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Is Kiva Systems a Good Fit for Your Distribution Center? An Unbiased Distribution Consultant Evaluation.

Introduction

February, 2012. This white paper provides an unbiased review of Kiva Systems and the solutions that the company brings to the material handling market. The article provides an overview of the company, the solutions that have been developed, and the customers that have invested into Kiva's applications. Our intent is to help your company better understand if the Kiva Systems solutions may provide a good fit for your distribution operation. **MWPVL** International has reviewed this article with Kiva Systems to ensure its factual accuracy. Any opinions expressed within this article are strictly those of the author.

This white paper was written and published shortly before the stunning announcement that Kiva Systems was acquired by Amazon.com in an all-cash deal for $775 Million on March 19, 2012. We will continue to update information on Kiva Systems as news becomes available. Kiva's robots are used by Quidsi Inc. (the company behind Soap.com and Diapers.com) that Amazon acquired for $545 million in 2011.

Kiva Systems - Company Background

Headquartered in Woburn, Massachusetts, Kiva Systems was founded in January, 2003, by Mick Mountz who is the CEO of the firm. Mick is an MIT engineering graduate (1987) and a Harvard MBA (1996). He started his career with CIM Systems as a manufacturing engineer and later joined Apple Computer for 4 years. In 1999, Mick joined Webvan which was an on-line grocery home delivery distribution company that served customers in seven U.S. markets: Chicago, Los Angeles, San Francisco, Orange County, San Diego, Seattle and Portland, OR. Unfortunately, the complexity of Webvan's automated material handling equipment and the resulting high cost of order fulfillment ultimately led to the company filing for chapter 11 bankruptcy in July, 2001. But it was at Webvan that Mick earned an appreciation of the challenges of material handling and distribution operations which subsequently led to the founding of Kiva Systems.

From the beginning, Mick was seeking a way to improve the pick, pack and ship process through a goods-to-man system based on one basic principle - it must be able to deliver any item to any operator at any time. Together with two experts in engineering and robotics, Professors Peter Wurman and Raffaello D'Andrea, Kiva Systems was launched and within 20 months the company had its first prototype solution working. Initially, Kiva Systems was funded with $1.6 Million through a group of private "angel" investors. In 2004, Bain Capital Ventures in Boston injected $5 Million of venture capital and Bain subsequently invested an additional $15 Million over the next three years. Bain clearly understood that the $100 Billion e-commerce market was ripe for growth and that Kiva has an important role to play in this market. By 2009, Kiva Systems was named the 6th fastest growing company in the US by Inc. 500 and their incredible growth shows no signs of letting up (last year sales were reportedly up by 130%).

Today, Kiva Systems is cash flow positive and is backed by $33 Million of investor capital. As at February, 2012, the company has approximately 275 full-time employees (100 were added last year), and 25 customers operating their solution within 35 distribution centers across North America, the UK, and Europe. Plans are also underway for geographic expansion with a new European office in the works. While the majority of Kiva's success to date has been driven by rapid growth within the Internet retail sector, Kiva Systems is already seeking new ways to expand into other distribution sectors that can benefit from its unique approach.

Solution Overview - How It Works

The Kiva Systems solution is comprised of several fundamental building blocks as described below:

1. The orange ottoman-shaped robots (i.e. ItemFetch or CaseFetch robots in Kiva's vernacular) are the most recognizable system component in the Kiva solution. All day long, these autonomous robots are instructed by a central computer to go an fetch inventory pods to be brought forward to restocking and picking/packing work stations.

   a. There are two basic models that handle different weight capacities. The most commonly deployed robot handles up to 1,000 pounds of load weight. The more expensive heavy-duty model handles up to 3,000 lbs of weight. The robots are designed to handle shelf bays (i.e. pods in Kiva's vernacular) and/or pallets.

   b. The smaller robots measure about 2 feet x 2.5 feet x 1' high and weigh about 250 pounds. They are equipped with a corkscrew-type lifting mechanism to elevate the pods off of the floor prior to transport. The lifting mechanism is in effect a custom-built ball screw powered by a single DC drive motor. To keep the pod motionless in transit, the robot rotates its wheels in the opposite direction (and at the exact speed) of the ball screw. The robots travel at a speed of about 3 miles per hour which is similar to walking speed.

   c. The robots run on rechargeable lead-acid batteries that are charged at frequent intervals throughout the day such that

there is no battery change-out process required. The robots simply travel to designated charge stations every couple of hours where they receive a 5-minute battery re-charge before returning to production. For the purposes of budgeting, assume that at any time 5% of the robots will be out of commission for short re-charging intervals. When developing the business case for this technology, it is important to note that the batteries are considered a consumable item that requires periodic replacement. For batteries that undergo consistent daily usage, the typical battery life cycle is in the order of 1.5 - 2 years for planning purposes. Alternatively, Kiva has developed a new program that replaces batteries for an annual support fee.

d. The robots travel around a street and highway grid that is mapped out on the floor in the form of 2" x 2" stickers with 2D bar codes that are placed every 40" to 60" along the street grid (note that this is a huge advantage over having to install permanent wire guidance systems). The robot is equipped with one camera that looks upward and one camera that looks downward. The cameras detect the stickers which enables the central computer to know where the robot is within the grid. As well, every pod storage location within the grid has a sticker which identifies the location to the computer system.

e. Every robot is equipped with sensors that detect if there is an obstacle in the way which if encountered prevents the robot from moving forward. This is to ensure that the robot does not hit an operator or a product that may have fallen off of a pod (note that this is a rare event). The work area / highway grid where the robots travel is not intended to be accessible by warehouse associates in any way so the sensors are really intended to ensure that the robots do not crash into each other.

f. One of the hidden benefits of Kiva's robots is that they can work in the dark which reduces carbon emissions and saves costs for air-conditioning and lighting.

2. Pods are shelf bays that are used to store merchandise. Robots transfer pods in priority sequence to storage locations within the floor grid, to replenishment locations where they are restocked with inventory, and to queuing lanes for work stations for picking and packing.

a. Pods come in 2 standard sizes with the most commonly deployed unit sized at 39" wide x 39" deep x 6' - 8' high. The larger pod is 49" wide x 49" deep x 6' - 8' high. In general the smaller pods are used in applications where the weight requirement is up to 1,000 lbs per pod, with the larger pod used in applications where weight requirements are up to 3,000 lbs per pod. As mentioned earlier, Kiva robots are also capable of transferring bulk goods on pallets.

b. While there is no technology on the pod itself, the pods are typically purchased as part of the Kiva solution because they are the physical building blocks of the solution. The pods are designed to prevent goods from falling off of the shelf levels in transit.

c. Keep in mind that the robot must go underneath the pod to lift it up prior to transport, hence there is a loss of usable height at ground level of roughly 24" (i.e. product is typically stored starting at knee-height upwards). As such, step-up platforms can be used at work stations if operators need to access taller pods (e.g. taller than 6').

3. Work stations are the ergonomically designed work areas that operators are positioned to perform replenishment, picking, and packing labor functions.

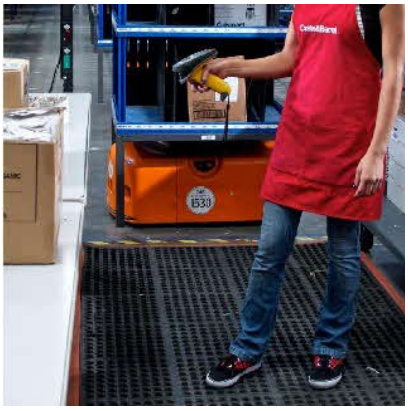
a. Stations can be strictly used for inbound restocking or for outbound picking/packing. For flexibility reasons, the stations can be configured to support both restocking and picking/packing functions however this strategy differs for each operation.

b. At receiving, incoming merchandise is typically putaway into high bay reserve locations within the warehouse and then subsequently pulled for restocking to the Kiva Fulfillment System. Goods can technically be moved from receiving directly into the Kiva system but it is important to keep in mind that SKUs are generally restocked in logical quantities such as in case quantities. The goal is to strike a balance such that enough inventory is held within the Kiva System to prevent a stock out during the work day, while at the same time minimizing the amount of inventory held within the Kiva System to keep the cost of the equipment/footprint to a minimum.

c. Goods are transferred from reserve inventory (or receiving) to designated restocking stations. If a WMS is being used within the warehouse, then there is a software interface that is required from the WMS to the Kiva material handling control system (MHS) to download information about the SKUs being transferred into the Kiva system. Typically, the operator scans the SKU being restocked and confirms the quantity being restocked to an incoming pod that is staged at the work station.

d. Pods are generally queued in advance at these stations to prevent operator dwell time. Replenishment rules can be configured to ensure that a SKU is replenished to a pod that already has inventory for the item assigned to it such that the item's inventory is always kept together within a single pod, or to any pod in general.

e. Picking / Packing work stations are typically set up so that the operator can pick multiple orders concurrently. The typical station is 6' x 6' with support for picking 6 - 12 orders at a time but this can be configured uniquely for each operation. A laser pointer illuminates the pick location on the pod where the item to be picked is positioned. Put to light technology is used to display the quantity to be picked for each line item being



picked. The operator picks the required quantity and puts it into one of the 6 cartons or totes being batch picked. The operator then pushes a put to light display button underneath the case/tote being picked to, in order to validate the "put" portion of the pick task. This process ensures that the operator puts the selected item into the correct carton or tote. Given that operators are working multiple orders concurrently, the laser display and the put to light technology are key elements of the system to ensure maximum order accuracy. As soon as the pick is completed, the pod moves on and the next pod is presented to the operator, a process that takes about 6 seconds to complete. Note that stations can be configured such that the picker also performs the packing function, or one can set these up as two separate functions involving two different people. This choice tends to be driven by the complexity of the packing requirement whereby more complex packing requirements generally require a separate packing function apart from picking.

f. After the item has been picked, the robot transfers the pod back into storage or to wherever it is needed next.

g. Note that pods can also be used to stage outbound orders at the work stations. In this situation a pod is used to hold multiple sales orders that are picked by the operator. Once the orders are completed, the pod can then be transported to another part of the warehouse for say packing; or for marriage to another portion of the sales order that is being picked in a different work area of the distribution center.

4. The Material Handling Control Software that manages the Kiva robots and the flow of inventory is perhaps the most important component of the overall solution.

   a. The MHE software is the brain behind the entire operation because it is manages the movement of the robots. The MHE software is basically a sub-system that is interfaced to the WMS system (or the ERP system in the absence of a WMS) to manage the work area controlled by the Kiva Fulfillment System.

   b. MHE consists a fairly complex set of algorithms that are needed to minimize operator dwell time while at the same time ensuring that the number of robots being used is minimized. In other words, how does one achieve maximum productivity levels with the least amount of capital investment. The amount of thought that has to go into this topic is actually quite interesting. It involves enough optimization algorithms and queuing theory to excite a mathematician.

   c. Kiva is one of the few material handling companies that guarantees the performance rates that workers will achieve at the work stations. The number of orange robots needed to support the fulfillment operation is in part based upon the speed at which operators perform their work. If operators work significantly slower than Kiva's expected rates then the system will be designed with too many robots and conversely if they work significantly faster than the expected production rates then the robots may not be able to keep up with the operators which introduces the risk of dwell time. In effect, dwell time is the time an operator spends waiting for goods to arrive at a station and it actually causes a reduction in productivity rates as a result. Hence this is a balancing act that needs to be determined up front through a detailed simulation effort to ensure that the system is implemented optimally.

   d. The MHE software automatically decides where to move and store each pod within the Kiva floor plan. To this end, not all pods are treated equally. The frequency of "hits" associated to the SKUs stored within a pod plays an important role in determining where the pod is stored within the plan. The highest velocity pods are positioned nearest to the picking work stations to minimize the transit time to and from these stations. As well, hyper-fast items may be purposely spread across multiple pods to ensure concurrent availability to multiple work stations.

5. Wireless Network:

   a. Kiva robots continuously broadcast their location within the distribution center by reading the 2D floor-mounted labels. At the same time, the robots receive directions from the MHE system which runs on a centralized computer that broadcasts instructions through the wireless network.

   b. Conventional Wi-Fi routers, mounted in the warehouse rafters, broker these communications to the server.

6. Professional Services:

   a. The final component of the Kiva solution is professional services which are an essential requirement to ensure success of the operation. The typical implementation requires about six months to set up the software and warehouse grid system, simulation modeling, testing and training. This is not an area that should have corners cut for the sake of expediency or cost reduction.

      I. First, it is critical for Kiva to run a simulation of the operating environment to ensure that the required number of robots is specified correctly. The simulation needs to take into consideration the number of pods, work stations, operator task requirements, operator performance rates, need for the robots to have battery charging breaks, need to handle peak volumes, and need for redundancy.

      II. Second, an efficient floor plan and highway grid needs to be designed based on the number of pods required to support the SKU variety within the distribution operation. A typical floor plan calls for blocks of 10 pods (i.e. 5 adjacent back to back so that all pods are facing a "street"). It is possible to store pods in a multi-deep environment such that the robot must move pod A in order to access pod B. This is a strategy that may make sense for slower moving SKUs where the pods are required less often. Pods can also be stored on mezzanines through the use of elevators. The robot simply moves the pod into an elevator where it is moved to another floor.

III. Third, this is a system that involves a high degree of automation and human interface, hence all human processes need to be clearly defined to enable the robotic system to be designed appropriately. As an example, there are process flow questions for the picking/packing function that need to be identified up front because they have an impact on the number of robots required in the system.

- Does the picker simply perform picking? or does the operator also perform a packing function?
- Does the picker need to scan the SKU being picked to verify pick accuracy?
- Does the picker need to create a packing carton with a label? or is the order picked into a tote that is then passed on to a packer?
- How many orders does the picker select concurrently?
- Are there any value added functions that the picker must perform as part of the pick and pack process (e.g. insert documents into the shipping carton; add special dunnage; gift wrapping, etc.)?
- These examples serve to illustrate that the work processes being performed at the Kiva work stations have an impact on the productivity rate of the order picker, hence they also have an impact on the rate at which the robots need to be queued at the work station to prevent operator dwell time.

IV. Fourth, there is a customized software interface that must be constructed to integrate the Kiva MHE application to the WMS or ERP software that runs the balance of the distribution center. There may also be a need for customized enhancements to be made to the Kiva software to support any particularities of a distribution operation.

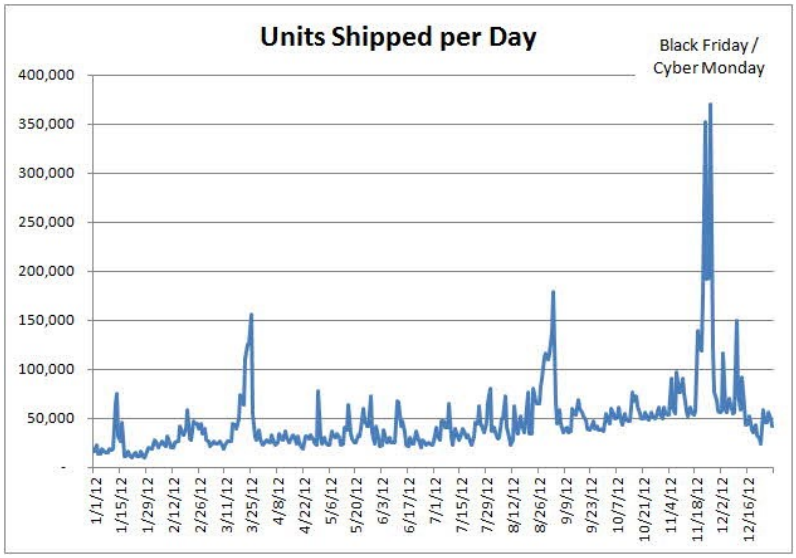
V. Fifth, training of the operators and support for go-live is required.

VI. Lastly, on-going support services are needed.

Which Companies Are Buying Into Kiva Systems?

To date, the majority (but not all) of Kiva's customers are Internet retailers. The simple truth is that most Internet retail distribution operations are dealing with significant uncertainty concerning growth rates, hence these companies are seeking solutions that are both flexible and scalable. If one had to generalize, automated material handling systems are generally rigid by design and difficult to scale incrementally or quickly. This is perhaps the foremost business advantage of Kiva Systems - it provides the advantages of automation yet it is also flexible and scalable.

Further to this point, most Internet retailers contend with massive spikes in their distribution shipping volumes. An example of this phenomenon is shown below where we can see the tremendous surge in shipping activity that takes place between November 1 and December 20 (Black Friday, Cyber Monday and the build-up to Christmas). The ability to scale up quickly to handle peak volumes is handled by Kiva Systems by simply adding more robots, pods or work stations through acquisition or through an innovative rental program designed specifically for this purpose. This is far less economically punitive than having to introduce a new module of automation for the majority of automated material handling solutions available in the market place today.



Kiva Systems also requires no infrastructural investments into building-specific requirements so it is easily adapted to an existing facility, and by extension, it is easy to pick up and relocate to a new facility. This is very important to Internet retailers because growth rates are so unpredictable that outgrowing a fulfillment center tends to happen much faster than anyone could have predicted.

The following list provides a shortlist of companies that have invested in Kiva Systems at the time of publishing this white paper

1. In the summer of 2006, **Staples** was the first company to go live with Kiva for their 650,000 sq. ft. distribution center in Chambersburg, PA. Staples started with a pilot project of 30 Kiva robots in a 50,000 sq. ft. area. The company has since installed 500 robots that handle 50% of its office supplies throughput volume in a 140,000 sq. ft. section of the facility. Operators are picking at a rate of 600 to 700 lines/hour as compared to a typical pick-to-belt operation where productivity rates are closer to 200 - 400 lines/hour.

2. In June, 2007, **Staples** opened a new 300,300 sq ft Denver, CO, distribution center designed around the Kiva Fulfillment System to support three business units: Quill which was purchased in 1998; Staples Business Delivery which ships Internet and catalog orders; and their contract business which is a B2B wholesale distribution operation . The Denver facility has about 150 K-Series ItemFetch robots moving 1,800 inventory pods and 200 order pods working within a 100,000 sq ft footprint within the facility. The distribution operation is shipping about 5,000 orders/day with Kiva robots. Productivity rates are reportedly double the rate of similar conveyor-run facilities and fulfillment "quality," a measure of how often customers get what they purchase, is 30% better in Denver than in other Staples warehouses. Between Chambersburg and Denver, Staples currently has over 1,000 robots in operation. **See the Video Here.**

3. **Walgreens** invested into the Kiva solution in November, 2007 at its 448,000 sq. ft. Mount Vernon, IL distribution center which services about 300 stores in the Midwest. The company has since expanded the Kiva system three times. Today, Kiva occupies 165,000 sq. ft. with nearly 1,000 mobile robots under a single roof. This represents one of Kiva's largest installations in the field. Walgreens uses the Kiva Mobile Fulfillment System to store split case inventory and pick orders to totes for its retail stores.

4. **Gap Inc. Direct** went live with Kiva's Order Fulfillment System in March, 2010 at its 1.2 Million sq. ft. Groveport, OH fulfillment center. Gap Inc. Direct is the e-commerce division of Gap which sells clothing, shoes, handbags and accessories from Gap, Old Navy, Banana Republic, Piperlime and Athleta. Gap Direct viewed Kiva as a compelling alternative to traditional tilt-tray and cross-belt sorters.

5. In January, 2010, **Saks 5th Avenue** launched a 30-month conversion to implement Kiva Systems at its 471,000 sq. ft. fulfillment center in Aberdeen, MD which supports the company's direct to consumer business. In February, 2012, Saks announced that it is opening a new 564,000 sq. ft. distribution and fulfillment center in LaVergne, TN in 2012 which will also be automated by Kiva Systems.

6. **DJO, Incorporated** is a global provider of orthopedic medical devices. The company implemented Kiva Systems in its 110,000 sq. ft. Plainfield, IN distribution center which services hospitals, clinics and orthopedic doctors. The facility uses 50 Kiva robots to fill orders within 24 hours and has helped the company to consolidate its distribution operations under one roof with less labor. The company cites its Kaizen culture, based on lean principles and continuous improvement, as the main driver behind choosing Kiva. **See the Video Here.**

7. **Crate and Barrel** implemented 50 Kiva robots in a 1.2 Million sq. ft. distribution center campus of 2 facilities in Tracy, CA. The Kiva robots were deployed in a 400,000 sq. ft. building dedicated to servicing the company's direct-to-consumer fulfillment operation. The distribution operation ships about 2,000 packages/day. Completed customer orders are conveyed from the Kiva Picking Stations to a custom packing station and then across an in-motion weigh scale and directly onto waiting UPS and FedEx trailers. **See the Video Here.**

8. **Office Depot** opened a 600,000 new distribution center in Penn Township, PA (about 30 miles west of Harrisburg) in July, 2010 to service office products to over 100 retail stores in the Northeast U.S. and to its B2B contract customers. The facility is equipped with one of Kiva's largest installations which replaced Office Depot's traditional approach of deploying conveyor-based split-case pick modules. There are 12,000 SKUs kept in the Kiva system, distributed among 3500 inventory pods, representing 25,000 unique locations. A total of 430 mobile robots are used to move pods to both picking and replenishment stations.

9. **Von Maur** is an upscale Midwestern department store company that deployed Kiva Systems to run their 46,000 sq. ft. e-Commerce fulfillment center in Davenport, IA which went live in October, 2010. The operation is equipped with 15 Kiva robots and 937 inventory pods which manage throughput for upwards of 1000 orders/day. **See the Video Here.**

10. **Gilt Groupe** is a luxury women's apparel and accessories Internet retailer that was launched in 2007. The company moved into a new 303,000 sq. ft. distribution center in Louisville, KY in August, 2010. The facility is a hybrid design that combines a 3-level pick module with 2.5 miles of conveyor systems along with a designated 40,000 sq. ft. area for Kiva's automated robots which are used to handle the company's "flash sales". Kiva robots transfer 1,600 shelves to stations where operators pick between 200 - 250 lines per hour for 65% of the total outbound order line activity. **See the Video Here** and **Here.**

11. **Quiet Logistics** is a 3PL logistics provider which was started in January, 2009. The company operates two distribution centers in Andover, MA and they have implemented Kiva Systems in one of the facilities where they distribute flat and hanging apparel; shoes; musical parts; jewelry, etc.. **See the Video Here.**

12. **Acumen Brands** is an Internet apparel startup based in Fayetteville, Arkansas. The company operates 12 separate online stores in 12 different niche categories. Acumen Brands has seen its warehouse employees' productivity more than triple and product return and order cancellation rates reduced by nearly 50% since it deployed Kiva Systems in its 60,000 sq. ft. distribution center. Acumen designed, built and installed the Kiva System over a 14 week period leading up to July, 2011. **See the Video Here.**

13. **Boston Scientific** is a manufacturer of medical devices. The company purchased Kiva Systems in January, 2010 to automate an 800,000 sq. ft. distribution center in North Quincy, MA (global CDC) and a 269,000 sq. ft. distribution center in Kerkrade, the Netherlands (International CDC). The main driver behind the company's decision was to ensure maximum reliability, to enable rigorous product /inventory control, and to increase order accuracy.

14. **Diapers.com (subsidiary of Quidsi, Inc. which was acquired by Amazon.com)** announced in October, 2008 that it was implementing the Kiva Fulfillment System at all three of the company's distribution centers. The Gouldsboro, PA distribution center is 1.25 Million sq. ft. and features about 260 robots working in a designated 200,000 sq. ft. area The Kansas City, MO distribution center is 102,000 sq. ft. and the Tahoe-Reno, NV. facility is 566,820 sq. ft. In total, the company has purchased

more than 350 robots to date and is planning to ramp up on this number. Diapers.com has also implemented Kiva's CaseFetch automated pallet fulfillment solution which handles mobile pallets and case shelving to service over 10,000 baby products to over 200,000 customers nationwide. **See the Video Here.**

15. **Toys R Us** opened its 300,000 sq. ft. e-commerce distribution center in McCarran, NV in September, 2011. The facility shipped nearly 100,000 units/day during the peak of its first holiday season and a portion of this volume was managed using the Kiva Fulfillment System.
16. **Dillard's, Inc.** announced in June, 2011 that it would implement Kiva Systems in the company's new 850,000 sq. ft. eCommerce fulfillment center in Maumelle, Arkansas which will be fully operational in late 2012.
17. **Drugstore.com** is an Internet retail pharmacy company which was acquired by Walgreens in March, 2011. The company purchased Kiva Systems in February, 2011 to process orders for health, beauty and general merchandise items to enable same day shipments with increased efficiency levels. Initial tests are being run at the company's 270,000 sq. ft. Swedesboro, NJ distribution center for 10,000 of the company's 50,000 SKUs including cosmetics, toys, vitamins, hair and skin care, natural supplements, food, fitness gear, baby items, and pet supplies.
18. **Follett Higher Education Group** announced in June, 2011, that it would be consolidating both its wholesale used book and direct-to-consumer warehouses into a single 551,200 sq. ft. Kiva-enabled distribution center in Aurora, IL. The company is moving its Virtual Bookstore operations in a transition expected to last through 2013.
19. **Timberland Company** announced in September, 2011 that it is building a new 430,500 sq. ft. distribution center in Almelo, The Netherlands. The company will implement the Kiva Fulfillment System to automate its picking/packing of consumer orders for footwear, apparel and accessories.
20. **Dansko**, a shoe retailer, announced in November, 2011 that it will implement Kiva Systems to automate its new 200,000 sq. ft. distribution center in West Grove, PA. Dansko will deploy Kiva Systems to handle orders for over 2,500 retail stores.

Kiva Systems won't disclose the number of robots currently active in the field but based on our estimates, the number is likely between 5 - 6,000 at the start of 2012. The company has exceptional marketing skills and we think that Kiva will exceed 10.000 robots in the very near future.

To date, Kiva has enjoyed success in the Internet retail sector where flexibility and rapid scalability are key benefits. The apparel and footwear industry are key target markets for the company. High volume distribution of health and beauty care merchandise, medical supplies, and office supplies are industry verticals where the company has enjoyed success. These markets alone provide Kiva with ample opportunity to grow their business. The question is where is this technology a good fit and why. We try to add insight to this question in the sections ahead.

What is the Cost of a Kiva System?

Kiva Systems does not publicly disclose system pricing, therefore for the sake of this article, we provide some approximate figures for informational purposes. It is important to note that this information is based on our research and has not been confirmed in any way by Kiva.

- A "startup kit" of robots, for a small warehouse operation, costs is in the order of $1 million to $2 million.
- A typical warehouse setup with say 50 - 100 robots costs between $2 to 4 Million.
- A large warehouse operation with say 500 - 1,000 robots can cost in the order of $15 million to $20 million.

Now these are some serious figures as far as distribution center capital investments are concerned. Clearly this is not a solution that fits all warehouses. As such it is important to understand where there is a strong fit for this type of solution which is what we explore in the next section.

Why Are Companies Buying Kiva Systems?

We list below nine (9) reasons that companies are investing into Kiva Systems for their distribution operations:

1. Increased stocking and order picking productivity and rates.
    a. There is no doubt that a goods-to-man system is faster than a man-to-goods environment. Quite simply, travel time associated with both restocking and order picking functions is eliminated. Travel time is typically 50 - 60% of the time spent picking orders in a traditional warehouse. In general, the larger the warehouse and the smaller the order size, the more travel that is required.
    b. The productivity gains being reported by Kiva-run distribution operations are fairly consistent. The gains being reported from the field are in the 2X - 3X order of magnitude as compared to pick-to-conveyor operations; and 5X - 6X as compared to manual pick-to-cart or pick-to-pallet environments. Pick rates of 600+ order lines per hour are achievable in a pure picking environment based on the fact that a new pod can be presented to the operator approximately every 6 seconds; and that a pod can have multiple pick facings on it. This is the amount of time required for the operator to pick an item, place it into a carton or tote, and for the next queued pod to move into place to present the next pick facing.
    c. To put this into perspective, the typical pick rate that we see in a conventional shelf bin warehouse environment, where operators are picking orders to carts, is about 100 lines/hour. We have seen some companies get clever with sophisticated order waving logic combined with intelligent cluster picking of multiple orders such that they achieve upwards of 180 lines per hour, but these operations are the exception rather than the rule. Thus it is conceivable that

for every 6 pickers that one requires in a traditional warehouse, one would require between 1 - 3 pickers in a Kiva-run fulfillment center. Assuming a fully burdened salary of $30,000/year per associate, the labor savings of reducing 6 people down to 1 - 3 people is between $450,000 - $750,000 over 5 years.

d. Now there has been some bad press lately about robots replacing people and the hysteria associated with this concept. Kiva is not about replacing people with robots because we still need people to pick and pack orders no differently than in a traditional warehouse. This is all about making people more efficient combined with a better quality of life which has always been the goal since time immemorial. All distribution centers have an obligation to their customers to provide accurate and complete orders on time at the lowest possible cost to the customer. The reason we don't send people out to pick orders with carts that have square wheels is because it is inefficient and to this end, Kiva is no different than any other invention (such as the circular wheel) that helps to improve efficiency.

e. Depending on the technologies in place in a traditional warehouse, it is not always possible to identify with precision the exact productivity rates that operators are working at. With Kiva, the central computer system monitors the performance rate of each person at each work station in real time. The Kiva system enables management to understand productivity rates by operator with exact precision. Performance or training issues can be dealt with immediately.

2. Increased order accuracy, order fulfillment rates and speed of order turnaround time:

a. With any human-based picking system, the opportunity for human error is impossible to eliminate and this holds true for Kiva as well. Even the automated A-frame picking systems make mistakes from time to time so eliminating the human from the pick process doesn't necessarily guarantee the perfect order.

b. In any sophisticated distribution center operation where WMS technology is in place, there are many techniques that companies have used to minimize error rates. The use of radio frequency bar code scanners, pick to light systems, voice directed picking systems, in-line weigh scales, etc. are all common tools that we invested in to minimize human errors that take place in a distribution center. Even in the best operations, error rates can range between 1 - 3 units per 10,000 units picked with more typical error rates being in the range of 1 - 3 errors per 1,000 units picked. In distribution operations that are paper-based, accuracy rates are generally lower than this. To compensate, companies will build in a redundant detailed order checking process that adds cost to the operation.

c. Kiva enables the highest levels of perfect orders and customer satisfaction by way of its design which is in fact quite simple relative to today's technology capabilities.

I. When the pod arrives at the work station a laser light beam is pointed to the exact pick facing on the pod that the operator needs to pick. The only way that this could be the wrong pick facing is if the restocker erroneously placed an item into the pod to begin with. To prevent this type of error, the laser pointer is used to guide the restocking operator where to place the inventory within the pod.

II. The order selector picks the required quantity which is displayed on the pick to light display for each order requiring a product from the pod. If the light tells the operator to pick 3 and the operator picks 2 then a quantity error can be made. Weigh scales can be used to detect quantity mis-picks.

III. Customer testimonials thus far indicate that the error rates from the Kiva portion of their fulfillment centers are closing in on perfect. The fact that the operator works in a quiet, ergonomically designed work station where the computer does all of the thinking is why error rates are almost completely eliminated.

d. Order fulfillment rates, which are sometimes referred to as scratch rates, define the number of units not shipped out as a percentage of the total units shipped. In a non-automated distribution center, scratch rates can vary depending on the type of technologies in place to enhance inventory accuracy, but it is not unusual to have 1 - 3+ scratches per 1000 units shipped. Companies using Kiva's Fulfillment System are reporting scratch rates of .01% which is roughly 1 unit scratched per 10,000 units shipped.

e. Kiva is a continuous order fulfillment system which means that it can eliminate the need for order wave planning and release, order batching strategies, etc. In effect, orders can be released all day long in real time with no negative impact on labor efficiency. As such orders can be turned around without the delays inherent in an order wave planning environment.

f. In most distribution centers it takes at least 2 - 4 hours to for a product to be received and stocked before it can be picked for an outbound order. Kiva customers are reporting as little as 12 minutes of elapsed time between restocking and picking. This may not be a requirement for all customer orders, but for many companies this single benefit can provide an extremely valuable competitive advantage. Believe it or not, there are many distribution operations where a 30-minute order turnaround time is expected.

3. Inventory Accuracy and Security:

a. In a non-automated warehouse, you will find the vast majority of your inventory discrepancies if you focus on cycle counting the pick slots. Most mistakes are made during the picking process, so bin-level accuracy is generally much worse in pick slots than in slots used to store reserve inventory. Inventory accuracy figures vary depending on the type of product being handled within a given facility. For example, a warehouse that handles glass items will typically experience annual adjustments in the range of 1.5% (due to broken inventory that is found during the count) despite having a highly accurate operation. For most companies with a WMS, inventory levels approach world class when they reach 99.7% and higher.

b. With Kiva Systems, inventory errors are not eliminated completely because there is still a human interface and people

can still pick the wrong quantity. Having said this, the inventory adjustment rates being reported from the field are so tiny that they are almost irrelevant. For example, the Staples Denver facility is reporting annual adjustments in the order of a few hundred dollars on sales that are in the millions of dollars.

c. We believe that it is safe to say that the level of inventory accuracy being achieved in Kiva operating environments is as close to perfect that one can get in an operating environment that involves people.

d. Lastly, a Kiva environment also offers more inventory security because the movement of inventory with high security requirements can be directed to specific work stations that are monitored. Also, humans never enter into the storage area where the pods are staged which reduces the probability of shrinkage.

4. Flexibility and Scalability:

a. Many high volume distributors use conveyor systems to reduce manpower for order picking. A conveyor system can enable batch picking of multiple orders concurrently which helps to significantly reduce travel time. Cross belt or tilt tray sorters can be used to automatically sort orders into discrete shipments. Investment cost is high but flexibility and scalability are low.

I. In most facilities, there are products that cannot be put onto the conveyor because their physical dimensions exceed the conveyor's capability. For example, if the conveyor can only accept cartons that are 18" long then any products that exceed this dimension cannot be picked to the conveyor system. There are also many products that are not conveyable because manufacturers are continuously seeking ways to reduce the costs of packaging materials. Think bagged per food as an example.

II. Conveyors are like highways that divide neighborhoods apart. They can cut off ease of access within a distribution center because they must ultimately transfer goods from storage and picking areas to a shipping dock. Good design will minimize this penalty by elevating the conveyors to allow vehicles to move underneath the conveyor system but this is not always possible in every facility.

III. Conveyors are expensive to pick up and move to a new building. Aside from the business disruption that is created in this scenario, it is not unusual to spend $1 Million to relocate a large conveyor system from one building to another.

IV. Conveyors are expensive to maintain over time. They require replacement parts and maintenance. Suffice to say that every 7 - 10 years one needs to budget for a large overhaul of the equipment which can cost 20 - 25% of the original cost of the system.

V. Once a conveyor system is designed and installed, it is not something that is intended to be modified unless this was done by design up front.

VI. These points serve to illustrate that despite their benefits, conveyors rank low in terms of flexibility and scalability.

b. Kiva Systems is appealing to Internet retailers because of the fact that the solution is both flexible and scalable, and this remains one of its strongest selling points. For most Internet retailers, growth rates are a wild card. If one had to generalize, Internet retailer growth rates tend to exceed expectations, which is why Kiva Systems provides a strong fit for their supporting distribution center operations.

I. It is a relatively quick exercise (e.g. 6 weeks) for a distributor to expand the storage street grid; to add more work stations; and to add more pods or robots. The central computer system is simply updated with information about the expanded environment and throughput capacity is increased with little or no effort.

II. Similarly, if the a company needs to move its operation to a new facility, the cost and complexity of moving the operation is minimal. The new street grid and wireless network can be implemented in the new facility so that the operation is moved over a weekend. No conveyor system to dismantle and reinstall at huge expense, no wires to be embedded into the concrete floors, no infrastructure that needs to be deployed. No headaches - pure and simple.

III. Kiva does not impose constraints around product sizes or formats in the same way that a conveyor system does. The Kiva System can move pods and pallets of up to 3,000 pounds (ed. note - the weight limitation is one of the few constraining factors with the current technology). Product packaging formats are a non-issue. Companies are using the Kiva system to handle flat and hanging apparel, along with a wide variety of different product types come in brown boxes.

5. Electricity Savings:

a. One of the unforeseen benefits of Kiva is its reduced electricity consumption which can be a significant figure when one considers the cost of powering an extensive conveyor system. Kiva robots require 5-minute battery charges every couple of hours, but unlike humans, robots do not need bright lights to perform picking operations. The area where the Kiva robots operate within can be nearly lights out because no humans are intended to work in this area.

6. Quality of Life:

a. In our experience, there is a wide variance in how companies think about this subject. In a distribution center, quality of life can be characterized in a number of different ways:

I. Safety - the probability that an operator may experience bodily harm because they are working in an industrial environment where man and machine are working together in the same space. With Kiva, the human machine-interface is safe because the area that the robots work within is off limit to the operators.

II. Ergonomics - the amount of bending and stretching that a person must do to perform their job. As people get older, this excessive bending and stretching can lead to injuries that ultimately result in higher rates of workman's compensation expense. In traditional warehouse operations there are ways that we can improve ergonomics, but there is no escaping the fact that order picking is a job that involves heavy lifting, reaching,

bending and stretching all day long. Kiva improves upon this by eliminating travel fatigue factor and by designing an ergonomic work station.

III. Noise level and cleanliness - distribution centers that are equipped with high volume conveyor systems tend to have the highest noise levels. Without the use of proper ear protection, operators that are exposed to loud conveyor systems for many years will ultimately suffer significant hearing loss over time. Kiva is as close to a clean and silent operation as can be found anywhere on the planet.

IV. Fatigue factor - in a large Amazon.com fulfillment center, it is not unheard of for an order picker to walk over 20 miles per day on concrete floors and mezzanines. In smaller distribution centers where pick to belt systems are installed, many operators walk 3 - 5 miles over the course of a shift. In the Kiva system, the operator can work on comfortable mats in a 6' x 6' work station to ease of the discomfort of standing all day. Personally I think every distribution executive should spend at least one day per year picking orders in the warehouse to understand the value of this point alone. Walking on concrete for 8 hours is physically demanding work and at the end of the day your feet and legs are tired, especially if you are 50 or older.

7. Reduced Training Time

   a. In many traditional distribution centers, a new associate is trained by an experienced associate and the expectation is that the new associate should be up and running within a 2 - 3 week time period. In distribution operations with engineered labor standards, the ability to reach the expected production standard can often require 6 weeks or more.

   b. Companies using the Kiva Fulfillment System are reporting training times in the order of 2 - 3 days. This is because the operator does not need to learn a warehouse numbering system, the aisles where goods are stored, etc. They simply need to stand at a work station and look at the lights that tell them what to do. The work station is designed to remove the thinking element of the job, and to replace activity with productivity. Therein lies the reason why people are up and running in a few days. This is an especially important benefit to Internet retailers where they need to scale their operation quickly, by adding new people, to meet the needs of peak season.

8. No downtime and built-in redundancy:

   a. The worst nightmare of a distribution manager is the day during peak season when the conveyor system goes down. I'll never forget a tour that I was on some 20 years ago where the Director of Operations was explaining how 90% of the annual volume goes out the door in the month of November which happened to be when we were visiting the facility. Just as he finished his sentence the entire conveyor system shut down and all 400 people in the operation suddenly stopped working. You could have heard a pin drop. With a conveyor system, when something goes down, you don't ship orders.

   b. An alternative goods-to-man technology is the horizontal carousel. With this equipment, goods are stored in pods of carousels that bring the inventory to the operator. While the person picks from one pod, the other pods are spinning to bring the next pick facing forward. The carousel is an example of a serial technology because only one person can work at the picking function at any given point in time in the typical setup. The carousel can only output a certain throughput per shift based on the picking rate of the order selector. For example, if the picker works at 300 lines per hour then the carousel work station can only output 2,400 order lines per shift. The carousel also needs to be replenished so there is a downtime required at some time during the day to restock the carousel pods.

   c. With the Kiva System, the design is based on parallel processing rather than serial processing. Thus if at any time an operator at a work station needs to stop working, then the other work stations can continue processing orders. If at any time a robot goes down, then another redundant robot is there to take its place. Restocking the shelves takes place concurrently with picking operations and there is never any system shutdown required to enable restocking. At no time does the entire system go down which eliminates the high degree of risk that is associated with other mechanized or automated systems where there is a single point of failure that can prevent orders from being shipped.

9. The 'Wow' Factor

   a. There is no denying it, watching the orange robots doing their job ranks high in what we call the 'wow factor'. While we don't want to dwell too long on this topic, suffice to say that one can never underestimate the marketing power that a solution like this brings to the table.

   b. For one publicly traded retailer, their stock price received a boost because analysts pointed out the efficiency benefits associated with their deployment of Kiva.

   c. For any 3PL logistics service provider, the use of Kiva Systems is a strong selling point that provides a leg up over the competition. This is particularly true in the apparel and footwear industry.

   d. For any distributor seeking to increase market share by making a favorable impression on customers, deploying a Kiva Systems operation provides a showcase distribution environment that is sure to instill confidence.

Why Kiva Systems May Not Be a Fit For Every Distribution Center

With all of the benefits discussed in the previous section, one might ask the question why Kiva Systems *may* not be the silver bullet for distribution centers all over the world? The answer is quite simply that there is no single material handling solution, with or without automation technology, that is universally applicable to all operating environments. In our opinion, Kiva Systems has a strong fit for certain types of distribution operations, but it is not a one-size fits all type of solution. To understand this point, we illustrate some examples below.

1. Distribution centers that process large orders (in terms of cube) will be less likely to pursue Kiva as a material handling solution.

   a. Keep in mind that the majority of Kiva installations to date are distribution operations where the picker is able to work multiple small orders at a time. The robots go out and fetch pods that have the required inventory for a group of say 6 - 12 small orders.

b. When the order size starts to get much larger in terms of physical volume then the strength of fit for the Kiva solution becomes more of a challenge. Now all 6 - 12 cartons or totes can be set up for a single store but what if the store order 500 or 1000 cartons of merchandise?

I. To create an extreme example of this , the typical large grocery supermarket places orders for dry grocery product in the range of 800 - 1,000 cases or more. Now imagine 50 stores ordering 1,000 cases each. The sheer volume of product that must be picked in the space of 1 - 2 hours would be too overwhelming for a goods to man type of system.

c. It is important to note that Kiva Systems is already deployed in distribution centers where the primary purpose is retail store order fulfillment. In most of these operations, Kiva is managing a portion of the overall distribution operation as opposed to the entire operation. Hence companies are figuring out ways to maximize the benefits of the Kiva application for the SKUs that are the most applicable to this technology. In general, we see that most Kiva Systems are being deployed to handle split case products that can be stored on shelving bins where the average order size can be managed in a typical 6' x 6' work station. While Kiva does handle the transfer of bulk inventory held on pallets, the pallets must be at floor level and it is less common for people to be using the robots for this purpose.

d. Having said the above, there is a definite interest within the Grocery industry for a Kiva-type goods-to-man solution to reduce labor requirements for order selection. Several retailers have already approached Kiva Systems with a strong interest in the technology for high volume full case distribution so it may just be a question of time before we begin to see new and interesting developments in this area.

2. Distribution centers that process primarily full case and/or full pallet orders are less likely to invest in Kiva Systems.

a. There are thousands of warehouse that ship in case and pallet quantities only, especially within the manufacturing sector of the economy. To this end, these companies require efficient material handling systems that maximize the use of labor and space. Companies in this sector sometimes invest in automated storage and retrieval systems that enable high bay storage, especially in a temperature controlled environment.

b. It is our opinion that Kiva as a concept, at least in its current generation, that is primarily suited to broken case picking environments and as such, it will be of greatest interest to retail distribution companies. Manufacturers and/or wholesale distributors that have labor intensive split case picking operations are also strong candidates for this technology.

3. Distribution centers with extremely high order throughput volumes and/or very high peak-to-mean ratios may be more challenging to deploy with a Kiva solution. The jury is still out on this one as explained below.

a. Some retail distribution centers output upwards of 500,000 - 1,000,000 order lines per day during peak season which is on the extreme upper end of throughput volume. These facilities process so much volume that the sheer magnitude of throughput can require upwards of 5,000 - 10,000 human beings to get the job done because any type of automation would be too cost prohibitive. The philosophical question is whether or not there is an upper-end constraint that exists for Kiva's automated technology?

I. Kiva Systems has one client site that processes upwards of 400,000 order lines over a 15 hour shift.

II. That's an incredible amount of throughput volume to say the least, so this indicates that there may or may not be a realistic upper limit of throughput volume that can be processed through a Kiva-operated distribution center.

b. Some high volume distribution centers have very high peak-to-mean ratios, which in general does not bode well for automation because the automation investment needs to be sized to manage these short-lived peaks.

I. In other words, if during regular conditions a facility ships 100,000 order lines per day and during a short peak period the facility ships 300,000 order lines/day, we refer to this as having a high peak-to-mean ratio.

II. The challenge with automation in this type of distribution center is that there is a high capital investment that is only fully leveraged for a short period of time during the year which is not good.

III. In our opinion, a high peak-to-mean ratio fulfillment center is more challenging to rationalize for Kiva or any other type of automation investment. However, it is important to note some innovative concepts that Kiva has used in the past to address this issue:

i. Kiva's rental program which allows a company to ramp up on robots for a short period of time.

ii. If pickers are also doing the packing function, then the packing labor can be decoupled during peak season. This enables the picker to strictly perform order picking work which effectively requires more robots to keep up with the faster pick rates, but enables greater throughput rates per hour.

iii. If pickers are batch picking multiple orders at their work stations then the size of the batch can be increased (e.g. batch size of 8 is increased to 16 orders). This implies that the person's pick rate will slow down because they have more walking to do within the work station, therefore more work stations are required to handle peak conditions.

iv. The option always exists to pull out the hyper-fast items from the Kiva operation during peak season to lessen the overall throughput volume requirements that are handled by automated equipment.

4. Distribution centers that handle bulk materials or extreme product shapes, sizes and weights of product are not good candidates for Kiva Systems.

a. At least for the current generation of Kiva Systems, any products that are stored in cantilever racks, or that exceed 3,000 pounds, or that have strange shapes are not conducive to a Kiva material handling system.

5. Parts distribution centers where SKU counts are say 100,000 SKUs or higher *may* not be good candidates for Kiva Systems.

a. This one is subject to debate but we believe that companies with an extreme number of parts that are inventoried are less likely to buy into the Kiva Systems solution. By this we mean aftermarket automotive parts distribution centers

where there SKU counts can realistically be 140,000.

b. These companies suffer the greatest productivity hit for travel time because order size is generally small and the travel time to stock and pick parts is very high. One would think that these companies make the best candidates for Kiva's solutions.

c. Most of these companies are running on tight margins and large capital investments into warehouse automation is the exception rather than the rule. The most sophisticated operations tend to utilize simple conveyor transfer systems to move goods from picking to packing/staging/shipping. For an operation with 140,000 parts, the number of pods required would be in the order of say 9 - 10,000. These pods would need to be stored within a multi-level building that utilizes the full height of the building otherwise the distribution center footprint would be doubled or tripled. Now Kiva has developed smart ways to prevent pods from being transferred on elevators from upper levels to ground level and back again (e.g. Work stations on each level; software analytics to keep slowest moving SKUs on upper levels; etc.) so the multi-level issue is less of a concern. However, in our opinion, the capital investment for building and equipment would be cost prohibitive as compared to distributing using a conventional approach. In addition, products like exhaust pipes are difficult to stock and move, and pods of brake pads and rotors are heavy to move.

6. Distribution operations where there is a need to maximize the cube utilization of the building because space costs are at a premium.

a. Most Kiva installations are running at floor level with no use of overhead space. Now it is important to note that there are Kiva installations where the robots access upper-level mezzanines by way of elevator, but the reality is that this is the exception rather than the rule. If Kiva is deployed in a low ceiling height environment then this becomes a non-issue. If there is 30' of overhead space being lost because the operation is at ground level then there is a space penalty that must be considered.

b. Mezzanines are not free and can actually be relatively expensive depending on the weight that needs to be supported. A mezzanine typically results in the need for sprinkler systems, additional lighting, more insurance and taxes, etc. We say this because there is a price to pay for warehouse space and this needs to be considered within the overall decision-making criteria. Companies that have a high need to maximize storage capacity utilization may therefore be less likely to invest in Kiva Systems.

Conclusions

After reading this article, we hope that you have a better sense as to why a company would or would not invest into Kiva's Fulfillment System. The benefits of the solution are plentiful in that it addresses all of the key areas that an automated material handling system needs to address - efficiency, accuracy, flexibility, scalability, ease of use, and quality of life. Most automated material handling systems lack flexibility and rapid scalability. Similarly, most automated systems are such that if the system goes down then you don't ship orders. We especially like the fact that Kiva enables parallel processing with built-in redundancy, since this eliminates the risk of not shipping orders due to a system failure. Again it goes back to the basic design principle that all goods should be accessible to all people at all times.

With all of its advantages, the Kiva fulfillment System is still not for everyone. We have discussed our opinions on why this is the case within the body of this article. We believe that this is a solution that best fits distribution operations that have a high degree of unit and/or inner pack picking, small order size and a high amount of travel time required to fill customer orders. We see the Kiva Solution having a best fit for distribution centers that have up to say 30,000 stocking items or thereabouts. We believe that parts distribution operations with 100,000+ parts in stock will be less inclined to invest in this type of technology because the investment costs are too high.

Kiva does not publicly disclose its sales revenues. There are some estimates that suggest revenues are in the order of U.S. $65 - 100 Million as at year-end 2011. Assuming that this figure is reasonable, then we believe that Kiva Systems can realistically grow revenues ten-fold to $650 Million over the next 5 - 7 years. We think that there is a strong need for this type of solution in the Internet retail market and also in retail store fulfillment, especially where the value of the merchandise is high and the store size is relatively small. We think that there is a significant opportunity for this type of technology to be expanded upon to support a wider variety of distribution operations. For example, there is no reason why this concept could not be deployed in a full case picking environment where SKU counts are modest and pallets are the platform used to transfer goods to the pick stations. Lastly, we believe that as production levels of the orange robots increase, there will be efficiency advantages to be gained. In turn, this will reduce production costs which will enable the overall solution price point to be lowered. This in turn will widen the market opportunity for Kiva because their solution will become more accessible to distributors who are trying to rationalize the business case for this innovative technology solution.

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