ICT IN E-COMMERCE

HANGZHOU, CHINA // DEC, 2019

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ACKNOWLEDGMENTS

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- Hangzhou Dianzi University and Worcester Polytechnic Institute for providing this opportunity.

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E-COMMERCE IN CHINA

E-commerce is the act of buying or selling products online. China has the largest e-commerce market in the world, having grown by 50 percent per year since 2011 and is expected to be worth one trillion USD in 2019. Demand is constantly growing, with over 400 million Chinese people spending an average of 18 to 27 percent of their disposable income online in 2016 (Sovereign, 2016).

OPEX's Perfect Pick Automated Picking Machine (Bastiansolutions.com)

The rapid growth of e-commerce in China has lead those managers operating warehouses to remain vigilant in terms of insuring of practices necessary to meet client and customer expectations. More businesses are turning to new technology to find an edge, as they reach the limits of optimizing conventional warehouse practices. New technologies like robotics and automated picking systems are becoming the norm as warehouses struggle to remain competitive.

Hangzhou, China is an epicenter of this boom in e-commerce, supported by the city's strong tech culture. The presence of Alibaba Group, one of China's biggest technology heavyweights, has made the city a magnet for emerging technology. This conflux of technology and business in Hangzhou has culminated in projections valuing Hangzhou's e-commerce industry at 142 billion USD in 2018. Hangzhou's GDP in the first half of 2019 was 100 billion USD, a record high for the city. The technology and business innovations that exist in Hangzhou today make it a perfect candidate for our study on warehousing practices and technology, as we seek to take advantage of this rich environment.

Ningbo Zhoushan shipping port located in Hangzhou Bay, (Cruisemapper.com)

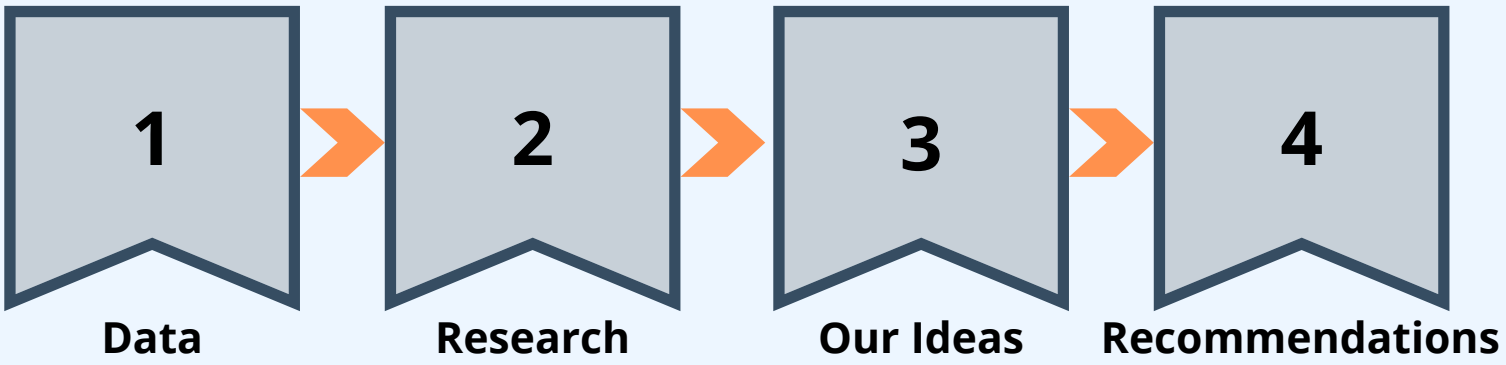
OUR PROJECT

Before arriving in Hangzhou, we anticipated our project would focus on warehouse practices and technology that are currently used in a local warehousing company called High Store Tech and provide them recommendations for improvement. Our plan was to collect operational data on High Store Tech and benchmark that data against other e-commerce warehousing companies. Once completed, we would have interpreted the data and identified best practices performed by each company.

Once we arrived in China, we learned that their automated warehouse would not be operational until January 1st, 2020 due to a change in business plans. This led us shift the focus of our project to the future of warehousing technology while still analyzing the data High Store Tech collected during trial operations conducted before we arrived.

The purpose of our project is to research the technology used at High Store Tech and other warehouse logistics companies to observe warehouse practices, present an analysis and recommendations for the future of warehousing.

OUR APPROACH



- Before the shift in our project, we collected efficiency data from other e-commerce companies. We categorized the other e-commerce companies based on their generated revenue. We then used the data to compare High Store Tech to each category of e-commerce companies and present an analysis.

- This study of current e-commerce warehousing companies inspired us to research future technology that experts believe will be developed in the near future.

- As young engineers, we took this opportunity to apply our problem solving technical minds to think about current problems found in warehouses and brainstorm our own technological solutions.

- Inspired by our data collection, research and brainstorms, we provided a set of recommendations to the Smart City Research Institute to assist e-commerce warehousing companies prepare for future technology.

WAREHOUSING & E-COMMERCE

The Customer

The customer places orders online for goods from the merchant. They initiate the process, and receive the end product from The Courier.

The Merchant

The merchant makes and sells products. They get an order from The customer for a product. The merchant contacts the warehouse to fill the order.

The Warehouse

The warehouse stores goods for the merchant. They receive an order's details from The merchant, and get the products from storage.

The Courier

The courier takes packages from one location to another. The warehouse hires the courier to deliver packages it has assembled from the merchant to the customer.

Warehouses are a key part of the e-commerce cycle. The warehouse stores products for e-commerce companies, and delivers those products when orders are placed.

Their massive storage capacity is what allows e-commerce companies to operate without storefronts. The number of warehouses located around the world make it more efficient for e-commerce companies to serve customers anywhere in the world.

Storage

Warehouses are divided into two areas, long and short term storage. Products that are picked in short term storage are replenished with products from long term storage.

Picking

The pickers in a warehouse take orders and search the warehouse for the products listed on the order. When the items have been gathered, the order is complete.

Quality Assurance

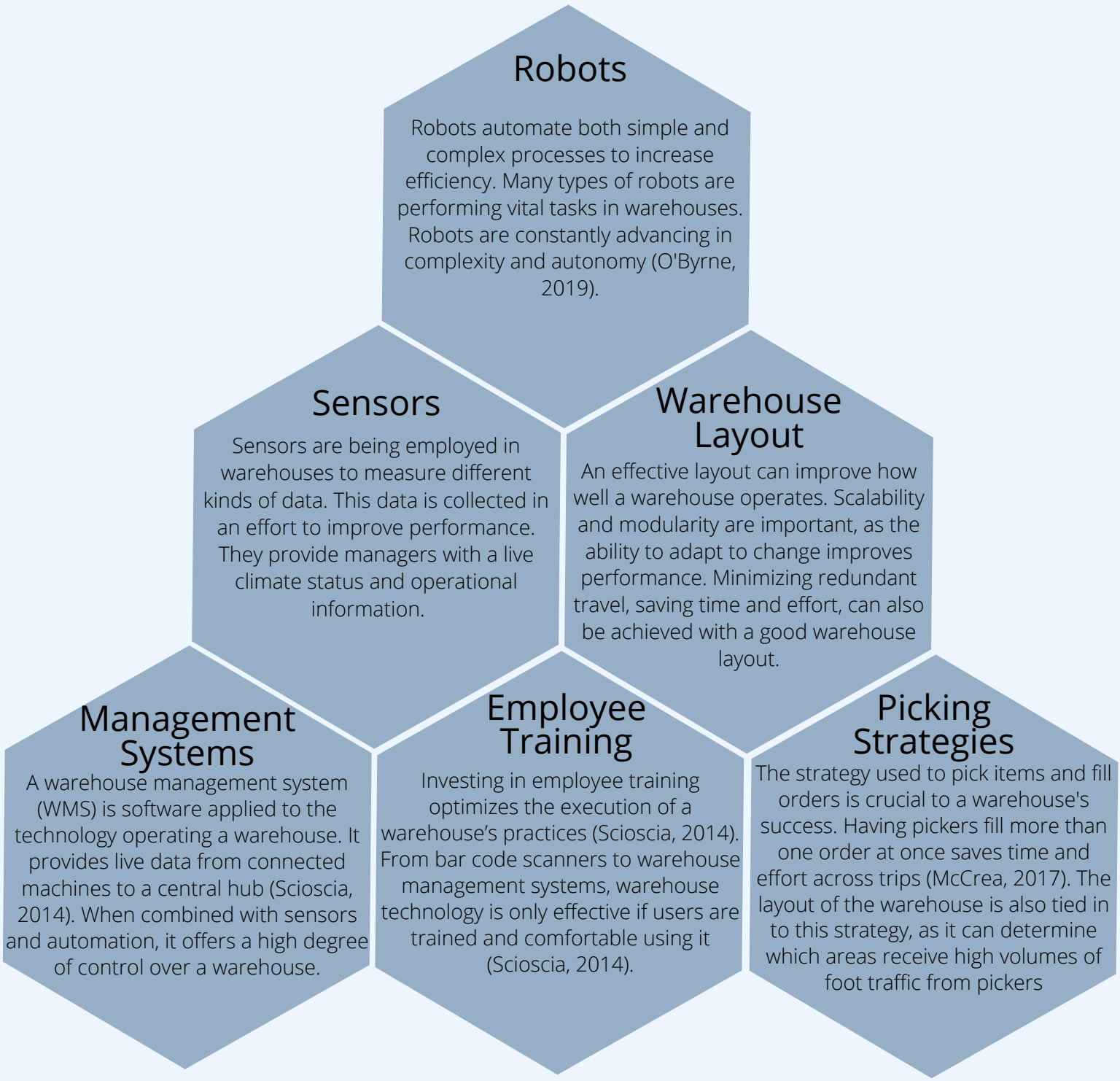
Quality assurance Inspectors look at completed orders that have been brought by the pickers. They ensure items match the order and that they are undamaged.

Packaging

The packers take completed orders from quality Insurance and package them so they can be shipped to customers. They use padded containers to protect the products.

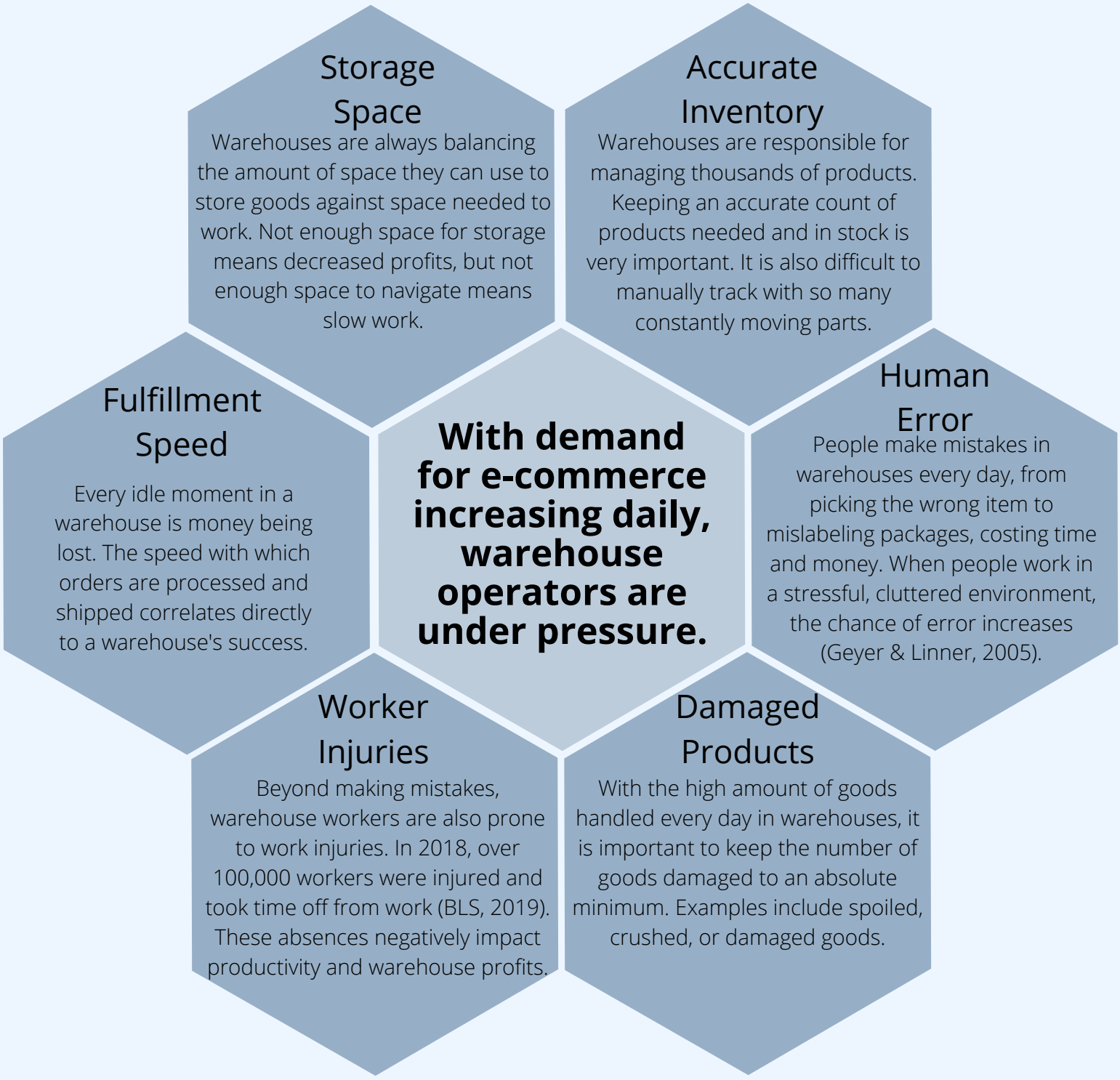
CURRENT PRACTICES

Warehouses are constantly changing their practices to keep up with demand for products and technological advancements. Described in the figure below are six practices that are currently utilized in warehouses and are considered 'best practices'.



CURRENT CHALLENGES

Even as warehouses take strides in advancing their business practices and technology to stay competitive, they must remain vigilant in combating those challenges which may undermine them. These are six common challenges faced by warehousing companies today.

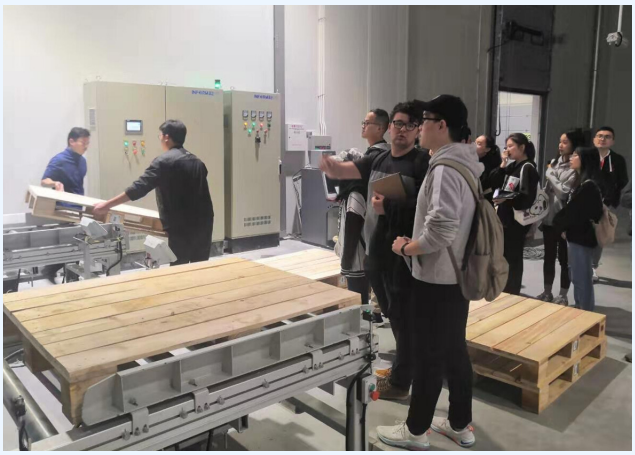


HIGH STORE TECH

HaiCang Technologies, also known as High Store Tech in English, is a Hangzhou based e-commerce warehousing company that we studied for our project. High Store Tech has over 800 employees and clients such as NetEase, Koala, and Yunji. It has a complete logistics division that is constantly seeking to improve their effectiveness and efficiency in warehousing. Our team visited warehouses owned by High Store Tech to collect efficiency data. We researched other comparable companies' efficiency data intending to benchmark against High Store Tech and provide suggestions for improvement to High Store Tech.

During our first visit, we toured two conventional warehouses where all operational processes are completed manually. Employees receive documented instructions to fill orders by retrieving products from storage. During this visit, our primary focus was on delivering a set of recommendations specifically to High Store Tech to improve the efficiency and effectiveness of their operations by analyzing their practices and comparing them to other e-commerce warehousing companies.

During our second visit, we toured the automated warehouse owned by High Store Tech. It was during this visit that we learned the facility's automation systems were still under construction due to the change in business plans. However, we still had the opportunity to observe trial operations of their automated system. High Store Tech developed this system themselves and named it the 'Ferris Wheel'. It is an automated picking and sorting machine that will be instrumental in their goal to be highly efficient.



Hunter and Larry (Lile) observing tests performed on the cold storage pallet retrieval system

The ICT team touring the conventional general goods warehouse lead by managers

Company Name	High Store Tech
Revenue	$10 million
Total Warehouse Floor Space	Over 300,000 square-meter
Total Number of Order Processed	40 million (in 2018)
High Store Tech Warehouse in Hangzhou	
Warehouse Floor Space	95,000 square-meter (Not fully utilized)
Number of Order Processed*	10,000 - 82000 per day
Number of Order Processed by Automation*	1800 - 14,000 per day
Average Number of Order Processed*	25,000 per day
Average Number of Order Processed by Automation*	4,300 per day
* Data are collected in Jan 2019	
Peak Performance (Singles Day)	200000 orders

Figure 1. High Store Tech Data

OTHER E-COMMERCE COMPANIES

After collecting data on High Store Tech, we researched nine e-commerce companies to benchmark against High Store Tech. We categorized these nine companies based on their revenue as either small, medium or large. Small companies are categorized as less than $500 million, medium between $1 billion and $10 billion, and large companies as greater than $20 billion. This method of data analysis allowed us to compare High Store Tech to companies of similar revenue size and companies that they want to compete with in the future.

BHFO.com
Best Brands. Better Prices.
(BHFO.com)

BHFO is an e-commerce company that sells clothes, shoes, and accessories through Ebay.

iHerb
(borntocoupon.com)

IHerb is an e-commerce company that specializes in natural products such as supplements, homeopathy, and beauty products.

ADORE ME
(Alleywatch.com)

Adore me is a women's lingerie company that is primarily e-commerce based (Adoreme.com, n.d).

TOLL
(dsei-japan.com)

Toll Group is a worldwide provider of logistics and transportation solutions.

newegg
(Wikipedia.com)

Newegg is an e-commerce company specializing in consumer electronics and computer hardware.

PUMA
(Puma.com)

Puma is a global sport brand operating both brick and mortar shops and an e-commerce store.

amazon
(Techtricksworld.com)

Amazon is based in Seattle, Washington, and is the largest e-commerce company in the United States.

苏宁易购 suning.com
(Wikipedia.org)

SuNing is a large e-commerce company based in Nanjing, China that sells a wide range of products

JD.COM
(Wikipedia.org)

JD.com is China's largest e-commerce company by revenue and sells a wide range of products.

SMALL REVENUE COMPANIES

All three of the small revenue companies that we collected data on utilize an automated picking machine made by a company called Opex. High Store Tech has created a similar automated picking machine, they named the Ferris Wheel, which qualifies these companies suitable for comparison.

BHFO

Although BHFO generates three times the revenue of High Store Tech, BHFO is a smaller operation with only 20,000 square feet of warehouse space compared to High Store Tech's 1.02 million square feet (95,000 square meters). Additionally, BHFO processes 1,800 orders per day when High Store processes an average of 25,000 orders. That means it takes 0.09 square feet of warehouse per order for BHFO while High Store Techonly requires 0.02 square feet of warehouse per order.

Company Name	BHFO(US)
Revenue	$30 million
Key Technology	OPEX Perfect Pick, Conveyor,Light-Directed Picking Devices,etc
BHFO Warehouse in Iowa	
Warehouse Floor Space	20,000 square-foot
Number of Shift	1 shift, 5 days per week
Number of Orders Processed	1,800 orders/5,000 items per day

Figure 2. BHFO Data

IHerb

IHerb can process 20,000 orders per day, which is very close to High Store Tech's average of 25,000 orders per day. However, even with High Store Tech's peak capability of 200,000 orders per day, Iherb's revenue is 10 times that of High Store Tech's.

Company Name	iHerb(US)
Revenue	$112 million
Key Technology	OPEX Perfect Pick, Sortation Conveyor,Light-Directed Picking Devices,etc
iHerb Warehouse in Kentucky	
Number of Orders Processed	over 20,000 per day
Order Cycle Time	15 minutes

Figure 3. IHerb Data

Adore Me

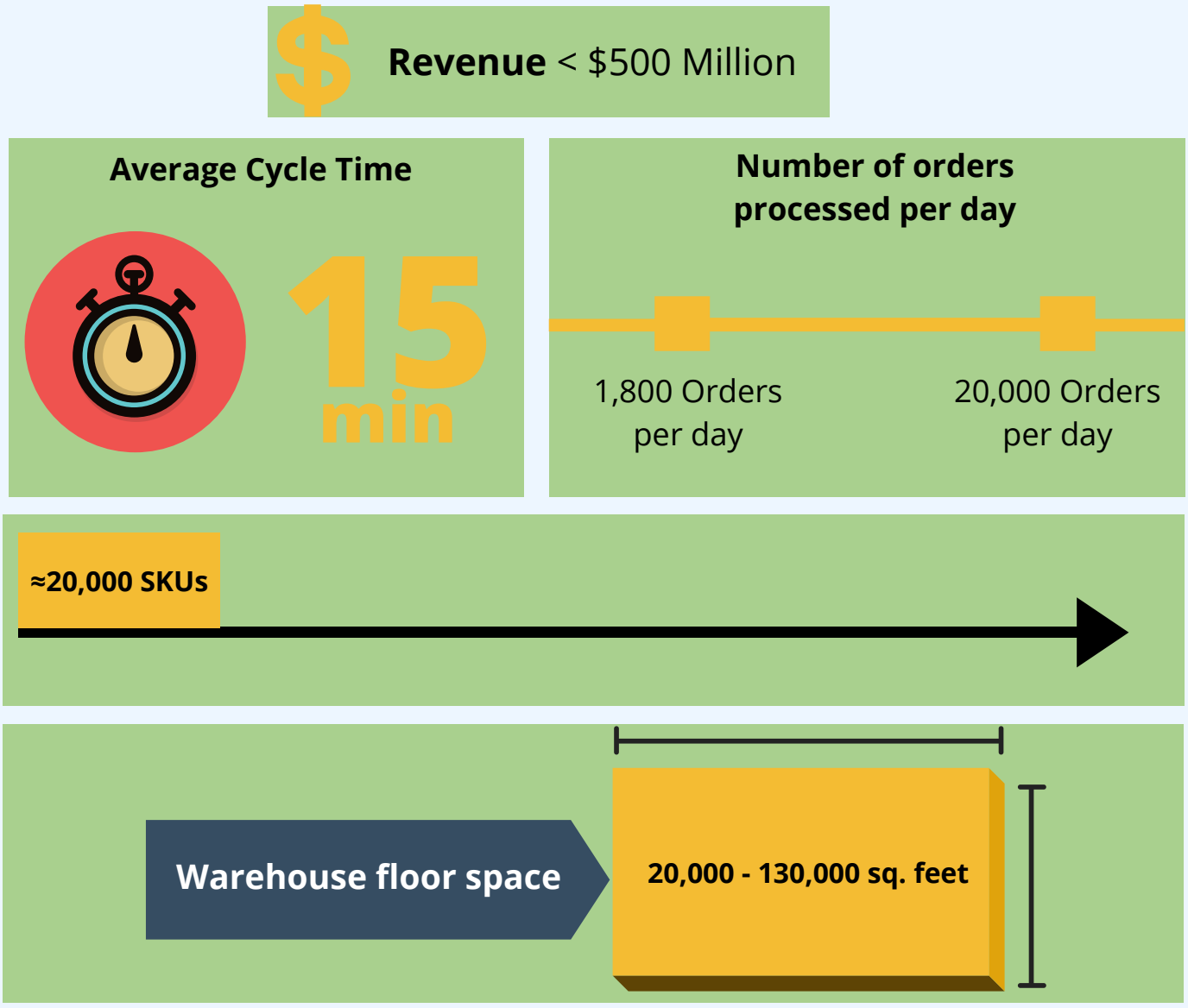
Adore Me uses only 0.15 square feet per order packaged in their 130,000 square foot warehouse, which has a peak performance of 20,000 orders per day. High Store Tech can reach a peak performance of 200,000 orders per day in their 1.02 million square foot warehouse, needing only 0.16 square feet per order processed.

Company Name	Adore Me(US)
Revenue	$100 million
Key Technology	AutoStore Picking System, OPEX Sure Sort, Automatic Labeling Machines,etc
Adore Me Warehouse in New Jersey	
Warehouse Floor Space	130,000 square-foot
Number of Robots	73
Number of Bins	33,000
Number of SKU	20,000
Number of Orders Processed	10,000 orders per shift
Peak Performance	20,000 orders per day

Figure 4. Adore Me Data

SUMMARY AND INTERPRETATION

If High Store Tech or other e-commerce warehousing company wanted to become a competitor as small revenue company, they should consider the following specifications.



Compared to other competing small companies, High Store Tech's operations are efficient and leading in performance. Their practices requires the second smallest warehouse area to process an order and have the potential to process a high volume of orders at their peak performance. High Store's average number of orders processed per day is equivalent to the peak performance of some of their competitors such as Adore Me. As a leader of the small companies in the metrics we focused on, High Store Tech appears to be ready to grow into a medium or large sized company.

MEDIUM REVENUE COMPANIES

These medium sized companies work on a larger scale than High Store Tech does but still not as large in revenue as other companies like Amazon. It became evident that High Store Tech is striving to become a similar company which qualified them for comparison.

Newegg

In Newegg's Indiana warehouse, they can achieve a peak performance of 18,000 orders per day, compared to High Store Tech's peak performance of 200,000 orders per day. Newegg has a much larger revenue of $2.29 billion.

Company Name	Newegg(US)
Revenue	$2.29 billion
Key Technology	OPEX Perfect Pick, Good-to-Person Shuttle System, Conveyor, Pick to Light/Voice,etc
Newegg Warehouse in Indiana	
Number of Orders Processed	6,000 - 8,000 per day
Peak Performance	18,000 orders per day
Order Cycle Time	20 minutes

Figure 5. Newegg Data

Puma

In Puma's California warehouse, they can process 200 orders per machine per hour. Having 170 machines, 34,000 orders can be processed per hour. Assuming the warehouse operates between 10-16 hours a day, Puma can package 340,000 to 544,000 orders per day. That average is at least 100,000 orders per day more than High Store Tech's peak performance ability.

Company Name	Puma(US)
Revenue	€4.64 billion
Key Technology	AutoStore Picking System, Autobagging Machines,Conveyor,etc
Puma Warehouse in California	
Number of Robots	170
Number of Bins	171,000
Number of SKU	30,000
Number of Orders Processed per Machine	200 e-commerce lines per hour & 700 wholesale units per hour

Figure 6. Puma Data

Toll Group

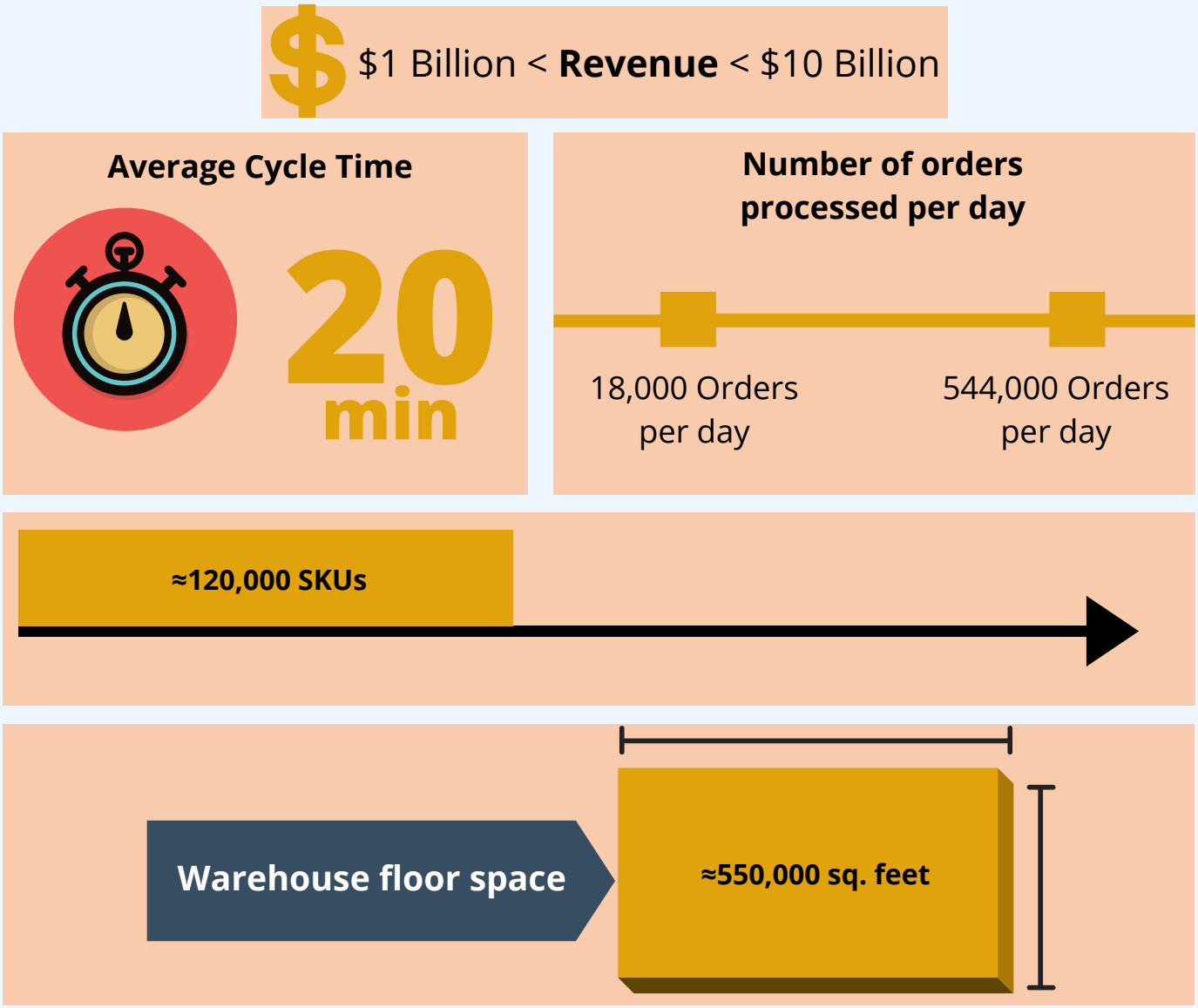
High Store's peak performance of 200,000 order per day is about the same as Toll Group's average of 160,000 to 200,000 orders processed per day. Although they may process the same number of orders per day, Toll Group operates in a 550,000 square foot warehouse which is almost half the area of High Store Tech's. Additionally, Toll Group has 120,000 SKUs while Puma, a worldwide sports brand, only has 30,000 SKUs. Toll Group's high number of SKUs and smaller warehouse area indicates a high level of efficiency in the company's practices.

Company Name	Toll Group(Australia)
Revenue	$8.2 billion
Key Technology	AGVs, Shuttle System,etc
Toll Warehouse in Sydney	
Warehouse Floor Space	550,000 square feet, including 113,000 square feet of automation
Number of SKU	120,000
Number of Shift	2 Shifts per day/ 5 days per week
Number of Orders Processed	80,000 to 100,000 units per shift

Figure 7. Toll Group Data

SUMMARY AND INTERPRETATION

If High Store Tech or other e-commerce warehousing company wanted to become a competitor as medium revenue company, they should consider the following specifications.



The data above indicates there is an inconsistency of medium sized companies' efficiencies. Some companies perform more efficiently than High Store Tech and others have comparable levels of efficiency. The products Newegg sells makes them more profitable than High Store Tech in terms of generated revenue. Newegg has 100 times the revenue of High Store Tech but cannot package as many orders per day. For a small e-commerce warehousing company like High Store Tech to become a medium sized company, they should find ways to increasing the number of orders they receive so they can consistently operate at their peak performance level.

LARGE REVENUE COMPANIES

High Store Tech and many other small or medium sized e-commerce warehousing companies hope to one day compete with the largest e-commerce companies in the world. We collected data on the leaders in the e-commerce industry such as Amazon, JD.com, and Suning, to demonstrate to small companies what their company may look like in the future.

Amazon

Amazon's Kiva system, comprised of automated guided vehicles (AGV), is performing the same task of picking by using AGVs rather than Opex's or High Store Tech's automated picking system. This system is new to Amazon's operations and it has proven to be 99.99% accurate, in addition to improving their productivity by up to 4 times as much as traditional systems in their warehouses.

Company Name	Amazon(US)
Revenue	$232.89 billion
Key Technology	Kiva System (AGVs),Robotic Arm,etc
Cost of Automation	$1 - 2 million (Small Warehouse)
Amazon Warehouse	
Warehouse Floor Space	1 million square-foot
Number of Employees	Over 1000 full-time employees
Number of Robots	800 Kiva Robots
Working accuracy	99.99%
Number of SKUs	562,000,000
Productivity compared to traditional system	Increase by 2 to 4 times

Figure 8. Amazon Data

Company Name	SuNing(China)
Revenue	$35 billion
Key Technology	Automated Storage and Retrieval System, A-frame Sorting System, SCS Good-to-Person System,etc
SuNing Cloud Warehouse in Nanjing	
Warehouse Floor Space	200,000 square-meter
Number of Items Stored	20,000,000
Number of Orders Processed	1200 per hour
Peak Performance	1,810,000 order per day
Order Cycle Time	30 minutes
On-time Performance	99.98%
Cost of Package	Decrease ￥0.30 per package

Figure 9. SuNing Data

SuNing

Suning's warehouse in Nanjing reports they process 1.8 million orders per day in their 2.15 million square foot warehouse. High Store Tech has less than half of Suning's area in all of Hangzhou. A single warehouse of this size greatly increases the storage capabilities and the company's ability to meet customers' demands.

JD.com

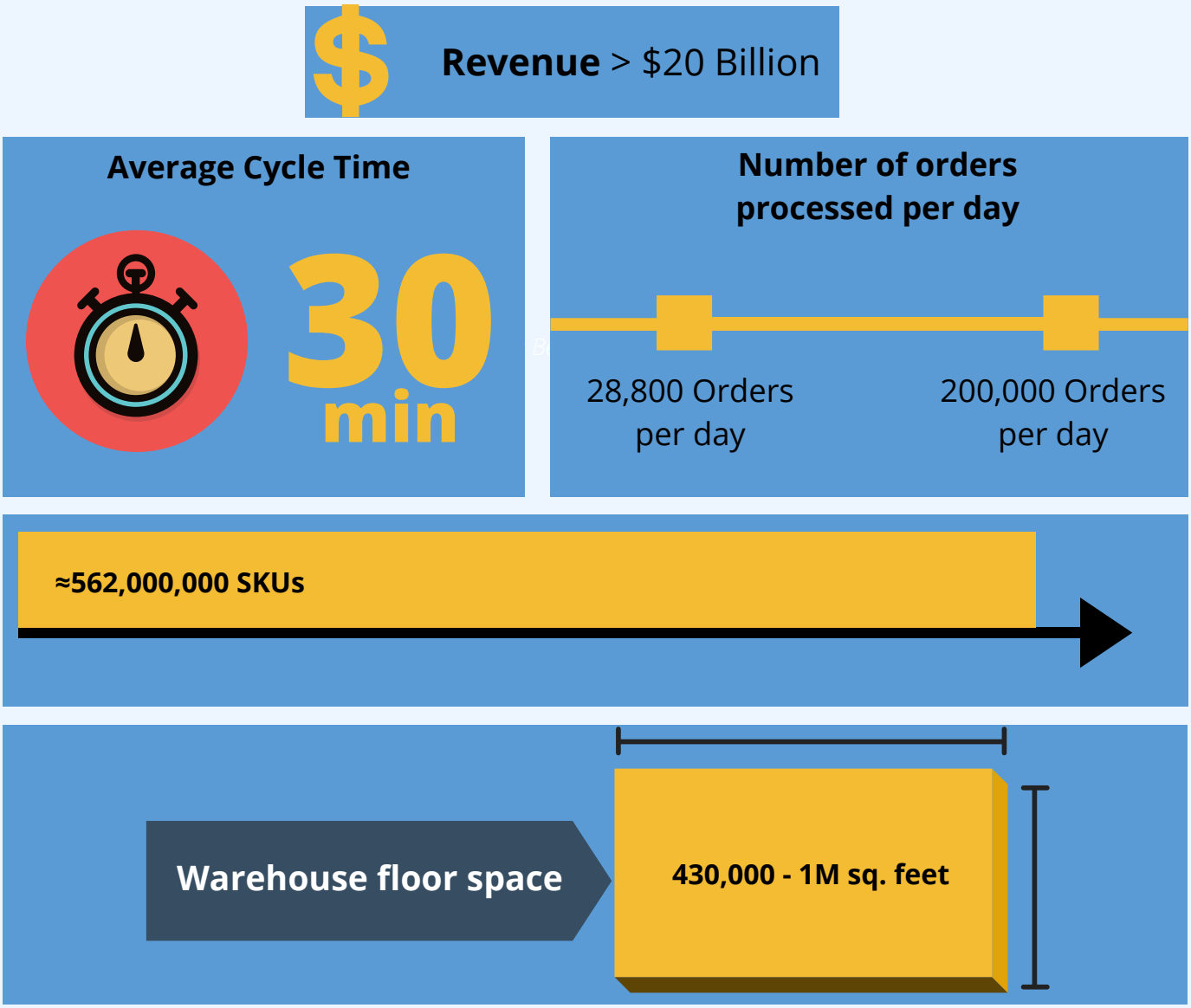
One of JD.com's warehouses reports producing 200,000 orders per day, the same number of orders as High Store Tech at peak performance.

Company Name	JD.com(China)
Revenue	$67.2 billion
Key Technology	2-D and 3-D Visual Identity,AGVs, Robotic Arm,Photovoltaic (PV) Generators,etc
JD Warehouse in Shanghai	
Warehouse Floor Space	40,000 square-meter
Storage Capacity	60,000 boxes of good
Number of Robots	1,000
Number of Item Sorted	3,600 per hour
Number of Orders Processed	200,000 per day

Figure 10. JD.com Data

SUMMARY AND INTERPRETATION

If High Store Tech or other e-commerce warehousing company wanted to become a competitor as large revenue company, they should consider the following specifications.



When a small company like High Store Tech has grown enough to start considering growing into a large company, analyzing other non efficiency metrics becomes more important. The value of products, the size of each order, and the numbers of orders placed per day are examples. As the company acquires more clients and begins to globalize, the locations of their warehouses are important to meeting customers' demands in a timely manner. Additionally, practices that are effective and efficient for the company when they are classified as a small revenue company may prove to be inefficient when they reach the classification of a large revenue company. For example, Amazon does not use a system comparable to the Ferris Wheel. The Kiva system used by Amazon was installed after they were classified as a large revenue company indicating that best practices vary depending on the company.

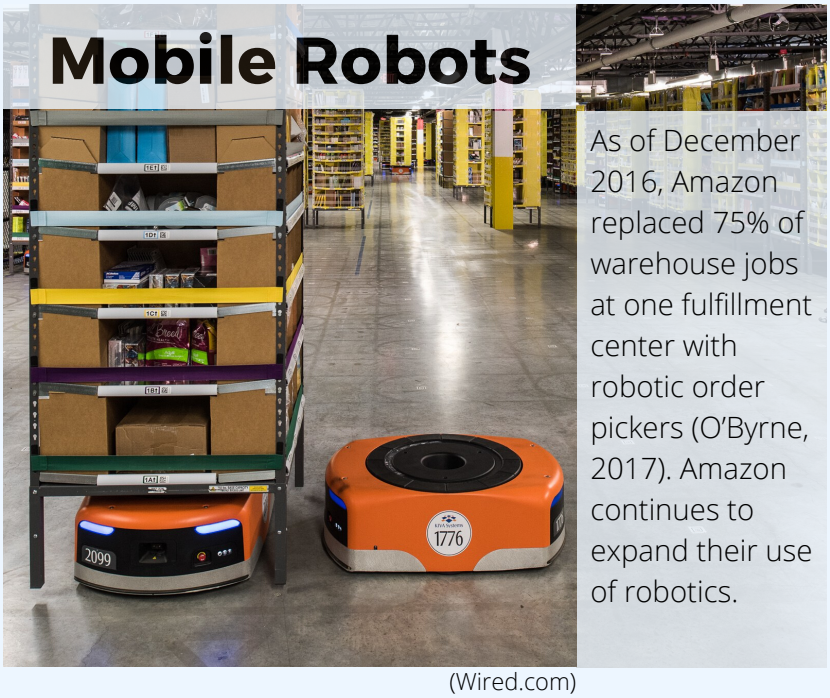
FUTURE TECHNOLOGIES

Due to the changes in High Store Tech's business needs, we took the opportunity to research evolving technologies that experts anticipate warehouses adopting in the future.

(jsoren.com)

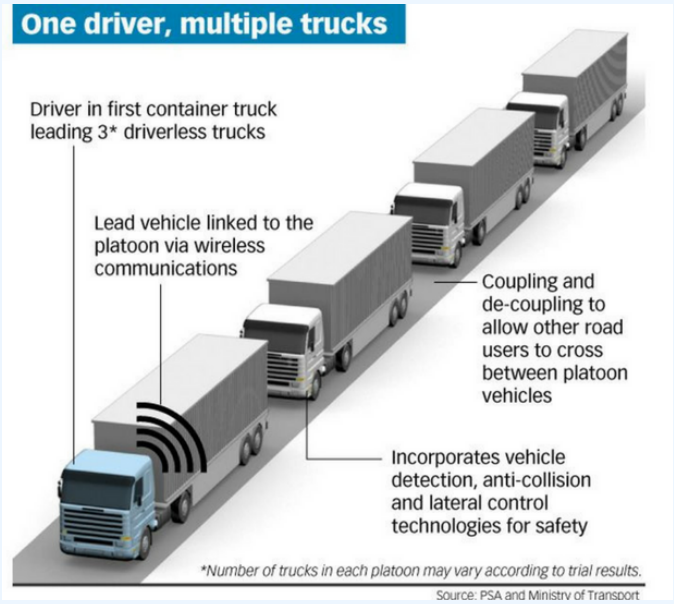
Utilizing VR and AR, managers can immerse their new hires in a hands-on training experience to show them everything they need to do in their job. Trainees will be engaged in the experience, increasing information retention rate and producing a higher quality employee in a shorter amount of time ("5 ways AR is changing", 2018). VR and AR have already been proven to be effective in classrooms and other educational settings.

Mobile robots provide an alternative to fully automated systems by offering a faster implementation process and allowing companies to purchase as many devices as they'd like, making them affordable. They can be used to perform tasks such as picking, transporting, sorting, scanning and other human performed actions. Some may have arms with grippers to pick while others may have multiple scanners to sort. A recent innovation allows robots to navigate with no guidance. Based on their software they can maneuver without anything on the floors or reflectors on the racks (Michel, 2017).



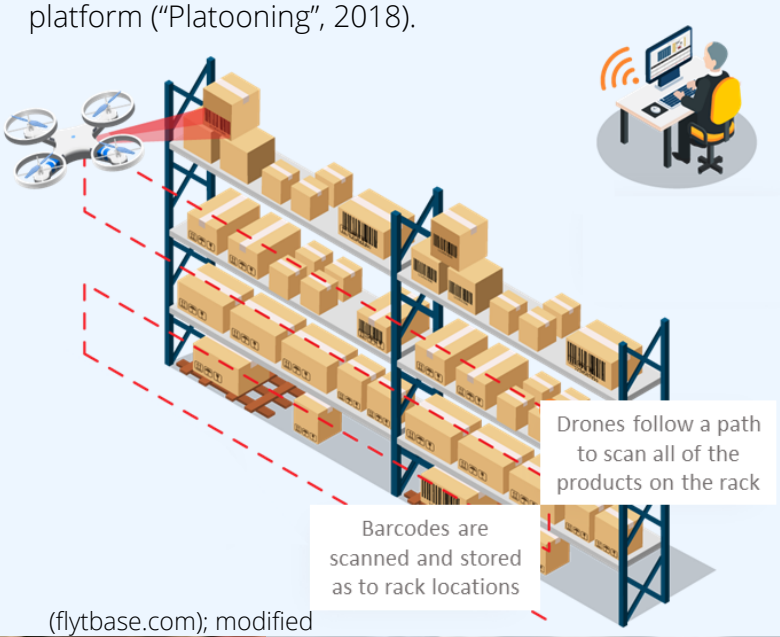
(Wired.com)

As of December 2016, Amazon replaced 75% of warehouse jobs at one fulfillment center with robotic order pickers (O'Byrne, 2017). Amazon continues to expand their use of robotics.

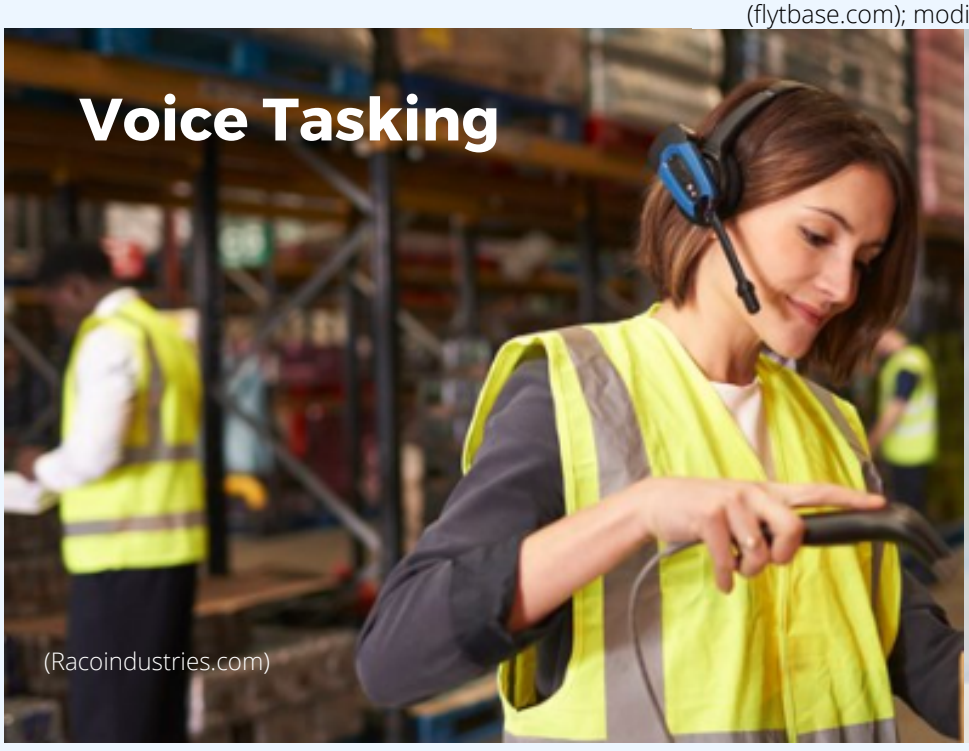


Self-driving vehicles reduce the amount of accidents that occur due to human error. Drivers can rely on this software to control the vehicle's operational systems. Linking automated truck's software provides opportunities for improving the transportation of goods. Aside from assisting the driver, this software can platoon trucks. This means that multiple trucks can be linked by syncing their software and communicating through the truck's information and communication technology (ICT) ("Platooning", 2018). Once they are linked, the trucks can drive within inches of one another to reduce the amount of air resistance and therefore increasing the truck's fuel efficiency. The first truck acts as the "leader" and all the following trucks are able to react and adapt to movements made by the lead truck through the ICT platform ("Platooning", 2018).

Drone delivery offers many advantages in terms of efficiency and safety. They are electric powered and lightweight, making them inexpensive to operate and environmentally friendly. They are not limited by road travel so they can deliver products much faster to customers.



(flytbase.com); modified



(Racoindustries.com)

Voice picking systems uses speech synthesis to provide warehouse operators with an audio picking itinerary. The picker on the warehouse floor uses a headset and microphone to receive instructions by voice, and verbally confirm their actions back to the warehouse management system (WMS). Before the pickers continue to the next order, the operators will validate picked items (Murray, 2019).

BRAINSTORMING

Based on our research of current practices used in warehouses and our understanding of current developing technology, we, as young engineers, developed technological concepts that we believe will emerge in the warehousing industry. The inefficiencies that we witnessed at our time spent at High Store Tech and research we conducted on other e-commerce companies were used as inspiration for our brainstorming. In developing our ideas, we tried to find abstract technological solutions that improved the inefficiencies we identified eliminate common problems in warehouses. We categorized our nine ideas based on when we anticipate their creation. The near future ideas are most to be developed with today's technological capabilities. The distant future ideas will take years for the necessary advancements are made for their creation. The "maybe someday" ideas are our most abstract ideas but will drastically change the warehousing industry if they can ever be created.

Near Future

- **Magnetic levitation conveyor belts**
- **Redesigned warehouse concept**
- **The "black-dot" tracker**

Distant Future

- **Wirelessly charged automation**
- **Zero gravity warehouse**
- **Exoskeleton**

Maybe Someday

- **Teleportation**
- **Force-field warehouse walls**
- **Mind controlled robotic bins**

Near Future

Magnetic levitation conveyor belts

How it works:

We envision packages levitating on magnetic tracks. Powered by opposing magnets, tracks can be polarized with an alternating current to push the floating packages to their destination. These floating packages can be outfitted with magnets in strategic locations to ensure stable movement while moving.

Advantages:

- Reduce electricity
- Eliminate friction between package and belt
- Fewer mechanical parts
- Reduce maintenance

Redesigned warehouse concept

How it works:

Conventional warehouses are large buildings located at long distances from their customers. Our concept decentralizes distribution centers to multiple locations around dense populations. These distribution centers will be placed underground and have multiple levels.

Advantages:

- Goods closer to customers
- Reduce delivery time
- Remove spatial limitations
- Increased security
- More efficient climate control

The "black-dot" tracker

How it works:

This tracker will be applied to each order and have the diameter of the head of an eraser. Each one would contain the order's destination, contents, and geographical location down to inches. This information can be easily be viewed with a smartphone app. They will be designed with water resistant materials and an extra strength adhesive.

Advantages:

- Water resistant material
- Strong adhesive
- Lightweight
- Easy to access information

Distant Future

Wirelessly charged automation

How it works:

Automated mobile robots and drones used in warehouses temporarily stop operating to recharge their power source. We predict that an adequate amount of electricity will be delivered through the air to charge these mobile devices. Batteries of conventional dimensions will composed of special materials that can receive wireless electricity.

Advantages:

- Eliminates recharge down time
- Eliminates battery changing hazards
- Continuous operation

Zero gravity warehouse

How it works:

Once inside the warehouse walls, gravity will not exist. Products will be secured in storage racks. upon request, products will be released and sent to a packing area. Products will be moved with automated robots. Employees will be outfitted with technology to easily control their movement.

Advantages:

- Vertically expand paths of travel
- Easy to move packages
- Reduce employee injuries
- Eliminate falling object threat

Exoskeletons

How it works:

We believe exoskeletons will be worn by employees. The exoskeleton will be made of strong, lightweight metal alloys and use motors, hydraulic lifts and leverage to assist users in natural movements.

Advantages:

- Increase lifting power
- Increase walking speed
- Provide muscular support
- Prevent lifting or strenuous activity related injuries
- Little training required

Maybe Someday

Teleportation

How it works:

Packages will no longer need to be picked, packaged, or even shipped. Robots will locate the product in storage and use a teleportation device to teleport the product to the customer's receiving module. Each receiving module will have a unique identity that will automatically be assigned to the order to identify the product's destination.

Advantages:

- Eliminate shipping cost
- Eliminate labor cost
- Instant delivery to customer
- Eliminate packaging material
- Reduce picking errors
- Secure product delivery
- Reduce work related injuries

Force-field warehouse walls

How it works:

We believe traditional warehouse walls will be replaced by a plasma bubble, aka. a force-field. These new walls that form the bubble will be selectively permeable and adjustable in size. The plasma material will also have thermal and electrical insulating properties.

Advantages:

- Easy access for drones with clearance
- Allows for warehouse expansion
- High level of security
- Protection from outside environment
- Thermally and electrically insulated
- Reduce climate control costs

Mind controlled robotic bins

How it works:

Employees will wear a headset that can read and record brain activity. That will be used to generate commands for the robot. The headset will send commands to a robot. Robots will also send feedback to the user.

Advantages:

- Easily control robots
- Reduce lifting injuries
- Reduce fatigue levels
- Feedback from robots

RECOMMENDATIONS

The following recommendations were provided to the Smart City Research Institute to further the advancement of warehouse technology and improve the efficiency and effectiveness of e-commerce warehousing companies located in Hangzhou. They were inspired by our research conducted on technology used In e-commerce warehousing and our experience at High Store Technologies. We came up with three areas of recommendations which are technology, the environment, and people.

Technology

The Environment

People

RECOMMENDATIONS

From the research we conducted, we found that the warehousing industry is quickly shifting towards technology and automation. Because technology growing so rapidly, we develop a set of recommendations that are designed to assist e-commerce warehousing companies adapt to the future technological advancements

Technology

- **We recommend warehousing companies capture critical KPIs on their operations.** Collecting KPIs from both machines and employees will highlight the areas of the warehouse that can be improved to increase their efficiency.

- **Incorporate automation into warehouse operations.** A fully automated picking system like the Ferris Wheel used by High Store Tech or mobile pickers used at Amazon will increase rate of picking while reducing the amount of human errors.

- **Form a team dedicated to technology brainstorming and innovation.** A team developing new technology at a company will set them apart from their competitors. It will creating appeal to clients and customers. Additionally, operations will become more efficient and effective from the developed technology.

RECOMMENDATIONS

Our brainstormed ideas and researched future advancements are all technology and robotic based. The materials used to build the technology, source of power, and waste produced by these technologies have potential to harm the environment. We developed two recommendations that assist the develop of technology in an enviromentally friendly way.

The Environment

- **Consider environmentally safe packaging materials.** Customers will have an additional incentive when they know they are receiving an eco-friendly package. Additionally, eco-friendly packaging will create a positive company image to the public. Eco-friendly packaging also has minimalistic design to reduce material usage and waste in addition to decreasing shipping costs. In some cases, packaging can be reused or repurposed which reduces a company's carbon footprint.

- **Consider using clean electricity.** Receiving electricity from clean sources will create a positive company image and reduce the environmental damage from fossil fuels. To reduce the amount of wasted electricity, consider using smart lighting, turning off unused machinery and using an efficient climate control system.

RECOMMENDATIONS

The warehousing industry is quickly moving towards automation which is replacing human jobs and having a social impact. We believe companies have a social responsibility to their employees. We developed a set of recommendations to assist companies responsibly integrate automation into society.

People

- **Retrain employees that are replaced by automation.** Demonstrating value in employees will create a positive image for companies. It also increases employee retention rates and decreasing new hire costs.
- **Consider paying for employee training and further education.** Employees will not only have valuable skills that improve operations but will be more loyal to the company.
- **We recommend regularly collecting employee feedback.** Expressing interest in employee's experience demonstrates that the company cares about their hires. This builds unity and moral which ultimately increases productivity.

PERSONAL REFLECTIONS

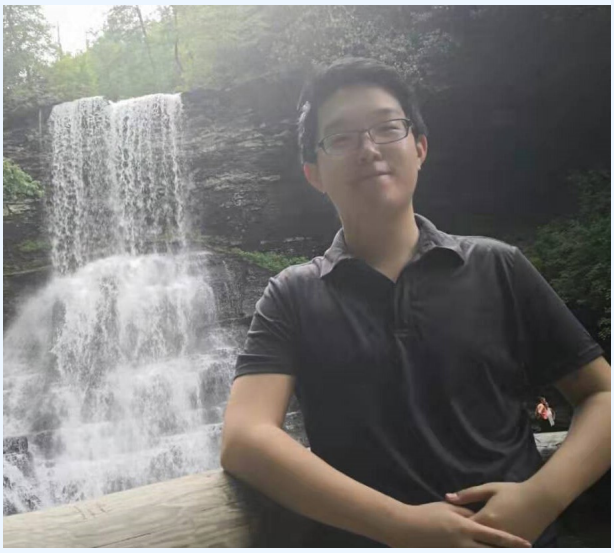
Xiaowei Chen

This project enriched me a lot. I took a very close look at the real warehouses and learnt the detailed methods about how to investigate the aspects for a project. Overall, it is a great pleasure for me to apply my knowledge and enthusiasm to the real issues. I worked with my teammates for a long time, which enhanced my ability of cooperating better with others to accomplish a job. My speaking and writing skills are greatly improved: I am now comfortable and confident to do presentations in front of a group of people, and now I have a clear idea about how to make a report more structured and logically. This is a fascinating experience, and I really appreciate that IQP provided me with such valuable opportunities.

Hunter Caouette

Being on IQP this term has made me more resourceful and taught me how to better respond to changing directives in a project. The work that I've done with my team has improved my ability to work as an effective member of a team and helped me learn when and how to take the lead. Every time we visited the warehouses here, I was amazed to see how the technology we learn to create in school is put into practice, and what a tangible effect that they can have on our daily lives. This project has reaffirmed my love for my field of study and helped me grow as I continue to pursue it in the future.

PERSONAL REFLECTIONS



Lile (Larry) Zhang

I have had a delightful IQP experience in Hangzhou. It is exciting and precious that I had the chance to observe the local warehouse and interview the experts. Professor Zhou, his students, and High Store Tech gave us great support and made this IQP an excellent opportunity. I was able to truly learn about the e-commerce warehousing industry and expand my horizon to topics I previously did not know about. My teammates were helpful in problem solving and our advisors provided me with valuable advice. Finally, I learned to always remember to work hard, be positive, and flexible.

Benjamin Seeto

After completing this project, I feel that my level of professionalism has improved and my ability to effectively work in a group has increased. The challenges we faced both as a group and as individuals taught me that effective communication, project organization and adaptability are essential to a successful group. I enjoyed learning about the e-commerce warehousing industry and working with our sponsor. I also could not have asked to work with a better group. Overall, I am thankful for this experience to develop as a professional and grow as a leader.

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