IoT-enabled locking mechanism on their front door. This could also provide new delivery options in last-mile logistics.



Figure 8: August Smart Lock - Smartphone-Controlled Security<sup>25</sup>

<sup>21</sup> Juniper Research, “Smart Wearable Devices Fitness, Glasses, Watches, Multimedia, Clothing, Jewellery, Healthcare & Enterprise 2014-2019,” September 2014.

<sup>22</sup> <http://www.forbes.com/sites/leoking/2014/07/15/google-smart-contact-lens-focuses-on-healthcare-billions/>

<sup>23</sup> <http://www.fastcoexist.com/3024773/worldchanging-ideas/you-will-swallow-a-sensor>

<sup>24</sup> <http://www.smarthings.com/benefits/home-security/>

<sup>25</sup> <http://august.com/>



## 2.3 Customer Experience

### 2.3.1 Connected Retail

Retail is an industry set for dramatic change because of IoT innovations. The “connected retail store” amounts to a diverse collection of IoT-enabled use cases, all promising greater operational efficiency and new forms of customer experience.

Research on the retail industry reveals the most valuable use cases (for both retailers and consumers) are those that drive greater efficiency in the shopping experience.<sup>26</sup> IoT in the retail industry will drive efficiency through in-shelf availability, inventory and merchandise optimization, planogram compliance, loss prevention, mobile payments, and more. This in turn will transform the customer experience.

For consumers, improved efficiency will flow from several key IoT-reliant applications, including:

- Checkout optimization tools such as Qminder and Waitbot
- In-store guidance for shoppers, such as the OSHbot, introduced by American home improvement retailer Lowe’s. This is a robot equipped with sensors, cameras, and speech and video analytics that assists with way-finding and the location of products
- Mobile payments, including Apple Pay

These applications extend beyond the store to omnichannel retail as well. Eggminder, a “smart egg carton” solution that keeps track of eggs in a refrigerator is an admittedly less-than-essential example in the burgeoning field of smart-home replenishment applications. However, a number of IoT-enabled solutions together may hold vast potential to improve the overall retail experience for consumers.



### 2.3.2 Customer Recognition and Context-aware Offers

IoT will be instrumental in creating exciting new experiences for many types of customers, in many different settings. One of IoT’s most robust use cases is the application of beacons and other sensors for customer recognition. Beacons are small sensors that can connect wirelessly to mobile devices such as smartphones and tablets. Typically, they use Bluetooth Low Energy (BLE) signals to detect individuals in proximity to the sensor, and recognize them through integration with analytics, mobile apps, and other enterprise applications. These low-cost sensors can be attached to walls, doors, ceilings, store displays, mannequins, point-of-sale systems, ATMs, and almost any other surface.

Apple’s iBeacon is a well-known example, but many other leading technology players are entering this space. Companies such as Estimote<sup>27</sup> and StickNFind make very small, very low-cost beacons that can be adhered to a variety of surfaces. It is easy to foresee a time when beacons become so small and cheap that they are virtually disposable and could be placed on millions of consumer products, even food items.



**Figure 9:** Estimote Beacons for Context-aware Offers<sup>27</sup>

Beacons and BLE technology enable greater precision and flexibility than many cellular or RFID-based location-sensing applications. But beacons are not merely delivering location coordinates; they enable interactions with mobile apps that can communicate with customers and add value in new ways. The ability to recognize a customer means companies can push targeted marketing messages, promotions, and value-added services to customers, and these can be customized to reflect the priorities of individuals in any given moment.

This approach to customer experience design and execution is known as “hyper-relevance”. Beyond mere personalization, hyper-relevance is a new paradigm, underpinned by IoT, which enables consumers to receive what they want, when and how they want it. It requires an analytics-driven approach that applies intelligence to

<sup>26</sup> <http://www.cisco.com/c/dam/en/us/solutions/collateral/executive-perspectives/ioe-retail-whitepaper.pdf>

<sup>27</sup> <http://estimote.com/>

the context of the consumer (where he or she is, what he or she is hoping to accomplish), thereby allowing companies to dynamically provide the most suitable experience.<sup>28</sup>



**Figure 10:** The Dandy Lab - The First Talking Store<sup>29</sup>

With IoT, we are seeing a proliferation of customer recognition capabilities in retail that enable new experiences via apps and connected products. The Dandy Lab<sup>29</sup> is an innovative British retail shop, powered by IoT, which bills itself as “the world’s first talking store”. Technology in the store enables customer recognition throughout, driving intelligent, context-aware interactions that create a unique shopping experience. Mondelez, the maker of snack food products such as Cadbury chocolates and Oreo cookies, is introducing a “smart shelf” that combines sensors and analytics to create intelligent advertisements and offers based on the gestures, physical characteristics, and dwell times of consumers in front of their displays. This also impacts operational efficiency for retailers by optimizing restocking, checkout processes, and staffing.

## 2.4 New Business Models

### 2.4.1 Becoming a “Service” Provider

IoT is empowering organizations to move into adjacent markets and monetize their assets in new ways. This involves sensor-enabling core aspects of the business to generate new insights that are of value to customers. Manufacturing, engineering, high tech, utilities, and other asset-intensive sectors are now evolving to comprehend business models that monetize these insights “as a service” through dynamic pricing and payment plans. The idea of “X as a service” is most often associated with cloud computing capabilities and of course cloud is an important companion for IoT in generating new sources of value. But the movement of companies to a service-oriented model is not purely a technological challenge. This can often imply a fundamental transformation for the organization — how the company goes to market (i.e., channels), what it

sells, the kinds of employee skill sets required, and so forth.

Real estate is one industry in which the sensor-enabling of physical assets creates the potential for value-added services. Real estate company Transwestern, a global leader in property and facilities management, embedded some 95,000 sensors in one of its flagship office properties in Houston, Texas. The data from these sensors — connected fire alarms, wireless access points, video surveillance cameras, temperature sensors, HVAC, and more — enables Transwestern to monitor energy usage in the building, creating valuable new insights that help tenants lower their utility bills.<sup>30</sup>

### 2.4.2 Usage-based Insurance

Property and casualty insurers are also tapping into the power of IoT. Insurers use the technology to create new business models that reduce guesswork, subjectivity, and a reliance on aggregated historical data in actuarial processes and for setting premiums. Sensors are connected to a car’s onboard diagnostics port and data is captured on variables such as average speed, distance traveled, times of day traveled, the frequency of hard braking and cornering, and the deployment of an airbag. Some insurers also equip car sensors with global positioning systems (GPS) to track location, although this is less common due to consumer and regulatory concerns about privacy. By having a more objective measure of an individual consumer’s behaviors, and the risks they pose, insurance carriers can more accurately price risk. For consumers, they can convert what is normally a fixed cost for auto insurance to a variable cost that changes according to behavior (to increase user acceptance, many insurers also guarantee that rates can only go down for consumers using “pay-as-you-drive” services). Several providers enable customers themselves to receive alerts when a car is speeding (for example, a parent could be alerted if their teenager is driving the family car too fast). Insurers offering pay-as-you-drive services include Aioi Nissay Dowa Insurance Company of Japan, General Motors Assurance Corporation (GMAC) and many others.<sup>31</sup>



<sup>28</sup> <http://www.cisco.com/c/dam/en/us/solutions/collateral/executive-perspectives/ioe-retail-whitepaper.pdf>

<sup>29</sup> <http://www.thedandy.com/>

<sup>30</sup> [http://www.cisco.com/web/tomorrow-starts-here/files/property\\_management\\_firm.pdf](http://www.cisco.com/web/tomorrow-starts-here/files/property_management_firm.pdf)

<sup>31</sup> See more at: “Pay-As-You-Drive Vehicle Insurance: Converting Vehicle Insurance Premiums Into Use-Based Charges,” Victoria Transport Policy Institute, May 2014.



### 3 IOT IN LOGISTICS

Amid the hype surrounding IoT today, one thing is clear: the logistics industry is a key player poised to benefit from the IoT revolution.

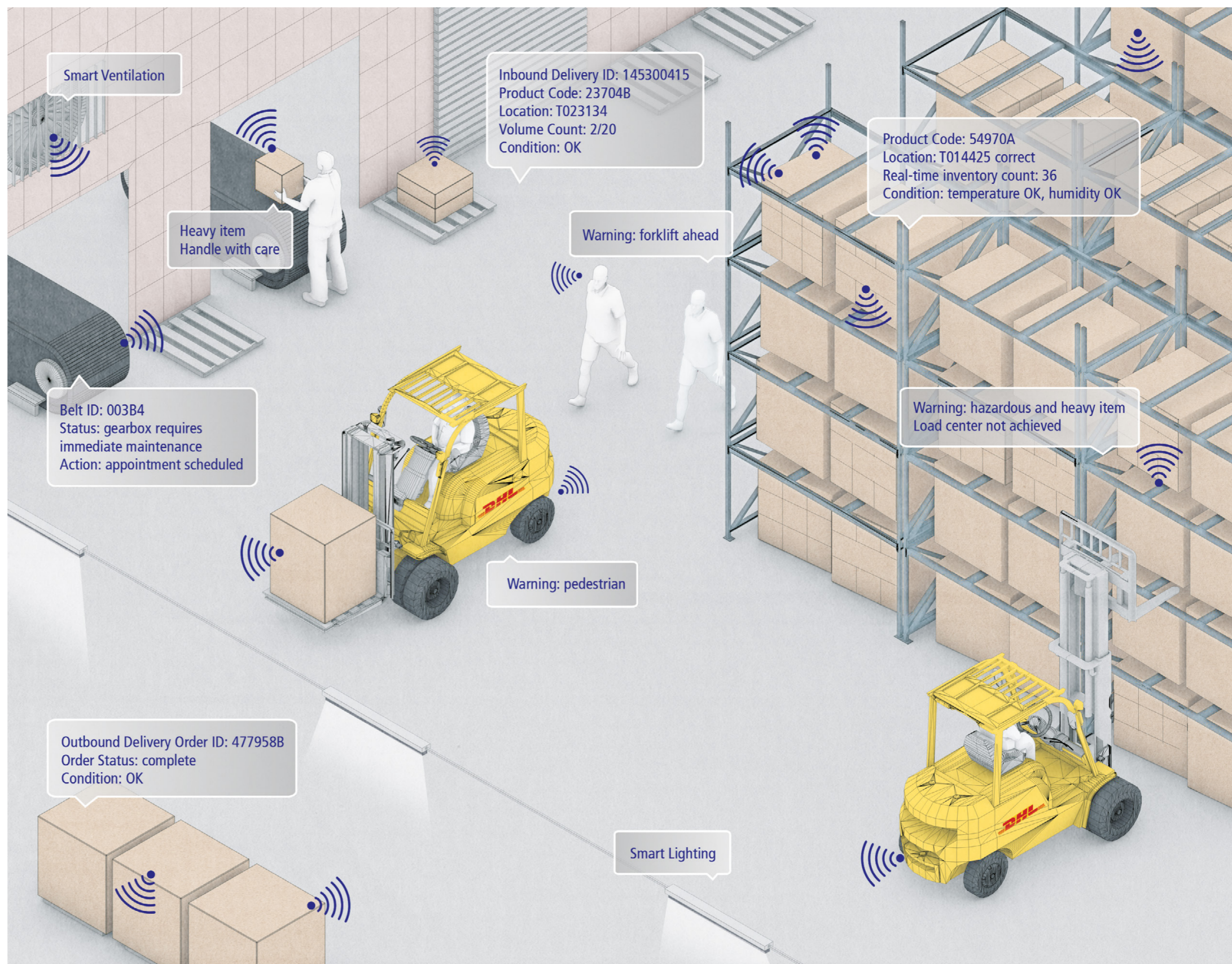
With millions of shipments being moved, tracked, and stowed by a variety of machines, vehicles and people each day, it is no surprise that logistics and IoT are a perfect match. In logistics, IoT can connect different assets along a supply chain in a meaningful way, and then analyze the data generated from these connections to capture new insights. By doing so, IoT enables logistics providers to unlock higher levels of operational efficiency, while creating customized, dynamic, and automated services for their customers. Falling prices of device components (sensors, actuators and semiconductors), faster wireless networks, and increasing data crunching capabilities only compound the business benefits, ensuring that IoT becomes a disruptive trend in the logistics industry over the next decade.

But just how nascent is IoT in logistics? Many of the technologies behind IoT — including sensors, microprocessors and wireless connectivity — have been in use in various logistics applications for a number of years already. Indeed, the logistics industry was among the first adopters of IoT technologies in operations, from the introduction of handheld scanners that digitized the delivery process to the multiple sensors that monitor cargo integrity and delivery truck performance. But even early adopters are just at the tip of the iceberg of fully exploiting IoT potential in the logistics industry.

In this section, we will explore some of the exciting use cases for IoT in logistics and cluster these within the bounds of warehousing operations, freight transportation, and last-mile delivery. IoT use cases relating to self-driving vehicles can be found in a separate DHL trend report titled *Self-driving Vehicles in Logistics*. At the end of this section, we will review the success factors for IoT adoption in logistics and provide a roadmap on how logistics providers can move forward and leverage this trend.

#### 3.1 Use Cases – Warehousing Operations

Warehouses have always served as a vital hub in the flow of goods within a supply chain. But in today's economic climate, they also serve as a key source of competitive advantage for logistics providers who can deliver fast, cost-efficient, and increasingly flexible warehousing operations for their customers.





This is no easy challenge. With thousands of different types and forms of goods being stored in the average warehouse today, every square meter of warehousing space must be optimally utilized to ensure specific goods can be retrieved, processed, and delivered as fast as possible. The result is a high-speed, technology-driven environment that is ideal for IoT applications. From pallets and forklifts to the building infrastructure itself, modern warehouses contain many “dark assets” that can be connected and optimized through IoT.

In the warehouse, the widespread adoption of pallet or item-level tagging — using low-cost, miniscule identification devices such as RFID — will pave the way for IoT-driven **smart-inventory management**.

Let’s examine a few instances of IoT in action in a warehouse. For starters, wireless readers capture data transmitted from each pallet as it arrives through inbound gateways. This data could include information on the product such as volume and dimensions, which could then be aggregated and sent to the WMS for processing. This capability eliminates the time-consuming task of manual counting and volume scanning of pallets. Cameras attached to the gateways could also be used for **damage detection**, by scanning pallets for imperfections.

Once pallets are moved to the right location, tags transmit signals to the WMS to provide **real-time visibility** into inventory levels, thus preventing costly out-of-stock situations. If any item has been misplaced, sensors can alert the warehouse manager, who can track the item’s exact location for corrective action. For quality management, sensors monitor the condition of an item and alert warehouse managers when the temperature or humidity thresholds are about to be compromised. This would allow warehousing staff to take corrective action, ensuring service quality and greater customer confidence.

During outbound delivery, pallets are scanned through an outbound gateway to ensure that the right items – in the right order



## Spotlight



Aletheia was a German government-funded project run by DHL, Fraunhofer IIS, and other partners to create a wireless sensor network system that enables seamless, end-to-end tracking of items for different transport modes. Various sensor nodes on item and asset level were combined in a sensor network. This network can safeguard the integrity of goods in transit, checking location, temperature, humidity and shock.

<http://www.iis.fraunhofer.de/en/fff/sens/anw/log/aletheia.html>

for delivery – are being sent. Stock levels are then updated automatically in the WMS for **accurate inventory control**.

Beyond goods stored in a warehouse, IoT can also drive **optimal asset utilization**. By connecting machinery and vehicles to a central system, IoT enables warehouse managers to monitor all assets in real time. Managers can be alerted when an asset is being over-utilized or when an idle asset should be deployed to do other tasks. For example, a variety of sensors could be deployed to monitor how often assets in a sorting system, such as conveyer belts, are in use or idle, and at what times. Analysis of the data could then identify optimal capacity rates and tasks for the assets. One such innovation is Swisslog’s “SmartLIFT” technology. The solution combines forklifts sensors with directional barcodes placed on the ceiling of the warehouse and WMS data to create an indoor GPS system that provides the forklift driver with accurate location and direction information of pallets. It also delivers a dashboard for managers to observe the real-time speed, location and productivity of all forklift drivers as well as visibility on inventory accuracy. Bobcat deployed the solution in its warehouse and reported a 30 percent increase in pallets per hour with no inventory errors.<sup>32</sup>

Such solutions can in future identify inefficiencies in already automated processes. For example, an automatic guided vehicle (AGV), such as an automatic pallet mover, will do an assigned task over and over unless there is manual intervention to assign it to another task. By analyzing its capacity and patterns, the warehouse



**Figure 11:** Swisslog SmartLIFT Technology for Forklifts<sup>32</sup>

manager may find that on weekends, it is best used in another part of the warehouse and this triggers corrective action.

Connected assets in a warehouse also enable **predictive maintenance** for warehouse transport systems. As one example, sensors could be placed on a sorting machine to detect levels of physical stress by measuring throughput or the temperature of the machine. Cameras can also be employed to detect package damage or pile-ups as they occur. All of this data could then be collected and combined for predictive maintenance analytics, which can schedule maintenance appointments and calculate the expected lifetime of the machine at its current level of usage. Any pile-ups are alerted to staff so they can be fixed before causing serious damage.

IoT can also drive higher levels of worker **health and safety** through a connected workforce and connected vehicles. Statistics from the Industrial Truck Association (ITA) and the U.S. Occupational Health and Safety Administration estimate that there are about 855,900 forklifts in operation in the United States alone. Those forklifts are estimated to contribute to more than 100,000

accidents per year, which causes 94,750 injuries. Almost 80 percent of forklift accidents involve a pedestrian.<sup>33</sup> Multiplied on a global scale, this demonstrates the potential scale for improving safety within the warehouse.

Sensors and actuators combined with radar or cameras attached to forklifts can allow them to communicate with other forklifts and scan the environment for hidden objects that could cause a collision. Forklifts could be programmed to slow automatically at intersections when another forklift or pedestrian is detected around the corner.

Many accidents also result from workers loading the pallet incorrectly. Such accidents could be avoided by using pressure sensors to detect when a load has become too heavy, and also when an uneven load has been placed on the forklift. Ravas is developing smart forks that incorporate weight scales as well as load-center measurement technology for pallet trucks.<sup>34</sup> By alerting the driver when load capacity has been exceeded or when the load center is uneven, safety is increased.

<sup>32</sup> <http://info.totaltraxinc.com/blog/here-is-what-happens-when-big-data-and-forklifts-meet>

<sup>33</sup> <http://www.sick.com/us/en-us/home/pr/whitepapers/Documents/SICK%20White%20Paper-%20Collision%20Awareness%20Solutions.pdf>

<sup>34</sup> <http://www.ravas.com/en/int/products/show-product/iforks-touch/>

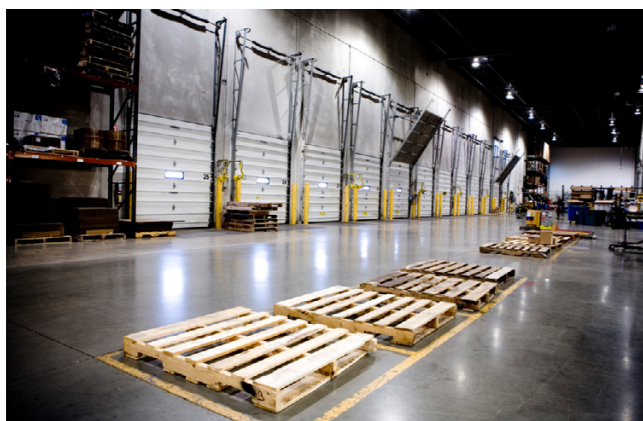


IoT technologies can also prevent falling pallets and products. A mix of sensors and cameras could be employed to detect risks from imperfect storage and calculate the likelihood of a pallet or item falling from a shelf. Once an issue is identified, an alert could be transmitted to the warehouse team for immediate action, reducing potential injuries to workers and cutting down on damage to goods. At all hours, these cameras could also be used for monitoring items to prevent theft.

In the near future, workers will opt-in to the IoT system, connecting via their smart phones, scanners, and wearables – in fact, smart glasses and other wearables are likely to bring an exciting new stage in machine-to-human interaction in the warehouse. IoT use cases relating to this topic can be found in a separate DHL trend report titled *Augmented Reality in Logistics*.

The emergence of the **connected workforce** provides new opportunities to monitor the health and fatigue of workers, track the fixed process paths of workers, and analyze where warehouse managers can improve walkways or change a process to make workers' lives easier and safer. One such solution is under development from Locoslab, which provides precise localization of mobile devices in indoor environments using active and passive RFID technology. It monitors the movement of people and objects within an indoor environment and applies location analytics to understand where processes can be improved.<sup>35</sup>

Sensors can also be integrated into the warehouse infrastructure itself. In an average warehouse, ordinary lighting accounts for up to 70 percent of energy use.<sup>36</sup> **Smart warehouse energy management** connects HVAC and utilities networks, including connected LED lights, to optimize energy consumption. In addition to automatically dimming and lighting according to activity, such systems regulate the energy consumption of devices, heating, and ventilation. The resulting reduction in energy consumption cuts overhead costs along with the carbon footprint of the warehouse (as with the Transwestern example in section 2.4.1).



### 3.2 Use Cases – Freight Transportation

With hundreds of thousands of ocean, air, and road assets, freight transportation presents great potential for IoT networks. IoT in freight transportation will move beyond track and trace. Today it is already possible to track and monitor a container in a freighter in the middle of the Pacific, and shipments in a cargo plane mid-flight. So, what else can IoT do for freight transportation in the future?

We expect IoT to provide the next generation of track and trace: faster, more accurate and predictive, and more secure. Freight-Watch recorded 946 cargo theft incidents across the United States

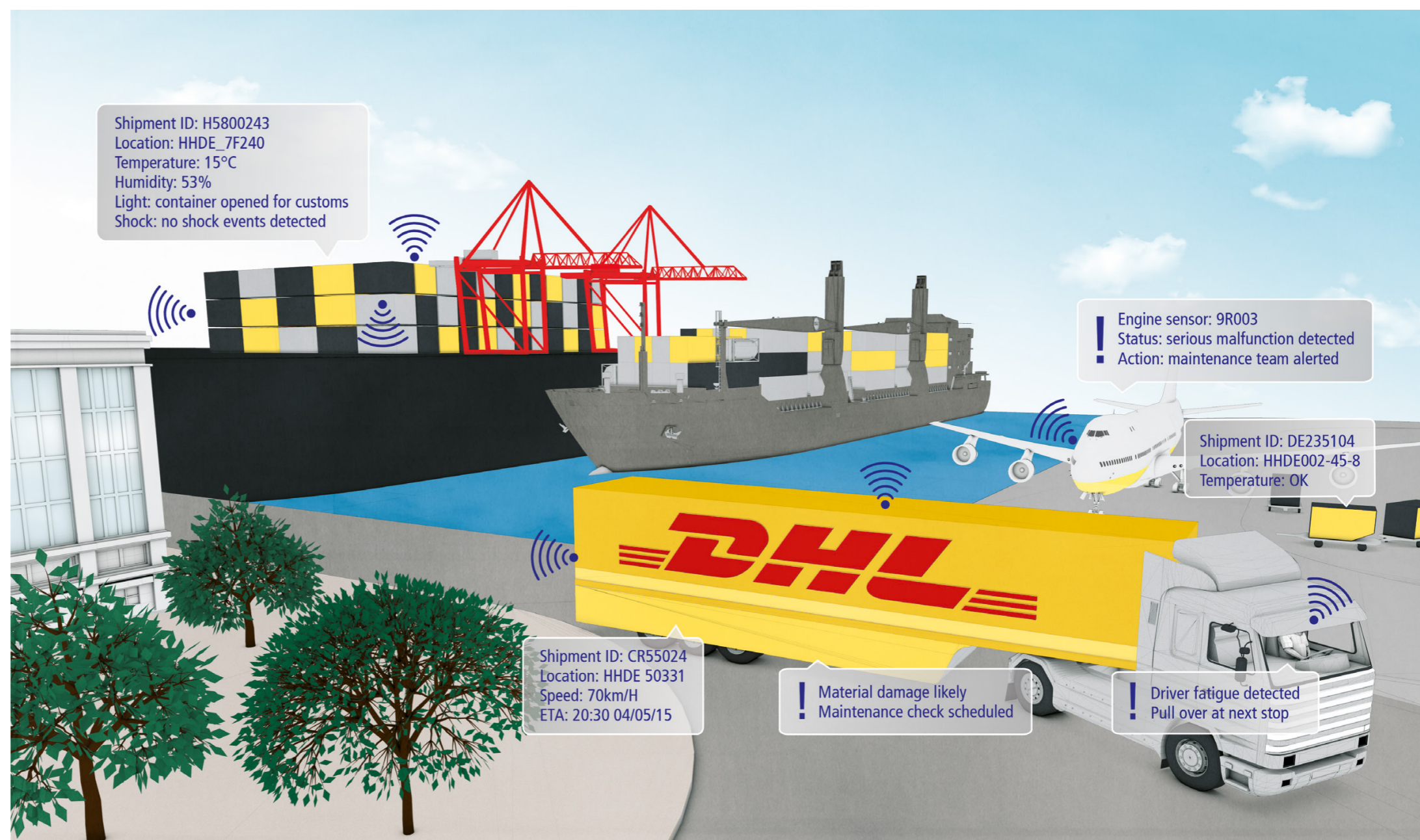
in 2012 and 689 in Europe,<sup>37</sup> with organized crime targeting ports and rest areas. Theft costs shippers and logistics providers billions of dollars each year, from the impact of inventory delays as well as the cost of stolen goods. Through IoT, logistics providers will gain clear visibility on the movement of goods — meter by meter and second by second — as well as item-level condition monitoring to ensure that goods arrive in time, at the right place, and intact.

As we have seen, **location and condition monitoring** through IoT will provide a new level of transport visibility and security. Telematics sensors in trucks and multi-sensor tags on items transmit data on location, condition (whether any thresholds have been crossed), and if a package has been opened (to detect possible theft).

#### Spotlight



One solution from DHL is the **SmartSensor**,<sup>38</sup> which offers full-condition monitoring. This intelligent sensor can monitor temperature and humidity, while also indicating shock and light events, to ensure complete integrity during transportation.



<sup>35</sup> www.locoslab.com

<sup>36</sup> [http://www.lighting.philips.com/pwc\\_li/main/application\\_areas/industry/ledsinindustry/assets/Warehouse-brochure.pdf](http://www.lighting.philips.com/pwc_li/main/application_areas/industry/ledsinindustry/assets/Warehouse-brochure.pdf)

<sup>37</sup> [http://www.globalinitiative.net/wpfb-file/freightwatch-2013-global-cargo-theft-threat-assessment-full\\_0-pdf/](http://www.globalinitiative.net/wpfb-file/freightwatch-2013-global-cargo-theft-threat-assessment-full_0-pdf/)

<sup>38</sup> DHL Smart Sensor: [www.smartsensor-temperature.net](http://www.smartsensor-temperature.net)

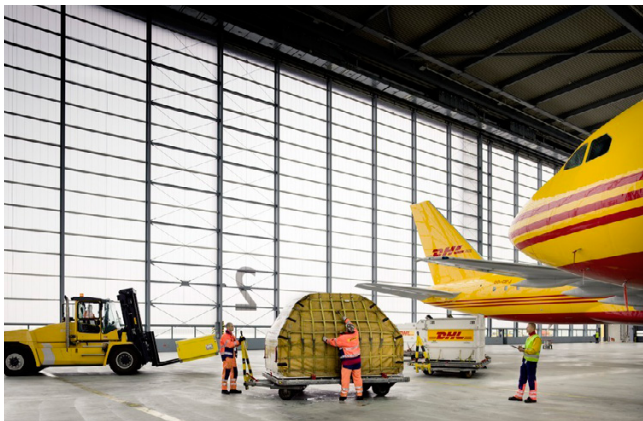


One challenge that the logistic industry is facing is that many of the existing solutions are proprietary, stand-alone solutions that are not connected to each other. New platforms need to be created that combine various existing hardware and software solutions for end-to-end integrity control of supply chains. Agheera, a real-time tracking solution provider, has developed an open platform for connecting various telematics and sensor hardware devices to consolidate data across different applications and modes. The platform merges multiple assets such as a connected swap body or truck into one easy-to-use portal with worldwide accessibility, allowing logistics providers and customers to track all assets and their various devices at once.



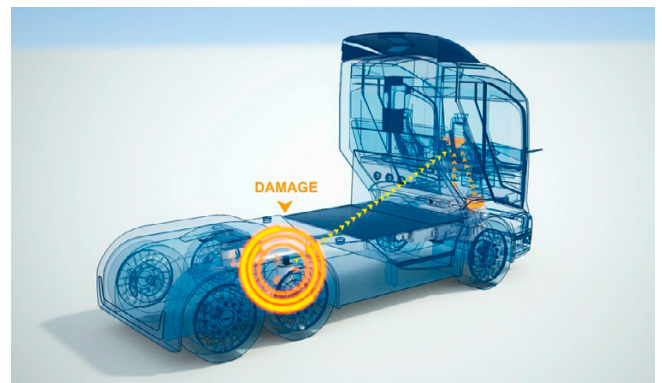
**Figure 12:** Agheera Real-time Tracking Portal

Another key area of IoT opportunity is **fleet and asset management**. For example, sensors can monitor how often a truck, container or ULD is in use or idle. They then transmit this data for analysis on optimal utilization. As noted earlier in this section, many logistics vehicles today are already brimming with sensors, embedded processors, and wireless connectivity. Sensors that measure the capacity of each load can provide additional insights concerning spare capacities in vehicles on certain routes. IoT could then enable a central dashboard that focuses on identifying



spare capacity along fixed routes across all business units. From there, it could recommend suggestions for consolidating and optimizing the route. This would create fleet efficiencies, improve fuel economy, and reduce deadhead miles, which account for up to 10 percent of truck miles.<sup>39</sup>

Similar to optimal asset utilization in warehousing operations, a connected fleet could also pave the way for **predictive asset lifecycle management**. This solution leverages analytics to predict asset failures and automatically schedule maintenance checks. One example is MoDe (Maintenance on Demand). This 2012 EU-backed research project between Volvo, DHL, and other partners sought to create a commercially viable truck that autonomously decides when and how it requires maintenance. The latest sensor technology was embedded in key areas such as oil and damper systems to identify material degradation or damages. Data was then transmitted first to a central unit in the truck via a wireless network, then to a maintenance platform for analysis. The driver or maintenance crews were then alerted to potential problems. The system was found to increase vehicle uptime by up to 30 percent<sup>40</sup> and decrease potential danger to truck drivers through constant condition monitoring of vehicles.



**Figure 13:** The Future of Trucking - MoDe<sup>40</sup>

IoT can also play an additional role in **health and safety**, preventing potential collisions and alerting drivers when they need to take a break. Long-distance truck drivers are often on the road for days in hazardous conditions. Cameras in the vehicle can monitor driver fatigue by tracking key indicators such as pupil size and blink frequency. This is already being applied by Caterpillar, the world's largest manufacturer of construction and mining equipment, which is using this technology to keep sleepy truck drivers from getting into accidents. If the solution senses the driver is losing attention on the road, it activates audio alarms and seat vibrations. An infrared camera is capable of analyzing a driver's eyes through glasses and in the dark.

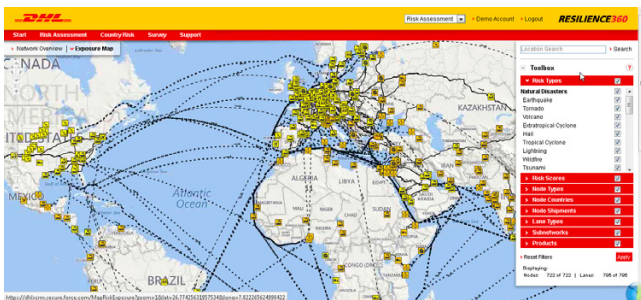
<sup>39</sup> <http://www.epa.gov/smartway/forpartners/documents/trucks/techsheets-truck/420f00037.pdf>

<sup>40</sup> <http://fp7-mode.eu/>





**End-to-end supply chain risk management** is yet another area in which IoT is becoming increasingly useful. Rising volatility and uncertainty in global supply chains is causing traditional supply chain management models to break down. Natural disasters, sociopolitical unrest, conflict, economic uncertainty, and market volatility all threaten catastrophic disruption, often without warning. How does IoT help identify and prioritize such risks? One tool is DHL Resilience360 for supply chain risk management, which provides a multi-tiered visualization of the end-to-end supply chain.



**Figure 14:** DHL Resilience360 Supply Chain Risk Management Portal<sup>41</sup>

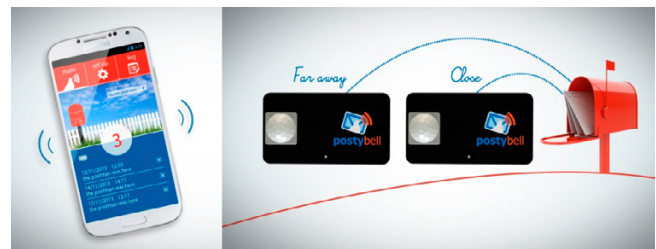
Any disruptions on a global scale are checked for their effects on key trade lanes; if they pose a strong risk, appropriate mitigation strategies are triggered automatically. In the future, Resilience360 could integrate all the data transmitted from assets and respond when a truck carrying urgent cargo is about to break down or when a warehouse has been flooded from a storm. It could also move a shipment from air freight to road freight to compensate for an airline strike.

Managing threats such as port strikes, airport closures, and highway closures may not seem like an obvious IoT application at first glance, but analytical capabilities are becoming sophisticated enough not only to predict them, but increasingly to respond.

### 3.3 Use Cases – Last-mile Delivery

With the final part of the delivery journey (the so-called “last mile”) being highly dependent on labor, and as consumer demands become more sophisticated and delivery points continue to multiply, logistics providers face new challenges. They need to find creative new solutions for this important stage in the supply chain – cost-effective solutions that provide value for the end customer and operational efficiency for the logistics provider. IoT in the last mile can connect the logistics provider with the end recipient in exciting ways as it drives dynamic new business models.

One IoT-enabled use case for the last mile creates **optimized collection from mail boxes**. Sensors placed inside the box detect whether it is empty and, if so, transmits a signal that is then processed in real time. The delivery person can then skip that box for collection, thereby optimizing daily collection routes. Start-ups such as Postybell<sup>42</sup> have created proximity sensors that detect when mail has been placed in a private mailbox and can also monitor the wetness inside the mailbox. A delivery then triggers an alert to the recipient’s phone via GSM. They can, for example, be reminded to check their mailbox or keep track of it while they are on holiday. The same principle could be applied to the DHL Paketkasten or Parcelbox, which are solutions to accommodate the e-commerce boom – users can install a personal parcel locker at their front door. This is currently being launched in Germany. But as letter volumes decrease and parcel volumes increase, we can imagine a future in which temperature-controlled smart lockers eventually replace traditional mailboxes and ensure first-time every-time delivery of parcels, groceries, and other environmentally sensitive goods.



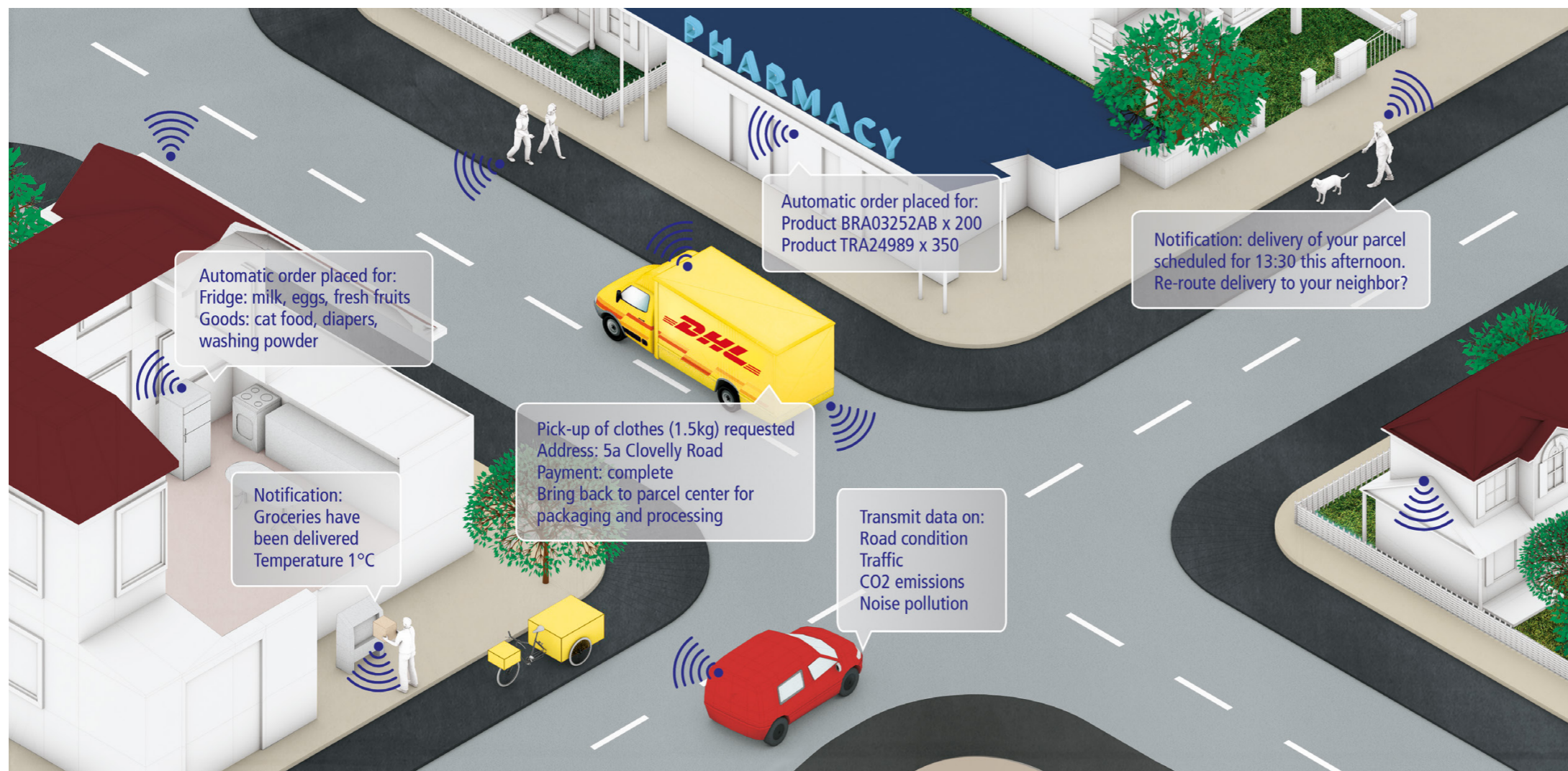
**Figure 15:** Postybell Smart Mailbox<sup>42</sup>



**Figure 16:** DHL Paketkasten for Parcel Delivery

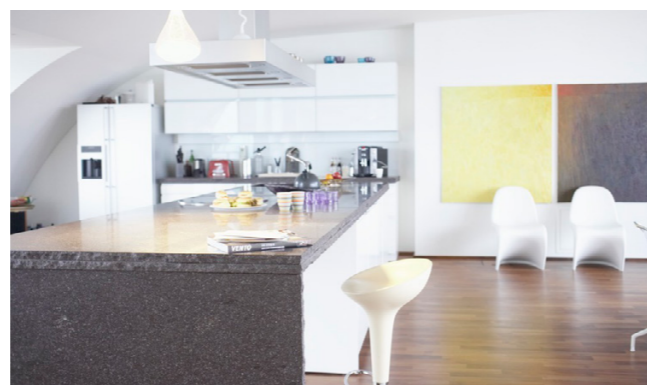
<sup>41</sup> [www.dhl.com/en/logistics/supply\\_chain\\_solutions/what\\_we\\_do/resilience\\_360.html](http://www.dhl.com/en/logistics/supply_chain_solutions/what_we_do/resilience_360.html)  
<sup>42</sup> <http://www.postybell.com/>





The connected mailbox is just one part of an overall trend of “smart home” products that consumers are beginning to adopt. One common IoT-based example in the consumer world is the connected fridge. It tracks the expiration dates of products being stored, detects when supplies are running low, and orders more online automatically. Such **automatic replenishment and anticipatory shipping** solutions have implications for logistics providers. For example, sensors detect when a retailer is low on stock and places an order automatically at the nearest distribution center, reducing lead time and avoiding stock-outs that result in missed sales. Amazon has even patented an algorithm that predicts a purchase by a customer before he or she confirms it, to enable anticipatory shipping. This moves the predicted product for purchase closer to the customer’s usual delivery address to save lead time on delivery. Thus, by combining sensor data with customer data, logistics providers could in future provide a wide variety of *ad hoc* and anticipatory delivery services for homes and local businesses.

Another IoT use case arising from the proliferation of smart devices and home products is the **flexible delivery address**. Today, most online consumers have the choice of giving one preferred



delivery address or selecting an alternative means of delivery, such as to a parcel station. Many experiments have been conducted to provide more flexible delivery, but one of the key issues has been in matching real-time delivery to the given addresses and time slots in a cost-effective manner for the logistics provider. With IoT-enabled solutions, tagged parcels offer more visibility to the recipient on when their parcel is expected to arrive and whether a change in address is required — for example, if they are at work. If a delivery is planned during the day, a customer could change the address to that of a neighbor who is home or at a workplace in the

vicinity. If it is unclear what a recipient’s schedule will be, smart-home products with proximity sensors (e.g., smart lights) could sense if the recipient is at home and communicate to the delivery person ahead of time if a delivery is possible. A flexible delivery address service could also be initiated by the logistics provider. Applying predictive analytics to the recipient’s historical mobile device location data (with the recipient’s opt-in to the service), the provider could request confirmation of the expected delivery window and location.

New business models to **monetize and optimize the return trip** are also possible with IoT, as it connects delivery people with surrounding vehicles and individuals. Innovative startups such as Shyp<sup>43</sup> are developing new ways to send products and to do pick-ups. Consumers simply take a picture of the item they need shipped and enter all delivery information in an app, and a Shyp employee collects the item for packing and delivery. Through IoT, logistics providers can connect with people or businesses on their delivery route who would like to send things but don’t have the time or means to go to a post office or properly prepare and pack

<sup>43</sup> <http://www.shyp.com/>

an item for pick-up. These items could be collected with dynamic pricing models and bring more value to the return trip and to the consumer.



Figure 17: Flexible Shipping Powered by Shyp<sup>43</sup>

Additional services can also be introduced with the rise of item-level tagging. We imagine that in the future, as RFID or other sensory tags become ubiquitous, a single product will be monitored via a printed NFC smart label that incorporates sensors to monitor temperature and humidity. The proliferation of these low-cost printed smart labels will allow consumers to gain **next-generation visibility** on the products they have purchased.

For example, when chocolates or other perishables are ordered online, consumers will be able to use their smartphone, via NFC, to check upon arrival if the correct temperature was maintained during transportation and whether the seal was broken. In homes and supermarkets, consumers could scan items such as packaged poultry to see if the ideal temperature has been maintained from the moment the poultry was packaged until it reaches the home refrigerator. In a growing B2C market for pharmaceutical goods, the end consumer could check the integrity of his or her medical product (e.g., serum) before use.

## Spotlight



SemProM (Semantic Product Memory) was a co-research project between DHL, DFKI and other partners to create a digital product memory or “Smart Labels” for a product. The smart items can store product-related information over the whole product life-cycle and make it possible to control various business processes with this information. For example, production processes are controlled without access to backend systems by production routing stored directly on a work-piece RFID tag.

[http://www.semproM.de/semproM\\_eng/](http://www.semproM.de/semproM_eng/)

One innovative company leading the production of printed electronics is Thinfilm, which has also recently partnered with Xerox to create mass-printed smart-memory labels. Thinfilm has recently experimented with Diageo on the concept of a smart whiskey bottle that provides consumers with information on integrity as well as other add-ons such as promotional offers.



**Figure 18:** Diageo and Thinfilm's Smart Label Solution<sup>44</sup>

If this level of detailed information becomes available for a single product, logistics providers in the last-mile could have much greater transparency on the contents of a parcel (assuming the customer allows it). They could understand, for example, if an item requires specific attention to temperature or if it is particularly fragile. This would, of course, add complexity to delivery but it would also create an opportunity for logistics providers to increase service standards for customers and end consumers.

<sup>44</sup> [http://media4.s-nbcnews.com/i/newscms/2015\\_09/909191/jw\\_blue\\_smart\\_bottle\\_3\\_daa76080b995da41124e94f423027c02.jpg](http://media4.s-nbcnews.com/i/newscms/2015_09/909191/jw_blue_smart_bottle_3_daa76080b995da41124e94f423027c02.jpg)



### 3.4 Success Factors for IoT in Logistics

So far, this report on IoT in logistics has focused on individual use cases along the supply chain. But this is by no means a complete list of use cases! Companies looking to leverage IoT in their operations should not just consider implementing a single use case within warehousing, transportation, or last-mile delivery. The key to success lies in understanding the convergence of these use cases with one another. For example, a car that cannot connect to another vehicle or to an intelligent parking lot will be less effective; a smart pallet that can be used for inventory management in a warehouse but not in the retailer's shop will provide only limited benefits.

Therefore, at its core IoT will require the creation and management of an intelligent network of assets connected to different verticals and horizontals within the supply chain (see Figure 19).

But before we consider the connectivity standards between different industries, the first step must be to connect within the logistics industry itself! Logistics is a typically low-margin and fragmented industry, especially in road freight where there are tens of thousands of different suppliers with varying operating standards for local, domestic, and international operations. Additionally, as logistics is such a networked business, it will be necessary to adjust

entire networks before implementing new solutions – and this means substantial investment must be made.

To successfully implement IoT in logistics will require strong collaboration, along with high levels of participation between different players and competitors within the supply chain, and a common willingness to invest. The shared end goal will be to create a thriving IoT ecosystem.

**To achieve this, there will be some key success factors required:**

- Clear and standardized approach for the use of unique identifiers or 'tags' for various types of assets among different industries on a global scale
- Seamless interoperability for exchanging sensor information in heterogeneous environments
- Establishment of trust and ownership of data and overcoming privacy issues in the IoT-powered supply chain
- Clear focus on reference architecture for the IoT
- Change in business mindset to embrace the full potential of the Internet of Things

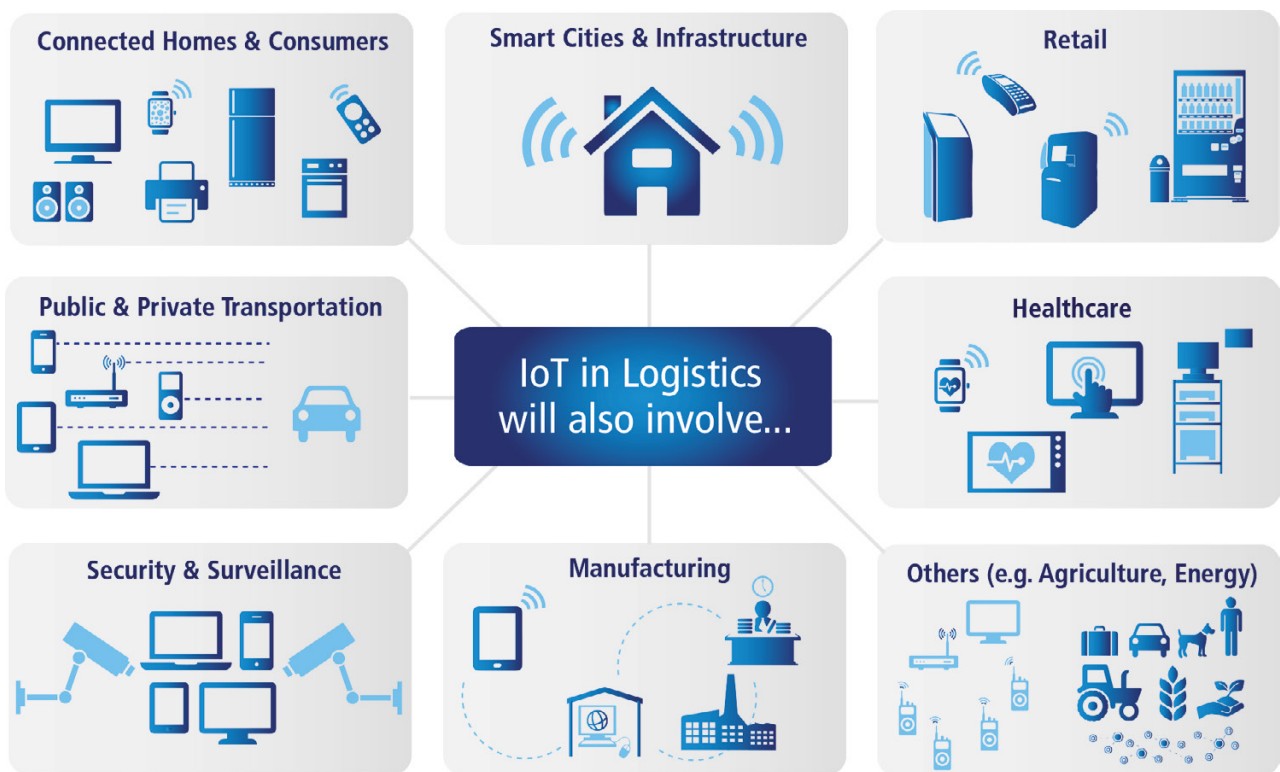


Figure 19: The IoT Ecosystem

## OUTLOOK

The breadth of applications highlighted in this report underscores how IoT is impacting virtually every sector of the economy, and portends momentous changes for the logistics industry and society as a whole.

Important questions remain about the future of IoT, particularly in the realms of work, security, and privacy. As noted in this report, IoT presents many opportunities for automation, and this is likely to change how some logistics jobs are performed.

In addition, connecting what has been previously unconnected may, in some circumstances, highlight new security vulnerabilities. As we interconnect IT and OT, for example, there may be new points of ingress for hackers, cybercriminals, terrorists, mischief-makers and others who wish to do harm. It is therefore vital that all actors within the supply chain, including governments and the high-tech industry, collaborate to ensure IoT security is prioritized on technology agendas in the coming years. All will need to devote significant financial and human resources to counter wrongdoing. Indeed, if IoT is to reach its full potential, it will be essential to address the legitimate concerns of citizens and policymakers about the privacy and control of personal information.

While IoT may present different security challenges than the logistics industry has faced in the past, it may also support many new enhancements to safety and security, particularly when combined with analytics. And there are other clear benefits to successfully answering these challenges, including greater efficiency and convenience; new sources of economic growth, productivity, and job creation; better health and wellbeing; and improved environmental sustainability.

To conclude this report, let us consider the scale of future impact. Over the next five years, humans will more than triple the number of “things” connected to the Internet, growing them from 15 billion today to 50 billion by 2020. Still, 50 billion represents only a tiny fraction of what could be connected — something on the order of 3 percent of all connectable things. The sizzling pace of innovation in recent years, particularly the proliferation of embedded sensor technology, wearables, and apps, has already caused incredible change in just a few short years. But what will the world of logistics look like when not 1 percent of things, nor 3 percent of things, but 30 percent of things are connected? As we reflect on these developments in the context of the Internet of Everything, it is clear that we are just beginning to connect the unconnected.



“ The Internet of Things represents \$1.9T in Value at Stake for the logistics industry over the next ten years. Bountiful opportunities therefore exist for logistics providers to leverage IoT in their organizations in order to increase productivity, reengineer existing processes and provide new services that challenge traditional business models. However to derive significant commercial value from IoT will ultimately depend on how well connected assets, such as containers or parcels, are networked along the entire supply chain. This of course entails close cooperation and collaboration between all players in the logistics industry. ”

**Rob Siegers, President Global Technology at DHL Customer Solutions & Innovation**



## SOURCES

### MIT AutoID Lab

<http://newsoffice.mit.edu/2012/auto-id-cloud-of-things-big-data>

### Global Internet Connections Counter

<http://blogs.cisco.com/news/cisco-connections-counter>

### Scenario for 2020 by Cisco

Strategy Analytics, “Connected World: The Internet of Things and Connected Devices in 2020,” October 9th, 2014.

### Study by Zebra Technologies and Forrester Research

“IoT in the Enterprise Up Three-Fold, Study Finds,” Network World, November 24th, 2014.

### M2M vs. IoT

“What’s the Difference Between M2M and IoT?” Machina Research, September, 2014. See also “The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things,” IDC, April 2014.

### IoE Value at Stake

[http://internetofeverything.cisco.com/sites/default/files/docs/en/ioe\\_vas\\_public\\_sector\\_top\\_10%20insights\\_121313final.pdf](http://internetofeverything.cisco.com/sites/default/files/docs/en/ioe_vas_public_sector_top_10%20insights_121313final.pdf)

### Parking Management Solution by Streetline and Cisco

[www.streetline.com/2013/10/streetline-and-cisco-expand-collaboration/](http://www.streetline.com/2013/10/streetline-and-cisco-expand-collaboration/)

### Parking Management in France

[http://web.mit.edu/11.951/oldstuff/albacete/Other\\_Documents/Europe%20Transport%20Conference/traffic\\_engineering\\_an/the\\_time\\_looking\\_f1580.pdf](http://web.mit.edu/11.951/oldstuff/albacete/Other_Documents/Europe%20Transport%20Conference/traffic_engineering_an/the_time_looking_f1580.pdf)

### IDC on IoT

“IDC’s Worldwide Internet of Things (IoT) Taxonomy,” IDC, October 2013.

### Seoul City Transportation Information Center (TOPIS Center)

[http://internetofeverything.cisco.com/sites/default/files/pdfs/Korea\\_TOPIS\\_Jurisdiction\\_Profile\\_final.pdf](http://internetofeverything.cisco.com/sites/default/files/pdfs/Korea_TOPIS_Jurisdiction_Profile_final.pdf)

### Hamburg’s Smart Port

[http://internetofeverything.cisco.com/sites/default/files/pdfs/Hamburg\\_Jurisdiction\\_Profile\\_final.pdf](http://internetofeverything.cisco.com/sites/default/files/pdfs/Hamburg_Jurisdiction_Profile_final.pdf)

### Connected Production Floor by AeroScout and Continental Tires

<http://www.aeroscout.com/files/RFID-Journal-AeroScout-and-Continental-Tires-04-25-2012.pdf?1>

### Union Pacific Predictive Software

<http://blogs.wsj.com/cio/2012/03/30/union-pacific-using-predictive-software-to-reduce-train-derailments/>

### Dundee Precious Metals (DPM) Use of IoE

<https://www.youtube.com/watch?v=SGxJLUS7hQQ>

### Wearable Technologies Study

“Smart Wearable Devices Fitness, Glasses, Watches, Multimedia, Clothing, Jewellery, Healthcare & Enterprise 2014-2019,” Juniper Research, September 2014.

### Smart Contact Lens by Novartis and Google

<http://www.forbes.com/sites/leoking/2014/07/15/google-smart-contact-lens-focuses-on-healthcare-billions/>

### Estimote

<http://estimote.com/>

### The Dandy Lab

<http://www.thedandylab.com/>

### Chronic Disease Management – Proteus Smart Pills

<http://www.fastcoexist.com/3024773/worldchanging-ideas/you-will-swallow-a-sensor>

### IoT Improvements in Physical Security

<http://www.smartthings.com/benefits/home-security/>

### August Smart Lock

<http://august.com/>

### Connected Retail Study

<http://www.cisco.com/c/dam/en/us/solutions/collateral/executive-perspectives/ioe-retail-whitepaper.pdf>

### Transwestern Energy Efficient Smart Building

[http://www.cisco.com/web/tomorrow-starts-here/files/property\\_management\\_firm.pdf](http://www.cisco.com/web/tomorrow-starts-here/files/property_management_firm.pdf)

### IoT and Vehicle Insurance

“Pay-As-You-Drive Vehicle Insurance: Converting Vehicle Insurance Premiums Into Use-Based Charges,” Victoria Transport Policy Institute, May 2014.

### SmartLIFTby Swisslog

<http://info.totaltraxinc.com/blog/here-is-what-happens-when-big-data-and-forklifts-meet>

### Forklift Collision Reduction Solutions

<http://www.sick.com/us/en-us/home/pr/whitepapers/Documents/SICK%20White%20Paper-%20Collision%20Awareness%20Solutions.pdf>

### Ravas iForks Touch

<http://www.ravas.com/en/int/products/show-product/iforks-touch/>

### Connected Workforce Solution by LocosLab

[www.locoslab.com](http://www.locoslab.com)

### Smart Warehouse Energy Management

[http://www.lighting.philips.com/pwc\\_li/main/application\\_areas/industry/ledsinindustry/assets/Warehouse-brochure.pdf](http://www.lighting.philips.com/pwc_li/main/application_areas/industry/ledsinindustry/assets/Warehouse-brochure.pdf)

### FreightWatch International

[http://www.globalinitiative.net/wpfb-file/freightwatch-2013-global-cargo-theft-threat-assesment-full\\_0-pdf/](http://www.globalinitiative.net/wpfb-file/freightwatch-2013-global-cargo-theft-threat-assesment-full_0-pdf/)

### Improved Freight Logistics

<http://www.epa.gov/smartway/forpartners/documents/trucks/techsheets-truck/420f00037.pdf>

### Maintenance on Demand (MoDe)

<http://fp7-mode.eu/>

### Postybell

<http://www.postybell.com/>

### Shyp

<http://www.shyp.com/>

### DHL Smart Sensor

[www.smartsensor-temperature.net](http://www.smartsensor-temperature.net)

### Potential Supply Chain Risks

[http://www.dhl.com/en/logistics/supply\\_chain\\_solutions/what\\_we\\_do/resilience\\_360.html](http://www.dhl.com/en/logistics/supply_chain_solutions/what_we_do/resilience_360.html)

### Johnnie Walker Smart Bottle

[http://media4.s-nbcnews.com/i/newscms/2015\\_09/909191/jw\\_blue\\_smart\\_bottle\\_3\\_daa76080b995da41124e94f423027c02.jpg](http://media4.s-nbcnews.com/i/newscms/2015_09/909191/jw_blue_smart_bottle_3_daa76080b995da41124e94f423027c02.jpg)

## OUR PARTNERS



### **Words Europe Limited**

Kay Mussellwhite  
Suite 211  
80 High Street  
Winchester SO23 9AT, UK  
Phone: +44 208 144 1340

e-mail: [kay@words-europe.com](mailto:kay@words-europe.com)  
[www.words-europe.com](http://www.words-europe.com)



### **VISION UNLTD. CREATIVE WORX GmbH**

Neusser Str. 27-29  
50670 Cologne, Germany  
Phone: +49 221 56978 0

Managing Director: Ercin Filizli  
Team: Stephanie Helou, Ismail Erkol, Gintarė Kaveckaitė,  
Ilya Tselutin, Henrik Ehrhardt

e-mail: [info@vucx.de](mailto:info@vucx.de)  
[www.vucx.com](http://www.vucx.com)



## FOR MORE INFORMATION

About *Internet of Things in Logistics*, contact:

### Dr. Markus Kückelhaus

DHL Trend Research  
Junkersring 55  
53844 Troisdorf, Germany  
Phone: +49 2241 1203 230  
Mobile: +49 152 5797 0580

e-mail: markus.kueckelhaus@dhl.com

### James Macaulay

Cisco Consulting Services  
181 Bay St., Suite 3400  
Toronto, ON | M5J 2T3, Canada  
Phone: +1 408 894 8922

e-mail: jmacaula@cisco.com

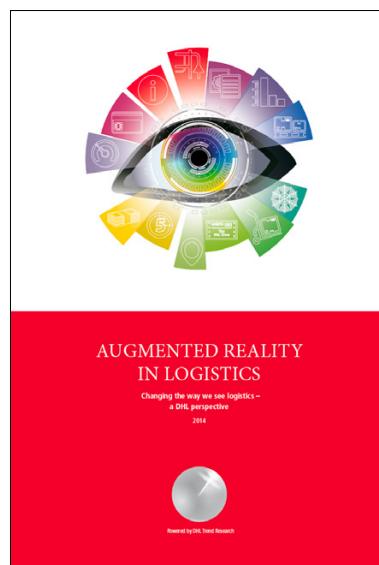
## RECOMMENDED READING

### LOGISTICS TREND RADAR



[www.dhl.com/trendradar](http://www.dhl.com/trendradar)

### AUGMENTED REALITY IN LOGISTICS



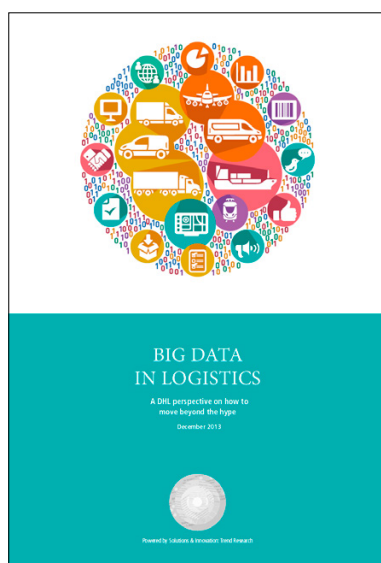
[www.dhl.com/augmentedreality](http://www.dhl.com/augmentedreality)

### LOW-COST SENSOR TECHNOLOGY



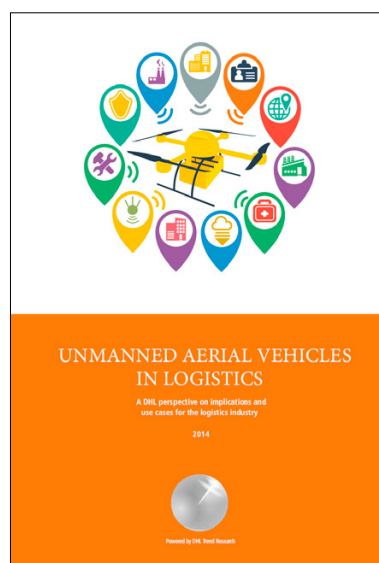
[www.dhl.com/lcst](http://www.dhl.com/lcst)

### BIG DATA IN LOGISTICS



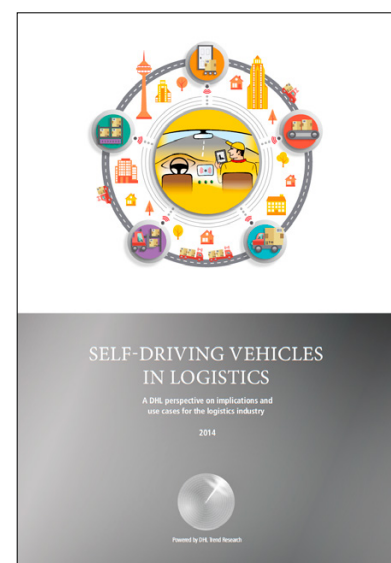
[www.dhl.com/bigdata](http://www.dhl.com/bigdata)

### UNMANNED AERIAL VEHICLES IN LOGISTICS



[www.dhl.com/uav](http://www.dhl.com/uav)

### SELF-DRIVING VEHICLES IN LOGISTICS



[www.dhl.com/selfdriving](http://www.dhl.com/selfdriving)



**PUBLISHER**

Represented by Matthias Heutger  
Senior Vice President  
DHL Customer Solutions & Innovation  
53844 Troisdorf, Germany

**PROJECT DIRECTORS**

Dr. Markus Kückelhaus	James Macaulay
DHL Trend Research	Cisco Consulting Services

**PROJECT MANAGEMENT AND EDITORIAL OFFICE**

Gina Chung	Lauren Buckalew
DHL Trend Research	Cisco Consulting Services

**AUTHORS**

James Macaulay, Lauren Buckalew, Gina Chung

