



# WPI



## **Improving Customer Satisfaction and Fulfillment at Emuge U.S.A**

A Major Qualifying Report Submitted to the Faculty of  
**WORCESTER POLYTECHNIC INSTITUTE**  
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## Abstract

The overall objective of this Major Qualifying Project was to design and integrate a barcoding system with Emuge's SAP Inventory Management system at their North American warehouse located in West Boylston, MA. The goal of this barcoding system was to offer a financially viable complement to Emuge's current SAP Inventory Management system in lieu of the company purchasing a costly, new SAP package, without interrupting their daily operations. The proposal included methods the warehouse could implement to operate more efficiently, while reducing human error and verifying that the correct products are delivered to the correct customers. A financial analysis of the costs associated with shipping errors was performed. A recommendation of technology used to eliminate fulfillment errors was provided, as well as an analysis on the project's potential return on investment.

A review of the state of the art revealed inefficiencies in Emuge's current shipping operations. Observations showed that Emuge employees are subject to human error while picking products from inventory for customer orders. Personal interviews with Emuge employees verified this observation revealing minute details differentiating products that are often difficult to discern for employees after processing large volume customer orders with multiple product types. These human errors can lead to inaccurately completed customer orders that result in increased cost. Resolving this issue within Emuge's shipping operations will reduce costs associated with shipping errors and improve their bottom-line results and brand reputation.

The approach was to understand Emuge's unsatisfactory shipping operation errors by analyzing their current process and connecting input from Emuge employees.

The methods used to complete this project included site visits and direct personal observation, interviews with Emuge staff, as well as resources from outside the company, a

detailed financial analysis, an axiomatic design decomposition using Acclaro® software, and additional independent research on inventory management practices was performed.

The results of our project illustrated the feasibility of successfully integrating a barcode scanning system into Emuge's SAP Inventory Management, as well as the costs associated with implementation.

After analyzing the collected data, measuring the effectiveness of the barcoding system with SAP, and performing a detailed financial analysis, we concluded that: It would be both financially viable and beneficial for Emuge to implement the barcoding system with their current SAP Inventory Management package.

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# Chapter 1 - Introduction

## 1.1 Company Background

Founded in 1920, Emuge Corporation is a global manufacturer of precision cutting tools, such as taps, thread mills, drills, end mills, tool holders and workpiece clamp devices. With their headquarters located in Lauf, Germany, Emuge has over 1,600 employees and provides services to over 50 countries worldwide. Emuge also owns the Franken milling company which is why their German headquarters operates under the name “Emuge-Franken” (Emuge, 2018).

In 1984, Emuge established “Emuge USA” in an effort to better serve the North American market by providing local inventory and distribution means through their West Boylston, Massachusetts facility. This facility primarily acts as a distribution center responsible for holding inventory received from Germany and shipping directly to consumers in the U.S and Canada through orders placed with their joint sales team. However, as of 2015, Emuge has been able to provide manufacturing capabilities for speciality products due to their opening of a tool reconditioning center at their West Boylston facility (Emuge, 2018).

Throughout their almost 100 year existence, Emuge has obtained numerous patents, as well as being credited with the invention of the spiral point tap in 1921. As seen in Appendix A, Emuge’s products allow for increased manufacturing productivity across nine industries, the largest of which are general machining, automotive, energy, and heavy equipment. Emuge credits their growth and success to their dedication to “craftsmanship, innovation and quality” (Emuge, 2018).

## 1.2 Problem Statement

Due to the potential for human error within their “picker-to-part” system, inefficiencies and mistakes can arise during the inventory picking process when the incorrect tool and/or quantity is shipped (Chao-Hsien Pan et al., 2012). Shipping errors compromise Emuge’s reputation and affect their customers’ ability to conduct their own processes using Emuge’s products. Emuge’s most popular products sell for between \$20 and \$200 dollars, with shipment errors occurring approximately 10 to 15 times per month (Shipping Operations Manager - Emuge, 2017).

With the exception of the SAP inventory tracking system, Emuge’s entire picking and shipping process is manual, and relies heavily on human interaction and decision making. A detailed explanation of each step of Emuge’s process is shown in Figure 2. When an order is processed from the sales department, a packing list is released via a printer in the outbound section of the warehouse. An employee uses the location code of the products on the packing list to retrieve the products from the correct bins. Here lies the opportunity for human error due to little differentiation between product codes. The product is then picked and signed by the whoever retrieved the product. The order is then double checked by another team member and signed off for shipment. This is the final opportunity for human error because when the item leaves this station the employee responsible for shipping does not check the product.

## 1.3 Objective

The goal of this project was to reduce or eliminate the possibility of shipping errors from Emuge’s West Boylston distribution center through the design and implementation of a barcode



scanning system that integrates Emuge's SAP inventory picking process. There are other opportunities for human error within Emuge's inventory management operations, such as the incorrect placement of tools into their storage locations; however, the focus of this MQP was on eliminating errors specifically incurred from shipping operations. Our deliverable is to provide a solution which seeks to eliminate human error from picking, at a reasonable cost, while at the same time limit disruption to the warehouse environment.

## 1.4 Field of Review by Chapter

Chapter 1 provides an introduction to this project, which includes a problem statement and project objective, as well as a company background.

Chapter 2 communicates the impact that inventory control systems can have of customer satisfaction and company performance.

Chapter 3 addresses Emuge's warehouse process and the benefits the company would gain by integrating a verification system within the warehouse. Additionally, this chapter provides details about implementation should Emuge choose to invest in a verification system.

Chapter 4 ties together chapters 2 and 3 by discussing how a subsidiary, such as Emuge, can increase their reputation within a multinational corporation. It also discusses the role of incentives in promoting culture growth. By developing their prowess as a subsidiary, Emuge may receive a larger portion of investments and become the standard for Emuge-Franken best practices.

Chapter 5 contains a summary of the entirety of the paper and makes conclusions based on data analysis.

# Chapter 2 - The Impact of Inventory Control on Customer Satisfaction

## 2.1 Introduction

Given that customer satisfaction encompasses a large field of subjectivity, it is difficult as a company to measure the financial and reputational impact poor satisfaction may have. This is largely in part due to the loss of a potential customer, not a current customer. There is no way for a company to quantify the number of potential customers they may lose from one customer's dissatisfaction. However, customer loyalty has been shown to have a dramatic potential to increase or decrease profits for a firm (Eckert, 2007). Dissatisfied customers spread poor reputation more than satisfied customers, making it essential for companies to focus a significant portion of their efforts on full satisfaction. Supply chain management plays a major role in ensuring a high level of consumer happiness. Fulfillment errors during B2B exchanges, that stem from poor inventory control, promote unsatisfied customers leading to potential loss of profits, and reputation (Tracey et. al, 2005).

## 2.2 Background

The team investigated the effects of poor customer satisfaction on firms, while focusing on the negative returns from fulfillment errors. The team consulted "Inventory Management and its Effect on Customer Satisfaction", as well as an empirical study "The Impact of Supply-Chain Management on capacity Business Performance", which analyzed the relationship between inside-out supply chain management and its effect on four performance metrics. Inside-out supply-chain management refers to the processes undertaken after the good is received in the

warehouse, such as: inventory control, finished goods warehousing, packaging, and outbound transportation.

### 2.2.1 The Effect of Customer Satisfaction on a Company

Customer satisfaction refers to the customer's experience during the life cycle of products or services they receive (Eckert, 2007). A satisfied customer is more likely to repurchase items from the same company and develop brand loyalty (Eckert, 2007). Brand loyalty can be achieved by creating a superior product, but in non-monopolistic markets, customer service is likely to achieve the desired effect when products across the market have limited differentiation (Eckert, 2007). Satisfaction can encompass quality, ongoing business, price-performance ratios, and exceeding customer expectations (Eckert, 2007).

There is a disproportionate relationship between the factor or cause, and the consequence for the company. An increase in loyalty as much as 5% can improve profits for a company by 25% to 85% (Eckert, 2007). Eckert also found that loyal customers are six times as likely to repurchase or recommend the product to their peers (Eckert, 2007). Satisfied customers are likely to tell five other people about the purchase, while dissatisfied customers may tell up to nine of their peers about the company's failure to meet expectations.

On average, 4% of customers will complain about the product. A company can reduce this percentage in their own products by achieving the "Perfect Order" scenario; When the customer feels they have received the right product, at the right destination, in the correct condition, with documentation and acceptable cost (Eckert, 2007). Company's can achieve "Perfect Orders" by using aggressive inventory management, restructuring supply chain operations, and updating standards to the perfect standard (Eckert, 2007). Components of the path to meeting the "Perfect Order" include: successful demand forecasting, data

synchronization, lack of damaged or unusable products, days in supply, as well as the ordering time cycle (Eckert, 2007). Technology's role in inventory management will improve customer service and vendor partnerships, while increasing data integrity (Eckert, 2007). A high level of data integrity within the system is significant as it produces detailed performance metrics, and potentially real time alerts for errors (Eckert, 2007).

### 2.2.2 The Competitive Nature of Inventory

Having excellent inside-out processes such as: packaging, finished goods warehousing, inventory control and outbound transportation, allows companies to keep promises to customers while maintaining acceptable inventory levels and expenses (Tracey et. al, 2005). The quality of these traditional physical distribution activities have "important repercussions regarding the firm's capacity to satisfy customers" (Tracey et. al, 2005).

An empirical study conducted by Michael Tracey et. al was designed to test the impact of supply-chain management capabilities on business performance to determine if customer-oriented issues influence the company's competitiveness and performance (Tracey et. al, 2005). The study covered inside-out capabilities' effect on four performance metrics: (a) perceived product value, (b) customer loyalty, (c) market performance, (d) financial performance (Tracey et. al, 2005). To conduct the study, the researchers analyzed 468 out of 3,255 five-point Likert scale surveys from managers and executives across four manufacturing industries: furniture and fixtures, fabricated metal products, industrial and commercial machinery, electronic and other electrical equipment (Tracey et. al, 2005). The respondents proportionally represent each industry in the study. Using a Lisrel analysis, the researchers were able to conclude that inside-out capability has significant direct effects on all four measures of the performance construct, including customer loyalty, and perceived product value (Tracey et. al, 2005).

## 2.3 Discussion

Emuge U.S.A acts primarily as a service and distribution subsidiary of Emuge-Franken. However the empirical study used for this analysis is applicable, as Emuge stands behind their parent companies' products as if they were manufacturing them themselves. Emuge's most popular products sell for between \$20 and \$200 dollars, with shipment errors occurring between 10 and 15 times per month (Shipping Operations Manager - Emuge, 2017). Although there is no data available to measure the impact of fulfillment errors on customer retention, there is data that show unsatisfied customers are likely to share their experience with about twice the number of people than satisfied customers (Eckert, 2007). Each incorrect order Emuge ships has the potential to lose a customer, or a potential customer. This affect on brand reputation and profits holds Emuge back from greater customer satisfaction, higher loyalty, and thus higher profits. Satisfying customers in "today's marketplace encompasses picking orders accurately, meeting their packaging specifications, fulfilling delivery schedules, responding promptly to customer requests, and in general performing well in regards to outbound logistics" (Tracey et. al, 2005). By improving Emuge's fulfillment stage they have the strong opportunity to increase their profits through a boost in their reputation. Although you cannot directly link fulfillment errors as the sole reason of customer dissatisfaction, to a loss of customer, it certainly is a component of it. The obvious cost of a shipping error is the potential loss of a customer, what is not obvious is the cascading impact on potential new customers and partnerships. In a study conducted in Sweden by Eugene Anderson et. al found that firms with an average net income of \$65 million that experience an annual one point increase in customer satisfaction, obtain a net present value of \$7.48 million over five years because of their customer satisfaction(Anderson et. al, 1994). The

findings of Anderson also indicate that returns from improving customer satisfaction are not necessarily realized right away. This is largely in part due to customer satisfaction affecting future purchasing behavior, where returns are realized in subsequent periods (Anderson et. al, 1994). Managers of firms need a long-term viewpoint to fully realize the impact of their investment in customer satisfaction. By treating customers as assets, instead of “disjoint mutually exclusive transactions”, managers of firms can apply a value to their asset and work towards growing that asset (Anderson et. al, 1994).

# Chapter 3 - Integrating Verification System for Inside-Out Supply Chain Management

## 3.1 Introduction

The team reviewed several resources as a guide through background information relative to the topics of SAP, barcoding, axiomatic design and order picking. The methods section of this chapter informs the reader of the tools used in the design of the solution for Emuge U.S.A's current picking verification system. The results and discussion section details the current process, as well as the proposed solution, and compares the costs versus the benefits of implementation. The chapter concludes with a high cost solution recommendation detailing best practices within industry.

## 3.2 Background

### 3.2.1 SAP

SAP, an acronym for, "Systems, Applications and Products", is an enterprise resource planning software produced by SAP SE, a German-based multinational software company that gives enterprises across various industries the capability to operate their business more efficiently due to its ability to analyze, store, and convey data in real time (SAP Software Solutions, 2018). Among other functions, it is used as an inventory management tool because of its ability to organize inventory by assigning storage locations for items, as well as track the movement of inventory into, within, and out of a warehouse (SAP Extended Warehouse Management, 2018). Its ability to generate and track sales reports alerts companies if an item is on back order and even has the capability of automatically ordering more of an item from the

supplier once the amount in inventory reaches a certain level. Additionally, it can help companies make inventory based decisions that affect their sales. Because of SAP, companies can, among other things, optimize their inventory management processes and successfully deliver their products to their customers when the customers want them (Klappich and Tunstall, 2017).

### 3.2.2 Barcoding

Barcodes are vertically even, varying width parallel lines used to represent digits assigned to a particular product (Account Manager - Barcodes Inc., 2017). They are meant to be read with an optical scanner that can produce automatic identification of the product the barcode is positioned on (Barcodes Inc., 2015). The use of barcodes is common in warehouse management systems as they can improve the efficiency of logistics operations, reduce management costs, and improve “picking” accuracy by acting as a verification system (Hong-ying, 2009). Barcodes lend necessary assistance to point of sale management by providing detailed up-to-date information on business processes. Barcodes allow for fast selling items to be identified quickly and reordered immediately, as well as preventing inventory buildup by identifying slow moving products (Hong-ying, 2009). Historical data stored from transactions can be analyzed through statistical analyses to detect seasonal fluctuation or order behavior. Barcodes need a line of sight from a reader in order to process the limited data storage they have, resulting in a dramatic increase in processing time trying to first locate the barcode on a product, and then lining up the optical scanner to process the barcode (Siram et al., 1996).



### 3.2.3 Axiomatic Design

Axiomatic design method is a design methodology that uses a systematic approach based on two domains, Functional Requirements (FRs) and Design Parameters (DPs), to decompose any design flaw and reach an optimal design solution that fulfills Customer Needs (CNs) (Suh, 1999). FRs consist of any requirements needed to solve the problem, whereas the DPs are any components needed to fulfill the corresponding FR's. It's hierarchical structure calls for both "Top Level" FRs and DPs, each of which are broken down into "Sub Level" FRs and DPs, each of which are contingent on their preceding FR (Functional Specs, Inc., 2017). Axiomatic design is based on two design axioms, the Independence Axiom and the Information Axiom. This means that each FR should be independent from one another and that there needs to be as little information as possible within the system to successfully fulfill the FRs (Functional Specs, Inc., 2017). When two designs both satisfy the independence axiom, the design with the least information within the system is the most suitable design. This design method is valuable to engineers because it uniquely "takes you from argument to analysis" in evaluating any design while changing design from a series of ideas into a science (Brown, 2006).

### 3.2.4 Order Picking

Order picking is "the retrieval of a number of items from their warehouse storage locations to satisfy a number of independent customer orders" (Petersen II, 1997). There are numerous methods of order picking, both automated and manual (Barcodes Inc., 2015). Manual order picking methods can rely heavily on warehouse layouts because the distance and time it takes an employee to travel to a storage bin and back is considered non value added time because labor costs still apply (Chao-Hsien Pan et al., 2012). Due to its simplicity, the most common method of manual order picking is known as "Picker-to-Part", which requires a warehouse

worker known as a “picker” to travel to a storage location to retrieve ordered items (Chao-Hsien Pan et al., 2012). However, technologies such as mobile computers can be easily implemented into a “Picker-to-Part” method as a way of ensuring a degree of verifiable accuracy (Barcodes Inc., 2015).

### 3.3 Methods

In order to successfully complete our project objective it was necessary that our methods clearly illustrated how our data was collected and how it was analyzed. Our data collection and analysis methods consisted of the following:

#### Observations

Site visits and observations were conducted to develop a better understanding of Emuge’s shipping operations by gathering hands-on experience through the shadowing of employees throughout the fulfillment process.

#### Interviews

Interviews were conducted to develop a better understanding of the functional requirements of the current system and how Emuge could leverage barcoding to reduce or eliminate human error. Several correspondences were made between industry professionals familiar with standard warehouse functionality, best practices, and SAP software functionality. This included a branch manager from Harvey Building Products, as well as an Account manager from Barcodes Inc., a software and hardware consultant for inventory management.

### Problem Decomposition

Through the use of Acclaro® the team developed a hierarchical decomposition of the functional requirements and their corresponding design parameters necessary to satisfy the goal of the system.

### Financial Analysis

A financial analysis was executed to satisfy the financial viability of our solution compared to costs pertaining to errors in shipping.

### Research on Alternative Inventory Control Methods

Research on alternative inventory control methods was performed as a way of studying best practices associated with warehouse management and shipping operations.

## 3.4 Results and Discussion

This section details the results of the methods used by the team in search of meaningful inventory management improvements for Emuge. The discussion includes observations made within Emuge's facility, the results of conducted interviews, the use of axiomatic design through Acclaro for problem decomposition, a financial analysis of related costs and potential return on investment (ROI), as well as independent research into best practices within the industry.

### 3.4.1 Understanding Warehouse Operations

The team held observation periods at Emuge U.S.A during business hours to gain insight into the flow of traffic through the warehouse and the efficiency of picking methods. A walkthrough of the entire process from receiving to shipment was completed to thoroughly understand how products interact with SAP and the methods used by employees to store, pick, package and ship products.

The team developed a warehouse layout diagram that was invaluable in visualizing the functional requirements of the problem decomposition. Additionally, the warehouse layout diagram was beneficial in explaining to interviewees Emuge’s current inventory control system and shipping operations. The warehouse layout can be seen below in Figure 1:

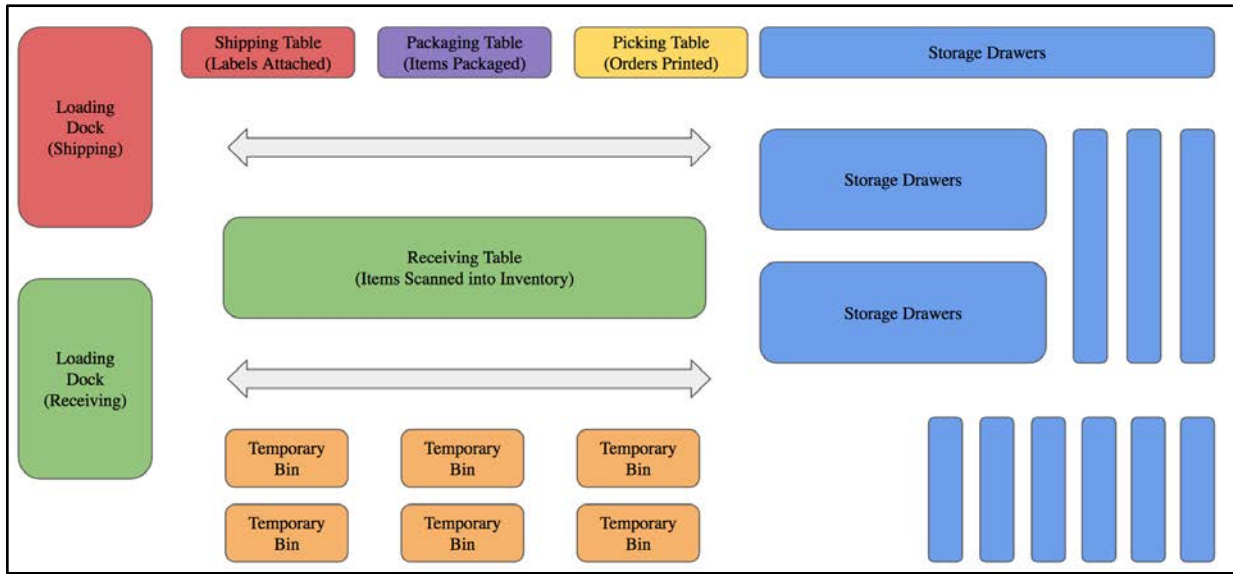


Figure 1: Emuge Warehouse Layout

Emuge uses an inventory classification system as a method of inventory planning. Similar to “ABC Inventory Classification” discussed in the background section, Emuge classifies their inventory as either “A” items or “B” items. These classifications are based on order frequency, with “A” items located closest to the shipping station to minimize travel distance for their employees in an effort to reduce non-value added time. (Inventory Manager - Emuge, 2018).

Furthermore, the team analyzed each individual step of Emuge’s warehouse operations, from receiving to shipping, and developed a Process Flow Chart (Figure 2) as a result. The Process Flow Chart also proved to be invaluable during interviews with outside professionals familiar with warehouse design and barcode verification, particularly with the Account Manager

from Barcodes Inc, as it offered insight to exactly what happens at each step of the warehouse operation.

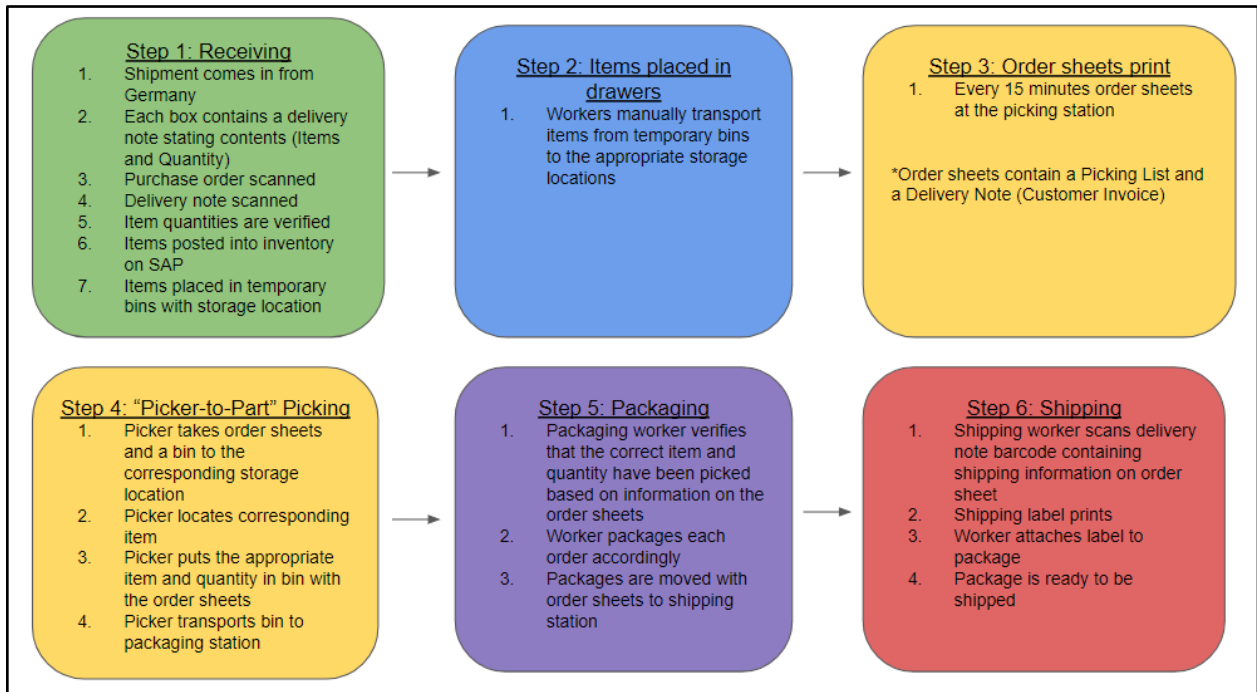


Figure 2: Emuge Process Flow Chart

The team found that, with the exception of items being scanned into inventory during step 1 of Figure 2, Emuge’s entire process employs no automation and relies fully on human interaction and decision making. When an order is processed from the sales department, a packing list is released via the printer in the outbound section of the warehouse in step 3 (Figure 2). An employee uses the location code of the products on the packing list to retrieve the products from the correct bins in step 4 (Figure 2). Here lies the opportunity for human error due to little differentiation between product codes as seen in Figure 3.

Figure 3: Limited Product Code Differentiation



The product is then picked and signed by the employee who retrieved the product.

Limited drawer organization acts as another contributing factor to picking errors during step 4 as seen in Figure 4 below.

Figure 4: Poor Drawer Organization



The order is then double checked by another team member during step 5 and signed off for shipment (Figure 2). This is the final opportunity for human error as shown in Figure 5 and 6;



Figure 5 & 6: Final Check and Boxing

when the item leaves this station the employee responsible for shipping does not check the product. To further elaborate on how this issue of human error can not only result in shipping errors, but also shortage costs, consider the scenario below:

*Emuge has 30 units of Tool A and 30 units of Tool B. They receive an order for 20 units of Tool A but, as the result of a shipping error, they send 20 units of Tool B, leaving them with 10 remaining units of Tool B in their inventory. They then receive an order for 20 units of Tool B but are unable to fulfill it because of their previous shipping error and have to place Tool B on backorder, bringing about shortage costs.*

### 3.4.2 Problem Decomposition

Using an axiomatic design approach, the team’s FR and DP decomposition and coupling matrix can be seen in the Figures 7, 8 and 9 below:

#	[FR] Functional Requirements	[DP]
0	Eliminate shipping errors at Emuge	Irr
1	Determine that the information going into the system stays correct	
1.1	Verify that units and their quantity are being scanned into the system	
1.2	Verify that units are being stored in the correct temporary bins	
1.3	Verify that units are being stored in the correct drawers	
2	Determine that the information in the system stays correct	
3	Determine that the information coming out of the system is the correct information to fulfill customer needs	
3.1	Verify that the customer delivery requirement information matches with what was physically picked from the system	
4	Determine that the new process is more efficient than the current process	
5	Determine that the designs level of integrity justifies its value	

Figure 7: Functional Requirements (FR’s)

[DP] Design Parameters	[DP]
Implement and follow necessary changes to system	
Establish a clear, strict system at the receiving station	
Scan delivery note from Germany containing all items that are to be placed in inventory	
Clearly label bins	
Place items that are going to the same drawer in the same temporary bin at the receiving station	
Perform cycle counts as a means of inventory control and accuracy	
Implement an automated verification system	
Implement a barcode scanning system during the picking phase to cross check the items with the items ordered	
Eliminate the need for the packager to verify that the correct items and quantity have been picked	
Measure fulfillment errors and costs after implementation	

Figure 8: Design Parameters (DP’s)





of the preceding FR's (Park, 2007). Since each DP fully satisfies its corresponding FR, the design is considered to be uncoupled and not decoupled (Park, 2007). Although both uncoupled designs and decoupled designs may satisfy the independence axiom, a decoupled design requires that each DP is considered fixed after meeting the corresponding FR (Park, 2007). Thus when choosing DP<sub>2</sub>, you must satisfy FR<sub>2</sub> with your choice of DP<sub>2</sub>, as well as the fixed DP<sub>1</sub> (Park, 2007). Given the nature of Emuge's system, and that each of the competencies do not rely upon each other, their FR's and corresponding DP's have no effect on the previous FR's. Thus instead of a lower triangular matrix, the design follows a diagonal matrix. Order of adjustment does not apply because the design is uncoupled and follows a diagonal matrix, not a decoupled lower triangular matrix.

Together the summation of FR<sub>1</sub> through FR<sub>5</sub> equal FR<sub>0</sub>. It should be noted that FR<sub>1</sub> and FR<sub>2</sub> are already satisfied through Emuge's current system. Items are scanned into the system at the receiving station and are then placed in clearly labeled bins associated with storage location. Furthermore, Emuge performs cycle counts based on item classification, where "A" items are counted twice per year and "B" items are counted once per year (Inventory Manager - Emuge, 2018). Their use of cycle counting helps fulfill FR<sub>2</sub> by helping to maintain inventory accuracy.

### 3.4.3 Barcode Integration to SAP

The team consulted the Branch Manager from Harvey Building Products for insight regarding their barcode scanning system within their warehouse. Harvey Building Products uses mobile computers that connect with their SAP system through a terminal emulation software called Telnet (Branch Manager - Harvey Building Products, 2017).

The team also maintained recurring contact of over 10 interviews from November 2017 to March 2018 with an Account Manager from Barcodes Inc, a barcoding company based in Chicago, Illinois in regards to barcode integration to SAP. With the help of the detailed Process Flow Chart, the team was able to determine that due to the existing picking and packing functionality within Emuge's current SAP system, barcode scanning implementation was not only possible, but feasible (Account Manager - Barcodes Inc., 2018). Additionally, clarity was gained on how a terminal emulation software would work in conjunction with Emuge's SAP system through the use of mobile computers. Wavelink, a terminal emulation software, as well as potential mobile computer hardware, such as the Motorola MC3200, were suggested (Account Manager - Barcodes Inc., 2018).

#### Terminal Emulation

A terminal emulator is a program that extends a host system, such as SAP, to a mobile device, allowing for mobile functionality (US Patent, 1980). In a warehouse setting, terminal emulation can be beneficial because it can allow workers to send and receive data remotely to their host system from anywhere in the warehouse via their mobile computer. This is key because it can increase efficiency and worker productivity within a warehouse, as well as improve accuracy of data transfer throughout a system (Ivanti, 2018). There are numerous terminal emulation software that are compatible with various operating systems such as Windows XP, Android, and Mac iOS. Such software require a licensing fee, as well as an annual maintenance fee, however, these fees are particularly inexpensive compared to a host system, which, depending on the size of a company and desired functionality, can cost millions (Barcodes Inc., 2015).

## Improved Process

Terminal emulation connecting a mobile computer with SAP will solve Emuge's 15 to 18 shipping errors as a result of their human error during step 4 of Figure 2. Terminal Emulation significantly decreases non-value-added waste because it would give Emuge employees the capability to verify that the product they are picking is correct through the use of its barcode scanning functionality, thereby reducing overall time spent relying on human verification. During the proposed step 4 of Figure 9, upon locating the storage location for the desired product, the "picker" would subsequently scan the barcode on the picking sheet and then scan the barcode on the product to verify that it is in fact the correct product. If the product does not match the information contained in the barcode located on the picking sheet, an audio and visual cue will emit from the mobile computer (Branch Manager - Harvey Building Products 2017).

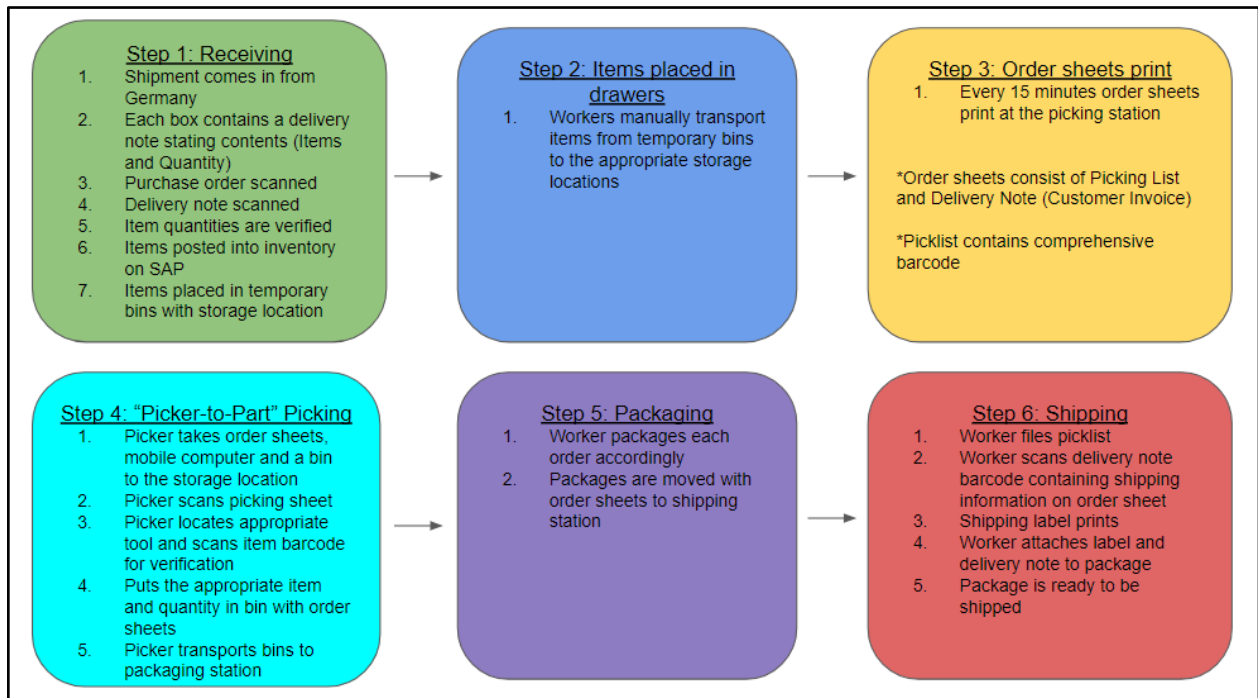


Figure 9: Proposed Emuge Process Flow Chart

### 3.4.4 Financial Feasibility

As mentioned previously, the goal of this barcoding system was to offer a financially viable complement to Emuge's current SAP Inventory Management system, rather than purchasing a costly, new SAP package. In order to accomplish this goal our team executed a financial analysis. Part of our financial analysis consisted of a Cost/Benefit analysis being that it quantified both the benefits and costs of a project which, in turn, generated a numerical value that represented whether or not it was worth Emuge's time and/or money. Our team determined several elements, or costs, of "fixing" a shipping error in an effort to calculate exactly how much money Emuge lost per shipping error. After taking all of this information into consideration, the final piece of our financial analysis consisted of our team calculating Emuge's estimated Return on Investment (ROI) from our proposed solution. The cost associated with shipping errors include both tangible and intangible errors. Tangible errors consist of communication and customer service costs, replacement shipment costs, and return shipment or product abandonment costs. For the purpose of this paper intangible errors such as estimated lifetime value of a customer, and negative reviews which cause potential orders from customers to be placed elsewhere are not included.

#### 3.4.4.1 Communication and Customer Service Costs

The average cost of processing a fulfillment error with a support staff member is \$5.63. The average time taken to process the order is 20 minutes (Customer Service Agent - Emuge, 2018). From this the team calculated the communication and customer service costs by multiplying the average salary of a customer service agent found in occupational employment statistics by the ratio of order processing time of 1/3rd their hourly wage (Bureau of Labor Statistics, 2016). The calculation is shown below in Equation 1 and 2:

$$\text{Customer Service Cost} = \text{Cost of Labor per Hour} \times \text{Ratio of Order Processing Time per Hour}$$

*Equation 1: Formula to Calculate Customer Service Cost*

$$\text{Customer Service Cost} = (\$16.91) \times (1/3) = \$5.63$$

*Equation 2: Calculated Customer Service Cost*

#### 3.4.4.2 Replacement Shipment Costs

Replacement shipment cost is the summation of the postage for shipping the replacement item (\$9.51), the estimated combined cost of the box, packing paper, label, tape and printed promotional materials (\$.53), and the cost of labor for picking and packing the reshipment (Chief Financial Officer - Emuge, 2018). The cost of labor can be calculated by multiplying the mean hourly wage of \$15.61 for order fillers by the ratio of re-picking, packaging and shipping processing time per hour (BLS, 2016)( Barcodes Inc., 2018). The equation is shown below in equations 3 and 4.

$$\text{Replacement Shipment Costs} = \text{Cost of Postage} + \text{Cost of Materials} + \text{Cost of Labor}$$

*Equation 3: Formula to Calculate Replacement Shipment Cost*

$$\text{Replacement Shipment Costs} = \$ (9.51 + .53 + (15.61 \times 1/12)) = \$11.34$$

*Equation 4: Calculated Replacement Shipment Cost*

#### 3.4.4.3 Return Shipment or Product Abandonment

Emuge has no criteria for product abandonment, thus the company pays for the return of the incorrect product 100% of the time (Hellinger, 2018). Thus the summation of costs associated with returning the item are equal to the cost of return shipment. These costs include: cost of return postage (\$9.51), cost of insurance or package tracking (\$8.56), cost of receiving

and processing the physical return (\$9.35) (Chief Financial Officer - Emuge, 2018). These costs are calculated in equation 5 and 6 below:

$$\text{Cost of Return} = \text{Cost of Postage} + \text{Cost of Tracking} + \text{Cost of Receiving}$$

*Equation 5 Formula to Calculate Cost of Return*

$$\text{Cost of Return Shipment} = \$(9.51 + 8.56 + 9.35) = \$27.42$$

*Equation 6 Calculated Cost of Return Shipment*

#### 3.4.4.4 Cost of Errors Analysis

The total cost per shipping error is \$44.39. There are on average 180 errors per year (Shipping Operations Manager - Emuge, 2017). Thus the total cost due to errors is  $\$44.39 \times 180 = \$7,990.20$  as show in equations 7 and 8:

$$\begin{aligned} \text{Total Cost} &= \text{Customer Service Costs} + \text{Replaced Shipment Cost} + \text{Return Shipment Cost} \\ &\times \text{Errors Per Year} \end{aligned}$$

*Equation 7 Formula to Calculate Total Shipping Error Costs per Year*

$$\text{Total Cost} = \$(5.63 + 11.34 + 27.42 \times 180) = \$7,990.20$$

*Equation 8 Calculated Total Shipping Error Costs per Year*

#### 3.4.4.5 Cost Associated with Implementation of Mobile Computers

Wavelink, a terminal emulation software developed by Ivanti, an IT Solutions company, requires a one-time licensing fee of \$148 and an annual maintenance fee of \$43 (Barcodes Inc. 2018). The only other requisite expense is the cost of the mobile computer(s), which can range in price depending on desired functionality. The recommended Motorola MC3200 with barcode scanning functionality costs \$1440 and comes with the Wavelink software downloaded

(Barcodes Inc., 2018). The cost of three mobile computers with licensing fees is approximately \$4764 (Barcodes Inc., 2018).

#### 3.4.4.6 Benefit Analysis

Emuge incurs errors amounting to \$7,990.20 per year. The cost of implementing three mobile computers is \$4764 which will completely eliminate picking error discrepancies (Barcodes Inc. 2018). Thus, Emuge's initial investment will be paid off within the first year. Assuming machinery industry averages of a 16.49% tax rate and a 7.38% weighted average cost of capital (WACC), the investment of 3 mobile computers with emulation software returns a net present value (NPV) of \$16,923 after forecasting over five years, as shown in Figure 10 (Damodaran, 2018). The team assumes the salvage value of the devices to be \$0 with equal depreciation each year.

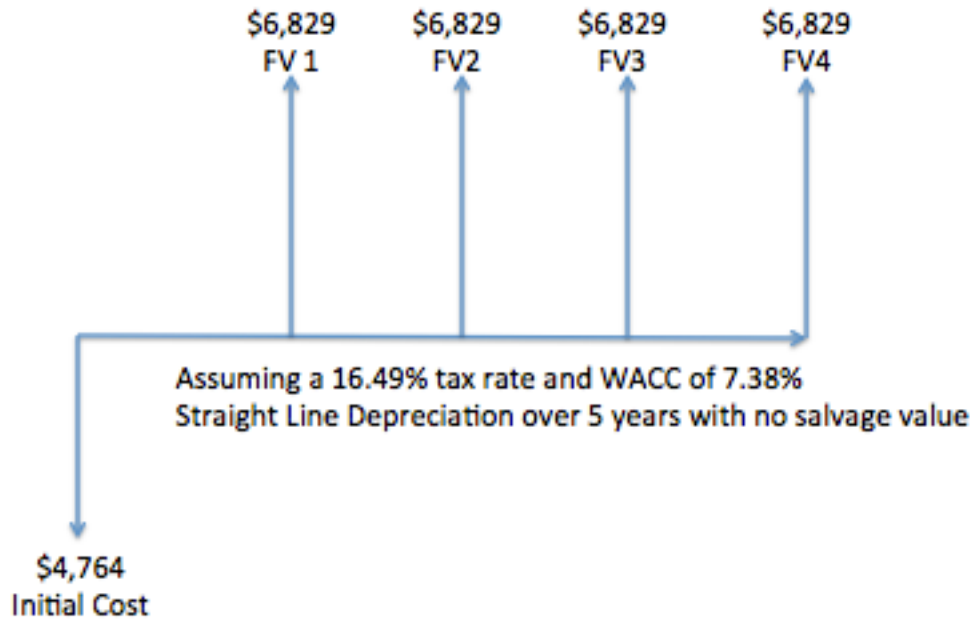


Year	0	1	2	3	4
Cost of Hardware and set up	\$ 4,764.00				
Savings from hardware		\$ 7,990.20	\$ 7,990.20	\$ 7,990.20	\$ 7,990.20
Hardware Depreciation		\$ 952.80	\$ 952.80	\$ 952.80	\$ 952.80
Salvage Value of Hardware					\$ -
<b>Cash Flows From Hardware Implementation</b>	\$ (4,764.00)	\$ 6,829.73	\$ 6,829.73	\$ 6,829.73	\$ 6,829.73
<b>NPV</b>	<b>\$16,923.70</b>				
Weighted Average Cost of Capital	7.38%				
Tax Rate	16.49%				

Figure 10: NPV of Mobile Computer Investment

Figure 11 below consists of a cash flow diagram detailing the real cash flows over a 4 year period after implementation. The diagram includes straight line depreciation due to the simple nature of the investment, and the limited time software technology remains relevant.

Figure 11: Cash Flow Diagram



## 3.5 Alternative High Cost Solution

### 3.5.1 RFID

Barcoding systems cause inventory inaccuracy by way of shrinkage and misplacement. Shrinkage is permanent inventory loss resulting in a smaller actual inventory compared to what is shown in the IT system. Misplacement on the other hand are items which are unavailable for sale but can be recovered via a physical audit. Thus barcoding systems take the form of informational loss during warehouse management and shipping downstream through the supply chain. This sort of information misrepresentation resulting from the “failure to obtain the correct inventory information at the decision making point” becomes unavoidable, driving up costs (McCathie and Michael, 2005). Advantages arise when using new radio frequency identification (RFID) technology for better inventory movement control through frequent monitoring and non-line-of-sight reading. RFID tags or labels contain a circuit and an antenna that transmit information through radio waves, therefore eliminating the necessity of an optical scanner (McCathie and Michael, 2005). Advanced RFID visibility allows warehouse managers to align the actual inventory information with the recorded inventory in real time. In this way, RFID enabled visibility does not prevent errors, but instead allows managers to make informed decisions about discrepancy information. RFID can reduce shrinkage by 67% at the manufacturing level and 47% at the retailer level, leaving a large margin for warehouse management and shipping reduction.

RFID technology has the potential to save a dramatic amount of time within warehouse processes. The time necessary to receive products could be reduced by 60%-93%, limiting backorders waiting to be placed in inventory. Potential labor savings for picking can be increased by 36% while there is a potential for a 90% reduction in shipping verification costs (Dai and

Tseng, 2012). RFID are also damage resistant compared to barcodes which are susceptible to ripping and smearing. RFID can be unique for Emuge as items returned to the warehouse for refurbishing will also be labeled with an RFID tag, allowing them to be tracked throughout the warehouse as well. Smart shelves also allow RFID enabled tags to transmit location data down to the specific drawer or bin within a warehouse, making picking easier than ever. RFID is estimated to save the U.S economy \$50 billion in inventory management costs each year (Dai and Tseng, 2012).

### 3.6 Recommendations

Following the completion of all methodologies and analysis of the results, the team was able to develop the following recommendations for Emuge Corporation:

1. Implement a barcode scanning system at the picking portion of the shipping operation through the use of mobile computers and a terminal emulation software. It's verification capabilities will eliminate picking errors and subsequently reduce their shipping error costs. A financial analysis determined that such an implementation is financially viable and worth the investment. Lastly, implementation will prevent disruptions to daily operations.
2. Consider implementing a comprehensive RFID inventory management system. RFID is becoming the best practice in sustainable and efficient inventory management throughout every portion of the supply chain. RFID allows for real time inventory tracking without line of sight saving Emuge a maximum of 36% in labor costs and a 90% reduction in shipping verification costs. The use of smart drawers would drastically improve inventory auditing and would make cycle counting obsolete as item location information is updated in real time. RFID gates at receiving and picking stations would ensure orders are

grouped together correctly and always remain in the system until the last possible moment.

## **Chapter 4 - Developing Subsidiary Influence Within a Multinational Corporation**

### **4.1 Introduction**

The premise for this chapter is that a subsidiary can develop influence within a multinational corporation (MNC) through two methods: technological prowess and business acumen (Mudambi et al., 2014). The objective of this chapter is to analyze the validity of both of these methods and discuss whether or not Emuge attains prominence in each of these areas.

### **4.2 Background**

A Multinational Corporation (MNC) is any business or organization that operates in more than two countries around the world. As expressed by the Columbia Business School, MNC's are "the organizational form that defines foreign direct investment" (Semelser, 2001). One such way in which an MNC's reaches foreign markets is through acquiring local companies, otherwise known as subsidiaries, in different countries. This strategy can allow an MNC to gain a competitive advantage over their competitors (Porter, 1986).

Subsidiaries operate under a mandate provided to them by their parent-company, the MNC, each of which include detailed responsibilities and activities that subsidiary holds (Birkinshaw, 1996). Furthermore, the roles and responsibilities of different subsidiaries under the same parent-company usually differ (Birkinshaw & Hood, 1998). However, even though different subsidiaries may perform different roles within the same MNC, their performance can dictate how great of an influence that they have on the MNC's operation as a whole (Mudambi & Navarra, 2004). This gives individual subsidiaries incentive to perform at a higher level than each of their peers.

The relationship between an MNC and its subsidiary can be analyzed through the Resource Dependence Theory. This theory was initially put forth by Jeffery Pfeffer, Professor of Organizational Behavior at the Stanford Graduate School of Business, and Gerald R. Salancik, former professor at Carnegie Mellon University, in 1978 through the publication of their book “The External Control of Organizations: A Resource Dependence Perspective”. The theory argue that “external constraints affect organizations and provides insight for designing and managing organizations to mitigate these constraints” (Pfeffer & Salancik, 1978). A 2014 study that collected data from over 2,100 senior executives at subsidiaries from across different industries showed that this theory applies to an MNC based on the level of competence and independence a subsidiary possess (Mudambi et al., 2014). Ultimately, the less dependent a subsidiary is on its MNC means the more dependent an MNC is on the subsidiary. It was found that subsidiary competence is derived from both technology-related power and business-related power.

#### 4.2.1 Technological Prowess

The technological prowess of a subsidiary largely matters because it is a component of the functional power of the subsidiary (Mudambi et. al, 2014). The less that a subsidiary relies on its MNC to function on a day to day basis, the less dependent they are on the MNC. Technology-related power matters even more today due to continuous technological innovation and its importance to the overall functionality of an organization. Some examples of technology-related power are software systems, IT solutions, and automation.

#### 4.2.2 Business Acumen

Business acumen can be described as “keenness and quickness in understanding and dealing with a business situation in a manner that is likely to lead to a good outcome” (Reilly &

Reilly, 2009). The managerial team and decision making of a subsidiary possess a great role in determining how much business-related power is associated with a subsidiary. Subsidiary initiatives, defined as “entrepreneurial activities carried out by foreign subsidiaries of multinational corporations”, play a key role in a subsidiaries ability to gain more business-related power (Birkinshaw and Ridderstrale, 1999). They gain such power because, in most cases, engaging in initiatives exceeds the expectations their mandates from the MNC (Delany, 2000).

Three key factors play a role in why a subsidiary would engage in initiative activities. The first is that a foreign subsidiary usually has a much greater knowledge of their environment than their parent-company and have a better understanding of business opportunities within their respective country. Second, a subsidiary is motivated by increasing their presence and power within an MNC. And the third factor is when the entrepreneurial attitudes of a subsidiaries managerial team steers them towards initiatives in addition to their mandated orders from the MNC (Dorrenbacher & Gammelgaard, 2011).

In addition to subsidiary activities, areas such as distribution, logistics, marketing, purchasing, and sales all fit under the realm of business-related power (Mudambi et al., 2014).

#### 4.2.3 Entrepreneurial Activities

According to a joint study conducted by the Dublin Institute of Technology and the University Dublin College in which CEOs and senior executives across 1,100 different subsidiaries were interviewed in regards to how they seek to achieve growth, the development of entrepreneurial activities within a subsidiary is highly encouraged (Scott & Gibbons, 2009). A companies’ willingness to take risks and seek out potential opportunities promotes a culture of proactive and innovative behavior because it emphasizes the importance of long-term goals (Scott & Gibbons, 2009). Introducing strategic reward systems and not being afraid of short-term

failure are two beneficial actions that a company can take to spark entrepreneurial activities (Scott & Gibbons, 2009).

### 4.3 Results and Discussion

Emuge currently holds both technology-related power and business-related power within their MNC, Emuge-Franken. The opening of their “New Cutting Tool Technology Center” in September 2016 is just one example of their technological prowess. Additionally, they have recently released numerous innovative technologies such as their “Line of Innovative Circle-segment End Mills” in November of 2016, and their “New Solid Carbide Coolant-Fed Micro Drills” in February of 2017 (Emuge, 2018).

Emuge also demonstrates their business acumen by engaging in subsidiary initiatives, most recently through their partnerships with “Mastercam” and “OPEN MIND”, both of which are CAM/CAD Software Development companies (Emuge, 2018). The reasoning behind these partnerships is to improve upon and develop more highly productive machining solutions for their customers. These partnerships also give them more technology-related power within Emuge-Franken through the development of solutions using better technology.

Emuge clearly cares about their customer service, as seen in their strategic partnerships to develop better machining solutions for their customers. However, through the implementation of a verification system within their warehouse, they would, as a result, provide even better customer service by diminishing the amount of shipping errors.

We recommend that Emuge implements an incentivized program within their warehouse operation that rewards those who commit no shipping errors. As mentioned above, this type of



entrepreneurial activity would potentially hurt them in the short-term as they would have to pay additional bonuses to their employees. However, in the long-term they would benefit because it would create a culture where individuals are more cautious when ensuring orders are fulfilled correctly. This benefit to culture within the warehouse adds significant accountability, while at the same time incentivizes employees to improve company operations during inside-out processes.

## Chapter 5 - Conclusion

### 5.1 Introduction

This project revealed that there are inventory management opportunities available to Emuge through the use of technology to eliminate the majority of human error involved in warehouse management and shipping operations. The cost benefit analysis portion revealed that Emuge has the ability to increase their yearly revenue by approximately \$7,990.20 after a considerably small implementation period of the new equipment suggested in this paper. The investment of 3 mobile computers with terminal emulation software is financially viable as the NPV of the investment is positive. The NPV of the investment is equal to \$16,923.70, which would add value to the firm by streamlining inside-out supply chain practices, and increase Emuge U.S.A's reputation in successful fulfillment of orders, compared to the small investment necessary to undertake the project.

### 5.2 How Inventory Control Bolsters Emuge's Share of their MNC

Emuge has the opportunity to improve their inventory control during inside-out supply chain management, greatly improving their customer satisfaction by increasing their credibility from the elimination of fulfillment errors. With the opening of Emuge U.S.A's "New Cutting Tool Technology Center", the company has already made strides in developing their business acumen. The subsidiary has continued to drive innovation by engaging in partnerships with software development companies within the U.S.A. Through their already growing attention to development within their market, they will garner more influence within the parent company Emuge-Franken. However, Emuge U.S.A is losing approximately \$8,000 by using human

verification within their inside-out supply chain. By implementing mobile computers that leverage a terminal emulation software, Emuge U.S.A can use existing modules within their customized S.A.P package to automatically verify products during picking. Through the elimination of a large percentage of errors incurred by human verification, Emuge U.S.A may save up to \$27,316 over five years. This form of process improvement is likely to garner recognition from the MNC and could likely be standardized across all Emuge-Franken subsidiaries using out of date inside-out processes. Emuge U.S.A also has the ability to improve their current attention to detail during their picking process by adding incentives for employees who perform the best. This shock to their current system could cost Emuge U.S.A financially in the short term, but would change warehouse culture and promote picking improvement and company reputation over the long term. By growing their share of successful business practices within the MNC, Emuge U.S.A will increase their chances for greater investment, adding to their growing technological prowess, consistently demanding further investment, while at the same time becoming the blueprint for successful fulfillment of Emuge's products.

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# Appendices

## Appendix A: End User Market Analysis 2016

