A Look Into Logistics Automation
Investment Commentary – July 2017

Jeremie Capron, ROBO Global Director of Research

SUMMARY

- We believe logistics is one of the most promising applications for Robotics and Automation (R&A) technology from an investor’s perspective. The industry is at an inflection point as the boom in e-commerce dramatically raises the bar for supply chain efficiency across the economy.

- We view Amazon’s introduction of Prime – the all-you-can-eat express shipping membership program and its 2012 acquisition of Kiva Systems – the pioneer of autonomous mobile robots for warehouses, as the key catalysts of an arms race to automate warehouses and supply chains. The $14bn acquisition of Whole Foods Market and its 450 high-end grocery stores announced earlier this month is likely to extend the race to the still nascent online grocery retail industry.

We see a long runway for growth. We estimate the warehouse and logistics automation market to be worth over $40bn, with growth potential in the high-single-digits to low-teens annually.

- Innovation and M&A point to a rapidly transforming industry. In the past 3 years alone, four of the top-10 supply chain automation players were acquired.

- The ROBO Global R&A index provides significant exposure to these trends, with best of breed players in logistics automation equipment, software and services as well as supply chain automation technology providers from the US, Europe and Asia accounting for 9% of the index.

- In many cases, we believe that investors underestimate the potential for sustained growth in revenue and profits at these companies. Many are concerned by orders and revenue reaching prior cyclical highs - we believe logistics automation is still in the early stages of adoption.

- Logistics automation plays have been important contributors to the performance of the ROBO Global Robotics & Automation Index in recent years. Over the past three years, stocks in the sub-sector have all outperformed the S&P500 by a significant margin.
E-commerce is driving a dramatic shake up of the logistics industry

The online retail industry has grown at more than 20% per annum in recent years to reach $2trn\(^1\) globally in 2016 and is seen doubling to $4trn by 2020, as the share of online sales continues to increase from just under 9% to 15%. In fact, e-commerce in China already represents 18% of total retail sales, making it the largest e-commerce market in the world at approximately $900bn. This compares to 14% in the UK, Europe’s most developed e-commerce market, and just 7% in the US, where online sales accelerated last year to reach $395bn\(^2\), a 16% increase YoY and the highest growth rate since 2013.

Online retail is a $2trn industry growing at 20%+

The logistics industry is struggling to keep up

The boom in e-commerce is compounding the major labor challenges faced by the $5trn global logistics industry. Not only are shipment volumes growing rapidly, but online retail also typically requires more logistical work per item than brick & mortar retail. Indeed, online purchases require individual picking, packing and shipping, as opposed to the bulk

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\(^1\) E-marketer: https://www.emarketer.com/Article/Worldwide-Retail-Ecommerce-Sales-Will-Reach-1915-Trillion-This-Year/1014369

\(^2\) US Commerce Department
transportation models of traditional brick & mortar retail.

This is putting tremendous strains on supply chains, from freight to parcel handling to last-mile delivery, perhaps well reflected in UPS’ recent announcement of delivery surcharge fees for black Friday and Christmas orders to recoup increases in labor and infrastructure costs during the busiest periods. Indeed, US parcel delivery and postal services companies have all struggled to meet deadlines and control costs during each of the past five year-end holiday seasons.

It all became very clear to investors when UPS reported its 2016 results and presented a downbeat profit outlook for 2017 in January. Not only did fast-rising costs cut into its bottom line, but the company also pledged to boost capital investments by a massive $1bn or 33% YoY, to $4bn in 2017 to automate more package-sorting facilities and open new distribution centers, after a 25% increase in 2016.

This is not just a US phenomenon. In Japan, Yamato Holdings, which owns one of the largest trucking and delivery companies in the country, also had to revise down its earnings projections as it struggles to keep up with demand for small parcel deliveries and labor shortage issues.

Traditional retail is undergoing a major transition to omni-channel

Meanwhile, the $22tn traditional retail industry is undergoing a major transition as it strives to respond to the Internet, social-media and mobility-driven change in consumer buying behavior. The overwhelming trend today is omni-channel marketing, which seeks to integrate physical and digital channels to offer a unified customer experience and meet demand from every channel (webstore, ERP, point-of-sale, call center, mobile app, etc.). All brick-and-mortar retailers, as well as online retailers expanding their brick-and-mortar presence, are in the process of upgrading their supply-chain operations to provide better inventory visibility and deliver high-level consumer experience.

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4 UPS 31 January 2017 earnings call
Robo

tics & Automation: key success factor

The reality is that robotics & automation is rapidly becoming a key success factor in e-commerce and is about to make a very large impact on the world of logistics. From autonomous mobile robots and automatic storage systems to track & trace technologies and advanced supply chain software, it is a game changer enabling increasingly speedy, safe and error-free distribution, shorter time to market and ultimately lower costs to businesses and consumers.

Amazon kicked off the arm race to automate warehouses & supply chains

We view Amazon as a driving force for the logistics automation industry. In 2005, the e-commerce company introduced Prime, its all-you-can-eat express shipping membership program for about a million products. Today tens of millions of Prime members enjoy fast, free, unlimited shipping on more than 30 million items\(^5\), free same-day delivery on more than a million items, and even one-and-two-hour delivery on tens of thousands of items in certain cities. Prime has cost Amazon millions if not billions of dollars over the years, but eventually proved sustainable with scale and automation. Prime is now the de facto benchmark in the online retail industry, setting consumers’ expectations in terms of shipping performance at a very high level for the entire industry.

Amazon Prime would not be viable without leveraging cutting-edge advances in Robotics & Automation technology, which the company internalized and turned into a sustainable competitive advantage. In 2012, Amazon made a bold move to acquire Kiva Systems in a $775m deal. Kiva Systems, now known as Amazon Robotics, pioneered the use of autonomous mobile robots for warehouse automation, introducing a revolutionary approach to order fulfilment. Kiva robots navigate autonomously around the warehouse, moving dynamically-stored shelves of ordered items to packers to fulfil orders, in a smooth robotic dance choreographed by cutting edge control software – see founder Mick Mountz narrate a play-by-play video of how Kiva robots automate a warehouse environment [here].

\(^5\) https://www.amazon.com/p/feature/zh395rdnqt6b8ea
Today Amazon Robotics automates the company’s fulfilment centers using more than 45,000 autonomous mobile robots, up more than 50% from 30,000 at the end of 2015. It is the clear global leader in autonomous mobile robots, with the largest installed base and cutting-edge control software, language perception, machine vision and machine learning capabilities.

According to Raffaello D’Andrea, a co-founder of Kiva Systems, professor of dynamic systems and control at ETH Zurich and member of ROBO Global’s Advisory Board, “cost efficiency was the main driver behind Kiva’s initial model, but it quickly turned out that flexibility, adaptability and reliability – i.e. less human errors, were the really exciting value-adds in the eyes of warehouse operators. The fact that you can set up a warehouse in six weeks instead of two years, that you just need empty floor space to expand capacity, and that you can easily reconfigure on the go, which you could not do with traditional factory automation systems.”

Amazon continues to aggressively ramp up its patent applications in supply chain & logistics. The company filed at least 78 logistics patents applications in 2016⁶, according to tech research firm CB Insights. This was an all-time high and more than double the 33 filed in 2012, the year it acquired Kiva.

⁶ https://www.cbinsights.com/blog/amazon-warehouse-patent/
With Kiva technology confined to Amazon warehouses since 2015, many companies have scrambled to fill the void and we are now seeing a proliferation of mobile robotic systems with various degrees of autonomy. The industry is still in its infancy, with competitors ranging from established players such as Swisslog, a subsidiary of KUKA recently acquired by Chinese electrical appliance giant Midea, and Adept, also recently acquired by Omron of Japan, to a multitude of startups such as Fetch Robotics in the US, Mobile Industrial Robots (MiR) in Denmark, which was started by a co-founder of Universal Robotics, GreyOrange based Singapore with customers in India, as well as Hikrobot Technologies, a subsidiary of Hikvision in China, among many others that ROBO Global tracks.
Autonomous mobile robots are already venturing outdoor, with several startups such as Starship Technologies and Marble experimenting with unmanned delivery robots on sidewalks and crosswalks. Florida was the fourth US state to pass a law permitting their use this year, after Virginia, Idaho and Wisconsin. The main use-case targeted is food-delivery, a fast-growing market with brutal economics. Starship robots have already reached 50,000km in autonomous driving.

Mobile autonomous robots are only the tip of the iceberg.

In terms of automating the order fulfillment process alone, there is a wide range of options available today. Automating the picking process can start with Warehouse Management Software, hands-free scanning and voice-directed systems, or RFID tagging, which would typically cost less than $1m per facility. This is the core of the $10bn Automatic Identification and Data Capture (AIDC) market\(^7\), which is dominated by Zebra Technologies and Honeywell.

Zebra Technologies’ hand-free scanning, wearable computer and voice-directed picking solution

The next step is the introduction of mechanized solutions, such as conveyors, sorters, pick modules, automatic wrapping and labeling machines and other mechanical equipment, increasing capital costs to the $2-5m range. The third level consists in semi-automated solutions with Automated Storage and Retrieval Systems (AS/RS) and more advanced software controlling equipment and the flow of products in real time, with projects in the $10-15m range. Fully-automated solutions add industrial robots for layering/delayering and palletizing, truck loading/unloading and can cost over $40m per facility.

\(^7\) CLSA “Zebra Technologies – Earning its stripes”, August 2016
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Source: Viastore, MODEX 2016

**Conveyors**

**Swisslog high-density autostore**

Source: KION, Swisslog
DHL parcel robot
A long runway for growth

Only 5% of warehouses are automated

We estimate the warehouse and logistics automation market will grow at a 9% CAGR over the next five years, from $42bn in 2016 to more than $75bn in 2022.

Around 80% of US warehouses are manually operated with no supporting automation, 15% are mechanized, and just 5% are automated, according to St Onge\(^8\), a supply chain consulting firm that runs an annual survey of Distribution Centers. This leaves a long runway for the logistics automation markets to grow well faster than the global economy and industrial production.

Revenue at the top-20 automated warehouse solutions providers grew at an 8% CAGR from $11bn in 2011 to $17bn in 2015, according to KION\(^9\). The company expects the supply-chain automation market to grow at a 10% CAGR through 2019. The market for material handling equipment and warehouse automation solutions remains fragmented although consolidation accelerated in the past two years with several large deals, such as KION Group’s acquisition of US market leader Dematic ($2.1bn) and Honeywell’s purchase of Intelligrated ($1.5bn) in 2016. Other top players with comprehensive offerings and annual revenue in excess of $1bn include Japan-based Daifuku, Muratec and Toyota Industries, as well as Germany-based SSI Schaefer. We like the business model, which favors long-term relationships and growing share of higher-margin service revenue.

\(^8\) http://www.supplychain247.com/article/2016_warehouse_dc_operations_survey_ready_to_confront_complexity

\(^9\) KION April 2017 Investor presentation
The $10bn Automatic Identification and Data Capture, which includes mobile computing, specialty printing for barcode labeling, RFID and data capture, is expected to continue to grow in the mid-single digits. Global leader Zebra Technologies targets 4-6% topline growth through the cycle. Honeywell is the only other player with global scale and a comprehensive offering. Cognex, whose machine vision based code readers are rapidly displacing laser-based technologies in logistics, targets over 30% annual growth in Automatic Identification revenue.

The $10bn Supply-Chain Management software market, which includes Warehouse Management Software and Transport Management Systems, is on track to reach $16bn by 2020, a 9.5% CAGR over the next four years, driven by an uptick in warehouse automation and growing demand for distributed order management, which help traditional retailers develop omni-channel marketing strategies and compete with e-retailers. The market is fragmented, with the large ERP leaders SAP and Oracle at the top and smaller, niche players such as Manhattan Associates, Epicor and RedPrairie (acquired by JDS Software) commanding a combined 50% share.

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The online grocery market may be ready for prime time

Amazon recently announced its intention to acquire Whole Foods Markets in a $14bn deal with wide ranging implications for the e-commerce and logistics industries and a sign that online grocery shopping may be ready for prime time. We think the deal will mark a seminal moment in the US online grocery market, which remains in its infancy, at only 2% of the $675bn US grocery market and around 6% in the more developed UK market. In recent years, a number of online-only grocery services such as Ocado have tested and proven the business model, with very high automation intensity but relatively limited scale. Meanwhile, traditional grocery retailers have struggled with the last-mile logistics nightmare. Given the additional logistical challenges presented by grocery picking and shipping such as cold chain.

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M&A activity on the rise: four of the top-10 players acquired in the past 3 years

We note that M&A activity is clearly accelerating in the logistics automation arena. Four of the top-ten players in logistics automation were acquired in the past three years. Traditional material handling equipment players are looking to strengthen their offering with technology and provide one-stop solutions. Meanwhile, Chinese capital is playing an increasingly important role, a reflection of the country’s aggressive policies to develop a domestic R&A industry as outlined in the 13th five-year plan presented last year, and of Chinese companies’ appetite for foreign technology.
Key logistics automation deals

The KION Group acquired Dematic, the US market leader in supply chain automation, for $2.1bn in 2016. This came on the heels of the $72m acquisition of AGV provider Egemin and that of Retrotech, a US system integrator of warehouse and distribution solutions. The deals essentially transformed KION from a top-2 global player in forklifts into a full-spectrum, one-stop provider of material handling and supply chain automation solutions. KION is controlled by Chinese state-owned enterprise Weichai Power, which acquired an initial 25% in 2012 and increased its stake in recent years to 43% of late.

Toyota Industries acquired Vanderlande Industries, the Netherlands based material handling and logistics automation company ranked global #5 (and #1 in airport baggage handling), in a $1.3bn deal announced in March 2017 and another case of a forklift giant going after the intralogistics automation market. The Japanese company is also in the process of buying Indianapolis-based Bastian Solutions (#16) for $260m.

Honeywell acquired Intelligrated, a leading US provider of automated warehouse solutions ranked #8 globally, for $1.5bn in 2016. Honeywell had already acquired its way to global #2 in the Automatic Identification and Data Capture market behind Zebra Technologies by spending more than $2bn on Hand Held Products, Metrologic, EMS Technologies, Intermec and Datamax-O’Neil. Intelligrated builds on this strong position in scanning and mobility to push into automated material handling.

KUKA acquired Swisslog, the global #10 player in material handling systems with a strong offering of intralogistics automation solutions, in a $357m deal at the end of 2014 and a unique combination of a big four industrial robotics company with a logistics automation specialist. KUKA itself was acquired by Chinese electrical appliance giant Midea in 2016 in a tender offer valuing the company at $4.2bn or 1.6x sales and 19x Ebitda.

Zebra Technologies acquired Motorola Enterprise Solutions for $3.5bn in 2014. The transformative deal created a global leader in the AIDC market, adding highly complementary, leading franchises in mobile computing, data capture and networking to Zebra’s barcode printing and RFID platforms.

Amazon acquired Kiva Systems, the pioneer of autonomous mobile robots for warehouse automation, in a $775m deal at the end of 2012 and later renamed the company Amazon Robotics – see detailed discussion on page 4.

EQT Partners acquired Autostore, the Norway-based provider of automated storage and retrieval systems with approximately $60m in revenue, in December 2016.

Hubei Huachangda Intelligent Equipment Co, a China-based provider of industrial conveyance equipment and factory automation acquired Dearborn Mid West for US$54m in 2015.

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11 Modern Material Handling’s “Top 20 systems suppliers” list 2016
12 idem
Earlier this month, Singapore Technologies Engineering agreed to acquire Aethon, the Pittsburgh-based maker of the TUG smart autonomous mobile robot focused on hospitals and intralogistics applications, for $36m.

Innovation

In the long-run, we believe a dramatic expansion in the scope of applications for warehouse and logistics automation will be driven by innovation in mobile autonomous robots, grasping technology, artificial intelligence and drones.

Grasping technology is the next frontier in warehouse automation. Current robotic picking systems are still far from replicating human performance in grasping random objects in unstructured environments. This is a vision and gripping problem that has become one of the most widely explored areas of robotics in recent years. The fact that Amazon organizes an annual Picking Challenge to spur the advancement of automated picking is testament to the potential for the technology to revolutionize logistics. Last year, the robot that won the competition failed to pick up and move the correct item 17% of the time. However, the important point here is that performance improvement over the winner of the 2015 edition was more than 3X.

Recent research from researchers at the University of California at Berkeley and Google points to significant progress with the application of Artificial Intelligence in the form of deep learning and convolutional neural networks and accessing datasets in the cloud. See a video here. RightHand Robotics unveiled at the 2017 Automate tradeshow in Chicago a solution called RightPick that can pick items at a rate of 500 to 600 per hour, on par with a human worker. It uses a machine learning background and a sensorized robot hand to recognize and handle thousands of items. Machine learning and artificial intelligence will impact logistics automation well beyond machine vision’s benefits to picking technology, by greatly enhancing the flexibility and ease-of-use of a wide range of automated systems.
**Drone** delivery is one of the most exciting applications for Unmanned Aerial Vehicles and companies like Amazon, Google, FedEx, DHL and Walmart have come out publicly to talk about the potential to circumvent many of the “last-mile” delivery challenges and are running test-programs. Amazon is leading the charge. The technology has improved significantly since Jeff Bezos touted it in a 60 Minutes interview in 2013 and the company’s patent applications include many drone-related innovations. Just earlier this year, Amazon it granted a patent for a multi-level "beehive"-like fulfilment center that would deploy and receive delivery drones. However, regulatory hurdles remain extremely high and will most likely prevent any sizeable commercial deployment in public spaces in the near future, especially in the US. We think recent progress in mini-drones opens the door to interesting use cases indoor, such as inspection work and inventory control in warehouses and stores.

**ROBO Global Robotics & Automation**

We expect the above trends to translate into strong growth in demand for:
- Automated material handling equipment (Robotics, Automated Storage and Retrieval Systems, Autonomous Guided Vehicles),
- Track and trace technologies (Automatic Identification and Data Capture, Enterprise Asset Intelligence).
- Supply chain and warehouse management software
- Factory automation equipment in general (sensing, motion, controls etc.)

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*Logistics automation represents 9% of the ROBO Global Robotics & Automation Index*

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**ROBO Global® Industry Classification**

<table>
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<td>Integration</td>
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The ROBO Global Robotics & Automation index provides significant exposure to these markets. The logistics sub-sector accounts for around 9% of the index and is composed by leading players in Material Handling System providers (Daifuku, KION, Cargotec), Automated Storage & Retrieval Systems (Kardex), Enterprise Asset Intelligence (Zebra Technologies) and Supply-Chain Management software (Manhattan Associates), across a wide range of geographies and market capitalizations – see summary table on page 15.

In many cases, we believe that investors underestimate the potential for sustained growth in revenue and profits at these companies. Many are concerned by orders and revenue reaching prior cyclical highs - we believe logistics automation is still in the early stages of adoption. Second, investors are reluctant to forecast much margin expansion from here – we believe these companies have an opportunity to add increasingly more value to their customers as they enable the new infrastructure required for the new world of retail and distribution.

**Zebra Technologies** is the world’s leading provider of Automatic Identification and Data Capture solutions, helping customers obtain greater visibility and insights into their operations to improve efficiency, productivity, asset utilization and customer experience. Its comprehensive track & trace solutions are increasingly critical to supply-chain and field-force automation in retail, logistics and manufacturing. We think Zebra is well positioned to benefit from some of the most powerful industry trends: automation, mobility and, eventually, the Internet of Things. We believe Zebra can grow EPS at double-digits CAGR through a combination of 4-6% sales growth, margin expansion and capital deployment.

**Kardex** is a leading provider of Automated Storage, Retrieval and Materials Handling Systems, a key cost and efficiency factor in e-commerce and traditional production and distribution facilities. We view Kardex as a geared play on the modernizing of storage and warehouse facilities in the coming years. Kardex developed from a product and service supplier into a globally acting industry partner with an attractive product, service and software offering under the Kardex brand name. Its solutions reduce operating costs; increase the availability of stored goods and save space. With an installed base of over 100,000 Kardex Remstar machines and 900 Kardex Mlog warehouses including more than 2,000 stacker cranes, Kardex has a broad existing customer base that also needs ongoing after-sales services.

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**Manhattan Associates** is the best of breed provider of supply chain management software and services, with over 1,200 customers. The company designs, builds and installs supply chain commerce solutions consisting of software, services and hardware, which coordinate people, workflows, assets, events and tasks holistically across the functions of a supply chain, from planning through execution. Based in Atlanta Georgia, Manhattan Associates is
a key beneficiary of the secular automation trends in the logistics/warehouse industry and the boom in e-commerce.

**Daifuku** is the global leader in material handling systems and a rare pure-play on warehouse and logistics automation. The Japan-based company designs, manufactures, installs and services logistic systems and material handling equipment. This includes automated storage and retrieval, conveyor systems and automatic guided vehicles, as well as sorting and picking solutions. While Daifuku is focused on distribution and logistics applications, its solutions are adopted in a wide variety of manufacturing industries including automotive, electronics, pharma, food & beverage. Daifuku provides exposure to China, already the largest e-commerce market in the world.

**KION** is a leading provider of material handling and logistics solutions based in Germany. KION is Europe’s top supplier of industrial trucks and services and the world’s second largest by revenue, with an installed base of 1.2m units (Linde, Still, Fenwick). With the 2016 acquisition of Dematic, KION has become the world’s third largest supplier of warehouse and supply chain automation solutions, with comprehensive range of high-end storage and material handling technology. KION is controlled by Chinese state-owned enterprise Weichai Power (43% stake).

**Cargotec** is the global leader in intelligent cargo handling, based in Finland, with three main business areas. Kalmar offers cargo handling equipment and automated terminal equipment, software and services used in ports, terminals, distribution centres and various industries. Hiab is the global market leader in on-road load handling solutions. MacGregor provides engineering solutions and services for marine cargo and offshore load handling designed to perform with the sea.

**Amano** is a leading provider of time management systems and automated parking solutions based in Japan. The Time Information business is the market leader in Time & Attendance management in Japan with ~40% market share and an installed base of ~500,000 time recorders. The parking solutions business is market leader in Japan with ~60% share.
### Total Return:

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<th>Ticker</th>
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Note: priced on 26 June 2017, Bloomberg. Manhattan Associates was included starting 2Q17. Zebra Technologies was included starting 2Q16.

Beyond companies directly included in the Logistics Automation category, several other members of the ROBO Global Robotics & Automation Index are major beneficiaries of the secular trends at play in this sector. **Cognex** is a good example. The global leader in machine vision is experiencing tremendous growth in demand for its automatic identification solution from e-commerce, logistics and parcel delivery companies, as its high-performance vision technology displaces laser-based bar code readers.

Logistics automation plays have been important contributors to the performance of the ROBO Global Robotics & Automation Index in recent years. Over the past three years, all but one of the stocks in the sub-sector outperformed the S&P500 by a significant margin. Small-cap Kardex and the Japanese stocks Daifuku and Amano stand out with 3-year total returns of 155%, 122% and 117% respectively, compared to 33% for the S&P500. So far in 2017, the group continues to outperform, led by Cargotec (+45%), Daifuku (+44%) and KION (+41%), compared with 10% for the S&P500.

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A Look Into Logistics Automation – July 2017 was written by **Jeremie Capron**, Managing Partner & Director of Research at ROBO Global. **ROBO Global is the first benchmark index for the global robotics & automation industry.**
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