Key Attributes Used to Compare Pick-to-Light and Put-to-Light Technologies

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Randall L. Patzke, P.E.

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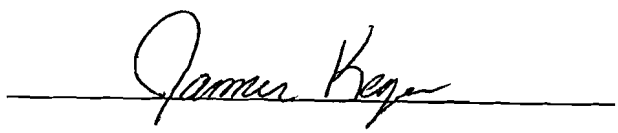

James Keyes, Ph. D.

The Graduate School

University of Wisconsin-Stout

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The Graduate School
University of Wisconsin-Stout
Menomonie, WI 54751

Author: **Patzke, Randall L.**

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ABSTRACT

A survey of equipment manufacturers, material handling consultants and material handling system integrators of order picking equipment for distribution centers was conducted in order to identify the perceived key attributes of their systems. The list of the top ten attributes was distributed to a select group of distribution center managers, who ranked the list and provided input on their experience with the two technologies. The resulting lists of the most important attributes of the pick-to-light and put-to-light systems provided by the equipment manufacturers, material handling consultants and material handling system integrators and the distribution center managers are compared and found to not be in agreement. The distribution center managers' responses to the questionnaire are further analyzed to separate those who are experienced from those who are not experienced with the technologies to determine if there is a significant difference in the results. Information on purchasing procedures and the use of the Maynard Operational

Sequence Technique for labor modeling is included. This discussion includes some considerations for technology selection for an application and some information from the equipment manufacturers, material handling consultants and material handling system integrators about the reasons that companies select these technologies

The Graduate School

University of Wisconsin-Stout

Menomonie, WI

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CHAPTER I: INTRODUCTION

Introduction

A national retailer is interested in evaluating the technologies of a pick-to-light system and a put-to-light system for possible use within a less than case quantity picking operation for one of their regional distribution centers. Order picking is the most expensive and labor intensive operation in a warehouse accounting for 50% of the warehouse labor, with some peaking at 65% (Coyle, Bardi & Langley 1996). Orders are becoming smaller, which increases the labor required for processing less than case quantity orders, but expectations for order quality and accuracy are increasing (Caputo & Pelagagge 2006). Combining technology with picking, handling and storage equipment will generally increase picking through-put (Saenz 2001). The retailer has been store picking less than case quantity items within a multi-level picking module for shipment, to retail locations. The retailer has determined that either a pick-to-light or put-to-light system could be the next evolution of technology to improve the less than case quantity picking application in the distribution center. The retailer is interested in determining the key criteria that should be used to evaluate the technologies. This is to be completed prior to initiating the request for information, visiting installations of either technology, or making a purchase.

Statement of Problem

It is necessary to define the key criteria that should be compared when choosing to adopt a pick-to-light technology versus a put-to-light technology for a less than case quantity picking application. The application is for a distribution center operation that processes waves of 20 to 50 stores, with a possible six thousand different stock keeping

units and fifteen hundred sort locations for the products that are being shipped to retail locations.

Purpose of the Study

This research paper will describe the key criteria that should be compared when selecting a pick-to-light or a put-to-light system for less than case quantity items that are picked at a distribution center and shipped to a retail location. Companies operating distribution centers need to implement processes that can improve sort/picking accuracy and reduce logistic distribution costs. The order picking and processing of less than case items is one of the most labor intensive steps and most expensive processes within a distribution center (Saenz 2000; Caputo & Pelagagge, 2006)

Assumptions of the Study

The assumptions made for this study included the following:

- The company operates distribution center(s) with a large quantity of less than case quantity stock keeping units and requires multiple ways to sub-sort these stock keeping units.
- The company has significant capital and adequate space available for the purchase and installation of either technology.
- The company has the technical support staff to implement and maintain either system.
- Other technologies are not being considered. These could include but not be limited to: carousels, voice picking, manual store picking, A-frame dispensers, and batch picking with secondary sort.

- Put-to-light will be full case quantities with no remnants that will have to be restocked.
- The pick-to-light system could involve less than case quantities and a limited amount of full case stock keeping units.
- Replenishment for the pick-to-light procedure was not considered.
- The picking process for the put-to-light procedure was not considered.
- The company is using either new corrugated boxes or totes to ship to the retail locations. They are not re-using master pack cartons for shipping.
- The company has radio frequency equipment and the warehouse staff is familiar with the use of this technology.
- This system is only being considered for the store replenishment and is not being used in conjunction with on-line order fulfillment.

Definition of Terms

Automatic Storage and Retrieval System: Combines un-manned cranes and conveyors to put product container or pallets into a storage location and retrieves the same and brings it to a discharge area. The discharge area can be a picking area or a take-away conveyor.

Distribution Center: A facility that receives, processes and stores finished goods or raw materials prior to shipping to a customer. The customer could be a manufacturer, retailer or end user.

Integrator: A firm that is generally not an equipment manufacturer. The integrator supplies the correct equipment from multiple manufacturers and combines it into a complete system for the end user. The integrator generally provides a complete turn-key

system that includes purchase, programming, installation, commissioning and training on the equipment.

Less than Case Quantity: This carton will have multiple selling units inside, which are broken down and shipped as a less than case quantity.

Master Pack Carton: The carton that the manufacturer ships to the distribution centers. This carton will have multiple selling units inside, which are broken down and shipped as a less than case quantity stock keeping units.

Non-Disclosure Agreement: A legally binding agreement between firms to protect a product without a patent or company secrets. The Non-Disclosure Agreement can be one-way or two-way. One-way may be requested by one of the parties, but both firms have responsibilities to protect the information discussed. If the information is not protected, either firm can seek legal recourse from the other firm.

Pick Directive: The information on the orders that a distribution center employee will be processing. It could include bar coded slips of paper with the actual lists or a stack of labels that will be applied to or placed with a tote/container.

Pick Module: A material storage device that is used to store product for order processing. In a full case application might be full pallets of product on pallet flow rollers, and in a less than case quantity it might be a combination of pallet locations with flow rollers, shelving, or carton flow shelving. Typically, each stock keeping unit is assigned a permanent forward pick location, and the stock keeping units are re-assigned when the pick module is re-profiled. Some pick modules are equipped with take away conveyors.

Pick-to-light: A digital display will light a number at a storage location indicating to the operator the number of items that are to be removed and placed into the tote/container. The operator must confirm the pick when it is complete by satisfying the light.

Put-to-light: The operator will scan a container of parts and a digital display will light a number at the sort locations indicating to the operator how many items to place into the tote/container in the sort location. The operator must confirm that the put is complete by satisfying the light.

Voice Picking: A distribution center employee using a wearable computer is directed with a voice to a location for a pick and the quantity. The operator confirms the location with a random check digit and verifies the quantity that were picked.

Wave Picking: Processing of a sub-group of all the stores that the distribution center normally serves. This is a method used to address capacity when the facility does not have the physical capacity to do a door per store or staging area per store.

Zone Skipping: Using a conveyor to cause the picking container to bypass a picking zone.

Limitations of the Study

The complex nature of comparing pick-to-light and put-to-light technologies has forced the study to be limited as follows:

- Only twelve of the major equipment manufacturers, consultants and system integrators have been reviewed, and not all the features of the systems have been discussed.

- The material handling equipment and processes related to handling dunnage within the operation are not included.
- The material handling methods for getting shipping cartons or totes to the operators are not included.
- The material handling methods for getting cartons or totes from the operators for either the pick-to-light or put-to-light has been reviewed only briefly.
- The use of conveyors for zone skipping is not included.
- The method of financing the equipment was not included. It is assumed it will be purchased with existing capital.

Methodology of the Study

The study includes a literature review of relevant articles and books related to pick-to-light, put-to-light, order processing, distribution centers, material handling methods, quality assurance, engineering standards, and purchasing in order to establish the current state of knowledge of this topic. The use of equipment manufacturers' information was limited in the literature review. Chapter Four: Results provides some additional information from equipment manufacturers, consultants and integrators and includes descriptions of layouts and estimates of productivity based on the Maynard Operation Sequence Technique System. The results also provide information from the equipment manufacturers, consultants and system integrators about space, labor costs, the key criteria of the technologies, and feedback from the distribution center managers who ranked the criteria.

CHAPTER II: LITERATURE REVIEW

Introduction

Pick-to-light and put-to-light are both technologies that can be used within a distribution center. Distribution centers often are called warehouses, although this does not necessarily describe the operations that are completed within the facility. A distribution center provides value-added functions in addition to product storage. Some distribution center activities include: receiving product in trailer load or non-trailer load (full or partial trailers), shipping of like product in less than trailer load quantities, shipping of less than a full case of a product, storage of the product, product pricing, returns to a vendor, returns from a customer, inventory control, filing freight claims for damaged product, shipping according to customer directions, and order picking. When order picking, the distribution center would pick full pallets, partial pallets, full cases, and less than case quantities. For full pallet picking, a distribution center would generally pick a pallet from pallet rack or bulk floor locations. For less than pallet or full case, picking would be from a pallet rack location, a bulk floor location or even a full case pick module. Less than case quantity picking makes use of different material handling methods and systems. These can be as simple as static shelving or carton flow shelving or pick module to horizontal or vertical carousels; the most complex would be an automatic storage and retrieval system. Both pick-to-light or put-to-light technologies require the interface with a warehouse management system to function (Bodenburg, 2007; Feare, 2003; Tompkins & Smith, 1998). The warehouse management system software, interfaces with the radio frequency

system and pick-to-light or put-to-light which provides directions to the warehouse worker.

Pick-to-Light

Operation/Functionality

The warehouse worker with a radio frequency scanner scans a tote/carton/pick directive. The warehouse management system might then direct the warehouse worker to select a specific size of carton/container, based on the total volume of the pick directive. When the warehouse worker has selected the carton/container he or she confirms the selection via the radio frequency scanner or voice pick to the warehouse management system. The warehouse management system then illuminates the light-emitting diodes digital display showing the location the stock keeping units are to be picked from and the quantity to pick for the pick directive. After the warehouse worker places the correct quantity within the container/tote the pick is confirmed by pressing the button on the display (Bodenburg, 2007; Feare, 2000; Saenz, 2001, Tompkins & Smith, 1998; Trebilcock, 2007a). When the stock keeping unit pick is completed the warehouse worker moves to the next picking location and repeats the procedure (Forger, 2005b; Maloney, 2003). Some of the pick-to-light systems will automatically advance the carton to the next pick zone (Bodenburg, 2007; Trebilcock, 2007b). A pick-to-light installation typically will include modular displays that are wired to each pick location (Langnau, 2001). The modular displays typically contain: digital display for quantity, task complete button, up/down arrows to count down as product is picked short from the picking location (Bodenburg, 2007). Recent

changes in technology offer increased flexibility in the installation of the modular displays (Langnau, 2001). Some manufacturers do not require a module display but only a reflector at the pick location. This technology uses a laser to illuminate the reflector and a voice pick system or radio frequency scanner to identify the quantity to pick and the pick completion. ("Innovative," 2006)

Applications

Companies as different as Harley-Davidson, Weil-McLain boilers and Lantis Eyewear are users of the pick-to-light technology ("Boiler Maker," 2000; Maloney, 2003; Langnau, 2001). Harley-Davidson is using pick-to-light for supplying motorcycle service parts to dealers and customers from a three level pick module with carton flow shelving (Langnau, 2001). Weil-McLain is using the pick-to-light technology with three horizontal carousels for shipping repair parts to distributors ("Boiler Maker," 2000). Lantis Eyewear is using their pick-to-light in a three level pick module with carton flow shelving for order picking for both major retailers and small retailers (Maloney, 2003). DOTS, a women's fashion retailer for extreme-value trend merchandise, has updated their pick-to-light system (McCoy, 2004). Easton Sport replaced the warehouse management system and a tilt-tray sorter with a pick-to-light system for customer orders (Maloney, 2002). Bardwil Industries is a linen supplier that uses their pick-to-light system for picking store orders for various national retailers (Trebilcock, 2007a).

Quality/Accuracy

Distribution center operations are seeing an increase in less than case quantity picking, a decrease in full case quantity picking, and in the meantime, customers are expecting 100 percent accuracy from the picking process (Caputo & Pelagagge, 2006). The combination of a warehouse management system and a pick-to-light system serves to increase the accuracy of both picking the right stock keeping unit and the right quantity of the stock keeping unit on each pick (Feare, 2000; Kantor, 2007; Tarn, Razi, Wen & Perez, 2003). Harley Davidson projected that the installation of the pick-to-light system would permit them to obtain an accuracy level of 99.1%. They have been able to maintain a rate of 99.7% (Langnau, 2001). Sanford and Newell Office Products increased their peak season accuracy to 99.95% over the paper picking system (Feare, 1999). The order picking accuracies using pick-to-light technology can, in fact, range from 99.9 to 99.999% (Feare, 2003; Forger, 2005a; Witt, 1997). Bardwil Industries experienced a short-term drop in order accuracy after the installation of a new pick-to-light system. This drop was explained as reflecting the learning curve for the new technology and methods (Trebilcock, 2007a). In at least one case, order accuracy improvements have been related to changing the order picking process and requiring additional radio frequency scans. These changes and the pick-to-light system have lead Easton Sports to experience a 99.8% order accuracy (Maloney, 2002). The additional record keeping and the variety of reports that are available now allows DOTS quality control department to find the pick zone in

which an error was made. This information is also used to track worker quality performance and productivity (McCoy, 2004).

Some firms use weigh-in-motion to check the accuracy of the picking operation by comparing the total weight of the carton with contents against the calculated weight derived from product weight information contained in the stock keeping unit master files. The weigh-in-motion process is done by automatically diverting a carton/container from the transport conveyor line and using conveyors to convey the cartons/containers to in-line weigh-in-motion scales that compare the actual weight against the expected weight to confirm the sort accuracy using the container and individual product weights. If the carton/container weight is not within the expected range it would be diverted to another line for 100% inspection by a packer (Maloney, 2003; "Put-to-light makes," 2002; Tompkins & Smith, 1998; Trebilcock, 2007a). Weigh-in-motion weighing is a more reliable, faster and more efficient method to confirm order picking accuracy than a manual audit. Weigh-in-motion does not work for all products. An example of products for which weigh-in-motion would not be successful is compact disks or digital video disks. These packages weigh the same with both correct and incorrect stock keeping units. However, it should be possible to confirm the total quantity of pieces in a carton.

Productivity

Vitacost, an internet vitamin and supplement retailer, which receives 90% of their orders from on-line sales has been able to increase from 1,000 orders per day to 6,000 orders per day with the same number of warehouse workers after the

implementation of a pick-to-light system (Bodenburg, 2007). The layout and organization of the picking zone is important as about 50% of the time a warehouse worker spends functioning as picker is devoted to traveling. Many firms experience productivity increases of 40-50% over a paper-based picking system. Some firms have experienced improvements as high as 400% (Caputo & Pelagagge, 2006; "The Right," 2003). "It's all across the board." said George Feigley of Siemens, now Dematic (Feare, 2003, p.41). Sanford and Newell Office Products has been able to increase productivity by over 65% in a new facility with pick-to-light as compared to their three outdated warehouses (Feare, 1999). Weil-McLain's Ken Niemi stated:

> "Besides doubling the number of orders and poundage that we process on a man-hour basis, we have virtually eliminated our order backlog. Today, if an order is here before noon, it normally ships the same day." ("Boiler Maker," 2000 p. 112)

The ability to track in-process orders as well as real time reporting have lead to an increase in productivity (McCoy, 2004). Easton Sports experienced an increase of 14% over the batch picking method using a tilt-tray sorter to sort the customer orders (Maloney, 2002). Bardwil Industries' has increased from 100-150 units per man-hour to almost 300 units per man-hour since the pick-to-light system was installed (Trebilcock, 2007a).

Put-to-Light

Operation/Functionality

Put-to-light systems are a newer use of the same technology as pick-to-

light systems (Feare, 2003), and are considered "close cousins" of the pick-to-light systems ("Manage Productivity," 2003). P Bakker Hillegom B.V., seed and bulb retailer, considers the put-to-light system to be a goods to man concept and their old method a man to goods method ("Pick-to-light," 2000). The put-to-light software "will light the lights and produce some reports for management." says George Feigley of Siemens Dematic, now Dematic. ("Manage Productivity," 2003, ¶ 1) The warehouse worker with a radio frequency scanner, scans a tote/carton/pick directive. Then the warehouse management system might direct the warehouse worker to select a series of specific sizes of cartons/containers, based on the total volume to be packaged for each location. When the warehouse worker has selected the cartons/containers and confirms the selection via the radio frequency scanner or voice pick to the warehouse management system, the warehouse management system will illuminate the light-emitting diodes digital display showing the location and quantity of the stock keeping units that are to be placed in each carton/container. The warehouse worker places the correct quantity within the container/tote and confirms the put by pressing the button on the display ("Put-to-light systems," 1999; Witt, 1997). When the warehouse workers have placed all the products from the carton/tote they are putting to light, they repeat the process, scanning the next tote/carton and continue putting the product in the carton/containers. The hardware and operation are very similar to that of the pick-to-light. A put-to-light installation will typically include modular displays that are wired for each pick location (Feare, 2003). The modular displays usually contain: digital display for quantity, task complete button, up/down arrows to

count down as product is placed short from the carton/tote (Langnau, 2001). The newest technology now offers increased flexibility for wiring modular displays when they are installed (Bodenburg, 2007). Put-to-light is sometimes considered to be the reverse of pick-to-light ("Put-to-light systems," 1999).

Applications

Put-to-light applications are not commonly used as are pick-to-light at this time. Some of the companies that are using put-to-light include: Best Buy, Hot Topic, Lantis Eyewear, Tween Brands, P Bakker Hillegom B.V and Target. Best Buy uses their put-to-light system for processing on-line customer music and movie orders. Lantis Eyewear's put-to-light system is actually fed from their pick-to-light system. They are using it for the sorting of glasses for the preparing of point of sale displays (Maloney, 2003). Tween Brands, a clothing retailer for female teenagers, is using their put-to-light for store merchandise (DesMarteau, 2006; "Tween," 2008). P Bakker Hillegom .B.V. uses the put-to-light to sort customer orders for seeds, plants, bulbs and accessories ("Pick-to-Light processes," 2000). Target uses the put-to-light for shipping less than case quantity items for the stores; they currently are not using it for on-line order processing (Co-worker personal communication, November 11, 2007).

Quality/Accuracy

Tween Brands has been able to maintain almost perfect inventory accuracy since the installation of the put-to-light technology and the upgrading of their warehouse management system. Their order accuracy is also nearly perfect for shipment to the stores (DesMarteau, 2006). Sheetz, a regional convenience

store chain, has been able to improve order processing accuracy from about 96.5% to greater than 99.8% since the installation of the put-to-light systems ("Sheetz takes," 2004).

Productivity

Tween Brands has seen significant decreases in training expenses, productivity boosts of 25% and a through-put increase of 70% over four years ago (DesMarteau, 2006). P Bakker Hillegom B.V. has been able to improve the facilities capacity and throughput with the installation of a put-to-light. They now process over 400,000 items per day. The put-to-light system is installed in their order processing department ("Pick-to-light," 2000). Hot Topic, a national music and clothing retailer, uses put-to-light to sort music for their stores (Kempfer, 2005; Hot Topic, 2008). New employee training is completed with a six light sample instead of the normal seventy-five and can be completed in half a day (Kempfer, 2005).

Engineering Standards

Engineering standards like Maynard Operation Sequence Technique are an off-shoot of predetermined motion time studies. Predetermined motion time studies were developed by combining the work of Fredrick Taylor with time studies and the work of Frank and Lillian Gilbreth with motion study. In 1948 Harold B. Maynard, G.J Stegemerten and J.L. Schwab published their work Methods Time Measurement (Zandin, 1990). Methods Time Measurement is available in the public domain, very accurate, and the most widely accepted predetermined motion time studies application in use; furthermore, it has been re-

worked by engineers to make it a better tool (Zandin, 1990). For example, Maynard Operation Sequence Technique (MOST) has four different levels of work measurement namely, Mini-MOST, Basic MOST, Maxi-MOST and Clerical-MOST (Hodson, 1992). The appropriate level to use is determined by the required accuracy level, the weekly frequency of the operation and the distance moved.

Maynard Operation Sequence Technique provides three common sequence models that can be used to build the operations from. These sequences are:

-General Move Sequence, used for spatial movements, this is the most common

-Controlled Move Sequence, used for movement of an object that remains in contact with a surface or one that is attached during the move

-Tool Use Sequence, to be used with common hand tools

A fourth sequence called Manual Crane Sequence is used with manual crane operations sequences (Zandin, 1990).

The Maynard Operation Sequence Technique process is broken into a multitude of sub-activities that are used to build the sequence models that describe the activity. Each movement, motion or activity has predetermined Time Measurement Units that are recorded on a worksheet and added together to determine the process time. The process time is multiplied by the multiplier for the work measurement selected. This product is the total Time Measurement Unit for the task being evaluated. This can be converted to either hours or minutes. To

derive minutes, it is necessary to multiply the Time Measurement Unit count by 0.0006 minutes. The totaled time are validated and can become the engineering standard (Hodson, 1992; Zandin, 1990). Information from the Maynard Operation Sequence Technique system review can provide standardized labor costs and can be used to evaluate different layouts in a theoretical model for testing system enhancements or improvements without making the actual changes.

Purchasing Criteria

Capital equipment purchasing/procurement is comprised of many different aspects. A few of these are discussed to point out the importance of the capital purchasing/procurement process in the overall success of a transition to new technologies. This description is not meant to be all-inclusive.

Purchasing/procurement personnel are responsible for obtaining the approved equipment without paying too much, with the features defined by the approval team, and at terms favorable to the buyer and agreed to by the vendor (Burt & Pinkerton, 1996; Coker, 2007; Dobler & Burt, 1996).

The purchasing/procurement process should involve a cross functional team that includes representatives from Distribution Center Operations, Facility Engineering, Industrial Engineering, Finance, Legal, Purchasing/Procurement and any possible consultants (Burt & Pinkerton, 1996; Coker, 2007; Dobler & Burt, 1996). The cross functional team should prepare the short list of equipment suppliers whether the firms are system integrators or manufacturers that a request for information will be sent to. From these responses the cross-functional team

farther reduces the list down to three to five firms that a request for proposal shall be sent to (Burt & Pinkerton, 1996).

Since the equipment and technology for a pick-to-light or put-to-light system are complex, multiple discussions with vendors are required. The request for proposal process should be used because it implies that additional discussions and presentations are expected. The request for quote should not be used because it implies bottom line pricing with no further discussion (Burt & Pinkerton, 1996).

The cross-functional team is responsible for preparing a sample contract, sample Terms and Conditions, bid form, and equipment specifications (Burt & Pinkerton, 1996). The specifications could be one of the following types, depending on the system requirements and needs of the company: Performance, Full Technical or Minimum Criteria. Relationships with firms can also have an effect on the level of specification that is required (Benton, 2007; Dobler & Burt, 1996).

Prior to sending out the Request for Proposal the purchasing/procurement and legal team members should confirm that non-disclosure agreements are in place and current with each firm. If they are not, purchasing/procurement and legal personnel must be responsible for securing the proper non-disclosure agreements. The purpose of non-disclosure agreements is to protect confidential information for both companies. The proposal might describe a new process that is projected to give the seller, a competitive advantage that the seller would not want to have shared with competitors (Moore, 2001a).

Prior to sending out the request for proposal the cross-functional team should have prepared the various criteria, Likert scales and weighting factors that shall be used to compare the vendors and two different technologies. The forms are best created in a matrix format that can take advantage of a spreadsheet program such as Microsoft Excel (Coker, 2007).

Matrices for comparing the different suppliers should be divided into technical, vendor and finance versions with a weighting factor for each. The technical version should include: the specification that was provided and the value-engineered solutions the vendors may have proposed. Every key item in the specification should have an entry including operational considerations, productivity, maintenance, installation requirements, project schedule with ratings and weighting on each item in the comparison matrix. The vendor matrix should include the features that are important from a purchasing/procurement standpoint, not the technical features. The vendor matrix should include such items as: proposal completeness, change order process, down payment percentage, progress payments (percentages and schedule), payment terms late payment interest rate, project schedule, the various legal terms, warranty, limits of liability, business interruption penalties, and minimum insurance levels (Coker, 2007). The finance version should include: Return on the Investment, Return on Assets, Internal Rate of Return, total cost of ownership, depreciation schedules and other company-required information (Benton, 2007; Burt & Pinkerton, 1996; Dobler & Burt, 1996; "Use the," 1997).

These rating worksheets should be completed by the team members after a presentation by the short-listed firms. Any firm that responds with a complete proposal should be given an opportunity to present their proposal to the cross functional team and to answer clarifying questions. Each firm must be allowed to make their presentation without any of their competitors present. The information should be treated as confidential. Submission of updated proposals after this meeting would not be un-expected. After re-evaluating the proposals, a visit to see the equipment in use in a similar application or manufacturer's facility should be expected. This visit would be conducted by selected key members of the cross-functional team. At this point the company will typically work with one or two of the highest rated companies to finalize the design and proposal (Burt & Pinkerton, 1996).

Some firms require larger capital purchases to be reviewed by an additional team consisting of senior engineers, senior level operators, and maintenance staff. This group recommends on equipment enhancements that might reduce maintenance costs, increase productivity, improve process control and increase equipment life (Moore, 2001b), using the 3-30 rule, which provides for 30 percent additional capacity for an additional three percent cost of equipment ("Use the," 1997). These approaches apply a total cost of ownership model (Benton, 2007; Dobler & Burt, 1996). They are not looking at the process as one designed to obtain the lowest installed cost and minimum adequate design (Moore, 2001b).

At this point, the proposal becomes final and justifications are completed by the cross-functional team and reviewed by Finance for inclusion in the request for funding process. If approved, then purchasing, final engineering, installation, commissioning, training and system start-up take place.

Summary

Pick-to-light and put-to-light both operate in a similar manner. A pick-to-light system directs a warehouse worker where to take product from and a put-to-light system directs a warehouse worker were to put the product. The systems make use of similar technologies and equipment. Both claim increases in productivity, order accuracy, and available reporting on an individual warehouse worker or on a work zone.

The engineering standard can be used to estimate the productivity on a new process or system prior to installation, or to compare current standard methods against the actual productivity. The engineering standard can then be validated and used as the production standard.

Purchasing procurement practices are discussed, including the cross-functional team, request for information, request for proposal, request for quote, non-disclosure agreements and rating matrices for comparing various vendors and solutions. The concept of the 3-30 rule for mentioned about gaining 30 percent more capacity for a three percent increase in price is mentioned.

CHAPTER III: METHODOLOGY

Introduction

The study reviewed the information documented in various published sources and websites and compared it with information submitted from suppliers of the pick-to-light and put-to-light technologies, engineering standards and input from actual users of the technologies. The University of Wisconsin-Stout Institutional Review Board approved both the questionnaire that was used to gather the vendor information and the questionnaire that was submitted to the users of the technologies prior to sending out any e-mail correspondence requesting evaluation. The author participated in the University of Wisconsin-Stout Institutional Review Board on-line training program before preparing the questionnaires. Prior to submission to the Institutional Review Board the documents were discussed, reviewed and approved by the research advisor.

Questionnaire

A group of twelve consultants, manufacturers and integrators of pick-to-light and/or put-to-light systems were sent a short questionnaire about their products. The questionnaire was a request for information and was sent to the consultants, manufacturers and integrators using the University of Wisconsin-Stout e-mail system. This letter is shown in Appendix A, Manufacturer/Consultant/Integrator Questionnaire, on pages 56-58. The author sent the request for information directly to sales representatives or known contacts within each company. If no formal contact was known, then the request for information was sent using the firm's website, and their company contact

procedures were followed. The questionnaire that was sent to the suppliers also explained why the information was being requested and included the University of Wisconsin-Stout Institutional Review Board's required statements and approval block. It was explained further that the request was designed to compare the technologies, not the company systems with each other. A sample drawing of each technology used in a successful application, was requested, along with permission to use and possibly publish the information submitted for the study. The three questions asked were:

-What are the main features of your pick-to-light and/or put-to-light system ranked by importance to the average user?

-What are the key attributes that should be considered for comparing the two different technologies ranked by importance to the average user.

-Why do you or your firm consider these key attributes to be the most important for comparing the two technologies?

The key phase, section of the phase or criteria of each answer was identified and used to compile the data. The answers to the three questions were compiled into tables and figures for showing the mode of each answer. The information was also manipulated to determine the weighted ranking of the responses. The criteria collected were ranked by a weighting scale determined by taking the response with the greatest number of criteria and multiplying it by ten. This number was applied to the first item in each firm's response and the next was given a value of ten less, this was repeated and so on. The new values of the answers were added together and ranked in descending order to provide a list of

criteria in order of importance from the vendor point of view. For the first question, the responses were analyzed as put-to-light, pick-to-light, and with the two combined. The combined version did not change the top eight items. This process was followed for all three questions, and tables and figures were prepared.

Twenty-five percent of those surveyed responded within seven days. A follow up telephone call were made thirteen days after the original e-mail to the individuals/firms that did not respond. In three cases, a second e-mail was sent to a revised e-mail address provided by the firms. After the telephone call and second e-mail and a total of twenty-one days, the total response was 58.3%. As this was an unacceptable level, another e-mail was sent, requesting a response by the end of the week, or twenty eight days after the original e-mail. Following the third e-mail, the response rate was 75%, which was believed to be still un-acceptable. At this time, a second phone call was made to the remaining three firms. One of the firms submitted a response, one did not respond, and it was discovered that one of the e-mail addresses used was invalid. The final response rate was 91.7%.

The information provided by the manufacturers, consultants and integrators was not collected in a blind manner, so keeping track of the firms that responded was easy and the firms requiring follow-up letters were simple to determine.

The key criteria were then compared against the features of the systems being studied. The top eight weighted responses were combined with conveyor

brand or conveyor system partnership preference and cost. This yielded the list of ten items to be ranked by the distribution center managers.

Engineering Standard

One of the equipment manufacturers submitted drawings of both a put-to-light system and a pick-to-light system, making it possible for the basic Maynard Operation Sequence Technique work measurement tool to be completed on each of the layouts. The basic Maynard Operation Sequence Technique work measurement tool provides a realistic method for comparing different layouts and different methods without requiring that the equipment or technology be physically available.

Since, no standard operating procedures were provided assumptions had to be made about the processes used for both systems, although it is recognized that the procedures for operating the two systems are very similar. The Maynard Operation Sequence Technique results were compared to determine the more productive technology.

Since no standard operating procedures were provided by the equipment manufacturer, no attempts were made to suggest improvements in the process after the initial sequence of activities was prepared.

User Ranking and Input

A sample of fifty four distribution center managers was contacted and asked to respond to a non-random questionnaire ranking the ten key attributes for the selection of either the pick-to-light or put-to-light technology. The managers were also asked to provide any information that they believed might be useful

about their experiences with both technologies. The questionnaire was sent to the distribution center managers via the University of Wisconsin-Stout e-mail system. The letter used is shown in Appendix B: Distribution Center Manager Questionnaire on pages 59-61. The questionnaire sent to the distribution center managers also explained why the information was being requested and provided the University of Wisconsin-Stout Institutional Review Board's required statements and approval block. The e-mail to the distribution center managers requested a response or non-response by a given date, outlined the reasons for the study, and sought permission to use their responses for possible publication in an un-credited format. This gave the distribution center managers more freedom and latitude to answer the questions, since none of the responses were to be directly quoted or attributed to them or their companies.

The distribution center managers were asked to rank the following ten items: accuracy, brand preference or conveyor system partnership, costs, eliminate paper, labor management, productivity, real time, reports, selectable functions, and software. In addition, they were asked to respond to two statements and one question. These were:

1. Please describe some of your experiences with pick-to-light technology
2. Please describe some of your experiences with put-to-light technology
3. Are there any key criteria that you think should have been included that are not and why?

Some of the distribution center managers responded that they did not have experience with either pick-to-light or put-to-light technologies. These respondents were requested to answer the question as if they were going to purchase one of the technologies, showing how they would rank these items.

The results of the ranking were weighted and compiled into tables and figures to clarify them for the reader. The information was calculated a second time using only the positive responses to either of the first two statements. It was then calculated a third time using the negative responses to determine if the data might vary. The method used to weight the responses was to give the highest rated response a ten, the second highest a nine, decreasing by one for each position to the lowest-rated, which was given a one. The values were added together and the responses ranked from greatest valve to lowest value.

The response rate for this questionnaire was 33.3% within three days. By the requested response date, the rate was only 61.1 %. An additional e-mail and, in select cases, a telephone call offered an additional three days to respond. The additional time and contact resulted in a total response rate of 85.2 %, which was 46 responses. From the responses, it was determined that 28.3% had experience with the technologies, 45.7% had no experience with the technologies, 23.9% declined to participate, and the remaining 2.1% could not open the response file.

The information provided by the distribution center managers was not collected in a blind manner, so keeping track of the respondents was simple, and determining which of the distribution center managers required follow-up e-mails was easy.

Process

The information from all the sources mentioned was compared and compiled. The results of this process are enumerated in the next chapter. Chapter Four contains comparisons of technology features by the manufacturers, consultants, and integrators, features of the technologies regarded as of primary importance by the manufacturers/integrators, information on different system layouts. Maynard Operation Sequence Technique work measurement techniques, the weighted rankings and distribution center manager's feedback about their actual experiences with the different technologies of pick-to-light and put-to-light. These are being compared to determine the ranking of the ten most important attributes to be considered when comparing put-to-light or pick-to-light technology for a national retailer in a less than case picking application.

CHAPTER IV: RESULTS

Introduction

The results of each survey question sent to the Manufacturers/Consultants/Integrators have been presented in different formats. The responses were classified by using key words or key phases. Key phases were kept consistent throughout the analysis of each question. The Manufacturers/Consultants/Integrators responses to each question have been analyzed using different methods. The distribution center managers' responses have weighted and analyzed using simple separation criteria to determine if the responses vary significantly for the three highest rated responses. The results of the Maynard Operation Sequence Technique are shown following the review of the surveys.

Question #1 Manufacturers/Consultants/Integrators

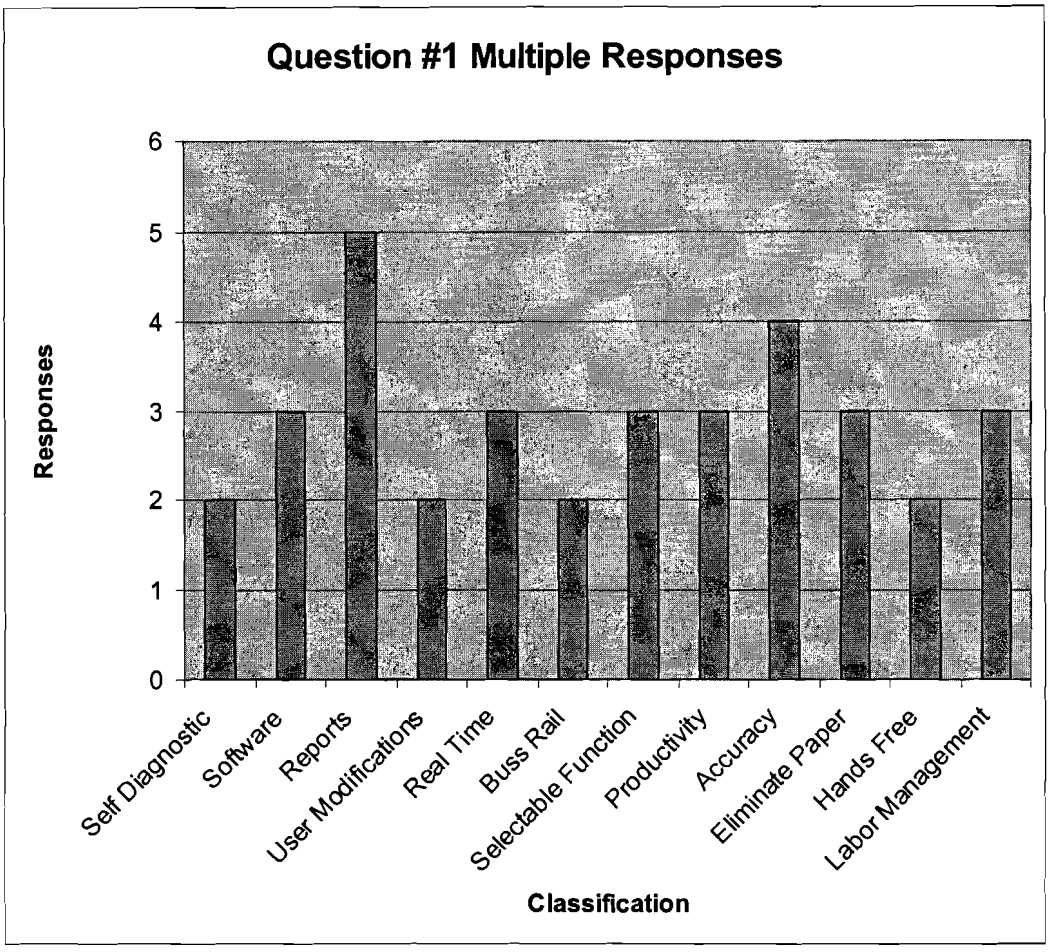
The results of the questionnaires were classified based on key words or key phases in the response. Question #1 is "What are the main features of your pick to light and/or put to light system. Ranked by importance to the average user?" The verbatim responses from the questionnaires are contained in Appendix C: Manufacturer/Consultant/Integrator Questionnaire Responses on pages 62-80. There were a total of thirty (30) different responses. Of these eighteen (18) had only a single response. These are listed following Figure 1 Question #1 Multiple Responses. The remaining twelve (12) had multiple responses, and these are provided in Table 1 Question #1 Multiple Responses, followed by Figure 1

Question #1 Multiple Responses. The mode for the classified responses was the item labeled "Reports."

Table 1
Question #1 Multiple Responses

Response Classification	**Responses**
Self diagnostic	2
Software	3
Reports	5
User modifications	2
Real time	3
Buss rail	2
Selectable function	3
Productivity	3
Accuracy	4
Eliminate paper	3
Hands free	2
Labor management	3

Figure 1
Question #1 Multiple Responses



The single response items are as follows: equipment ruggedness, self manufactured, redundant design, 100% quality assurance testing, voice capability, light displays sequentially, multi color device, eliminate scanners, ergonomic displays, secondary functions, proactive notification, low voltage, non-technical maintenance, no zone controller, slotting analysis, cluster picking, automatic bin mapping and multiple waves.

The responses were next weighted and tabulated for put-to-light, pick-to-light and both combined. The top ten results are shown in Table 2 Question #1 Weighted Responses, Figure 2 Question #1 Pick-to-Light Weighted Responses,

Figure 3 Question #1 Put-to-Light Weighted Responses and Figure 4 Question #1 Combined Weighted Responses.

Table 2
Question #1 Weighted Responses

Classification	**Put-to-Light**	**Pick-to-Light**	**Combined**
Reports	440	440	440
Accuracy	390	390	390
Eliminate paper	330	330	330
Productivity	270	270	270
Software	260	260	260
Labor mgmt.	240	220	220
Real time	230	240	240
Select. Function	230	220	220
Buss rail	170	170	170
Self diagnostic	160	160	160

Figure 2
Question #1 Pick-to-Light Weighted Responses

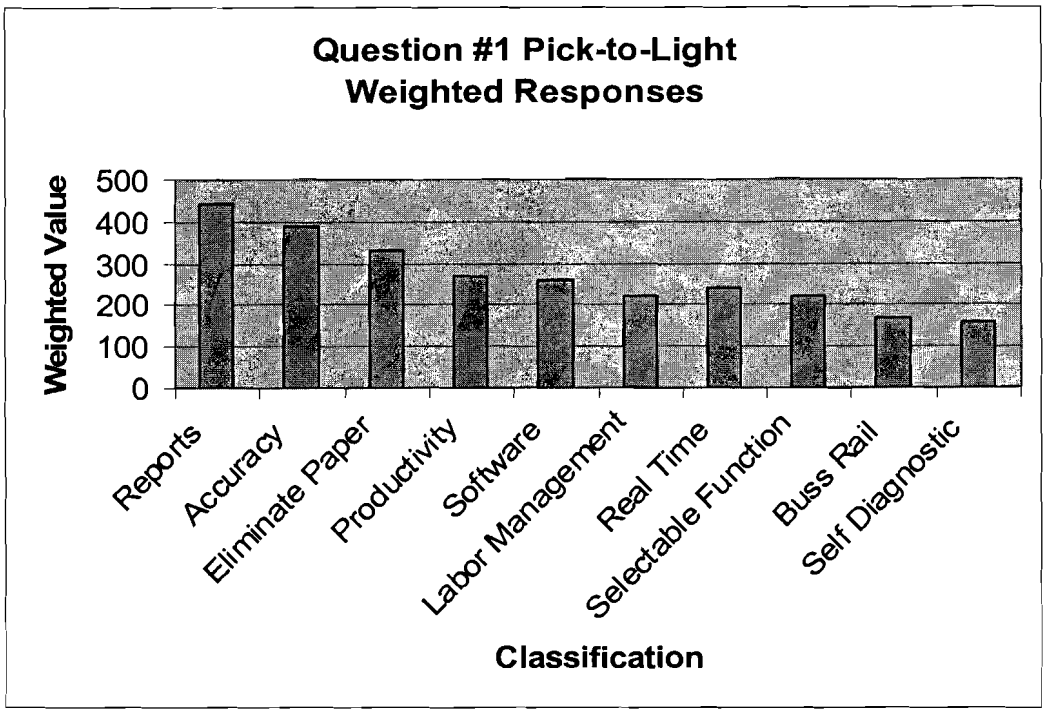


Figure 3
Question #1 Put-to-Light Weighted Responses

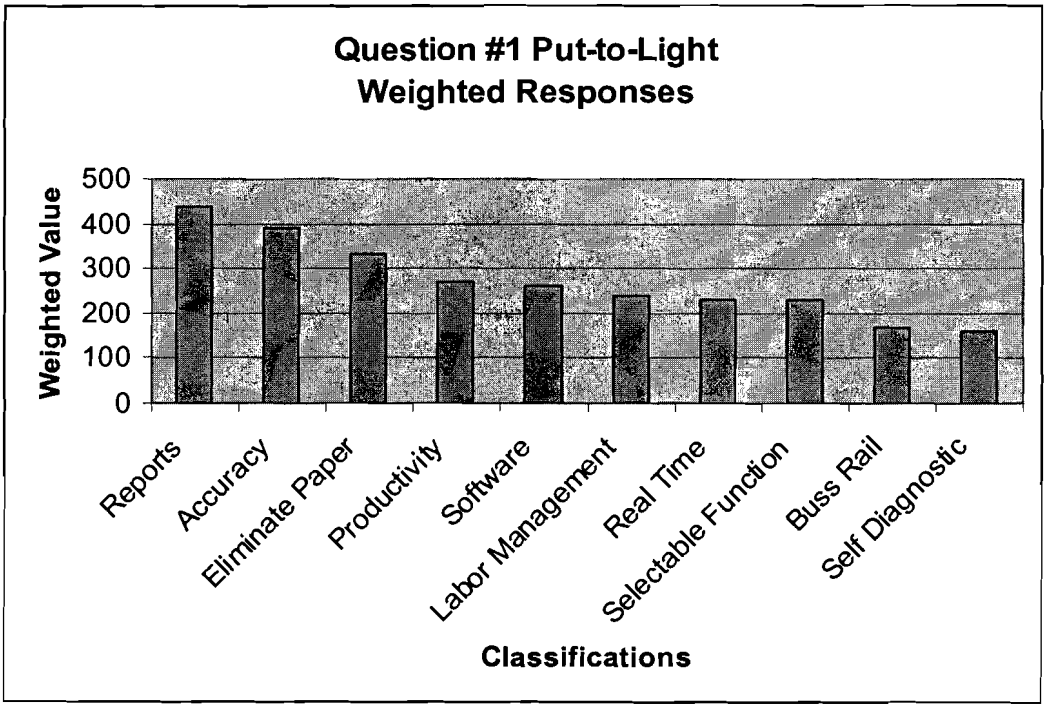
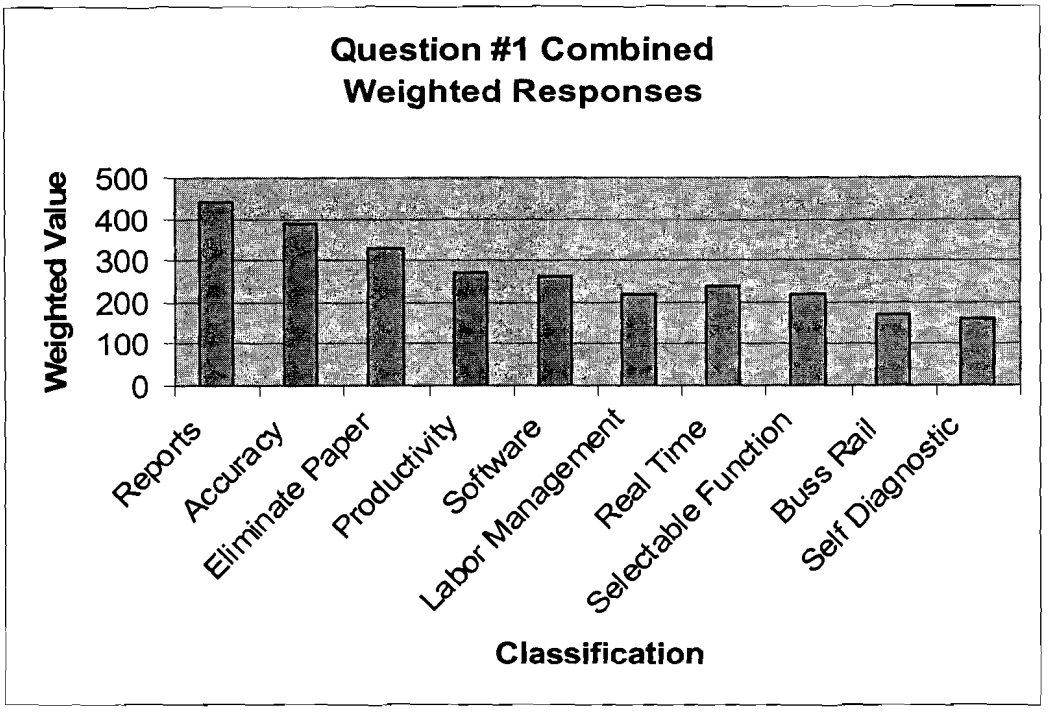


Figure 4
Question #1 Combined Weighted Responses



The weighted responses for the pick-to-light and put-to-light varied slightly between the sixth and eighth positions. The additional changes are outside of the areas of concern for this study. These variations have no importance when the highest rated eight items are combined with costs and conveyor brand or conveyor system partnership preference for rating by the distribution center managers.

The net result of all three analyses produces the eight highest weighted responses namely: reports, accuracy, eliminate paper, productivity, software, real time, selectable function and labor management.

Of the weighted responses, only eliminate paper and selectable functions were unexpected responses. The elimination of paper would be of importance to

distribution centers that are currently using paper based pick lists. The user modifications or self diagnostic were expected by the author to appear on the list.

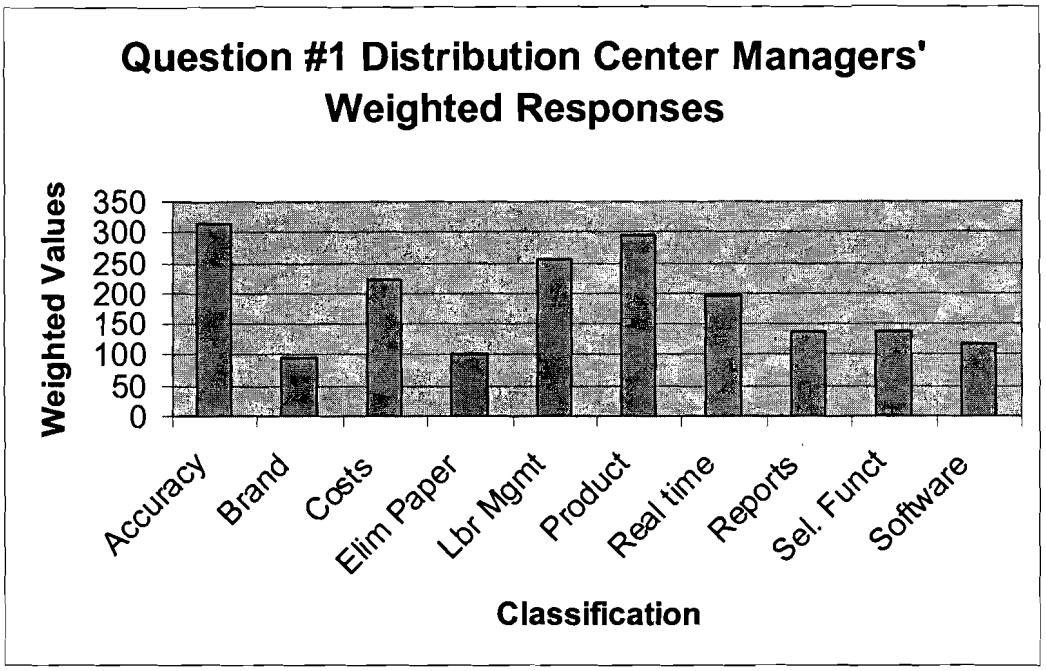
Distribution Center Managers Ranking

The combined distribution center managers' responses were weighted and put into Table 3 Question #1 Distribution Center Managers' Weighted Responses. This is followed by Figure 5 Question #1 Distribution Center Managers' Weighted Responses. The responses from the questionnaires are contained in Appendix D: Distribution Center Managers' Responses on pages 81-84.

Table 3
Question #1 Distribution Center Managers' Weighted Responses

Classification	**Weighted Value**
Accuracy	313
Brand preference	96
Costs	223
Eliminate paper	102
Labor management	256
Productivity	294
Real time	195
Reports	138
Selectable function	138
Software	117

Figure 5
Question #1 Distribution Center Managers' Weighted Responses



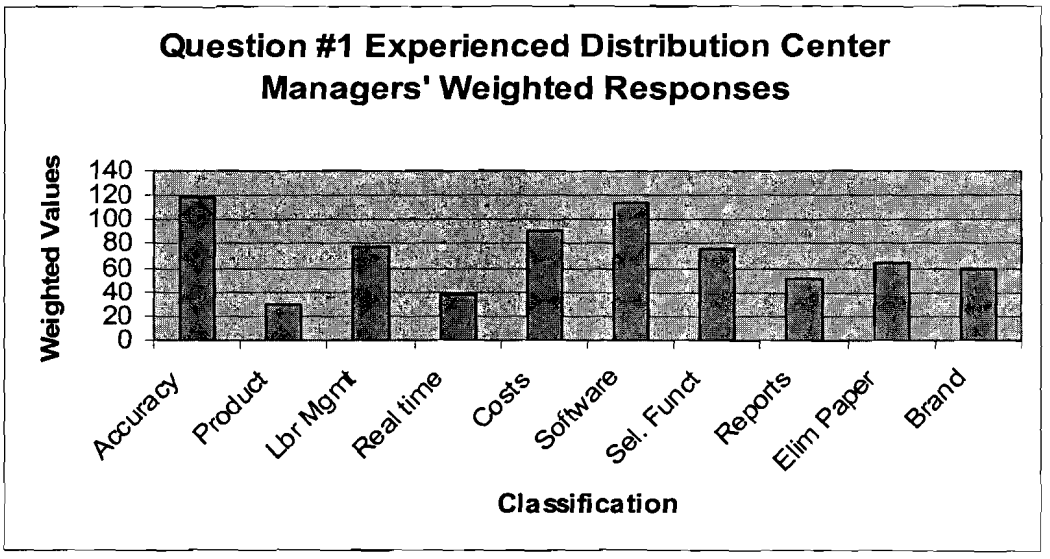
The data clearly shows that accuracy, productivity and labor management are the most important criteria. It also shows that software, elimination of paper and brand preferences are the least important criteria.

When the data is reviewed for distribution center managers with experience with either pick-to-light or put-to-light or both, the responses do not change significantly. Software increases in importance and reports falls into the bottom three. This is shown in Table 4 Question #1 Experienced Distribution Center Managers' Weighted Responses and Figure 6 Question #1 Experienced Distribution Center Managers' Weighted Responses.

Table 4
Question #1 Experienced Distribution Center Managers' Weighted Responses

Classification	Weighted Value
Accuracy	91
Brand preference	24
Costs	51
Eliminate paper	30
Labor management	70
Productivity	86
Real time	58
Reports	39
Selectable function	50
Software	51

Figure 6
Question #1 Experienced Distribution Center Managers' Weighted Responses



When the data is reviewed for the distribution center managers without experience with either pick-to-light or put-to-light the responses do not change significantly from the distribution center managers with experience with pick-to-light or put-to-light. The responses are the same for the top three items and software falls back into the lowest three. This is shown in Table 5 Question #1 Non-experienced Distribution Center Managers' Weighted Responses and Figure 7 Question #1 Non-experienced Distribution Center Managers' Weighted Responses.

Table 5
Question #1 Non-experienced Distribution Center Managers' Weighted Responses

Classification	**Weighted Value**
Accuracy	167
Brand preference	53
Costs	136
Eliminate paper	57
Labor management	140
Productivity	154
Real time	103
Reports	79
Selectable function	65
Software	46

Figure 7
Question #1 Non-experienced Distribution Center Managers' Weighted Responses

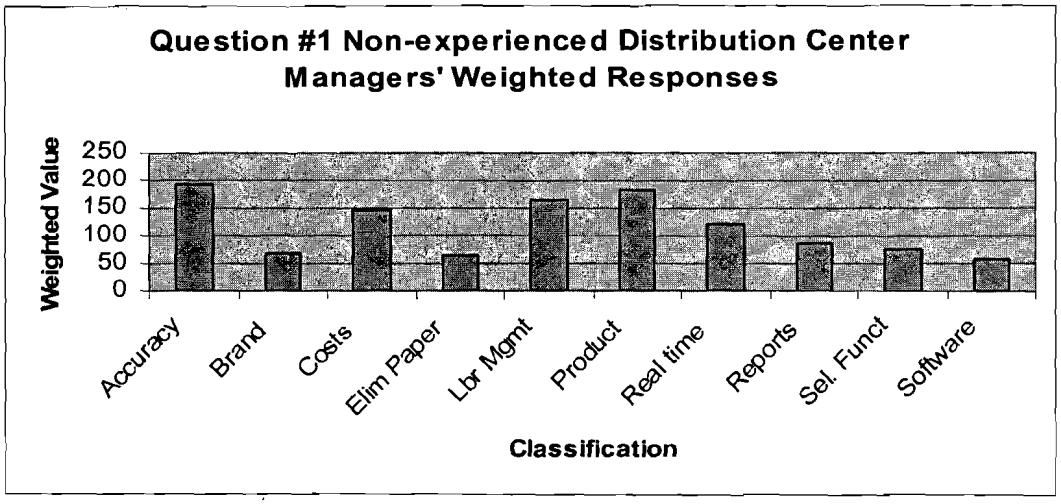


Table 6 Question #1 Distribution Center Managers' Top Three Distribution and Table 7 Question #1 Distribution Center Managers' Lowest Three Distribution show that the total weighted values are reflected in the actual distribution of the responses.

Table 6
Question #1 Distribution Center Managers' Top Three Distribution

Ranking	**Accuracy**	**Productivity**	**Labor mgmt**
10	16	8	5
9	5	9	10
8	4	6	9
7	3	2	2
6	0	2	2
5	0	1	0
4	0	0	0
3	0	0	0
2	0	0	0
1	0	0	0

Table 7
Question #1 Distribution Center Managers' Lowest Three Distribution

Ranking	Software	Eliminate paper	Brand preference
10	1	0	0
9	1	0	0
8	1	2	0
7	1	1	1
6	1	1	3
5	3	2	3
4	2	4	2
3	2	5	1
2	12	4	8
1	4	9	10

When comparing the weighted responses between the Manufacturers/Consultants/Integrators and distribution center managers, there is not a consensus of opinion regarding either the most important items or the least important ones. This group chose reports followed by accuracy and eliminate paper as the most important, whereas the distribution center managers rated accuracy, productivity and labor management as the most important. The lists have only one common item. In addition, one item from the lowest-rated list for Manufacturers/Consultants/Integrators is included in the top three list generated by the distribution center managers. Another in the top three was in the lowest three of the distribution center managers, this being eliminate paper. The

distribution center managers as a group felt that accuracy, productivity and labor management are the most important. Labor management was in the lowest three of the Manufacturers/Consultants/Integrators. Overall the two groups did not agree on what is most important.

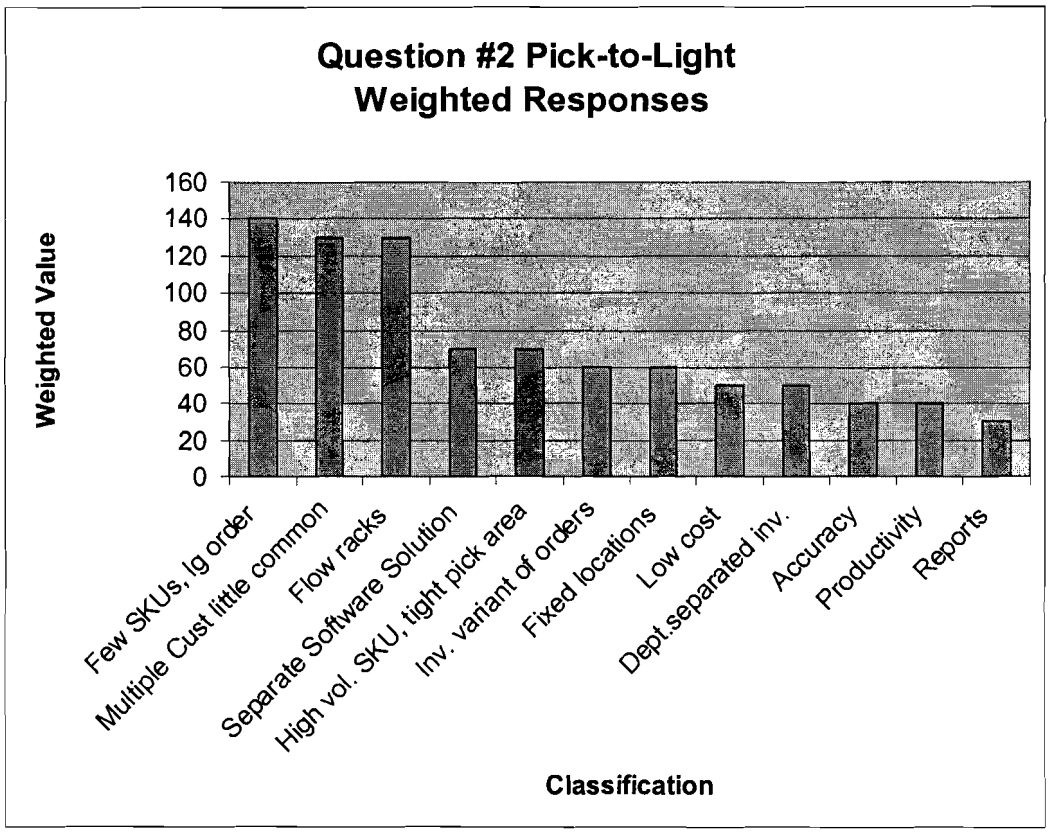
Question #2 Manufacturers/Consultants/Integrators

The attributes identified in Question #2. "What are the key attributes that should be considered for comparing the two different technologies? Ranked by importance to the average user." The verbatim responses from the questionnaires are contained in Appendix C: Manufacturer/Consultant/Integrator Questionnaire Responses on pages 62-80. The Manufacturers/Consultants/Integrators responses provided information on system selection based on distribution center operational requirements, meaning that selecting a technology that is better for a particular application was of the greatest importance to this group. The pick-to-light classifications are shown in Table 8 Question #2 Pick-to-Light Weighted Responses and Figure 8 Question #2 Pick-to-Light Weighted Responses.

Table 8
Question #2 Pick-to-Light Weighted Responses

Classifications	**Weighted Total**
Few SKUs, large order	140
Multiple Customer, little common	130
Flow racks, existing	130
Separate software solution	70
High vol. SKUs, tight pick area	70
Inventory variant orders	60
Fixed location	60
Low cost	50
Department separate inventory	50
Accuracy	40
Productivity	40
Reports	30

Figure 8
Question #2 Pick-to-Light Weighted Responses

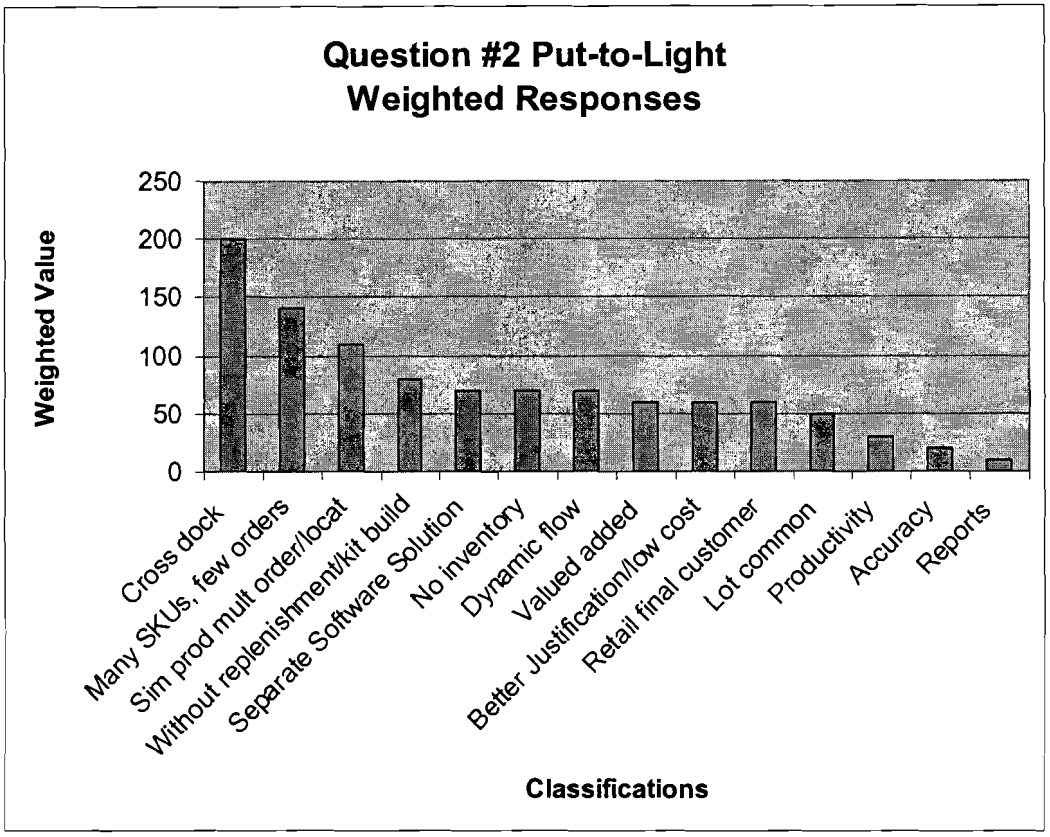


The put-to-light classifications are shown in Table 9 Question #2 Put-to-Light Weighted Responses and Figure 9 Question #2 Put-to-Light Weighted Responses.

Table 9
Question #2 Put-to-Light Weighted Responses

Classifications	**Weighted Total**
Cross dock	200
Many SKUs few orders	140
Similar product multiple order/location	110
Without replenishment/kit build	80
Separate software solution	70
No inventory	70
Dynamic flow	70
Valued added	60
Better justification/lower cost	60
Retail final customer	60
Lot in common	50
Productivity	30
Accuracy	20
Reports	10

Figure 9
Question #2 Put-to-Light Weighted Responses



The two lists have only a few items in common, and these include: separate software solution, productivity, accuracy and reports. productivity and accuracy are neither attributes nor design selection guidelines but, they are the result of a successful installation.

The pick-to-light criteria indicate that it is the better choice for applications with few stock keeping units, large orders, multiple customers with little in common, or when carton flow shelving are installed within the operation.

The put-to-light criteria indicate that it is the better choice for applications that cross dock, have many stock keeping units with few orders, or similar product with multiple orders.

The responses appear to be more relevant for a new facility, than for an existing distribution center operation. The exception to this is the reference to carton flow shelving.

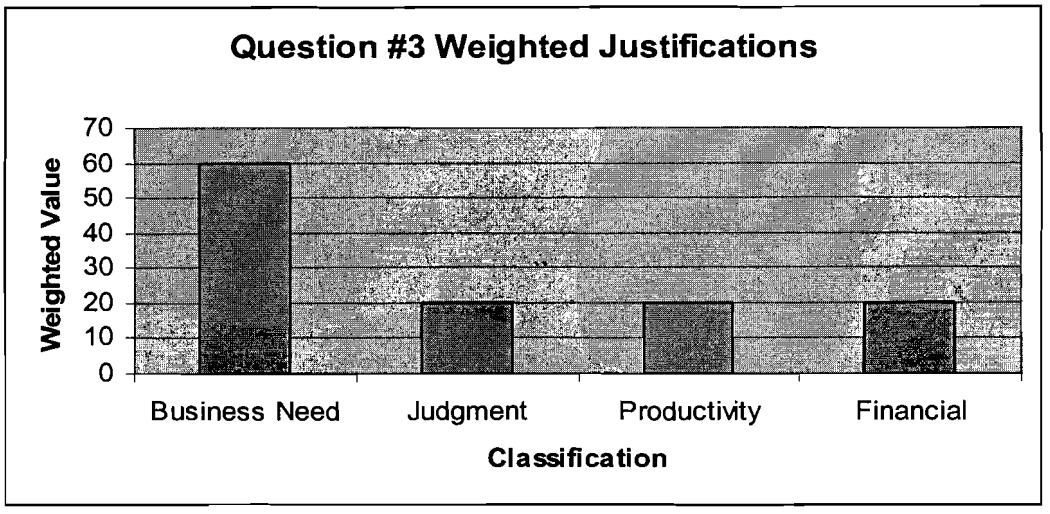
Question #3 Manufacturers/Consultants/Integrators

The Manufacturers/Consultants/Integrators provided business needs, judgment, productivity and financial as reasons why "your firm/you consider these key attributes to be the most important for comparing the two technologies." The verbatim responses from the questionnaires are contained in Appendix C: Manufacturer/Consultant/Integrator Questionnaire Responses on pages 62-80. These are shown in Table 10 Question #3 Weighted Justifications and Figure 10 Question #3 Weighted Justifications.

Table 10
Question #3 Weighted Justifications

Justification	**Weighted Total**
Business needs	60
Judgment	20
Productivity	20
Financial	20

Figure 10
Questions #3 Weighted Justifications



Most of the firms that did respond to this question made comments about project budget, cross docking, staffing goals, business models, customers, software complexity, and space. These all would ordinarily be part of a return on the investment calculation.

Estimated Productivity

The level of productivity is directly related to the processes and layout of the systems. The replenishment of the put-to-light and the picking for the put-to-light are not included in this discussion. The Maynard Operational Sequence Technique showed that the put-to-light process is about 5% more efficient than the pick-to-light process. The worksheets are contained in Appendix E: Maynard Operational Sequence Technique Worksheets on pages 85-89. The study showed that it would require approximately 194 minutes to process 3,000 pieces in a put-to-light process while the same 3,000 pieces would take approximately 215 minutes with a pick-to-light system. These savings would be quickly eroded if the

right mix of product were not available or problems arose with picking the correct quantities. A benefit of both of the technologies is with lower training curves for new employees, while both have significant negative effects on the rest of the facility when unscheduled downtime occurs. A key to the successful use of both technologies is keeping the pick density high per lineal foot of work area. The put-to-light system may require additional material handling equipment to get totes/cartons further into the put-away area. Either technology can be enhanced with the use of conveyors and other technologies.

Summary

The Manufacturers/Consultants/Integrators and the distribution center managers do not agree on the key criteria for the selection of the two technologies discussed. It would appear, however, that the results from the distribution center managers are more accurate. The three most important are: accuracy, productivity and labor management.

The results of the study suggest that the key element for system design is that of matching the application to the technology. In addition the technology selected will still have to fit with whatever fiscal policies the company has. The Maynard Operational Sequence Technique shows put-to-light should be favored over the pick-to-light but, this does not consider the unknown additional labor for both operations that might be needed within the distribution center. The results of the study also indicate that the key attributes from the distribution center management perspective are: accuracy, productivity, labor management, costs,

real time, reports, selectable functions, software, eliminate paper and brand preference.

CHAPTER V: NEXT STEPS

Introduction

The study was designed to determine the key attributes used to compare put-to-light and a pick-to-light technology for a less than case quantity picking application for a national retailer that currently store picks in a multi-level pick module. The study used surveys that were sent to a select list of equipment manufacturers, material handling consultants and material handling system integrators. The survey asked the firms to answer the following three questions:

1. What are the main features of your pick to light and/or put to light system. Ranked by importance to the average user?
2. What are the key attributes that should be considered for comparing the two different technologies? Ranked by importance to the average user.
3. Why your firm/you consider these key attributes to be the most important for comparing the two technologies?

The responses to the survey were classified, weighted, ranked and analyzed. The top eight results of question #1 were combined with Cost and Brand preference. This survey was then sent to a group of distribution center managers to rank and provide information on their experiences with the two technologies and to mention any criteria that might be missing. If they did not have experience with either technology, the managers were asked to rank the criteria based on what they believed would be important to them if they were to purchase either technology. The results of this survey were analyzed, first in a

combined format, and then as a sample of experienced distribution center managers and a sample of non-experienced distribution center managers. The results of the survey showed the top three attributes of the systems to be: accuracy, productivity and labor management. The survey showed that the lowest three attributes to be: software, eliminate paper and brand preference. The results from experienced and non-experienced distribution center managers varied in all except the ranking of accuracy.

Recommendation

The study did not address a number of items that should be considered for a future study. To begin with the make-up of the distribution center managers list should be addressed. Secondly, the Maynard Operational Sequence Technique should be expanded in scope. Furthermore, the study as constructed did not identify some important requirements of the two technologies, and it did not demonstrate some expected outcomes, primarily because the author did not have a large enough sample of distribution center managers with either pick-to-light or put-to-light experience. For this reason, some of the results may well be skewed, but this could not be successfully demonstrated. The author is confident in stating that the software is probably the most important item to be considered: yet it falls into the bottom third or upper third of the rankings, presumably because the complexity and importance of the software is underestimated by the non-experienced distribution center managers. The study did not address the possible differences between the needs of a new facility and those of a retrofit to an existing operation. Several unknowns should be examined to truly determine the

best system. These include: percent of product that is flow through, is it a door per store model, percent product that is cross docked, what value-added processes are executed, what is the store replenishment model, who are the end customers, what is the labor model goal, what are the trash handling capabilities, what order picking processes are used, what is the capacity of the warehouse management system, what technology is currently in use, should a batch pick with secondary sort be used, what material handling methods are in place for totes or corrugated boxes, product shipping processes, order consolidation, wave processing, continuous batch processing.

All of these considerations would serve as a starting point for an expanded study. Any future study should be designed to include the whole order processing operation including picking, replenishment, order preparation and travel time to shipping.

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Appendix A: Manufacturer/Consultant/Integrator Questionnaire

patzker@uwstout.edu
Menomonie, WI 54751

Current Date

Company
Name
Address

I am an engineer for a Fortune 100 company and a part-time graduate student at the University of Wisconsin-Stout working on my Master's Degree. A portion of the course work requires a research paper be completed. The problem statement for my research paper is: Define what the key criteria that should be compared and considered in the selection of pick to light technology versus put to light technology for a less than case quantity picking application. This Request For Information is being sent to a limited number of Pick to Light and Put to Light equipment manufacturers, consultants and Material Handling System integrators. In the literature research that I have completed I was not been able to find a list of criteria that should be considered in the selection of these technologies. My literature research excluded published information from equipment manufacturers. Now, I plan to include information from manufacturers and system integrators into the paper. I am looking to you and your firm to assist me with my research.

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

By answering three questions, providing up to system two drawings, and the names with e-mail addresses of two distribution center managers currently operating your system(s).
The three questions are:

1. What are the main features of your pick to light and/or put to light system. Ranked by importance to the average user?
2. What are the key attributes that should be considered for comparing the two different technologies? Ranked by importance to the average user.
3. Why your firm/you consider these key attributes to be the most important for comparing the two technologies?

It is important to remember that this study is not a comparison of Brand A over Brand B. But, when a potential customer looks at pick to light versus put to light technology these criteria are the most important to compare. I would also like to get a sample layout of a successful installation that can be used to apply MOST Engineering standards to. The layout can be sent as an AutoCAD file or a pdf as I have access to open and print either. Since, I will be publishing my study as part of my course work I am also requesting your permission to use the information you provide within my study and possibly within the final paper. Sources used within the paper shall be given proper credit

and inclusion in the reference section. The information submitted for the questions will be analyzed and consolidated. The results will then be sent out to a select group of distribution center managers including the ones you provide for ranking from a distribution center manager's perceptive.

The following is the formal Implied Consent to Participate in UW-Stout Approved Research.

Investigator:
Randall Patzke
Patzker@uwstout.edu

Research Advisor:
Jim Keyes PhD
236 Technology Wing
Menomonie, WI 54751
715-232-5165

Risks and Benefits:

Risks are minimal if at all since the requested information is on products you sell. The benefits to provide the information are that the responses of manufacturers and integrators will be consolidated and weighted by users of the technology.

Time Commitment and Payment:

The response time for this survey should be less than 90 minutes, most likely closer to 45 minutes. You will not be compensated for responding to the survey.

Confidentiality:

Information on the distribution center managers and layout drawings will be treated as confidential and will not be published in the paper. Sources related to the answering of the questions and manufacturer or integrators information will be identified in the reference section of the paper.

Right to Withdraw:

Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. However, should you choose to participate and later wish to withdraw from the study, it may not be possible to remove all of the information provided from the study.

IRB Approval:

This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator:
Randall Patzke
Patzker@uwstout.edu

Advisor:
Jim Keyes, PhD.
715-232-5165
keyesj@uwstout.edu

IRB Administrator
Sue Foxwell, Director, Research Services
152 Vocational Rehabilitation Bldg.
UW-Stout
Menomonie, WI 54751
715-232-2477
foxwells@uwstout.edu

Statement of Consent:
By responding to the questions and request for information you have agreed to participate in the research project entitled, Key Attributes to Compare Pick to Light and Put to Light Technologies.

Please submit responses to my University of Wisconsin e-mail address. Thank you for taking your time to respond to my questions and request for information.

Randy Patzke
patzker@uwstout.edu
UW-Stout
Menomonie, WI

Appendix B: Distribution Center Manager Questionnaire

patzker@uwstout.edu
Menomonie, WI 54751

Current Date

Company
Name
Address

I am an engineer for a Fortune 100 company and a part-time graduate student at the University of Wisconsin-Stout working on my Master's Degree. A portion of the course work requires a research paper be completed. The problem statement for my research paper is: Define what the key criteria that should be compared and considered in the selection of pick-to-light technology versus put-to-light technology for a less than case quantity picking application. I am either directly familiar with you, or your name was given to me by a mutual acquaintance or from one of the firms that has provided information for my research. I am requesting your assistance in ranking the ten alphabetically listed criteria in order of importance to you as a distribution center manager.

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

The following list of ten key criterions was ranked highest from the information provided by equipment manufacturers, consultants and system integrators. They have been listed in alphabetical order, to not provide any suggestion for ranking order.

Accuracy
Brand preference or conveyor system partnership
Costs
Eliminate paper
Labor management
Productivity
Real time
Reports
Selectable function
Software

Since I will be publishing my study as part of my course work, I am also requesting your permission to use the information you provide within my study and possibly within the final paper. I will not be doing any direct quotes to permit you the freedom to answer honestly. The two statements and question I would like to have your comments on are:

1. Please include some of your experience with Pick-to-light technology
2. Please include some of your experience with Put-to-light technology
3. Are there any key criteria that you feel should have been included that are not and why?

The following is the formal Implied Consent to Participate in UW-Stout Approved Research.

Investigator:
Randall Patzke
Patzker@uwstout.edu

Research Advisor:
Jim Keyes PhD
236 Technology Wing
Menomonie, WI 54751
715-232-5165

Risks and Benefits:

Risks are minimal if at all since the requested information is on products you sell. The benefits to provide the information are that the responses of manufacturers and integrators will be consolidated and weighted by users of the technology.

Time Commitment and Payment:

The response time for this survey should be less than 30 minutes, most likely closer to 15 minutes. You will not be compensated for responding to the survey.

Confidentiality:

Information for the distribution center managers will be treated as confidential and could be used in the final paper. Responses will be treated as an unidentified source.

Right to Withdraw:

Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. However, should you choose to participate and later wish to withdraw from the study, it may not be possible to remove all of the information provided from the study.

IRB Approval:

This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator:
Randall Patzke
Patzker@uwstout.edu

Advisor:
Jim Keyes, PhD.
715-232-5165
keyesj@uwstout.edu

IRB Administrator
Sue Foxwell, Director, Research Services
152 Vocational Rehabilitation Bldg.
UW-Stout
Menomonie, WI 54751
715-232-2477
foxwells@uwstout.edu

Statement of Consent:

By responding to the questions and request for information you have agreed to participate in the research project entitled, Key Attributes to Compare Pick to Light and Put to Light Technologies.

Please submit responses to my University of Wisconsin e-mail address. Thank you for taking your time to respond to my questions and request for information.

Randy Patzke
patzker@uwstout.edu
UW-Stout
Menomonie, WI

Appendix C: Manufacturer/Consultant/Integrator Questionnaire Responses

The following are the verbatim responses from the Manufacturer/Consultant/Integrator Questionnaire Responses by firm in alphabetical order. The key phase or wording used for ranking appears in the brackets.following each response. An attempt to match wording between firms was made. Photos, drawings and diagrams have not been included.

Question #1

What are the main features of your pick to light and/or put to light system. Ranked by importance to the average user?

Dematic Corporation

Grand Rapids, Michigan

- Equipment design ruggedness. The attached photos show equipment which underwent millions of test cycles to assure the quality and robustness of their design. [Equipment ruggedness]
- Self manufactured vs. buy out hardware. Assures that all of the design and testing in Number 1 is assured through a controlled buyer initiated quality assurance methodology. [Self manufactured]
- Redundant equipment design. All devices have redundant contact points and multiple quantity of LEDs in their buttons to assure that no one failure takes the device out of commission. [Redundant design]
- 100% end of line QA testing. The efficacy of this is obvious. [100% QA testing]
- Buyer accessible diagnostics. Dematic is alone in offering diagnostics on all hardware at the floor level rather than at a computer or controller level. This

assures ease of single person maintenance and lowest out of service time in the industry as device state can be investigated at any BayDisplay in the **system as well as** at the computer level. [Self diagnostics]

- Single software instance on single server will run both put and pick systems from the same server. [Software]
- Full end user capability to add, delete and modify layouts, devices locations and location counts. No costly return visits for minor modifications. [User modification]
- Most comprehensive reporting structure in the industry. [Reports]
- A true 'real time' system capable of supporting receiving and replenishment/putaway as well as just pick and put. [Real-time]
- Base system has fully embedded voice capability to allow for lowest cost, truly velocity dependent fulfillment system on the market. [Voice capability]

Diamond Phoenix Corporation

Lewiston, Maine

- Bus rail that eliminates the need for device to device wiring [Buss rail]
- Management tools that provide visibility to order, sku, operators statistics, and offer the ability to flex the system to be operationally cost effective and efficient to process work. [Reports]
- The ability to light displays sequentially or all at once in an active zone (configurable) [Light displays sequentially]

- Multi color device capability that provides easy zone to zone demarcation by the operators (one zone light pick alerts red, the next zone is green, etc) [Multi color device]
- Diagnostics to find faulty devices and back-up picking ability in each zone. [Self diagnostics]
- Operator selectable "functions" at pick slot device level (close a tote, short a tote, push a higher quantity to a store, etc.) [Selectable functions]

Gross Associates

Woodbridge, New Jersey

- Increased productivity [Productivity]
- Increased accuracy [Accuracy]
- Elimination of paper picking documents and the control issues associated with them [Eliminate paper documents]
- Elimination of the need for unit scanning during piece pick/put operations [Eliminate scanners]
- Hands free operation [Hands free]

Innovative Picking Technologies, Inc. (IPTI)

Ixonia, Wisconsin

- Highly visible and ergonomic displays/operator interfaces that indicate location and quantity and allow the operator to confirm the pick/put. [Ergonomic displays]
- Robust software that provides an interface to the customer's host and controls the functions of the picking system. [Software]

- A reporting system that providing useful production to management in an easy to use fashion. [Reports]
- Other functions that support required business needs such as lot tracking, printing of labels and packing lists, etc. [Secondary functions]
- Secondary functions that can provide further benefits such as requesting restocking, cycle counts, etc. [Selectable functions]
- Options that can further increase accuracy such as IPTI's Sense-Me (which senses that the operator has reached into the correct pick face). [Accuracy & Hands free]
- Options that can further increase productivity and labor tracking such as IPTI's Watch-Me (which tracks and reports which picker has made a pick or put). [Productivity & Labor management]

Lightning Pick Technologies

Germantown, Wisconsin

- By moving from a paper based system to an electronic based environment we have created much more real-time feedback from pick/pack operations. While this seems obvious the benefits are over looked as we eliminate paper printing batching of orders, distributing paper, and data capture operations to collect back what has been completed and eliminating lost of hidden paper work. Labor tracking is also a byproduct of electronic fulfillment. [Real time & Eliminate paper documents]
- Lights simplify the business process by creating a predictable business process. What goes in on the start is completed in fairly predictable measures of time, with very high quality i.e. 99.9x%. This allows business management to better plan

labor allocations to order fulfillment needs and be assured that the totes or boxes being shipped are correct. [Accuracy & Labor management]

- Our software product is Lightning Pick which has been designed as a packaged solution, meaning we configure the package to the clients desired business conditions not code software. We have designed our software as an object oriented very modular system which allows for very flexible adaptations to technology changes not only with new hardware such as RFID but new software capabilities. We are based upon Microsoft technologies which provide a very stable operating platform. Microsoft also does a fairly good job of sharing future technology plans with software developers such as Lightning Pick so we can build long term software strategies with a 1-4 year planning window. This allows us to provide upgrades to our clients that want advanced features while supporting systems that are 10 years old. [Software]
- We are now utilizing a component of windows called Message ques which now allow us to provide proactive notifications to situations that a distribution manager wants to be kept informed. This can include order completion updates, order wave release updates, down conditions ECT. We trigger events and can send instant email messages or post information to marques. [Proactive notification]
- Our software is also moving to more dashboard driven screens that can be easily customized so that pick supervisors and managers can customize the screens they with data elements they wish to monitor with easily displayed graphics. These

graphics then provide a drill down capability to get at the data behind the chart. [Reports]

- We have lead the industry with providing lights without wires, we have places our light in a track system with power ends connecting the light tracks to a power supply. This makes it:
    - Easier to implement a system as both power and data are provided over a two wire/two track duct system [Buss rail]
    - The system is low voltage 12vdc. Very safe and low power draws.[green] [Low voltage]
    - The lights are easy to adjust when more or less locations are desired. (Light Image example) [User modification]
    - The system can be maintained by non-technical individuals which is has been very important to systems installed in remote areas where pick managers are responsible for all aspects of the DC.[Non-technical maintenance]
    - There are no zone controllers installed in the racks. Lights are connected via the two wire system to the power supplies which then connect to Ethernet which communicates with the Lightning Pick server. This is a simple system to manage and maintain. (System Architecture Drawing has been provided) [No zone controller]

Working Machines Corporation

Berkeley, California

Pick-to-Light

- Reporting Tools—Events by Order, Notification Reports, Productivity Reports, Orders by Product, Shorted Line Items, Productivity by Bay/Team/Individual Picker and SKU velocity reports. [Reports]
- Labor productivity reporting tools (balancing of work zones and incentive pay) or Workload Planning. [Labor management]
- Slotting (using velocity history of picked items and whether parts/SKU's should be moved to a Golden Zone for fast moving items or to the lowest/highest shelf for slower moving SKU's) [Slotting analysis]
- Cluster Picking (ability to pick multiple orders at the same time along the pick line) for traveling once and picking 5 orders at a time vs. traveling 5 times to pick 5 orders. [Cluster picking]
- Exception Reporting at the Bay Display Unit "BDU". Some of the exceptions commonly used are "Out of Stock" (pick location emptied or not enough inventory to satisfy the pick requirement), "Hold Carton" (or tote is used when the operator wants to work on another order because inventory needs to be replenished at the Pick Face), "Call Supervisor" (alert sent to supervisor by operator, who may have a question or need a break), "New Carton" (or tote because the last one is filled), "Audit Mode" (verify SKU's and their locations), "Cycle Counting" (count inventory by picking operator). [Selectable functions]

- Data Mining of information—ability to export real-time information into Excel, HTML, XML, TIF and PDF. [Real time]

Put-To-Light

- The SwiftPic Graphical User Interface "GUI" provides authorized users with the capacity to view all relevant business information (Business Intelligence Dashboard). Important trends and anomalies will be observable with a glance at the screen. [Reports]
- Automatic "Bin-To-Store" mapping. SwiftPic can automatically assign store orders to bin locations using a set of business rules such as volume for store, when the order is assigned to ship, location to routing, etc. [Automatic Bin Mapping]
- Ability to process multiple Waves at a time. Most Put-To-Light companies have to wait for the Wave to be finished before "pushing off" completed orders, then opening a new Wave. SwiftPic has the ability to manage multiple Waves at a time and assign a new order to a slot/bin location that was just completed and open. [Multiple waves]
- Productivity reporting tools and ability to re-zone work areas to balance workload. [Labor management]
- Tracking of product in real-time. If customer allows SwiftPic to manage the batch picking of SKU's, induct to the Put-To-Light operation, zone routing, carton full push-off, transport to QA and/or to shipping sorter, then real time control with visibility for management and balancing of technologies/order fulfillment can be optimized. [Real time & Selectable functions]

World Source Integration, Inc.

Batavia, Illinois

- The main features are both applications are paperless solutions that focus on visual picking or packing methodology that significantly increases accuracy and productivity, thus, reducing FTE's (full time employees). [Eliminate paper documents, Accuracy & Productivity]

Question #2

What are the key attributes that should be considered for comparing the two different technologies? Ranked by importance to the average user.

Dematic Corporation

Grand Rapids, Michigan

- No direct response to the question

Diamond Phoenix Corporation

Lewiston, Maine

- Pick-to-light and put-to-light software. Pick-to-light software is sometimes "tweeked" to run a Put application. Look for a vendor that has both (like Diamond Phoenix Corporation) [Separate software solutions]

Gross Associates

Woodbridge, New Jersey

- Pick to light is favored when order picking to multiple customers with little common product mix [Pick-multiple customer little common]

- Put to light is favored when distributing a similar mix of products (potentially with differing quantities of each item per order) to multiple orders or ship to locations [Put-similar products multiple orders/locations]
- Put to light is favored when there has been a value added process which has created a unique SKU which will be totally consumed in the distribution process. This eliminates the need to create pick locations, initially stock and then replenish, etc. [Put-valued added processes]
- For filling predetermined distros in a cross docking process the put system will generally be the better option. [Put-predetermined cross docking]
- Note: it is possible to do a pick for unique or low volume SKUs with a put to the same shipper to distribute items best suited to a put system.

Innovative Picking Technologies, Inc, (IPTI)

Ixonia, Wisconsin

- Number of SKU's and number of orders/stores/locations. This is the most important factor in comparing pick and put technologies. Applications with a smaller number of SKU's compared to a larger number of orders processed will benefit most from pick to light technology. It may be more productive as it typically requires less"touches" of the product. It also can be implemented at a lower cost when the number of SKU's is low. Applications with a large number of SKU's compared to a small number of orders or stores can generally benefit from put systems by implementing a batch pick and put to light. When the number of SKU's is large, the financial justification may not be there to put a display at each location. Using put to light is sometimes seen as providing better

financial justification. [Pick-few SKUs larger orders, Put-many SKUs few orders, Put-sometimes has better justification]

- Commonality of items between orders. Typically when there is little commonality of items between orders (the same items tend not to be included in most orders), pick strategies are employed. Put strategies are more common in applications where there is a lot of commonality. In a put system where the commonality is high, there is little walk time as the picker is making a put into virtually every container they pass. [Pick-little commonality of SKU, Put-lots of commonality]
- Distribution model – Distribution centers that employ a cross docking strategy may benefit from a put strategy. Using put to light systems or sortation systems or a combination of the two are often the best case in these situations. Also many retailers that do not engage in a lot of replenishment type orders (such as clothing retailers) tend to benefit from put strategies because basically all of the inventory for any given item is pushed to the stores at one time and there is a great deal of commonality between orders. [Put-cross docking, Put-retailers without replenishment]
- Volume of product to be picked and/or number of pickers. In some cases, the cost savings that can be achieved is based on the total number of pickers and/or the volume of product being picked. In some cases this drives the decision to which system can be implemented at a lower cost in order to provide adequate justification. [Both-lowest cost justification]
- Accuracy. Both pick and put systems can result in high accuracy rates. Depending on how the system is implemented, however, it can become a deciding factor. For

example, distribution centers that require100% QC checks may benefit from a put system as the item may be scanned into the container – accomplishing both the put and the check. [Both-Accuracy]

- Production reporting. Both pick and put systems can result in improvements in management reporting. [Both-Reports]

Lightning Pick Technologies

Germantown, Wisconsin

- Normally the decision to implement a pick to light system verses a Pack to light system is based upon the client order attributes and the DC operations.
    - If the distribution philosophy is to not carry inventory in reserve and they have a fixed set of clients or stores to distribute product then a pack to light system maybe the preferred order fulfillment process. [Put-no inventory]
    - If there are a large number of SKU's that are bar coded in the DC, with less than case pick quantities and the items are smaller, a batch wave pick with a put to light for the items to the orders can be an alternative. Here the orders are picked in a group of say 25 taken to an order where the orders shipping containers are located. Each order is assigned a light location. As items are removed from the batch pick tote they are scanned and the associated customer order light illuminates, then the items is placed in the order. This not only reduces walking thru the DC but validates the order quality as it is checked thru the put process. QC is built into the process. Internet orders can be a good candidate for this type of

process as the average order has 1.7 pieces from a larger catalog. Multiple small orders could be picked at once and then sorted down to individual customer orders. [Put-batch pick lots of SKU]

- Another ruse for a put to light is when there are kits that need to be built for new product releases or for mfg support. Case qty of items can be brought to a put station where multiple kits can be produced. Kits for products with color variations or other options can be good candidates for this type of process. (see images) [Put-kit build]
- Pick to light is best applied in a flow rack where multiple cartons of the same sku can be loaded into a product/SKU lane. Each lane has a pick light with qty indicator associated to it. The orders pass in from of the pick locations. A bar code indication the order number on the shipping container or tote is usually scanned and this cause the lights in the order to be picked. The order is then usually passed on to another person who scans the order and picks items in their area or zone for the same order. [Pick-flow rack]
- Pick to light works best for items that remain in inventory with a wide variant of client orders. [Pick-inventory lots of variation]
- We also see pick to light lines created for specific clients i.e. Wal-Mart. There are weekly replenishment orders that need to be picked per each of the Wal-Marts stores scanner data. So each day a set of stores is picked and shipped, normally of less than case qty per SKU. Many times the items have specific price tags or other value added components to where it

is easier for the supplier to create a pick to light areas specific to a client. (see pick to light image) [Pick-kit build]

Working Machines Corporation

Berkeley, California

Pick-To-Light

- High volume SKU that make up 80% of the order volume fit the Pick-To-Light "candidate" profile due to its simplicity, scalability and cost effectiveness. Also a large number of picks in a small footprint of a building. [High volume SKUs, Lots of picks in small area]
- If hardware is already in place (customer has an investment already made) with Carton Flow Rack (and conveyor) that forces the customer "down the path" of Pick-To-Light. A SKU that is visited 10 or more times per shift would be a good candidate for Pick-To-Light. [Pick flow racks, high activity SKUs]
- If inventory is separated by department or division (pet store would have cat department, dog, fish, etc.) so the pick can be made into the tote/carton, which becomes "store ready" (or aisle ready in a retail environment) for the customer. [Inventory separated by department]
- Pickers can pick between 200 to 400 lines per person per hour (based on walking distance, amount of units per line, density of SKU locations in the forward pick module, speed of workers, amount of totes/cartons to pick into, etc.) We have one customer that can batch pick up to 5,000 cartons of cigarettes per person per hour. [Productivity is 200-400 units/ hour]

Put-To-Light

- Many SKU's that are not touched everyday. Batch pick then have the Put-To-Light sort. [Many SKUs daily touches with batch pick]
- Retail store is the final customer (starting to used more for E-commerce business as well). [Retail final customer]
- Ability to cross-dock directly from container (overseas) to the store location in the Put-To-Light (by-passing bulk/secondary storage and multiple handling). [Cross dock application]
- Ability to consolidate multiple orders into one location. [consolidation of multiple orders]
- Pickers can put between 600 and 1,200 units per person per hour. We have one customer that can put up to 2,500 cartons of cigarettes per person per hour. [Productivity 600-1,200 units/hour]

World Source Integration, Inc.

Batavia, Illinois

- Pick to Light is utilized in an application where you have a fixed number SKU's that will be picked from to fill orders for either stores or customers. [Pick-fixed SKUs to orders]
- Pack to Light is utilized in an application where you have a dynamic SKU allocation flowing through the facility filling orders for stores, thus, turning the SKU's not requiring fixed locations for every SKU, and having to pass an order box past the face of every SKU location. [Put-dynamic flowing orders, Pick-fixed locations per SKU]

Question #3

Why your firm/you consider these key attributes to be the most important for comparing the two technologies?

Dematic Corporation

Grand Rapids, Michigan

- No direct response to the question

Diamond Phoenix Corporation

Lewiston, Maine

- Randy, again there are judgment calls in deciding pick vs. put rather than attributes of the system. Consider the following: [Judgment]
    - Do you have a large SKU proliferation and smaller store count?
    - Do you have a crossdocking requirement that supports a Put application?
    - What might the replenishment tasks be if you implement a picking system?
    - What are the statistics of the order profiles for you business?
    - What is the number of FTE that you'd want to assign to order processing, Crossdocking PUT can minimize this with high productivity.

Gross Associates

Woodbridge, New Jersey

- The determining factor is the amount of handling required and the productivity resulting from the overall process. [Productivity]

Innovative Picking Technologies, Inc. (IPTI)

Ixonia, Wisconsin

- The selection of pick – vs. – put technology is done by answering two questions. Which technology will satisfy the basic business needs in terms of throughput, accuracy, management reporting, etc. In many or most applications, either technology may suffice, however, in some cases like centers that employ a crossdocking strategy facilities that have layout constraints, etc. one of the strategies may be excluded. Second, which strategy results in the greatest financial justification. This is almost always based on the factors cited above which are designed to reduce walk time and the other picker effort. [Business needs & Financial justification]

Lightning Pick Technologies

Germantown, Wisconsin

- The Lightning Pick system provides more of a software product based solution which is configured to meet our client requirements. We do not product a lot of VB or C++ code to deliver to the client requirements for either a pack or pick based solution.
- Our clients like the simplicity of our systems both in terms of software and hardware. It is ease to learn implement and is flexible for change.
- We have many clients who like to update their system every few years. We provide one new release annually with few features and support for new hardware.

- We have a very solid implementation and training process. It is important to get a new system off in the right way. We provide a "conference room pilot" where we setup the base of the system and clients are invited into our conference room where we test the orders transfer process, pick or put items in mini zones, run diagnostics and familiarize our clients with the overall system capabilities.
- The simplicity of our hardware design is appreciated by all of our clients. Many have expanded their system on their own. Our clients find the hardware and software to provide them with a lot of self sufficiency they have not been used to through other experiences.
- By supporting Windows it is very easy for clients to reuse printer ques and support our system as they normally have a lot of experience in house with Microsoft products. [No directed response]

Working Machines Corporation

Berkeley, California

- When working with potential customers, if they do not have an idea of which technology to use, we typically will recommend based on their business profile (are they in the retail business and the final customer are storefronts, then Put-To-Light is a strong solution).
- The second major factor is customer budget. Funding and pricing dictate a majority of projects we work on. A Pick-To-Light system is priced by the quantity of light tag devices required for the project plus the software "pick engine". A Put-To-Light system will have more expensive software (multiple

uploads/downloads, complexities of managing Waves, etc.), but fewer light tag devices can be required.

- Goals of the customer. Reduce cost per unit handled, or increase throughput, accuracy will help influence the type of technology as well.
- Flexibility. Does the customer want to have a fixed location for a SKU and process many orders throughout the day, or the ability to process any kind of order based on not having an order assigned to a location for a long period time?
- Space availability. A traditional Pick-To-Light system has a long facing of carton flow rack facing another row of carton flow rack separated by conveyor. The Pick-To-Light system can be two, three or four stories in height. A Put-To-Light system can take up a smaller footprint because of the ability to batch pick SKUs that have orders against them, induct onto conveyor (or dropped on the floor next to Put Module) and processed/Put into orders. A customer can have only 100 lights/order locations open at a time, but process 100 orders every 30 minutes based on throughput. [Business needs & Financial justification]

World Source Integration, Inc.

Batavia, Illinois

- Understanding the clients operational merchandise flow is essential for applying the correct solution as stated above. It is the difference between a successful implementation vs. a failure. [Business Needs]

Appendix D: Distribution Center Managers' Responses

The following four pages are the responses from the Distribution Center Managers. The responses are randomly numbered and listed. Columns with no entries indicate non-responses and columns with 0's indicate those who declined to respond. Comments have been edited to eliminate years of service, company names and other information that might identify a specific firm.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Accuracy	10		0			9	9	10	7	0	0	0	8	10	10	10
Brand	5		0			1	2	2	1	0	0	0	1	2	2	2
Costs	7		0			3	10	6	9	0	0	0	9	7	6	9
Elim Paper	4		0			2	1	7	5	0	0	0	5	1	1	3
Lbr Mgmt	9		0			7	7	8	6	0	0	0	7	8	9	7
Product	8		0			10	8	9	10	0	0	0	6	9	8	8
Real time	3		0			8	5	4	8	0	0	0	10	6	7	5
Reports	6		0			4	4	3	4	0	0	0	4	4	3	4
Sel. Funct	1		0			6	6	5	3	0	0	0	3	3	5	6
Software	2		0			5	3	1	2	0	0	0	2	5	4	1
Pick Exp	no					yes	no	no	yes				no	yes	no	yes
Put Exp	no					no	no	no	yes				no	no	no	no

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Accuracy	0	0	0	0	10	8	10	10		10	10	7	7	10	0	0
Brand	0	0	0	0	7	4	6	5		6	6	2	5	5	0	0
Costs	0	0	0	0	6	9	9	6		7	7	8	9	1	0	0
Elim Paper	0	0	0	0	5	1	1	1		4	1	1	3	2	0	0
Lbr Mgmt	0	0	0	0	9	7	7	7		8	8	9	8	9	0	0
Product	0	0	0	0	8	10	8	9		9	9	10	10	6	0	0
Real time	0	0	0	0	4	6	5	8		3	5	5	6	7	0	0
Reports	0	0	0	0	2	5	4	2		2	4	4	4	3	0	0
Sel. Funct	0	0	0	0	3	3	3	3		5	3	3	1	4	0	0
Software	0	0	0	0	1	2	2	4		1	2	6	2	8	0	0
Pick Exp					no	yes	no	no		yes	no	no	no	yes		no
Put Exp					no	yes	no	no		yes	no	no	no	yes		no

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Accuracy	10	7	10		10	9		10	8	10	10	10	0		0	10
Brand	1	1	2		3	7		2	2	2	1	1	0		0	1
Costs	5	10	8		1	6		1	9	7	8	5	0		0	6
Elim Paper	8	3	4		2	1		3	3	3	2	2	0		0	8
Lbr Mgmt	7	9	7		8	8		8	7	8	7	7	0		0	9
Product	9	8	9		9	10		7	10	9	9	8	0		0	7
Real time	6	6	5		5	5		9	6	4	6	3	0		0	5
Reports	4	5	6		7	3		4	4	5	4	4	0		0	4
Sel. Funct	3	4	3		6	4		5	5	6	3	6	0		0	3
Software	2	2	1		4	2		6	3	1	5	9	0		0	2
Pick Exp	yes	no	no		no	no		no	yes	no	yes	Yes			no	no
Put Exp	yes	no	no		no	no		no	yes	no	yes	Yes			no	no

	49	50	51	52	53	54	Total
Accuracy	9	8	8	9	10		313
Brand	2	1	1	1	4		96
Costs	3	2	9	8	7		223
Elim Paper	1	4	6	3	1		102
Lbr Mgmt	5	6	5	7	8		256
Product	10	5	10	10	9		294
Real time	4	7	7	6	6		195
Reports	6	3	4	4	5		138
Sel. Funct	8	9	3	2	2		138
Software	7	10	2	5	3		117
Pick Exp	yes	yes	no	no	no		
Put Exp	yes	yes	no	no	no		

Responses

Pick-to-Light

The pick was quick and mainly accurate. Have to be cross-trained for system failures. Lack of humidity caused short circuit failures. Single controller controls multiple pick areas. Like the minimal employee training curve. Not impressed with system down time and productivity. Works well in conjunction with voice picking. Works well on a small component part carousel. Pick paths can be congested.

Put-to-Light

It was an issue at end of wave with partial cases lots. Worked well on a carousel [because] it holds the remnants. Improved put density. Works well with large identified orders. Downtime affects whole facility. Have to have the right mix of SKUs. System can be used to pick to a cart. Processes needed refinement for accuracy and productivity.

Not included

Employee experience	Ergonomics
Training	Seamless integration
Voice pick	Carousels
Managing inventory ownership	Inventory turns
Flexibility	Can software handle significant capacity

Appendix E: Maynard Operational Sequence Technique Worksheets

Maynard Operational Sequence Technique worksheets have been put together using two different methods. The Maynard Operational Sequence Technique is based on the following information for both the pick-to-light and put-to-light scenarios: Totes contain 22 pieces, wave is 3,000 pieces, pick-to-light allows multiple pieces per pick, wave is 40 stores, Case contains an average of 14 units, wave contains 125 stock keeping units, pick-to light stock keeping units are within 64 lineal feet, put-to-light is 168 lineal feet, average of 2 cases per stock keeping units, there are 177 totes used in the wave, there are 250 cases per wave, there is 67% of the pick-to-light in the Golden Zone, the warehouse worker is at the first location, radio frequency equipment is powered on and logged in.

The symbols and values are from the Maynard Operational Sequence Technique procedures:

A -- Action Distance

B -- Body Motion

G -- Gain Control

M -- Move Controlled

I -- Alignment

P -- Placement

The numbers relate to weight, distance, complexity (Zandin, 1990)

Pick-to-Light

Assume worker is at first Station			MULTIPLER	TMU	TOTAL TMU
Face empty totes	B	1			
Reach for totes	B	1			
Grab 6 totes	G	1			
Lift totes	M	10			
Pull toward self	B	3			
Lower totes	B	3			
Set on conveyor	I	1			
Release totes	B	1			
		21	10	210	
Repeat 29 times					6,300
Lower hand to pocket	B	0			
Reach into pocket	B	1			
Grab label packet	G	1			
Raise label packet	B	1			
With 2nd hand reach for RF gun	B	1			
Grab RF gun	G	1			
Raise RF gun	B	1			
Aim RF gun	I	1			
Scan label with RF gun	B	0			
Lower RF gun	B	1			
Place RF gun in holster	B	1			
Release RF gun	B	1			
Lower arm back to pocket	B	1			
Release label packet	B	1			
Raise arm	B	1			
		13	10	130	
Single occurrence					130
Turn & Face pick locations	B	0			
Reach for highest bin with light on	B	1			
Grab item from bin/carton	G	1			
Retract arm	B	1			
Position over tote	B	1			
Lower arm	B	1			
Place item in tote	B	1			
Raise arm	B	1			
Position arm at button	B	1			
Push button for each item picked	B	1			
Raise arm position in bin	B	1			
		23	10	230	
Repeat 724 times for the top and middle row					166,750

Bend at knees	B	1			
Turn & Face pick locations	B	0			
Reach for highest bin with light on	B	1			
Grab item from bin/carton	G	3			
Retract arm	B	1			
Stand up	B	0			
Position over tote	B	1			
Lower arm	B	1			
Place item in tote	B	1			
Raise arm	B	1			
Position arm at button	B	1			
Push button for each item picked	B	1			
Raise arm position in bin	B	1			
		13	10	130	
Repeat 499 times for the lower two rows					65,000
Reach for back totes	B	1			
Push as walking	P	1			
Walk forward 4 feet	B	3			
		5	10	50	
Repeat 639 moves process					32,000
Remove hand from tote	B	0			
Reach for rear lid flap	B	1			
Grab rear lid flap on side	G	1			
With 2nd hand reach for front lid flap	B	0			
Grab front lid flap on side	G	1			
Raise both lid flaps	B	1			
Interlock lid flaps	B	1			
Push lid flaps closed	B	1			
release lid flaps	B	0			
Raise arms	B	0			
Lower arm to pocket	B	1			
Reach in pocket	B	1			
Grab 1 seal	G	1			
Raise arm to tote	B	1			
Position seal	I	1			
Push seal in tote lid hole	B	1			
Raise 2nd arm grab seal end	B	1			
Position seal ends together	B	1			
Push together and lock	B	1			
Release hands	B	0			
Lower arm to pocket	B	1			
Grab label packet	G	1			
Raise label packet	B	1			
Grab corner of label	G	1			
Peel label from backing sheet	B	1			
Position label on tote	I	1			

Push label down on tote lid	B	1				
Release label	B	0				
Position hand	B	1				
Lower hand to tote lid	B	1				
Sweep hand across label	B	1				
Lower hand with label packet	B	1				
Position into pocket	B	1				
Release label packet	B	1				
Raise both hands to sides of tote	B	1				
Grab full tote	G	1				
Raise tote approximately 16"	M	6				
Extend arms about 16"	B	3				
Lower tote to take away conveyor	B	1				
Release hands	B	0				
Raise and retract arms	B	1				
Turn and face pick locations	B	0				
		41	10		410	
Repeat 176 times						72,570
				Total TMU		342,750
				Minute convert		0.0006
				Estimated Total minutes		205.65

Put-to-Light

Assume worker is at first Station	MULTIPLER	TMU	TOTAL TMU
Worker faces empty totes, raises both arms, grabs a tote, lifts tote, pulls towards self, lowers tote, turns and faces put location, extends arms, positions tote, lowers/set down tote, rotate tote, turn 90 degrees, walk 2.75 feet			
B0, B1, G1, B1, B1, B1, B1, B1, I1, B1, M3, B0, A6,	18 10	180	
Repeat 39 times			7,200
Turn around, walk back to starting point 168 feet			
B0, B32			

	32	10	320	
Repeat 125 times, Average 125 SKUs per wave				40,320

Reach and select matching cases of product, lift and position on the flanker conveyor, push to starting point. Reach down and pick-up RF scanner for the holster, raise, aim, scan case, return RF gun to holster, remove box cutter from pocket, open box cutter, cutting away cut box open, open box, de-trash if required, remove product, place in store totes per the quantity shown on the light bar displays, confirm each piece put into a tote, empty case, repeat for next case, push empty cases toward trash conveyor line, as the pick progresses, continued walking as put progresses, lift empty cartons toss into the overhead trash conveyor, at end walk back 30 feet, toss empty cartons in trash conveyor.

B1, B3, P3, B0, B3, I1, B1, B3, B3, B1, B6, B1, B3, B42, B42, P1, B1, B3, B3 ,B1, B6, B1, B32, A3, A3, B0, B6

	173	10	1730	
Repeat 124 times. Average 2 cases per SKU.				216,250

Interlock the tote lids, push down, reach into pocket for a seal, position seal at hole, take seal ends, position, push the seal together, tighten, take tote label from bin, peel, place on top of tote, push down, sweep hand over label to secure, remove RF scanner from holster, aim, scan label, return RF gun to holster, lift tote, push onto take-away conveyor.

B1, B3, B1, B3, I3, G0, G3, B1, B1, B1, B1, B1, B1, A1, B3, G1, B0, B3, B3, M3

	34	10	340	
Repeat 177 times, average 22 pieces per tote.				60,180

Reach for RF gun, key in end of wave data, return RF gun to holster.

B1, B6, B1

	8	10	80	
				80

Total TMU	324,030
Minute convert	0.0006
Estimated Total minutes	194.418