Optimization of Material Handling in a Manufacturing Warehouse Facility

by

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ABSTRACT

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Customer satisfaction and organization competitiveness are contingent upon implementing and improving existing logistics strategies. Thus, warehousing has become an integral part of a comprehensive logistics strategy for organizations. Organizations are continuing to streamline material movement in order to reduce customer shipment lead times and minimize inventory storage requirements. Technological advances in enterprise resource planning and warehouse management systems have made these efforts easier to achieve. However, the implementation of technology into warehousing represents a beginning from which current performance and improvement opportunities must be constantly evaluated.

The following study will analyze the current utilization of a warehouse management system by a company in mid-western Wisconsin. The origins of logistics and warehousing will be examined along with the impact of an automated system in warehousing and its relation to enterprise resource planning. The research methodology and subsequent results will be revealed with a discussion and recommendations based on the findings.

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Most important, I would like to dedicate this work to my wife, Jennifer, family, and friends. I am eternally grateful for the tremendous support they have provided me.

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CHAPTER I: INTRODUCTION

Warehousing has retained its importance in today's marketplace despite the emergence of supply chain management optimization techniques like lean manufacturing and just-in-time delivery. Traditionally, warehousing was regarded as a non-value adding requirement in a logistics network. However, some warehouse and distribution facilities are being asked to do much more than simply stock inventory. Manufacturing and warehouse facilities are merging together to create cohesive units that are flexible to the changing requirements of the marketplace. Warehouse facilities are being asked to assemble, package, and ship inventory in some industries. The inventory could be raw, work in process, or finished goods.

The material handling practices of warehouse and distribution facilities can have a significant impact on overall profitability for an organization. Warehousing represents the largest operational cost in the supply chains of organizations (Vega, 2004). It can represent 2 to 5 percent of the costs of sales of a corporation (Frazelle, 2002b, p. 3). Thus, an emphasis on warehouse optimization can help the bottom line of a company. The efficient use of space, equipment, and labor in the warehouse is an utmost concern for organizations looking to trim distribution costs.

Statement of the Problem

Silicon Graphics Incorporated (SGI) is a publicly traded company (New York Stock Exchange symbol SGI) that engineers and manufactures high performance computers. The company also provides visualization and storage solutions. SGI was founded by former Stanford University professor Jim Clark in 1981. For over 20 years, the company has established a strong reputation for providing technology that is used in the following fields: manufacturing, energy, life sciences, media, and government and defense. The products of SGI have been used in a variety of ways from creating computer-generated imagery in the motion picture industry to studying global climate changes and finding oil more efficiently (Silicon Graphics, 2004). SGI employs approximately three thousand people around the world with headquarters in Mountain View, CA. SGI is a company with annual revenues close to 1 billion dollars as in fiscal year 2003. SGI has a manufacturing plant and warehouse facility located in Chippewa Falls, WI.

SGI uses the 11i application suite by Oracle Corporation for its enterprise resource planning (ERP) software needs. The ERP package includes software that helps manage customer orders, inventory, bill of materials, shop floor, costing, and accounting. SGI started using Oracle 11i in July of 2001. This system is used world-wide by SGI employees. In July 2002, SGI installed an integrated warehouse management system (WMS) from Oracle. The computerized WMS represents a tool that facilitates the automation and optimization of material handling processes. The material handling processes include receipt, stocking, assembly, and shipment of inventory. It has helped SGI improve inventory accuracy and facility usage, reduce labor costs, and enhance order accuracy. However, SGI is now looking to further optimize its material handling processes with the assistance of tools provided within the Oracle WMS. Specifically, SGI is looking to optimize travel time of human and equipment resources within its manufacturing warehouse facility.

Purpose of the Study

The manufacturing warehouse facility of SGI is required to store more material in response to the expanding manufacturing facility demands. SGI logistics personnel are concerned with adherence to world-class practices and standards in order to optimize resources and minimize material handling. The purpose of this research is to address these two areas by making a series of material handling and inventory storage recommendations for the manufacturing warehouse facility of SGI. This will be done with data analysis of warehouse activity profiling and benchmarking. The significance of this research will lead to a recommendation of how items can be grouped and slotted as well as how employees can efficiently travel around the warehouse for picking and putaway of inventory. The arrangement of warehouse tour routes will be incorporated into the inventory slotting research to minimize travel time for employees and equipment. Improvements to current picking and put away methodologies will be recommended based upon the data collected during this study.

Assumptions of the Study

This study assumes setups and data in the Oracle 11i database used by SGI personnel are accurate and properly maintained. It also assumes that there were not problems with the Oracle product which would have caused data corruption during data entry by material handlers.

Limitations of the Study

Results and recommendations of this study are limited to this business case from July 2003 to March 2004. Data gathered about warehousing and material handling practices came from the Oracle 11i application and database at SGI. Data within the application could have been corrupted by poor training or problems with the Oracle product. Poor training may have resulted in users not maintaining critical setups or performing transactions in the system improperly. Problems with the Oracle product would have caused data to be missed when using SQL to query the database.

Methodology

This research is an historical quantitative study of warehousing practices at the SGI manufacturing warehouse facility from July 2003 to March 2004. Internal benchmarks will be determined for inbound and outbound inventory logistics movement at SGI. The following study will begin with a literature review of logistics, warehousing, and warehouse management systems. Conclusions and recommendations regarding operational and Oracle software setup changes will be derived from the literature review and quantitative results.

CHAPTER II: LITERATURE REVIEW

Logistics

Logistics has become a term used to describe a variety of different functions within a corporation. There are many different definitions of what logistics encompasses. The Council of Logistics Management defines the term as “part of Supply Chain Management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers’ requirements” (Council of Logistics Management, 2003). Dr. Edward H. Frazelle of The Logistics Institute at Georgia Tech University has come up with a similar, but simpler manner to describe logistics by saying it is “the flow of material, information, and money between consumers and suppliers” (2002a, p. 5).

Logistics and supply chain management are often used interchangeably throughout organizations despite the distinction that exists between the terms. Supply chain management is the management of material throughout the different stages in a supply chain in order to maximize total profitability (Chopra & Meindl, 2001, p. 6). The plume represents all activities by people and automation in a network of facilities interacting during the fulfillment of customer orders. Logistics is part of the activities within supply chain management. In relation to supply chain management, Dr. Frazelle describes logistics activities as those which “connect and activate the objects in the supply chain” (2002a, p. 8). These activities include customer response, inventory management, supply, transportation, and warehousing.

The history of logistics was forged in the twentieth century. The United States military was the only organization using the term in the 1950s and 60's. Since 1950, there has been an evolution in terminology used to describe the increased scope and influence that logistics has had in organizations. In the 1950s, workplace logistics described the flow of material at a single workstation. Facility logistics or material handling evolved from workplace logistics with a concentration on material movement within a single facility during the 1960s and into the 1970s. The integration of information systems into logistics ushered in a new era of corporate logistics in the 1970s. Corporate logistics expanded upon facility logistics by emphasizing material movement between and within facilities in order to lower logistics costs. Information systems would continue to foster change in 1980s as logistics evolved into supply chain logistics. Supply chain logistics is the flow of material, information, and money between organizations. In the 1990s, logistics became a global organizational challenge with a focus on the flow of material, information, and money between countries. The expansion of the world economy and global internet access has made global logistics a new complex concern of logistics professionals (Frazelle, 2002a, p. 5-12). Figure 1 taken from *Supply Chain Strategy* by Dr. Frazelle illustrates the transformation of logistics over the past 50 years.

The future of logistics development has been subject to many different theories. Dr. Frazelle presents that the two most popular theories are collaborative logistics and virtual or fourth-party logistics. Collaborative logistics is described as a model relying on real-time information which flows seamlessly amongst all parts of the supply chain. Virtual or fourth-party logistics is described as third-party logistics providers who act as a general contractor of all logistics activities for an organization. Third-party logistics providers are organizations that supply transportation, inventory management, or warehousing services to another organization (Lawrence, Jennings, & Reynolds, 2005, p. 23). No matter how the field of logistics develops, Dr. Frazelle maintains “that it will continue to play a major role in the success or failure of most corporations, and that it will continue to expand in scope and influence as management theories and information systems continue to advance” (2002a, p. 11).

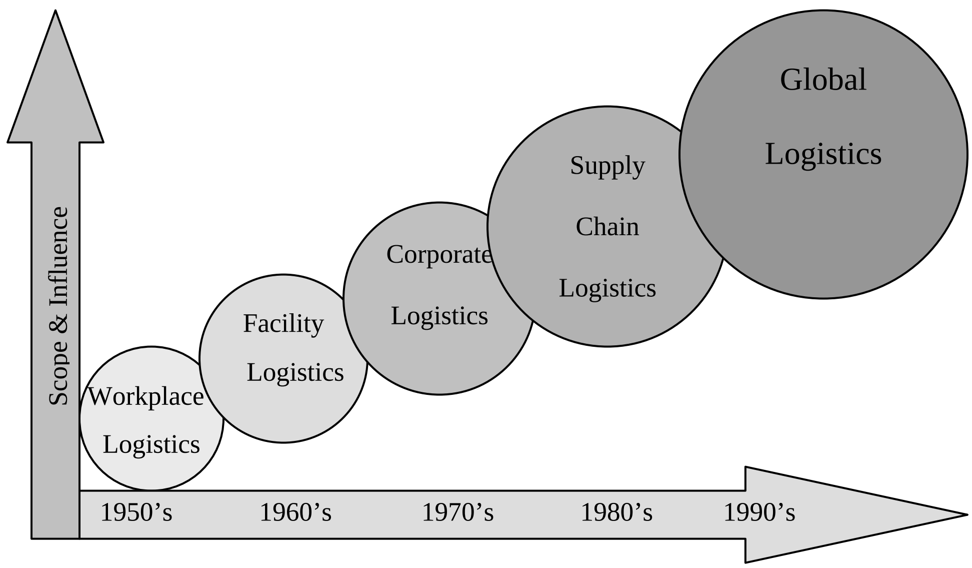


Figure 1. The Evolution of Logistics (p. 6).

The responsibilities of logistics functions within organizations have evolved along with the growing scope and influence of logistics. This is backed by the findings of the Supply Chain Management Research Group at Ohio State University. An annual survey is conducted each year to gauge how logistics functions are changing according to feedback from senior logistics and supply chain executives who are on the U.S. Council of Logistics Management. Figure 2 displays the feedback of how much responsibility the respondents had over various logistics functions for the *2003 Survey of Career Patterns in Logistics* compiled by Bernard J. La Londe and James L. Ginter of Ohio State University. The survey results are described as stable the past five years except for "a steady increase in *international* and *order processing/entry* in the decade of the 1990's (p. 12)."

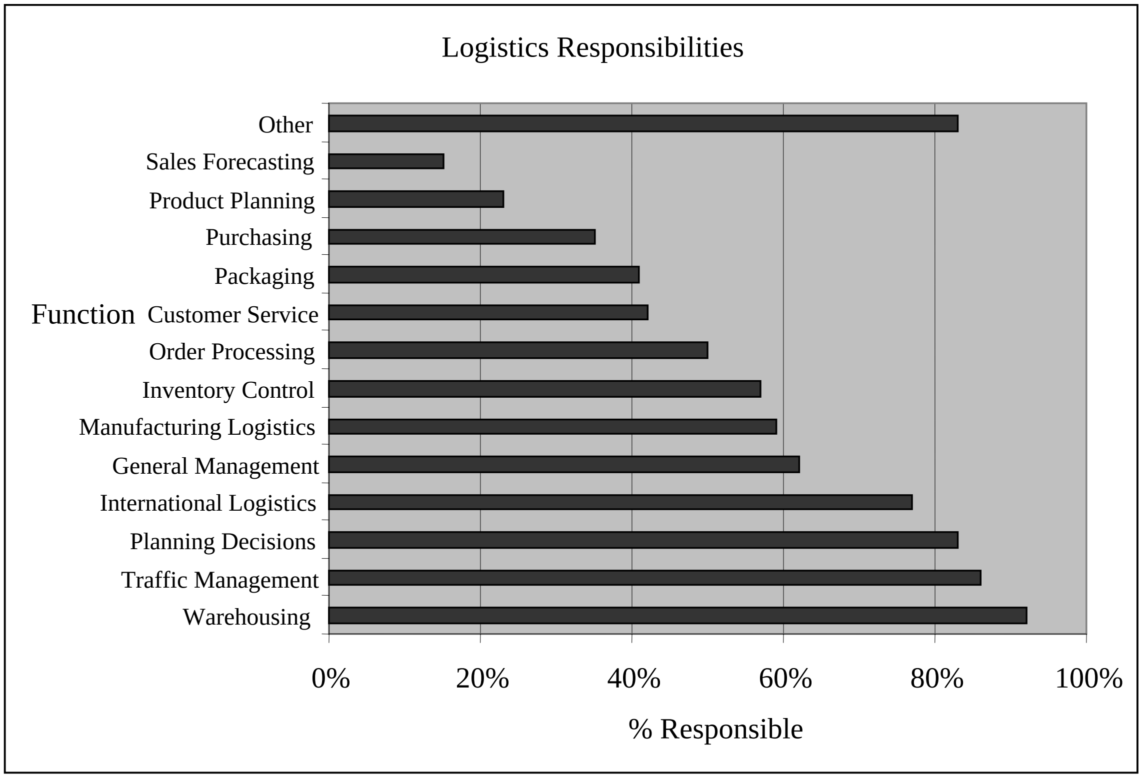


Figure 2. Responsibilities of Logistics Executives (La Londe & Ginter, 2003, p. 13).

The focus upon logistics efficiency increases competitiveness and customer satisfaction according to *The Warehouse Management Handbook* (Tompkins & Smith, 1998, p. 22–23). This is a core reason why the role of logistics continues to be emphasized in organizations. The evolution of logistics has moved it into an integrated business role that organizations must focus upon to stay competitive. Traditionally, logistics management was done in a silo according to Dr. Tompkins (p. 23). Logistics management used to be a separate business function from areas such as finance, manufacturing, sales and marketing, and quality. However, technological and philosophical advances in distribution networks, logistics methods, and logistics information systems have made logistics a key component of a business focused on customer satisfaction. Figure 3 taken from *The Warehouse Management Handbook* conveys how logistics is positioned in today's organizations.

Figure 3. Logistics' Place in 1990s Business (Tompkins & Smith, 1998, p. 23).

Warehousing

The history of warehousing goes back to the origins of humanity according to the work of Dr. Tompkins and Jerry D. Smith in *The Warehouse Management Handbook*. Humans stored food and merchandise throughout the development of civilization for commercial gain. The advances in transportation created a need for warehousing as trade points were established during the Middle Ages (1998, p. 3). This need has persisted into modern times.

The same fundamental reasons for the creation of a commercial warehouse in the Middle Ages have driven the advancement of warehousing in the United States. Warehousing became a necessity during the late 1800s and into the Industrial Revolution. Mass production and manufacturing facilities required the storage of raw and finished goods warehouses. The growing consumer sales throughout the country created a need for distribution warehouses closer to target markets. Warehouses were an important service which helped get goods to customers as fast as possible (Tompkins & Smith, 1998, p. 3-4).

Warehousing and material handling remain important areas in the supply chain of organizations today. Organizations are focusing on their logistics strategy in order to reduce costs and better serve customers. According to the *2003 Survey of Career Patterns in Logistics* conducted by Bernard J. La Londe and James L. Ginter of Ohio State University, the importance of warehousing in logistics has been growing in the 1990s and into 2003 (p. 12). Organizations have focused resources to help minimize warehousing costs which constitute between 2 and 5 percent of the cost of sales (Frazelle, 2002b, p. 3).

There are several functions performed within a warehouse which play a critical role in the supply chain. The traditional functions are broken into inbound receipt, storage, pick, and outbound shipment of goods (Tompkins & Smith, 1998, p. 2). Prepackaging, pricing, and sortation of batch picks are also becoming common warehouse activities required by organizations (Frazelle, 2002b, p. 9-11). The goods may be raw material, work-in-process, or finished goods when in the warehouse. The handling of the goods within a warehouse is dependent upon the role that the warehouse is playing in the supply chain.

Warehouses can be broken down into seven different types based on the services provided according to Dr. Frazelle. Raw material, work-in-process, and finished goods warehouses are usually located close to manufacturing facilities. Distribution warehouses and distribution centers are used to “accumulate and consolidate products from various points of manufacture within a single firm, or from several firms, for combined shipment to common customers” (2002b, p. 3). Fulfillment warehouses and fulfillment centers are designed for inbound and outbound shipment of small individual customer orders. Local warehouses are used to facilitate a quick response to customer orders which allows single items to be picked and shipped to customers every day. Finally, value-added warehouses are designed to perform activities that were traditionally part of manufacturing. These activities include sub-assembling, packaging, labeling, marking, pricing, and returns processing. Many warehouses end up spanning across the different types based on the requirements of an organization.

Warehouse Profiling

Warehouse activity profiling is the first step to identify problems with material and information flow. Dr. Frazelle describes warehouse activity profiling as “the systematic analysis of item and order activity (2002b, p. 15).” Profiling assists with identification of improvement opportunities and an objective basis for decision making. Customer orders, purchase orders, item activity, and inventory levels are some of the areas where data profiling can be useful. Key questions are asked about the profiled data in order to solve a planning and design issue. For example, customer order profiling has components such as order mix distributions, lines per order distribution, and lines and cube per order distribution. Data is gathered and compiled about these components. The data should be gathered at pre-determined intervals during normal warehouse activity (Bolten, 1997, p. 112). This data is then used to answer key questions about planning and design issues associated with order picking and shipping processes. Table 1 taken from *World-Class Warehousing and Material Handling* by Dr. Frazelle illustrates how data profiling can be setup for analysis.

Planning and Design Issue	Key Questions	Required Profile	Profile Components
1. Order picking and shipping process design	• Order batch size • Pick wave planning • Picking tour construction • Shipping mode disposition	Customer order profile	• Order mix distributions • Lines per order distribution • Lines and cube per order distribution
2. Receiving and putaway process design	• Receiving mode disposition • Putaway batch sizing • Putaway tour construction	Purchase order profile	• Order mix distributions • Lines per order distribution • Lines and cube per order distribution

3. Slotting	• Zone definition • Storage mode selection and sizing • Pick face sizing • Item location assignment	Item activity profile	• Popularity profile • Cube-movement / volume profile • Popularity-volume profile • Order completion profile • Demand correlation profile • Demand variable profile
4. Material transport systems engineering	• Material handling systems selection and sizing	Calendar-clock profile	• Seasonality profile • Daily activity profile
5. Warehouse layout and material flow design	• Overall warehouse flow design: U, S, I, or L flow • Relative functional locations • Building configuration	Activity relationship profile	• Activity relationship profile
6. Warehouse sizing	• Overall warehouse space requirements	Inventory profile	• Item family inventory distribution • Handling unit inventory distribution
7. Level of automation and staffing	• Staffing requirements • Capital-labor substitution • Level of mechanization	Automation profile	• Economic factors distribution

Table 1. Warehouse Design Issues and Related Profiles (2002b, p. 18).

Warehouse Measuring and Benchmarking

Measuring and benchmarking warehouse performance sets current warehousing performance against future goals. Benchmarking and goal setting can be defined as “the quantitative assessment of the opportunity for improvement in productivity, shipping accuracy, inventory accuracy, dock-to-stock time, warehouse order cycle time, and storage density” (Frazelle, 2002b, p. 45). It is critical to set goals at or above world-class standards an in order to focus on continuous improvement. Table 2 taken from *World-Class Warehousing and Material Handling* displays the view of what Dr. Frazelle constitutes as no-class (Stage 1) and world-class (Stage 5) warehousing.

PROCESS	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Receiving	Unload, stage, & in-check	Immediate putaway to reserve	Immediate putaway to primary	Cross-docking	Pre-receiving
Putaway	First-come-first-serve	Batched by zone	Batched & sequenced	Location-to-stocker	Automated putaway
Reserve Storage	Floor storage	Conventional racking & bins	Some double deep storage	Some narrow isle storage	Optimal hybrid storage
Picking	Pick-to-single-order	Batch picking	Zone picking-Progressive assembly	Zone picking-Downstream sorting	Dynamic picking
Slotting	Random	Popularity based	Popularity and cube based	Popularity, cube, and correlation based	Dynamic slotting
Replenishment	As needed-Pick face complete	As needed-Downstream complete	Anticipated-By sight	Anticipated-Automated	Pick from reserve storage
Shipping	Check, stage, & load	Stage & load	Direct load	Automated loading	Pick-to-trailer
Work Measurement	No standards	Standards used for planning	Standards used for evaluation	Standards used for incentive pay	Standards used for continuous feedback
Communications	Paper	Bar code scanning	RF terminals	Handsfree	Virtual Displays

Table 2. World-Class Warehousing Practices (2002b, p. 67).

Benchmarking can be internal, external, or competitive. The focus of internal benchmarking is on the operations of a particular business while external benchmarking is on operations outside of a firm’s industry. Competitive benchmarking looks at firms in the same industry (Frazelle, 2002b, p. 46). External and competitive benchmarking information can be found at The International Council of Benchmarking Coordinators (ICOBC). According to the ICOBC website, the organization is a provider of industry benchmarking data aimed at improving process and total quality.

Warehousing key performance indicators (WKPIs) can be used with benchmarking to indicate the overall state of warehouse operations. WKPIs are meaningful measurements which can be referenced periodically to analyze the current financial, productivity, quality, and cycle times for a warehouse facility. For example, warehouse quality performance measures would include the calculation of space utilization, inventory accuracy, order fulfillment accuracy (Bolten, 1997, p. 112). These measurements could be compared to internal, external, or competitive benchmarked data for gap analysis. The application of the financial measurements to the gaps can establish the potential cost savings if gaps are closed (Frazelle, 2002b, p. 52-57). Table 3 taken from *World-Class Warehousing and Material Handling* shows a summary of the WKPIs.

	Financial	Productivity	Utilization	Quality	Cycle Time
Receiving	Receiving cost per receiving line	Receipts per man-hour	% Dock door utilization	% Receipts processed accurately	Receipt processing time per receipt
Putaway	Putaway cost per putaway line	Putaways per man-hour	% Utilization of putaway labor and equipment	% Perfect putaways	Putaway cycle time (per putaway)
Storage	Storage space cost per item	Inventory per square foot	% Locations and cube occupied	% Locations without inventory discrepancies	Inventory days on hand
Order Picking	Picking cost per order line	Order lines picked per man-hour	% Utilization of picking labor and equipment	% Perfect picking lines	Order picking cycle time (per order)
Shipping	Shipping cost per customer order	Orders prepared for shipment per man-hour	% Utilization of shipping docks	% Perfect shipments	Warehouse order cycle time
Total	Total cost per order, line, and item	Total lines shipped per total man-hour	%Utilization of total throughput and storage capacity	% Perfect warehouse orders	Total warehouse cycle time = Dock-to-stock time + Warehouse order cycle time

Table 3. Warehouse Key Performance Indicators (Frazelle, 2002b, p. 56).

The use of warehouse profiling and benchmarking can establish a basis and plan for improvement. The physical movement of goods, equipment, and people can be modified along with the orientation of goods in order to meet the demands of the organization. However, a tool is still required to automate processes in order to maximize the use of warehouse resources. This is where the integration of information technology becomes a key component in warehousing. Information technology is a key to improvement when considering World-class warehousing practices.

Warehouse Management Systems

Warehouse management systems (WMS) have become an integral part of warehousing and enterprise resource planning (ERP) solutions. A computerized WMS represents a tool that can facilitate the automation and optimization of material handling processes. It can improve inventory accuracy and facility usage, reduce labor costs, and enhance order picking accuracy (Tompkins & Smith, 1998, p. 684). There are customer specific requirement accommodations with most WMS solutions. These key facets have continued to drive the importance of the WMS industry in relation to world-class warehousing. However, setting up the software and inherent business processes can be a challenge that can stymie the great promise associated with a WMS.

Successful WMS implementations are difficult for many companies. Typical of the entire industry, solution providers like Red Prairie and Oracle tout the ease of software configuration and quick realization of projected return on investments (ROI). However, WMS implementations are easier said than done. In fact, independent research analyst firm AMR Research of Boston, Massachusetts, found that nearly 60% of 100 companies contacted between 1999 and 2001 had a WMS project that did not fulfill the expected return on investment (ROI) (“Surviving,” 2002).

WMS Market

The WMS market continues to expand and change. Most of the top 1000 companies, as compiled by Forbes, in the United States have already implemented a WMS system, but many are legacy systems that have outlived their usefulness according to a July 2001 article in Modern Materials Handling by Bob Trebilcock. The WMS market, $971 million in 2000 per AMR Research, was expected to be $2.8 billion in 2003 based on 2000 industry estimates (Trebilcock, 2001). However, the economic slump of the 2001 and 2002 caused a decline in 2001 revenues for WMS systems by over 6% to an estimated $737.5 million worldwide. This included a 12% decline in the North American market, according to Steve Banker, director of supply chain research at ARC Advisory Group, Dedham, Massachusetts. Banker altered his prediction and stated that annual sales of WMS systems will not top $1 billion until 2005 (Trebilcock, 2002). The decline in sales has caused more competition for a market characterized as fragmented, with more than 400 regional and niche players fighting for business (Frazelle, 2002b, p. 219).

Survival in the WMS market has been a challenge. There have been a number of mergers and acquisitions over the past two years as providers fight for survival in the tough economic climate. In addition, major ERP providers such as Oracle and SAP have started to address the WMS market with the release of new modules that are completely integrated within their respective ERP suites. Previously, ERP providers had created a functionality gap for third party WMS solutions to fill (Frazelle, 2002b, p. 222). There are a wide range of constraints and complexities inherent to warehouse operations that contributed to this stance. All of the changes within the WMS market create an imposing decision for companies looking to address this important aspect of ERP.

The economic market has caused the price of WMS solutions to decline. Corporate mergers and acquisitions have coupled with the less than ideal economic conditions to foster lower prices for licensing and implementations. In fact, the president and CEO, Ken Lewis, of Provia Software in Grand Rapids, Michigan, has likened the current WMS market to pulling teeth (Trebilcock, 2002). Provia Software is one of the leading WMS solution providers with annual revenue of $30 million in Fiscal 2001. According to Bob Trebilcock (2002) of Modern Materials Handling, a typical high volume distribution center or warehouse would incur costs of $190,000 for software licensing fees and $360,000 for implementation costs. This total of $550,000 would go to the solution provider.

WMS Versus ERP

ERP vendors created the WMS industry. This is the viewpoint of Greg Aimi, vice president of product strategy for WMS provider McHugh Software International, Incorporated (Trunk, 1999). ERP solutions typically lacked in-depth warehousing and logistics capabilities. Thus, an opportunity was created for third party providers. However, the ERP providers have started to realize the opportunities that exist in the nearly one billion dollar market.

The ideal solution for companies with ERP packages is to purchase a WMS solution that is completely integrated. Otherwise, a WMS may need to interface with order management, finance, transportation, supply chain management, and other enterprise systems. Before 2001, none of the top five ERP providers (Baan, SAP, Oracle, JD Edwards, and PeopleSoft) had warehouse management capabilities in their products. Third party WMS software could interface with the product offering of each ERP enterprise. However, the industry lacked a completely integrated ERP solution which avoided the standard data dumps required between interfaced systems. SAP and Oracle introduced WMS solutions in 2001 which completely integrated with each respective ERP offering. Both companies touted the cost savings and accelerated implementation time associated with eliminating interfaced solutions. On the other hand, complete integration does not necessarily leave other WMS providers from gaining customers running Oracle or SAP ERP solutions. Oracle and SAP are new to WMS and not considered best-of-breed providers by analysts (Trebilcock, 2002). Experienced WMS providers such as Red Prairie still maintain a competitive edge by means of a mature product which has been successfully adopted by companies around the world.

Warehouse Management System Projects

There are steps to success and failure with a WMS project. As noted previously, WMS implementations do not always result in the desired cost savings and benefits spelled out in the project justification. A WMS implementation phases can be broken down into assessment, planning, design, implementation, deployment, and support (“Surviving,” 2002).

Assessment and Planning

A launching pad for WMS projects is the formation of a team to provide analysis of the current supply chain management structure. A review of the supply chain operations can setup the opportunities and subsequent goals of a WMS initiative. The team should consist of a project manager with WMS experience whose time is fully allocated to the project (Harrington, 2001). The project manager should be very familiar with information technology and warehouse operations according to John Hill, principal of a consulting and system integration services company called ESYNC, Toledo, Ohio ("Surviving," 2002). The rest of the project team should be formed based on who knows the former processes and who will be supporting the new system. Operating managers and information technology (IT) support personnel should be represented on the team and dedicated in parallel with the project manager. In fact, a marriage between IT and operations lead to the best implementations based on the viewpoint of Don DeCaro, executive director of implementation services for WMS solution provider MARC Global Systems, Dulles, Virginia ("Surviving," 2002). Finally, upper management should have ownership and engagement in the proceedings of the project team in order to provide strategic direction in line with the goals of the enterprise. This team will be slated with the important initial decision of what provider to use.

Picking a WMS vendor may not be the easiest step for a company even with the number of quality choices. The choice between more than 400 regional and niche players can prove difficult. The consumer may appear to be empowered with the number of competitors in the market and lack of industry dominance by one firm (Frazelle, 2002b, p. 219). However, there are a host of concerns that must be addressed in order for a suitable choice to be made.

Economic conditions during 2001 to 2003 have threatened the existence of WMS providers. Companies with WMS aspirations must determine if a potential provider is financially solvent in order to avoid a situation where the software is no longer supported after implementation. Furthermore, WMS implementers must choose a provider that suits the needs of the company while providing flexibility for potential process changes (Tompkins & Smith, 1998, p. 712). For example, a company may choose to use order-based picking, but there may be an opportunity for the company to incorporate batch or zone picking one day. A flexible WMS solution should be able to accommodate different material picking methodologies.

Another WMS provider consideration is the interfacing with third party software. The software and hardware of a WMS will likely need to communicate to a host ERP or another system. If custom code is required to permit non-integrated systems to communicate, the implementer ends up with a liability since neither third party software provider supplies direct support. This integration introduces risk to data integrity. An upgrade of interfaced software can break custom code links between applications. Richard Wilkins, vice president of WMS provider Robocom Systems, backs this point with his assertion that ERP or WMS providers will only maintain standard interfaces included with the respective product as opposed to custom (Trunk, 1999).

Enterprises will commonly require third party implementation assistance for one or more areas of the project. A third party company specializing in ERP and WMS implementations can provide valuable experience to a project. Frank Camean, senior project manager/senior associate with the New Jersey regional office of consulting and systems integration firm eSYNC International, warns that consulting services should be picked carefully in order to find someone who has gone through the pitfalls of third-party implementations (Harrington, 2001). Interfacing between WMS and another system may be a dangerous area that requires integration specialists like Catalyst International, Incorporated. Bradley Steger, product manager of integration strategies for Catalyst

International, Inc., believes that the integration issues between WMS and ERP software are not as significant as in the past (Trunk, 1999). However, this still means that a price must be paid for internal or external resources to limit any issues that might arise from interfaced software packages. In general, experienced outside consulting services can keep a project on time and budget.

The introduction of radio frequency (RF) technology may also prompt an enterprise to solicit outside help. RF technology is common to WMS solutions and allows wireless devices to be used with a system. Outside expertise is usually for companies without past RF technology experience. Failure to solicit third-party assistance can result in project delays and implementations that fail to fulfill projected ROI. There are vendors such as Redline Solutions, San Jose, California, that specialize in meeting the RF technology needs of WMS implementers. RF equipment integration with a chosen WMS system is one of the services offered by a third party vendor like Redline Solutions (Redline Solutions, 2002).

Design

A technical analysis is critical in the design phase. System design specifications will determine the required infrastructure setup requirements. This will include all networking, hardware, and software installation and setup plans. A network plan will be required for RF technology incorporation. This could be a challenge based on the inherent security risks with wireless technology. A hardware plan will ensure that servers and client devices can run software efficiently and effectively. Also, both the network and hardware require backup plans in case of service loss in the primary infrastructure.

Finally, the third-party application interfacing must be mapped out in order to facilitate communication for a WMS to another software application.

An operational analysis establishes a plan for process changes, physical warehouse layout changes, and end-user training. Processes will change with the introduction of a new WMS. The plan for new processes is required in order to setup the system as desired. According to Alan J. Reigart, principal with the St. Onge Company, York, Pa., current WMS systems are highly configurable and adaptable to new processes and changing environments (“Surviving,” 2002). End-user training should parallel the system design and support systems should be established and implemented to help users (Frazelle, 2002b, p. 228).

Gap analysis.

The identification of inconsistency points and recording of differences between what is needed and what a WMS can do should be done during the design phase according to Brian Fricke, principal consultant with PricewaterhouseCoopers' logistics/WMS practice in Atlanta (Harrington, 2001). This information is used to cover any discrepancies prior to the actual system configuration. Early detection of potential problems with system functionality can prevent project delays.

Implementation

The technical system installation establishes the required IT infrastructure for the implementation of the WMS operational setups. Most of this work falls to IT personnel. Database administrators setup and configure the servers. The software is then installed and readied for operational setups. Networking installs the wireless networking equipment in the facilities slated to utilize the system. Development readies the interface code and all other code that may be needed for testing.

Operational system setup is the point where processes and procedures are installed in the system. A WMS typically comes with a robust environment that allows for setups appropriate to the implementing company (Trebilcock, 2001). For example, WMS solutions are popular in the grocery industry since the system can dynamically indicate the special storage requirements for material. Products like milk and eggs need to be stored in refrigerated areas and the WMS system can direct a material handler to store material appropriately. Oracle WMS advertises its ability to handle hazardous material and other special needs products smoothly with the appropriate setups (Oracle Corporation, 2002).

Training.

Training is one of the most important aspects of the implementation phase. Early and extensive WMS training can serve many purposes. Training can provide proof of the WMS benefits as stated by Mike Rudolph, a logistics consultant with Provia Software, a WMS vendor headquartered in Grand Rapids, Michigan (Harrington, 2001). It can also indicate areas where operational setups can be tweaked in order to enhance processes. Finally, training during the implementation phase should permit lead trainers to document procedures and processes. This will become important during the first two to three weeks of deployment. Users will not be accustomed to the new system right after deployment and will require a reference point as stated by Rick Kiekens, project manager for WMS provider Ann Arbor Computer, Ann Arbor, Michigan (“Surviving,” 2002).

Deployment

The moment of truth for a WMS system is the flip of the switch and operation of it in production. However, there are important safeguards to minimize the risk when first using a new system. First, the deployment should occur during a slow period. Bob Carver, vice president of marketing for WMS provider LIS, Inc., Charlotte, North Carolina warns of an initial drop off in order shipments which could cost a company dearly in a busy period (“Surviving,” 2002). The second safeguard is a backup plan. Sorabh Mishra, information technology manager, for WMS implementer Sherway Warehousing, Toronto, Canada, made sure that his company had their legacy system available within 20 minutes if there was a failure with the new WMS software (“Surviving,” 2002). A final safeguard is rigid inspections of the data and documents outputted from the system. This will ensure instant problem recognition if something were to go wrong.

Support.

The parties responsible for the implementation will likely handle the initial production live support. Consultants could end up maintaining a system until it can be transitioned to personnel within the company. On the other hand, some companies choose to outsource the entire support for the system. This decision would have been made during the planning phase. It is important that support personnel have sound knowledge of the systems and procedures in order to handle any questions that users may have.

Common Mistakes

There are common mistakes which end up causing problems for WMS implementations. Problems can occur in any of the six phases previously mentioned. The mistakes include improper expectations, poor leadership, and poor design plan execution. A review of the implementation and ROI will assist in identifying mistakes. Also, an implementation audit can be a tool for ongoing improvement in the WMS setups and procedures. This will be especially true for WMS software upgrades (Harrington, 2001).

The implementation phase is vulnerable to several points of failure. Mission creep, inaccurate data, incomplete training and testing, integration failure, and operational inadequacies are five points of possible trouble. First, mission creep is common as companies try to implement sweeping changes. Mission creep is the addition of requirements to the initial scope of a project. Simplicity is recommended by analysts like Alan J. Reigart, principal with the St. Onge Company, York, Pennsylvania ("Surviving," 2002). Setup changes can always be made after deployment if a flexible WMS is chosen. Second, inaccurate data can limit the effectiveness of a WMS. Therefore, complete physical inventories are recommended to ensure accurate item- location information in the system (Harrington, 2001). Third, incomplete training and testing can also prove risky as new procedures are implemented. WMS implementers tend to mistakenly approach a project with a "big bang" concept according to Dr. Frazelle in *World-Class Warehousing and Material Handling* (2002b, p. 228). Users must be familiar with the new processes, and the system has to be sound in order for the implementation to be successful. Fourth, the importance of systems integration has been mentioned previously as a key to success. Data must be available to integrated systems for WMS to run correctly. Finally, operational inadequacies can develop from resistance to change. Operation managers may be hesitant to change processes, procedures, and warehouse layouts. The software will be useless if this attitude is adopted. Overall, the typical mistakes are avoidable with careful planning and a committed team open to change.

CHAPTER III: METHODOLOGY

SGI is looking to further optimize its material handling processes with the assistance of tools available within the Oracle WMS product. Specifically, SGI seeks to optimize travel time of human and equipment resources within its manufacturing warehouse facility located in Chippewa Falls, WI. This chapter will discuss the subject selection and description, data collection procedures, data analysis, and limitations of this study.

Subject Selection and Description

The Oracle 11i application suite and database used by SGI was chosen in order to collect data and analyze current procedures. SGI uses the 11i application suite by Oracle Corporation for its enterprise resource planning (ERP) software needs. An Oracle database holds the information generated within the application suite. SGI has been using the Oracle 11i application suite software and database since July 2001. SGI implemented Oracle WMS software in July 2002. The application software reveals the current warehouse process setups and designs. Setups would include methodologies for inventory receiving, storage, order picking, and shipping. The application database holds financial, productivity, quality, and cycle time data in relation to inventory movement in the SGI warehouse facility. The Oracle 11i application setups and database data provided information about the warehouse operations from July 2003 until March 2004. This information was used in this study to make recommendations.

Data Collection Procedures

Data was collected from the SGI Oracle 11i application setup and database as of March 2004. Application setup information was obtained by viewing the information within the warehouse management, inventory management, order management, and shipping execution modules of the Oracle 11i product at SGI. The Oracle 11i package is broken down into separate modules that help manage various business functions such as customer orders, inventory, bill of materials, shop floor, costing, and accounting. SGI also had configuration guides available which detailed the setups in the Oracle 11i application modules. This information was used as well.

Structured Query Language (SQL) was used to collect data within the Oracle database used by SGI. SQL is "a powerful, standardized programming language for performing relational database queries, updates, insertions, and other general-purpose database operations" (Base One International Corporation, 2004). SQL code was written for this research to capture key information about inventory receiving, storage, order picking, and shipping in the warehouse (see Appendix).

Data Analysis

Data analysis consisted of profiling and benchmarking current operations in the warehouse. Profiling the warehousing and material handling operations at the warehouse facility of SGI was done to identify improvement opportunities. Also, it served as an objective basis for decision making. Benchmarking data was gathered in order to establish current warehousing performance measurements. Profiling and benchmarking information was used together to establish the stage of warehousing in accordance with Table 2.

The profiled processes for this study were consistent with those found in Table 1: order picking and shipping, receiving and put away, slotting, material transport, warehouse layout, warehouse size, and automation and staffing level. Data from July 2003 to March 2004 was gathered from the Oracle database for compilation of the profiles. Oracle 11i application setups from SGI were used to determine the methodologies of the profiled processes. This information was compiled and used to identify problems with material and information flow.

Internal benchmarking was used for analysis at SGI. Internal benchmarking is focused on the operations of a particular business. Warehouse key performance indicators consistent with Table 3 were used to benchmark current operations within the warehouse facility. Information was compiled from queries of the Oracle database with data ranging from July 2003 to March 2004 (see Appendix). Internal benchmarking in the warehouse created a barometer which can be used to measure the success of future operational changes.

Limitations

Results and recommendations of this study are limited to this business case from July 2003 to March 2004. Data gathered about warehousing and material handling practices came from the Oracle 11i application and database at SGI. Data within the application could have been corrupted by poor training or problems with the Oracle product. Poor training may have resulted in users not maintaining critical setups or performing transactions in the system improperly. Problems with the Oracle product would have caused data to be missed when using SQL to query the database.

CHAPTER IV: RESULTS

SGI is looking to further optimize its material handling processes with the assistance of tools available within the Oracle WMS product. Specifically, SGI seeks to optimize travel time of human and equipment resources within its manufacturing warehouse facility located in Chippewa Falls, WI. This chapter will discuss the results of SQL inquiries into the Oracle database and analysis of Oracle module configuration guides of SGI.

Warehouse Physical Layout and Usage

The physical layout of the warehouse is defined within the setup of the SGI Oracle Inventory Management module. Two manufacturing business organizations of SGI use the warehouse facility. A standard new product manufacturing organization (MUS) and a remanufactured product manufacturing organization (RUS) share space and resources within the facility. Both organizations are created and defined within the Oracle Inventory Management module. MUS and RUS each have two defined subinventories for inventory storage and outbound shipment staging in the warehouse. Subinventories are defined as "unique physical or logical separations of material inventory" by Oracle (2003a, p. 2-26). The storage subinventories in MUS and RUS account for nine and six respective physical rows in the warehouse. Raw inventory, work in process, and finished goods inventory are held within the warehouse storage subinventories.

Storage locators are setup within a subinventory. SGI storage locators are defined by a three segment identifier that is separated by periods. An example of a storage subinventory locator at SGI is '100.A.RIGHT'. The first segment represents row and bin. The second segment represents shelf and the third represents shelf side. As of March 30, 2004, there were 3,952 locators setup in Oracle for the two warehouse subinventories. Each locator was defined with a maximum cubic volume in feet. An occupied volume is captured at the locator level as well and was reflected in the locator database data. Oracle uses a defined cubic volume in feet on items to update the locator occupied volume during material transactions.

The occupied cubic volume and maximum cubic volume were used to calculate overall space utilization in the warehouse storage subinventories. The utilization of warehouse storage locators in MUS and RUS was found to be 46% and 51% respectively. Figure 4 shows the breakdown of space utilization by row within the SGI warehouse facility. This information was captured on March 30, 2004. Rows 1 through 9 represent the MUS organization while rows 10 through 16 represent RUS.

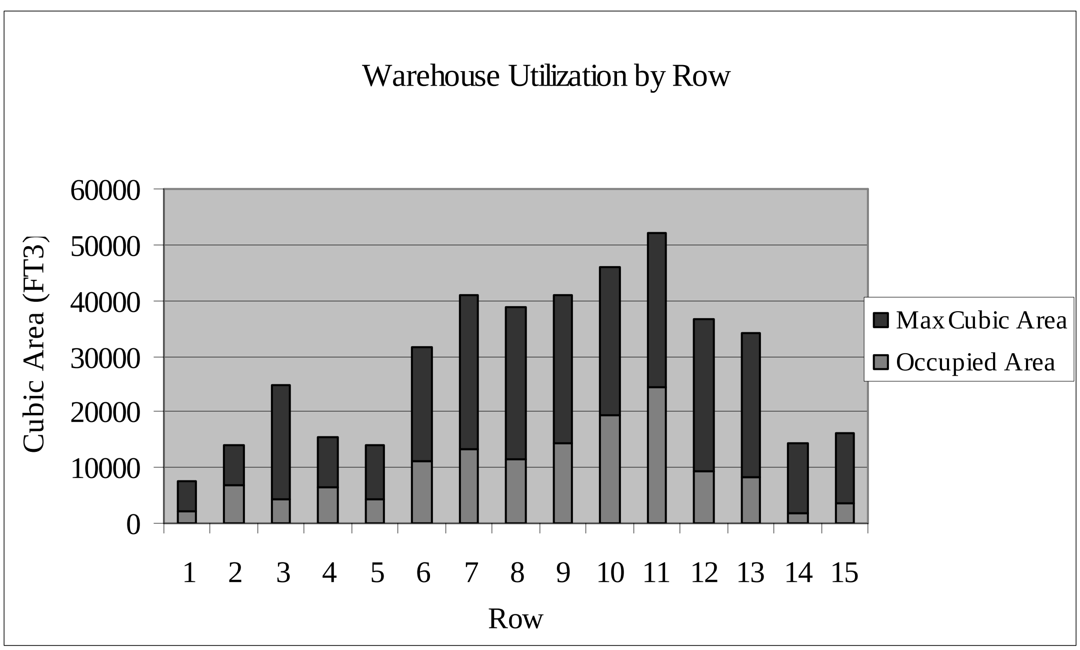


Figure 4. Warehouse utilization by row as of March 30, 2004.

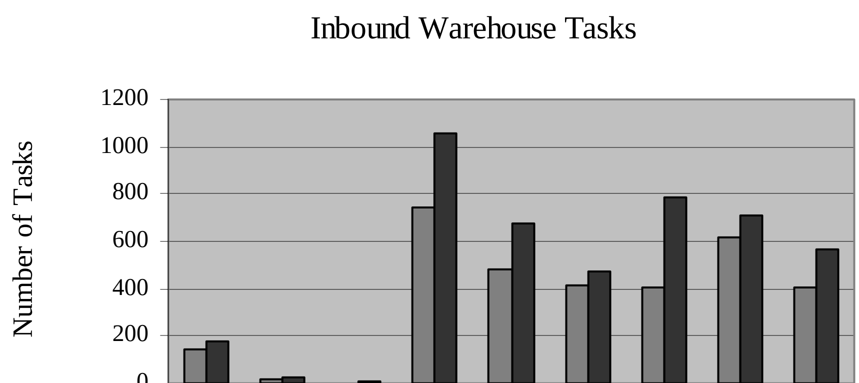
Warehouse Inbound Logistics

Purchase orders and internal inventory orders are the source of all inbound inventory in the warehouse facility of SGI. Oracle provides the option to use standard or direct receiving. Standard receiving mandates a two step transaction receiving process consisting of a receipt and delivery into inventory. Direct receiving requires a single transaction which handles the receipt and delivery (Oracle Corporation, 2003b, p. 292). SGI utilizes standard inventory receiving. Employees have the option to receive material in Oracle WMS or Inventory modules. Oracle WMS receipts are done on an RF device.

SGI uses tools within the Oracle WMS module to assist material handlers during inbound inventory stocking. Oracle WMS handles inbound deliveries with a put away transaction where the system will suggest a stock locator (Oracle Corporation, 2003b, p. 278). This suggestion is only available to material handlers if the original receipt was done in Oracle WMS and not Oracle Inventory. SGI setup a series of criteria for the system to consider when suggesting locations. The current setup looks for available space with like items present or empty locators. Material handlers are dispatched to the suggested storage locators in one of 16 rows. The storage locators did not have priority ranking or physical coordinates setup to minimize employee and equipment travel time.

Users must use one of two turret trucks when physically delivering inventory into storage locators. Turret trucks are useful in narrow isles since the vehicle does not have to turn to retrieve or put away pallets on either side of the aisle (Frazelle, 2002b, p. 103). SGI uses six foot wide aisles with embedded wire guides for the vehicles. The wire guides ensure that the vehicle does not deviate from the set path in the middle of the aisles. The distance from the receiving area to the first inventory storage aisle is approximately 125ft.

Analysis of Oracle WMS put away transactions found that material handlers overrode system suggested storage locators 72% of the time based on data collected from July 2003 to March 2004. Material handlers at SGI were forced to enter in a transaction reason if the suggested put away storage locator was not used. Transaction reasons setup within Oracle 11i Inventory Management are used to classify why a particular action was taken by a material handler (Oracle Corporation, 2003a, p. 415). The transaction reason used by material handlers at SGI for put away overrides indicated that the suggested locator did not have enough space or that the travel path was deemed inefficient. Figure 5 displays the 4,479 inbound warehouse delivery tasks and corresponding suggestion overrides performed by material handlers from July 2003 to March 2004.



	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Suggestion Overrides	145	15	4	742	478	414	409	615	407
Inbound Tasks	177	22	5	1059	679	477	783	710	567

Month (July 2003 to March 2004)

Figure 5. Inbound warehouse tasks and storage locator suggestion overrides from July 2003 to March 2004.

Warehouse Outbound Logistics

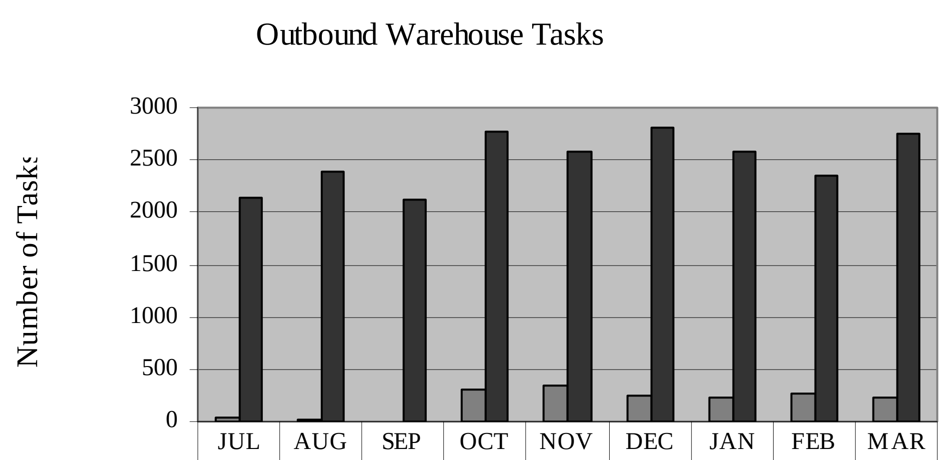
A material request for inventory stored in warehouse storage locators comes from three sources at SGI. One source is a move order. This occurs when inventory is required by the manufacturing shop floor. A move order created in Oracle represents an inventory movement request (Oracle Corporation, 2003a, p. 510). Move orders are created manually and automatically. Automatic move orders are created when the minimum on hand quantity is surpassed for an item in a particular subinventory. Customer and internal orders account for the remaining material request sources. These order types are manually created within Oracle.

All outbound material must be picked and shipped through Oracle WMS. Move, customer, and internal orders create tasks that material handlers can perform. Material handlers in the warehouse have access to pull all three order types. The tasks are dispatched to users on RF devices. Users can use an order selector or one of two turret trucks also available to inbound inventory to physically pull inventory out of storage locators. An order selector is used in narrow isles to lift the operator to pick piece parts from a storage rack (Tompkins & Smith, 1998, p. 529). The minimum distance from an inventory storage aisle to the shipment staging area is approximately 125ft. The maximum travel distance is approximately 350ft.

Outbound inventory picking tasks are dispatched in the order that the tasks were created. This causes tasks to be grouped and picked by move, sales, or internal order number. A supervisor does have access to prioritize a group of tasks for earlier completion if necessary. Oracle permits this action through the Warehouse Control Board. This tool is used to manipulate tasks: query, plan, release, assign, reassign, prioritize, and schedule (Oracle Corporation, 2003b, p. 393). Tasks are not sequenced in a particular travel path within Oracle WMS as setup by SGI. However, users do have access to manually determine a travel path through task prioritization in the Warehouse Control Board.

Oracle WMS provides pick from storage locator suggestions similar to a put away transaction in inbound logistics. The system will suggest a picking stock locator based on first-in-first-out (FIFO). The original receipt date of inbound inventory is captured upon receipt and delivery. This information is available within Oracle WMS and used by SGI for FIFO picking. Material handlers are dispatched to the suggested storage locators in one of 16 rows based on FIFO. As previously indicated, the storage locators do not have a priority or physical coordinates setup to assist in minimizing the travel time for material handlers. SGI also does not use order batching. SGI picks one order per picking tour.

Analysis of SGI Oracle WMS pick transactions found that material handlers overrode system suggested storage locators 7% of the time based on data collected from July 2003 to March 2004. Material handlers at SGI were forced to enter in a transaction reason if the suggested pick storage locator was not used. The transaction reason setup at SGI for picking override indicated that the suggested locator did not have the inventory or that the travel path was inefficient. Figure 6 displays the 22,480 outbound warehouse shipment tasks and corresponding suggestion overrides performed by material handlers from July 2003 to March 2004.



	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
Suggestion Overrides	44	18	3	298	341	252	225	271	226
Inbound Tasks	2134	2381	2118	2768	2584	2811	2579	2349	2756

Figure 6. Outbound warehouse tasks and storage locator suggestion overrides from July 2003 to March 2004.

Item pick frequency and average completion time was found by further analysis of the outbound warehouse tasks. There were 2,393 different items picked for outbound move, sales, and internal orders from July 1, 2003 through March 30, 2004. The top 34 most frequently picked items represented 21% of all 22,480 outbound warehouse shipment tasks. The average time from order task creation to completion was found to be 4.52 hours.

CHAPTER V: DISCUSSION

As stated earlier, SGI is looking to further optimize its material handling processes with the assistance of tools provided within the Oracle WMS product. Specifically, SGI seeks to optimize travel time of human and equipment resources within its manufacturing warehouse facility located in Chippewa Falls, WI. This study has examined the current warehouse facility usage and methodologies used for inventory slotting and picking. This was done by examining data within the database SGI uses with the Oracle 11i ERP application. This chapter will discuss the limitations, conclusions, and recommendations found during the course of this study.

Limitations

Results and recommendations of this study are limited to this business case from July 2003 to March 2004. Data gathered about warehousing and material handling practices came from the Oracle 11i application and database at SGI. Data within the application could have been corrupted by poor training or problems with the Oracle product. Poor training may have resulted in users not maintaining critical setups or performing transactions in the system improperly. Problems with the Oracle product would have caused data to be missed when using SQL to query the database.

Conclusions

Research results yielded information regarding the current warehouse facility usage and methodologies used for inventory slotting and picking. There were 3,952 storage locations examined for this study. Warehouse facility usage was calculated by examining the available and occupied cubic volume in feet for the storage locations. As of March 30, 2004, usage rates of 46% and 51% were found between the two manufacturing organizations of SGI which shared the warehouse facility.

The warehouse facility usage rates were affected by the inbound logistics strategy. Users were found to have been overriding system suggested storage locators 72% of the time from July 2003 through March 2004. The transaction reasons cited by users during the transactions indicated that the suggested locator did not have enough available space or that the travel path was deemed inefficient. This indicates a problem with the put away methodology setup by SGI in Oracle WMS. Inaccurate or missing volume measurements on stock locations and items could have caused the system suggestion failures due to the reliance on accurate cubic volume in the stocking methodology. Also, the storage locators did not have a priority ranking or physical coordinates setup to assist in minimizing the travel time for material handlers or to slot inventory in easier to access pick locations for outbound shipments.

The outbound logistics strategy setup with Oracle WMS performed better than inbound. Users were found to have been overriding system suggested storage locators 7% of the time from July 2003 through March 2004. The transaction reasons cited by users during the transactions indicated that the suggested locator did not have the inventory or that the travel path was deemed inefficient. Missing inventory would be dealt with under the inventory cycle count capabilities in Oracle Inventory. However, the travel path problems indicated the same issue found during the inbound logistics strategy analysis. Outbound inventory picking tasks were not being dispatched to users in an efficient travel path sequence. It was also found that picking by order from July 2003 through March 2004 led to an average task creation to completion time of 4.52 hours.

Recommendations

The usage percentage of Oracle WMS suggested put away and picking locations should match the cycle count percentage of the storage subinventory. Cycle counting is defined as the periodic counting of items designed to maintain accurate inventory quantities and values (Oracle Corporation, 2003a, p. 701). As of March 30, 2004, the cycle count percentage of the two warehouse storage subinventories was 95%. Put away and picking methodology changes should enable SGI to reach a 95% accuracy level on Oracle WMS suggestions. In the future, these changes should also decrease the July 2003 to March 2004 average task creation to completion time from 4.52 hours to under 2 hours.

Inbound and outbound logistics methodologies in the warehouse should be modified to improve stocking and picking efficiencies. One method would be to setup a locator priority ranking or position coordinates on the locators in order to dispatch tasks to users in an optimal travel path sequence. Oracle WMS task dispatching can release tasks based on priority, locator pick sequence, or approximate distance between locator position coordinates (Oracle Corporation, 2003b, p. 252). One drawback to position coordinates is that they do not take into account walls or barriers. The multiple rows and aisles used by SGI indicate that a locator pick sequence should be setup to enable an optimal travel path sequence. This will assist in inbound material stocking and outbound material picking.

The Oracle WMS picking setup at SGI had users picking by order. According to Table 2 taken from *World-Class Warehousing and Material Handling*, picking by order is the lowest stage among picking methodologies. SGI should look at setting up zone picking with downstream sorting. Oracle WMS supports this methodology (Oracle Corporation, 2003b, p. 63).

Frequently picked items could be stocked in dedicated storage locations closer to the shipment staging area. A category in Oracle Inventory can be setup for a group of items found to represent a particular percentage of outbound inventory picks. A category code is used to group items with common characteristics (Oracle Corporation, 2003a, p. 985). The inbound storage methodology in Oracle WMS could then be modified to restrict suggested stock locations for the category of frequently pick items. This will also assist outbound average task creation to completion time.

Further transaction reason codes should be setup to garner details about why users override system suggestions. Transaction reasons are setup within the Oracle Inventory module and are used to classify why a particular action was taken by a material handler (Oracle Corporation, 2003a, p. 415). Transaction reason codes setup in inbound warehouse logistics indicated that the suggested locator did not have enough space or that the travel path was deemed inefficient. Codes setup in outbound warehouse logistics indicated that a suggested locator did not have enough on hand inventory or that the travel path was inefficient. Separate transaction reason codes should be setup for each possible override explanation. This will enable system support personnel to determine the exact reasons why users are overriding system suggested locations for put away and picking tasks. Support personnel should run SQL or use the task exceptions report options in the Oracle Warehouse Control Board to determine task override percentages on a monthly basis (see Appendix).

Cubic volume on stock locations and items should be monitored and maintained in Oracle 11i as new items and locations are created or modified. The SGI Oracle WMS setups rely on accurate cubic feet volume measurements on items and locations in order to generate put away suggestions. Failure to accurately maintain these measurements will result in high task override percentages on inbound inventory put away suggestions. Warehouse storage space utilization will also be affected by poor volume maintenance in Oracle. As previously mentioned, detailed reason codes will help support personnel identify volume problems and facilitate corrective measures.

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Appendix

Structured Query Language Code

Warehouse Utilization

```
SELECT
SUM(mil.current_cubic_area)
,SUM(mil.max_cubic_area)
FROM apps.mtl_item_locations mil
WHERE mil.subinventory_code in ('&SUB')
AND mil.disable_date is null
AND mil.volume_uom_code is not null
AND mil.current_cubic_area is not null;
```

Inbound Logistics

```
SELECT DISTINCT we.*
FROM apps.wms_exceptions we
, apps.mtl_material_transactions mmt
WHERE we.last_update_date > '&Begin_Date'
AND we.last_update_date < '&End_Date'
AND we.subinventory_code in ('CWHS','CF-RSTK')
AND we.reason_id = 312
AND we.transaction_header_id = mmt.transaction_set_id
AND mmt.transaction_type_id in (18,15,12);
```

```
SELECT DISTINCT wdth.*
,mmt.transaction_type_id
FROM apps.wms_dispatched_tasks_history wdth
,apps.mtl_material_transactions mmt
WHERE wdth.last_update_date > '&Begin_Date'
AND wdth.last_update_date < '&End_Date'
AND wdth.transaction_id = mmt.transaction_set_id
AND mmt.subinventory_code in ('CWHS','CF-RSTK')
AND mmt.transaction_type_id in (18,15,12);
```

Outbound Logistics

```
SELECT DISTINCT we.*
FROM apps.wms_exceptions we
, apps.mtl_material_transactions mmt
WHERE we.last_update_date > '&Begin_Date'
AND we.last_update_date < '&End_Date'
AND we.subinventory_code in ('CWHS','CF-RSTK')
AND we.reason_id = 312
AND we.transaction_header_id = mmt.transaction_set_id
AND mmt.transaction_type_id in (52,53,63,64);
```

```
SELECT DISTINCT wdth.*
,mmt.transaction_type_id
FROM apps.wms_dispatched_tasks_history wdth
```

```
,apps.mtl_material_transactions mmt
WHERE wdth.last_update_date > '&Begin_Date'
AND wdth.last_update_date < '&End_Date'
AND wdth.transaction_id = mmt.transaction_set_id
AND mmt.subinventory_code in ('CWHS','CF-RSTK')
AND mmt.transaction_type_id in (52,53,63,64);

SELECT DISTINCT
 msib.organization_id
,msib.segment1
,msib.inventory_item_id
,msib.volume_uom_code
,msib.unit_volume
,count(*)
FROM
 apps.mtl_system_items_b msib
,apps.mtl_material_transactions mmt
,apps.wms_dispatched_tasks_history wdth
WHERE msib.organization_id in (4,5)
AND mmt.organization_id = msib.organization_id
AND mmt.inventory_item_id = msib.inventory_item_id
AND mmt.subinventory_code in ('CWHS','CF-RSTK')
AND mmt.transaction_type_id in (52,53,63,64)
```

```
AND wdth.transaction_id = mmt.transaction_set_id
AND wdth.last_update_date > '01-JUL-2003'
AND wdth.last_update_date < '01-APR-2004'
GROUP BY
 msib.organization_id
,msib.segment1
,msib.inventory_item_id
,msib.volume_uom_code
,msib.unit_volume;

SELECT DISTINCT wdth.*
,mmt.transaction_type_id
,to_char((wdth.last_update_date -
wdth.effective_start_date)*24*60,'9999999.99') CREATION_TIME_TO_FINISH
FROM apps.wms_dispatched_tasks_history wdth
,apps.mtl_material_transactions mmt
WHERE wdth.last_update_date > '&Begin_Date'
AND wdth.last_update_date < '&End_Date'
AND wdth.transaction_id = mmt.transaction_set_id AND
mmt.subinventory_code in ('CWHS','CF-RSTK')
AND mmt.transaction_type_id in (52,53,63,64);
```

```
SELECT DISTINCT wdth.*
,mmt.transaction_type_id
,to_char((wdth.last_update_date - wdth.dispatched_time)*24*60,'9999999.99')
DISPATCH_TIME_TO_FINISH
FROM apps.wms_dispatched_tasks_history wdth
,apps.mtl_material_transactions mmt
WHERE wdth.last_update_date > '&Begin_Date'
AND wdth.last_update_date < '&End_Date'
AND wdth.transaction_id = mmt.transaction_set_id
AND mmt.subinventory_code in ('CWHS','CF-RSTK')
AND mmt.transaction_type_id in (52,53,63,64);
```