Improving Work Flow Management in an Order Fulfillment Organization

by

Kuldip Sandhu

B.S. Electrical Engineering, University of California, Berkeley, 2003

Submitted to the MIT Sloan School of Management and the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degrees of

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and
Master of Science in Engineering Systems

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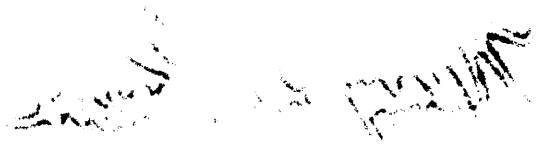

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Abstract

Amazon.com is experiencing dramatic growth in customer demand through increasingly diversified product offerings and from introduction of Amazon Prime Shipping. As the volume of customer orders increases and a higher number of orders placed are single unit orders, labor and work management at the fulfillment centers must be improved to increase the throughput while fulfilling orders on time. Managing outbound work flow and labor at Amazon fulfillment centers is a complicated process that is controlled manually through limited tools, but has large implications on operational performance and customer experience. The six month LGO project focused on improving the outbound flow management process at the RNO1 Fulfillment Center located in Fernley, Nevada.

This thesis analyzes the current workflow management process, identifies major concerns with this process, and outlines the solutions implemented to improve flow management. The project was approached using lean principles and methodologies, especially when identifying and implementing solutions. Specifically, the concepts of Genchi Gembutsu, PDCA (Plan/Do/Check/Action) and effective change management were used heavily.

The major changes implemented were flow management structure change, standardized training and tools to make flow decisions, optimal local settings for work in progress, inclusion of charge forecast into labor planning and hourly tracking of shift performance. The results demonstrated an annual cost savings of $353,000 at RNO1. The concepts described in this thesis extend beyond a fulfillment center setting to planning labor in manufacturing, service operations like customer service centers and healthcare facilities.

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I would sincerely like to thank my supervisors Jim Sharkey, Dave Graybeal, and Brent Hill, as well as my sponsor, John Tagawa, at the RNO1 fulfillment center. Their guidance and immense knowledge provided satisfying learning experience. I truly appreciate Brent's unparalleled support throughout the project. I further admire his thought leadership, which played pivotal role in making this project successful. I would also like to thank Micah Samuels, Brian Jordan, and Eric Rimling for sharing their time, resources and insights.

Finally and most importantly, I would like to thank my family and my finance, now husband Anmol Das, for their constant support.

Biographical Note:

Kuldip Sandhu, born and raised in India, migrated to the United States with her family at age 15. After finishing high school, she chose to attend University of California in Berkeley, CA, where she earned her bachelor's degree in Mechanical Engineering. During her time at Berkeley, she participated in a 6-monthcooperative education program with the NUMMI manufacturing assembly plant, well known as the joint venture between Toyota and General Motors. Kuldip spent majority of her time on the assembly floor identifying improvement opportunities and implementing countermeasures, while immersing herself in the philosophies of Toyota Production System. Her internship was a fulfilling experience yet it left her with a desire to advance her knowledge of Toyota quality, so she returned to NUMMI full-time as a quality engineer. Her next 4 years provided her opportunities to manage major quality projects on all three of assembly plant's products: Toyota Corolla, Tacoma, and Pontiac Vibe.

In early 2006, Kuldip encountered an entrepreneurship opportunity, which she grabbed with much enthusiasm yet feared her lack of previous business experience. She ran a retail shop for a year in addition to working at NUMMI simultaneously and finally decided to grow her business full time in 2007. As a sole proprietor, she was responsible for all aspects ranging from Sales to Marketing and from Inventory Management to Strategy.

After running a successful business, Kuldip decided to apply to business schools in 2008, and the following summer she matriculated into the Leaders for Global Operations (LGO) program at MIT. After graduation she hopes to use her recently acquired operations knowledge to continue to make an impact in the manufacturing and operations industry.

Note on Proprietary Information:

Please note that data presented throughout this thesis has been modified to maintain confidentiality and preserve any valuable information from the competitors of Amazon.com. Furthermore, the proprietary information from internal website screenshots has been blurred to protect Amazon.com.

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Table of Contents

List of Figures

1 Introduction

Amazon.com has revolutionized how consumers make purchases. Consumers no longer need to contemplate how an item compares with competing products, how they will be able to purchase an item from a nearby retailer, how many other items are on their shipping list, how they will make a return, etc. Amazon.com makes these decisions convenient through product comparison data, quick order processing with its 1-click feature, diversity in product offering, reasonable shipping cost with Amazon Prime, and easy returns process. Amazon.com's fast evolution can be largely attributed to the company CEO, Jeff Bezos, vision "to be the earth's most customer centric company; to build a place where people can come to find and discover anything they might want to buy online[1]."

1.1 Project Motivation

Since its inception in 1994, Amazon.com has grown from four employees operating out of a 400 square-foot garage in Seattle into an online company with a stock valuation greater than most Fortune 500 companies[2]. Jeff Bezos's vision has led to an ongoing product diversification and made Amazon.com one of the world's leading retailers. The diversification of the product offerings and the introduction of Amazon Prime have positively resulted in a growing customer base for Amazon.com, but this has also created challenges for the company's fulfillment operations.

The fulfillment centers including RNO1 have created and expanded secondary processes to handle single-item order volume and odd-shaped products (unlike the traditional books and media). On top of that, fulfillment centers have to carefully manage the complexity of orders and labor among its different processes such that labor is balanced while customer orders are shipped on time. RNO1 and other fulfillment centers alike continue to perform and meet customer expectations, but a robust study of

[1] http://www.entrepreneur.com/growyourbusiness/radicalsandvisionaries/article197608.html
[2] "Order Fulfillment: The Hidden Key to e-Commerce Success", Supply Chain Management Review, Fred R. Ricker and Ravi Kalakota

the internal supply of labor and work management was needed to improve work flow management to keep up with the growing customer demand and increasing product diversification.

This project is a systematic approach to understand current work flow management, more specifically, how the labor and work allocation decisions are made amongst the different outbound process paths and how the flow management system can be redesigned.

1.2 Problem Statement

Managing work flow and labor is a complicated process that is controlled manually with limited tools, but has large implications on operational performance and costs. On dayshift, flow is managed by one of the three Area Managers until lunch and then taken over by the Flow Operations Manager until end of the shift. On nightshift, flow was planned by that shift's operation manager and then handed over to one of the three area managers for the rest of the shift. This system was sub-optimal due to variations in flow management by manager and by shift, lack of standard in planning labor and reporting shift performance, and taking managers away from their departments for an average of 13 hours per week.

1.3 Thesis Overview

The research project took place at the RNO1 fulfillment center in Fernley, Nevada from February 2010 to August 2010. The thesis document is a result of this six month internship, and the collaboration between MIT faculty and Amazon.com. The document is organized as described below.

Chapter 1 describes the project motivation and the problem statement

Chapter 2 provides an overview of Amazon.com, its fulfillment network, and Amazon Prime

Chapter 3 provides detailed overview of the RNO1 Outbound operations including its major process paths, organization structure, and flow management

Chapter 4 presents the literature research on applications of lean principles and change management

Chapter 5 highlights the project approach, findings and results

Chapter 6 presents project summary and cost savings

Chapter 7 provides the list of appendices and bibliographies respectively.

2 Company Overview

Jeff Bezos founded Amazon.com in 1994 with the vision to build a successful online bookstore that offers a greater variety of books compared to a traditional brick and mortar store. While this innovative idea resulted in impressive sales growth, Amazon.com did not start earning net income until 2003. Amazon's net income and net sales since 2003 are shown in Figure 1.

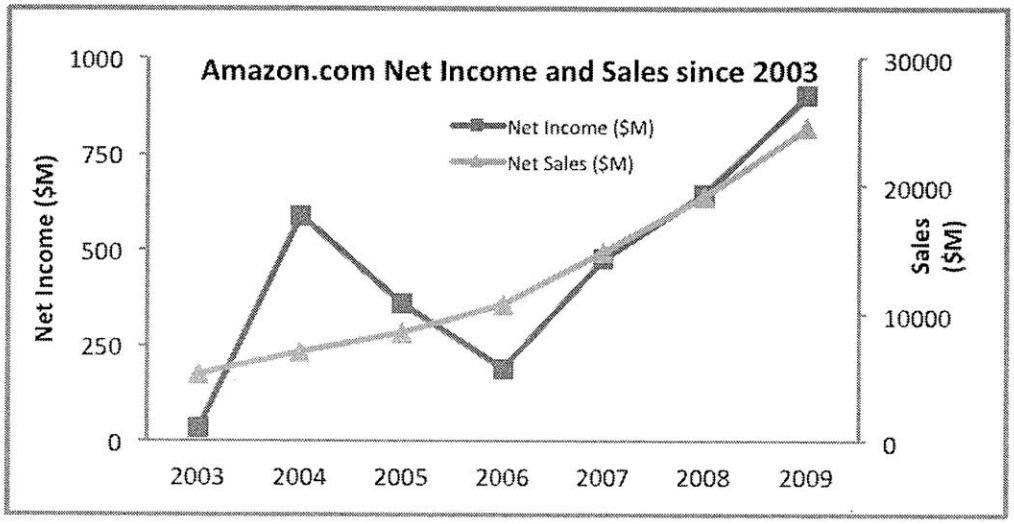

Figure 1: Amazon.com Annual Net Income and Sales[3]

Amazon has been successful in becoming the earth's most customer-centric company by focusing on three sets of customers: consumers, sellers, and developers[4]. The company serves consumers through its retail website by providing wide selection, lower prices, and convenience. Also, Amazon.com is known for easy-to-navigate website, reliable fulfillment, and timely customer service. For its seller group, Amazon enables them to sell their products through different channels: Fulfillment by Amazon, Checkout by Amazon, and Advertise on Amazon. Lastly, Amazon Web Services focuses on the developers by offering its technology infrastructure to build their own applications. Unlike the conventional dot.com websites, Amazon has rapidly evolved to stay competitive in the e-commerce market-segment.

[3] Amazon.com 10K Annual Reports from 2003 to 2009
[4] Amazon.com profile on Marketwatch.com: http://www.marketwatch.com/investing/stock/AMZN/profile

2.1 Amazon's Virtuous Cycle

Jeff Bezos believes that Amazon will continue to attract more buyers by bringing more sellers to its website. He illustrated this using the infamous virtuous business cycle (see Figure 2) on a napkin, which has since become an iconic model for Amazon employees. The concept behind the virtuous cycle is that by increasing the number of sellers on the Amazon.com, customers will find a wider product selection and hence a more convenient shopping experience. This will lead to increased traffic to the site

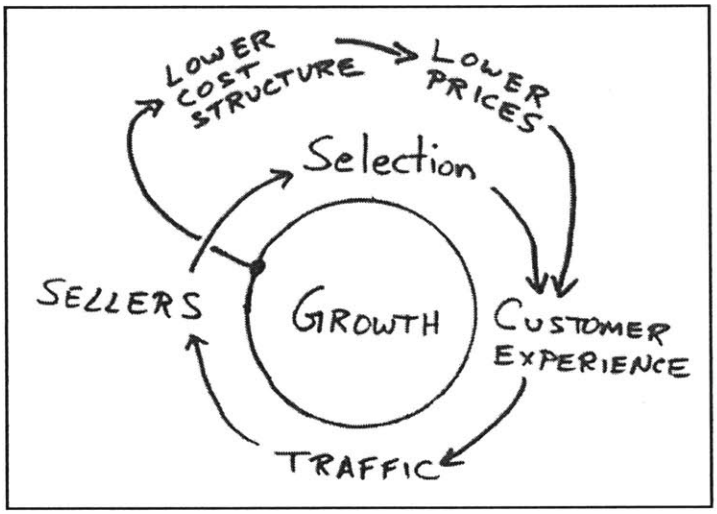

Figure 2: Amazon.com's Virtuous Business Cycle

and thus attract even more sellers. As this reinforcing feedback loop stimulates company's growth, Amazon benefits from economies of scale to achieve a cheaper cost structure. This will further allow the company to offer lower prices, which will again draw more consumers, consequently accelerating the process. Kashyap Patel compares Amazon's virtuous business cycle to a positive feedback system dynamics model where, "different stocks feed Amazon's growth, resulting in the virtuous cycle spinning faster to further fuel the expansion".

2.2 Amazon Prime Shipping

In 2005, Amazon.com introduced Amazon Prime, a membership program that allows unlimited fast shipping, such as free Two-Day shipping and One-day shipping for $3.99 per item on all eligible

purchases for an annual membership fee of $79[5]. To encourage Amazon Prime's usage, Amazon offers a free trial period to eligible customers such as students and new mothers. According to Brad Stone of Bloomberg Business Magazine, Amazon prime has been instrumental in company's stock price surge, "up 296 percent in the last two years—and the main reason Amazon.com's sales grew 30 percent during the recession while other retailers flailed". Although Prime members enjoy benefits of fast product shipping, this results in operational challenges at the fulfillment centers. The fulfillment centers have to react faster and prioritize orders in their operations to get the second and next day shipment orders fulfilled.

2.3 Types of Fulfillment Centers

Fulfillment centers (FCs) and the appropriate fulfillment processes play a very important role in meeting customer expectations for on time order shipments. Amazon.com has an extensive network of fulfillment centers that continue to evolve to keep up with the growing number of customers and diverse product offerings. Amazon uses four common types of FC's: Sortable, Non-Sortable, Forward Deploy, and Delayed Allocation.

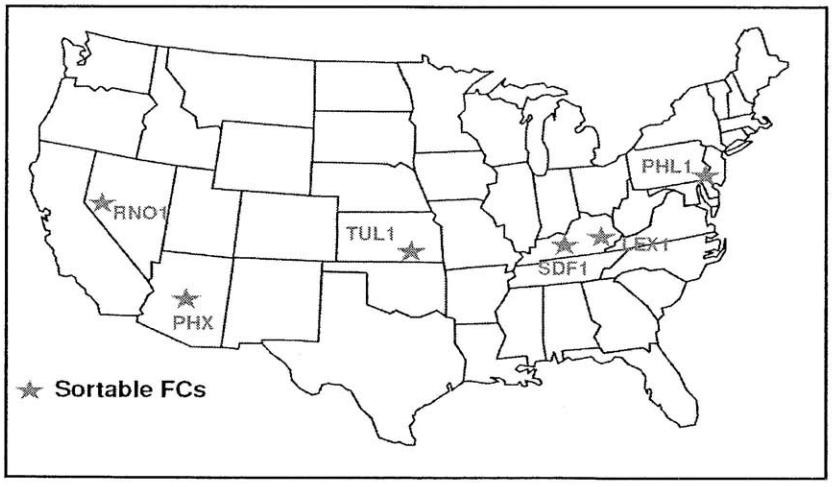

Figure 3: Domestic Network of Sortable Fulfillment Centers

[5] Amazon.com

Sortable centers are able to sort items to combine multiple items for a single shipment. These buildings process majority of customer orders and employ largest labor force in the network. The sortation process is either automated with equipment or performed manually. Both methods perform at similar efficiencies, but the manual operation allows for more flexibility. More labor can be added to the packaging process to increase capacity, but the auto-sortation system, also known as Crisplant, is constrained by induct stations and chutes. In comparison, capacity of manually sorted processes can be altered with more or fewer employees and has no physical limit. Figure 3 shows the domestic network of sortable FCs[6]. Another point to note is that the auto-sortation processes, such as the one at RNO1, requires totes and conveyance, which further restricts product dimensions that are stored in sortable FCs. The Sortable fulfillment centers have additional process paths to handle single unit orders. RNO1 Fulfillment center uses the Crisplant sortation equipment to sort its multiple unit orders, which will be discussed in further detail later.

Amazon uses different fulfillment centers to serve its diverse products and demand. The most popular and larger fulfillment centers are the Sortable FCs, as discussed above. The network of non-sortable FCs is growing to serve demand for large items such as appliances and diapers. Both of these types of FCs are tied into the delayed allocation fulfillment centers for faster selling items. Forward Deploy Fulfillment centers, on the other hand, are small warehouses located near metropolitan areas in the domestic FC network. These facilities receive daily shipments of product in totes from the sortable centers, notably known as transshipments. Next, the operations and various processes from the Sortable FCs are discussed in detail.

2.4 Operations within Sortable Fulfillment Centers

Fulfillment operations in sortable FCs have two major operations: Inbound and Outbound. The inbound operation includes all of the processes that receive products into the building and properly stow them as inventory. Items are held as inventory until a customer order triggers processing in the outbound

[6] (Smith, 2008)

operation. The outbound operation is responsible for picking, sorting, packaging, and shipping the orders to customers. Since the project focused primarily on RNO1 outbound operations, this thesis explains RNO1's organizational structure and outbound processes.

2.4.1 RNO1 Organization & Shift Structure

Similar to the other sortable FCs, the highest management level at RNO1 is a general manager (GM). There are four major departments that report to the general manager: Outbound, Inbound, Inventory Control and Quality Assurance (ICQA), and Facilities. Besides, there are other functional groups: HR, finance, and purchasing that are dotted line to the GM, with direct reporting to their

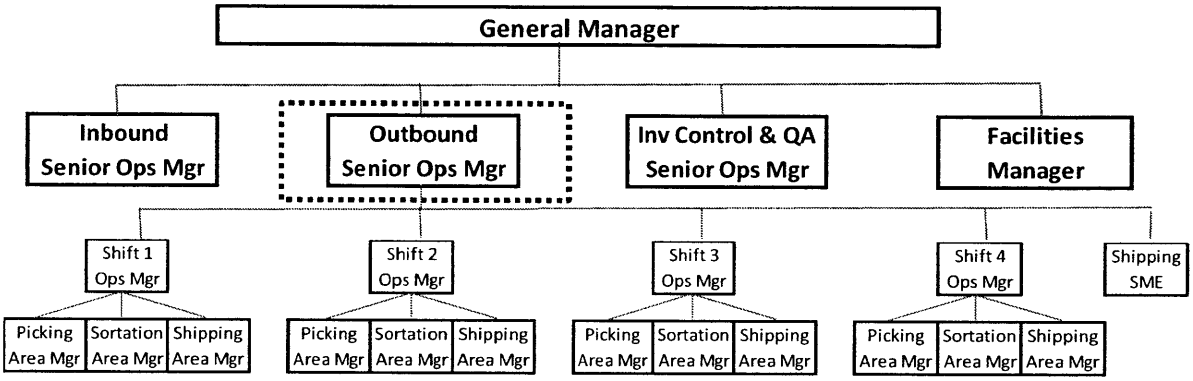

Figure 4: RNO1 Outbound Organizational Structure

respective department head in Seattle or the western region. The major outbound and inbound operations are led by senior operations managers, who report to the general manager. The Outbound Senior Ops Manager has four shift operations managers and a shipping subject matter expert (SME). Further down the chain, each shift operations manager is supported by functional area managers (AMs) from Picking, Sortation, and Shipping. RNO1 outbound organization structure is shown in Figure 4. Picking is responsible for getting the customer orders from inventory. Sortation refers to the auto-sortation Crisplant where multi-unit orders are sorted and packaged. Lastly, shipping department has two separate functions. Primarily, it's responsible for ensuring all shipments due per the truck departure time make it on the truck. Secondly, shipping department also manages the singles packaging operations, which will be discussed in further detail later.

RNO1 operates on a four shift schedule to fulfill customer orders around the clock. Each shift works on a 10.5 hours schedule including a 30 minute lunch and two 15 minute breaks. From flow management perspective, these breaks are ideal for shifting labor between functions. Further, as the schedule shows, labor and management on Wednesday is twice that of single shift days. While this helps to drastically reduce customer backorders, it also requires significantly more planning to allocate work and labor to keep the system in balance. The double shift days are also optimal for assigning labor to

Shift	Week days	Shift Schedule
1st	Sunday through Wednesday	7:00 a.m. to 5:30 p.m.
2nd	Sunday through Wednesday	6:30 p.m. to 5:00 a.m.
3rd	Wednesday through Saturday	7:00 a.m. to 5:30 p.m.
4th	Wednesday through Saturday	6:30 p.m. to 5:00 a.m.

Figure 5: RNO1 Shift Structure

work on projects, process vendor returns, and pick orders for transshipments for Forward Deploy centers. From labor planning perspective, the shift operation managers plan Wednesday's approximate labor on Tuesday and ask for volunteers to take time off, commonly referred to as VTO. Moreover, if the labor is still higher than needed at start of shift (SOS) or during the shift, the shifts ops manager works with AMs to ask for VTO sign-ups, and sends labor home. In summary, RNO1's four shift schedule, flexible labor model, and cross-trained employees helps the facility adjust work to customer demand.

Amazon experiences significantly higher demand during the peak holiday season from October to December, based on the quarterly revenues from 10k annual reports. To prepare for this period, the fulfillment centers including RNO1 make both physical changes by adding auxiliary work areas and labor changes by hiring temporary labor. The labor can increase to nearly four times the labor during the off-peak season. While the thesis project takes place during off-peak months, the impact of additional labor and processes is considered when evaluating flow management and implementing solutions.

2.5 RNO1 Outbound Operations Overview

Outbound is responsible for delivering the customer orders on time. Customer orders can be separated into Single unit orders and Multi unit orders. Single orders are primarily processed through Singles Paths, while Multi orders are processed through an automated sortation system called Crisplant. Once again, outbound is divided into three separate areas on all shifts: Picking, Sortation, and Shipping.

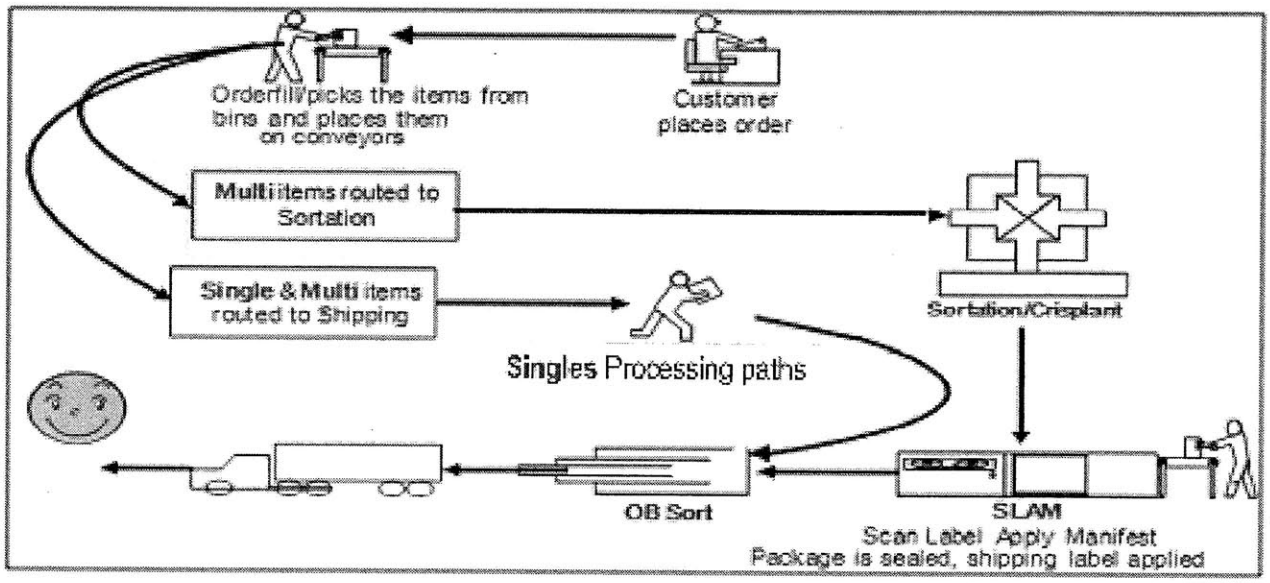

Figure 6: RNO1 Order Fulfillment System

RNO1 customer order fulfillment cycle is shown in **Error! Reference source not found.** above[7]. The first step in order fulfillment is picking the items from inventory; this function is done by picking associates. Each picker is given a specific picking path, which is identified by the Amazon picking software based on the open orders and available picking associates. The pickers pick the items into a tote and place the completed tote onto a conveyor. The conveyance system scans the totes for their destination and automatically routes the totes to the appropriate processing area. The totes containing multi-unit orders are routed to the Crisplant, while the single-unit orders are routed to one of the singles packaging areas. The packages from Crisplant pass through an auxiliary processing area SLAM (Scan Label Apply Manifest), where the package is sealed and the shipping label is applied. When managing labor, additional

[7] Roxanne, 2010

labor must be allocated for this function, whereas this extra step is automatically built into the Singles packaging paths. Packages from all paths are routed on the Outbound Sorting Conveyor where they are scanned to their destination truck. Finally, the trucks leave the facility at pre-determined times, known as critical pull time or CPT, to ship orders on time to the customers.

This is a brief overview of the customer order fulfillment cycle; the following sections will explain each of the process paths and the outbound functions in further detail. This will shed light on the type of work that can be processed in each area, the labor required for each process, and the constraints of each system; which are all very important in managing workflow.

2.6 RNO1 Outbound Process Paths

There are different process paths to handle the appropriate order volume. The process paths are used to group customer order picks according to the unique destination paths where the order is sorted, packed, and shipped. The characteristics of the order and the items dictate the packaging process path. The flow manager must manage flow considering constraints on the resources available and the allowed size of the buffers for each process path.

2.6.1 Crisplant Auto-Sortation

RNO1's primary process path is Crisplant that handles mostly multi-unit orders. Crisplant is a high-capacity tilt-tray sortation system, similar to systems analyzed in Johnson & Meller (2002). The system utilizes manual induction labor, automatic sort into individual orders, and manual order packing.

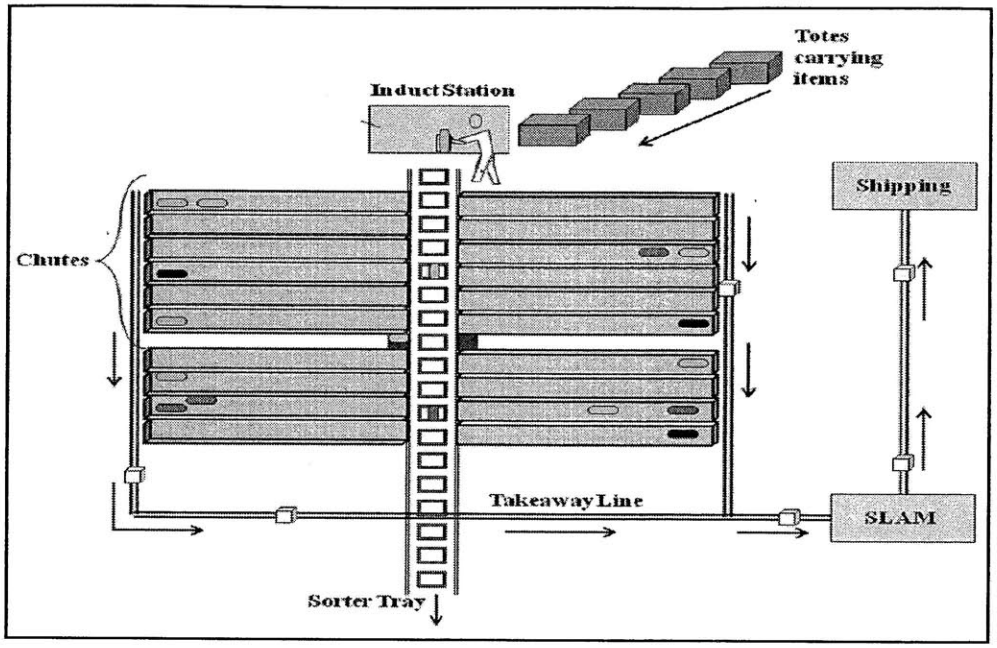

Figure 7: Crisplant Auto-Sortation System

Essentially, Crisplant takes the items delivered in totes from picking and matches them together to form completed orders. RNO1's Crisplant Auto-Sortation equipment is illustrated in Figure 7. Totes arrive to one of the ten induct stations where an inductor processes them in First in First out (FIFO) order. An associate called an inductor processes totes in a single piece flow by removing one item at a time. The barcode of each item is manually scanned and the item is placed on a conveyor belt, which automatically transfers the item to an empty sorter tray. The software logic memorizes the item held on each tray, and tilts the tray to drop the item to the proper chute. The empty trays are reloaded with more items when the tray passes the induct station again.

Each chute is assigned to a single customer order, and all of the items for that order are sent to that chute. Once all of the items are completed in the chute, the chute completion light turns green to indicate the chute is ready to be packed. At that time, an associate called a chuter consolidates the items from the chute into a box, which is placed on a conveyor to be sent to the final packaging process. RNO1 Crisplant system is restricted by number of chutes and induction stations; while there is no limit to the number of chuters. The expected inductor productivity is approximately four times that of chuter

productivity per hour. Also, inductors are tied to an induct station, whereas chuters are assigned to a zone and need to actively walk along their zone to look for completed chutes.

2.6.2 Singles Process Paths

In addition to the Crisplant, there are various Singles process paths that pack the single item orders. The totes arrive to one of the three designated Singles process paths. There is a number of singles process paths based on the type of ordered items. The first Singles path processes for small size items. The hourly productivity of this path is nearly the same as that of a chuter in Crisplant. The second type of singles path is the Variable Depth Folder (VDF) that packages single unit orders consisting of medium size items. Totes arrive to this process from Picking and wait in a queue on the VDF conveyor to be processed. The VDF line has sixteen stations evenly spread on both sides and the packaging associates are assigned to different stations starting at the front most station. A VDF packaging associate takes a full tote from the lane and packages each item from the tote in a single-piece flow. The packages are placed on a conveyor to be transferred to the shipping docks. The target pack rate per associate on VDF line is slightly higher than half of a chuter's hourly productivity per associate; thus the process capacity is limited by the stations and each associate's hourly productivity. The actual pack rates vary based on associates' experience, time of the day, equipment malfunctions on the stations and conveyors upstream and downstream, and supply of totes from picking.

The last singles processing path is TEKHO and it contains larger items. Similar to the VDF process, Single Tekho processes single unit orders of items beside books and media. This process is physically setup in parallel to the VDF line and shares upstream and downstream conveyance. The actual packaging process is similar to VDF except the packaging operators have to fold and tape a shipping box depending on the item being packaged. Due to limited space at each station and eight box variations, operators cannot pre-assemble boxes. Lastly, Tekho products require additional time to pick and pack, thus labor and work allocation decisions have to be made accordingly. There are 20 Tekho stations with one packer per station; each packer's productivity is half that of the VDF associate's hourly productivity.

In short, the customer orders have to be managed carefully through sufficient work and labor throughout the day in case an order spike during mid-day cannot be processed due to the process capacity constraint.

2.6.3 Manual Tote Sortation

The Manual Tote Sortation process path is part of the shipping department and the conveyance feeding this area is shared with the Singles Process feed lanes. This area requires varied amount of labor throughout the day to handle the tote volume that arrives to this area. Since the totes arrive to this area for different reasons, the operator must first scan the tote to identify its destination and sort the totes accordingly. In an event, the totes are not scanned fast enough and the feeding lane gets full, the entire upstream conveyance supplying the singles paths can shut down temporarily and needs to be reset after the Manual Tote Sortation lane clears. In essence, the workload in this area must be closely monitored to minimize impact on the Singles Path productivity and missing customer orders due to mistakenly sorted totes.

2.7 Summary of labor requirements

The labor requirements are different for each process and the actual number of associates is based on their process rates and customer order volume. In addition to direct labor, each department has indirect labor to support the functions. The first type of indirect labor is a process assistant (PA) who is a functional expert and supports the Area Manager in actively managing labor. Next, each functional area has problem solvers to address concerns with customer orders; the number of problem solvers varies on the workload and urgency in respect to volume due near CPTs. Another type of indirect labor is a Water Spider who is equivalent of a material handler and plays an important role in keeping the supplies replenished for pack stations. **Error! Reference source not found.** summarizes the type of labor required in the three functional areas.

Function	Type of labor	Function	Type of labor
Crisplant	Inductors	Shipping	VDF packers
	Chuters		Tekno packers
	Slam - packers		Levimatic packers
	Problem Solvers		Shipping associates
	PA - Crisplant		Water Spider(s)
	PA - SLAM		Problem Solvers
	Box Makers/Water Spider		Manual Tote Sortation
Picking	Pickers		Shipping - PA
	Picking - Problem Solver	In addition, there is a Flow lead per shift who reports to the shift Ops Mgr. This was implemented as a part of the internship.	
	Vendor Return Associates		
	PA - Picking		
	PA - Vendor Returns		

Figure 8: RNO1 Outbound Labor Requirements

3 Lean Principles, Tools, & Implementing Change

My methodology for the project was highly influenced by Toyota's lean production system (TPS). Toyota Production System and its lean methodologies are practiced widely across different industries to reduce operational inefficiencies. When applied properly, these principles can gain tremendous results, while many companies lose faith when they don't realize immediate results. There is a reason why Toyota has confidently opened its factories to visitors and yet continues to expand its productivity lead.

3.1 TPS Strategic Principles

There are five major strategic principles that underpin the Toyota methodologies: Customer Focus, Process Focus, Teamwork, Employee Participation, and Continuous Improvement[8]. Here, customer focus doesn't only refer to the external end consumer, but also to the internal customers within the organization who are 'next in line' in the processes. Furthermore, this implies involving all of your customers to learn from them and involve them in your improvement effort. Next, process focus involves managing and improving the technical aspects of the processing through use of statistical tools. It's just as important to manage the human aspects of processes through teamwork and employee involvement.

[8] (Murray & Chapman, 2003)

Teamwork includes cooperation between various functions, between managers, and between the organization and its supplier network. Along those lines, employee involvement should not be limited to simply asking for their ideas; employees must be empowered to pursue their ideas and work on teams to solve problems and improve the overall system[9]. Lastly, continuous improvement, also known as Kaizen, promotes constant refinement and improvement. These principles are practiced through the lean tools: Genchi-Gembutsu, 5-Whys, Standardization, Waste identification through Muri, Mura, and Muda, PDCA cycle, (Plan, Do, Check, and Act), and the cohesive A-3 reports. The principles and tools aforementioned were not only used to root-cause and solve the issues identified, but also helped the change sustain at the fulfillment center. Thus, some of the tools are briefly explained.

3.1.1 Genchi-Gembutsu

Genchi-Gembutsu is Japanese for 'Go & See' and suggests that in order to truly understand a situation "one needs to go to 'gemba' or, the 'real place' - where value is added"[10]. This principle underlies that problems are visible in the location where value is added, and the best improvement ideas come from going to the gemba. The gemba walk, similar to Management by Walking Around (MBWA), takes management to the front lines to look for waste and opportunities. Gemba attitude reflects the idea that reports transmitted to upper management are only a notion of what is actually going on in the "Gemba." Thus, problems should be managed more effectively and immediately when they're observed first hand.

3.1.2 Root-Cause through 5-Whys

The five-why's is a simple tool to help identify the root-cause of a problem, determine the relationship between different causes of a problem. This tool is most useful when problems involve human factors or interactions. By repeatedly asking the question, one can peel away the layers of symptoms which can lead to the root cause of a problem. Although this technique is called "5 Whys," the repetition may include fewer or more times than five whys.

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[9] (Chong, 1999)
[10] **(Liker, 2003**

3.1.3 Muri, Mura & Muda

It is not enough to just eliminate the non-value waste known as muda for an organization to become lean; it's just as important to understand the two other types of waste: Muri and Mura. Here, Muri refers to overburden or unreasonable work that management imposes on workers and machines; essentially, Muri means pushing a person or a machine beyond its natural limits. Mura, on the other hand, is inconsistency or unevenness where focus is needed to eliminate fluctuations through standardization. The most significant effects on process value delivery are achieved by designing a process capable of delivering the required results smoothly; by designing out "mura". It is also crucial to ensure that the process is as flexible as necessary without stress or "muri" as this generates "muda". The best way to find Mura, Muri, and Muda from an inefficient system is to visit the process through 'Gemba.'

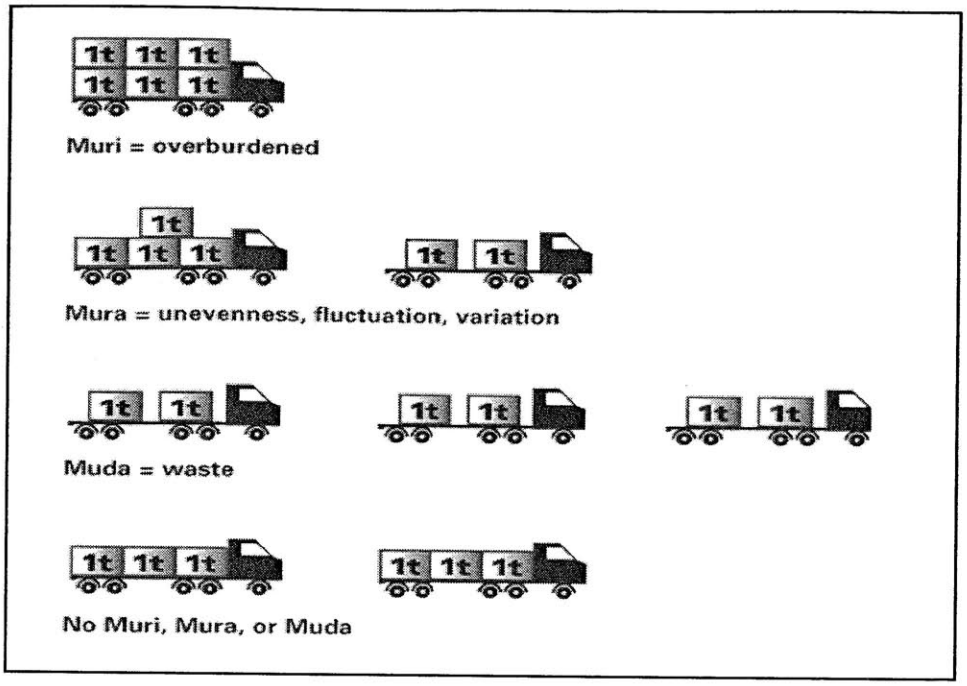


Figure 9: Concepts of Muri, Mura, and Muda (Lean.org)

3.1.4 PDCA (Plan-Do-Check-Act)

PDCA is an iterative four-step problem solving process where PLAN means establishing the processes necessary to attain expected improvements, DO refers to implementing the new processes, CHECK requires that the results from new processes are compared against the expected results to discover differences. Finally, ACT is the process of analyzing the differences, finding their causes, and brainstorming new ideas to obtain results. Essentially, the PDCA cycle is repeated until the process achieves the expected improvement.

These lean methodologies were used religiously throughout the project in identifying concerns inside RNO1's workflow management and in implementing the numerous improvements. Preface to implementing change is having an understanding of the various stakeholders and what motivates them. Next, there must be alignment amongst the stakeholders and they should participate in the process of coming up with change ideas. In respect to implementing change, I also used MIT instructor Jonathan Byrnes's philosophy of implementing the lowest number of changes with the highest amount of leverage and make sure these changes are implemented during the span of the internship. The next section details the project approach, flow decision making at RNO1, and opportunities for change.

4 Project Approach, Flow Management, and Findings

My project scope was to improve the current flow management system in Outbound across the four shifts, which was very broad and vague as there were no flow management performance metrics and data. To give it more definition, it was vital to first understand what it means to manage work flow and how it impacts outbound operations, before identifying improvement areas.

4.1 Project Approach

The project began with shadowing the Flow Operation Manager who was responsible for overseeing flow on all 4 shifts and shadowing Area Managers who managed flow during the shift. Interviews with the Flow Operations manager and the area managers clearly showed that the flow management process was very complex and lacked structure. The flow management decisions and reporting structure varied from one manager to another manager and from one shift to another shift. Moreover, it was difficult to document how a flow manager made decisions because of the number of inputs required for decisions as well as the impact of previous flow experience on decisions. In order to be able to make a sustainable impact, it was vital that I not only learn how to manage workflow but also become proficient in managing flow, tie flow management to outbound metrics, and initiate a continuous improvement culture within flow management. In order to understand the concerns and the results implemented, an understanding of the flow management objectives, flow tools and flow decision making is essential.

4.2 Flow Management at RNO1

Flow Management is a very critical role for functionality of the outbound department. The goal of flow management is to match the rates of production of the outbound functions in order to maximize outbound throughput while making customer promise. This can be converted to the following flow management objectives as well as the action taken by the flow manager.

- **Labor in the pick, pack, and ship processes is balanced**
    - Plan a balanced shift in respect to volume that needs to be processed
    - Assess deficiencies in department labor
    - Shift labor between departments to achieve and maintain balance throughout the shift
- **Customer demands are met on-time**
    - Monitor status of due orders to assign work and labor accordingly
    - Ensure balance of labor and worker productivity so that orders are processed smoothly
    - Keep an eye on dwelling shipments and assign problem solvers
    - Follow orders to confirm the shipments make it on the truck
- **Work in progress is optimal to ensure balance, increase productivity & meet customer demand**
    - Monitor work in progress to reduce overburden and keep labor productive
    - Monitor labor productivity and loss of sudden labor to modify work accordingly
    - Ensuring a balance of labor between departments
    - First In First Out (FIFO) approach to ensure orders don't dwell in the system
- **Outbound workforce performance meets or exceeds the plan set**
    - Keeping the workforce productive by providing enough work
    - Maximizing workforce productivity however possible
    - Helping facilitate the quick resolution of obstacles to workforce productivity (jams, mechanical issues, software issues, etc.)

The rest of this section focuses on how a flow manager distributes labor at the beginning of the shift, the information factors that indicate the health of the outbound fulfillment operations, and lastly the active flow levers used to adjust the system.

4.3 Flow Decisions at beginning of shift

The Flow operations manager started the shift using a simple Flow Planner, excel based calculator, which output the best distribution of labor in various functions. This Flow Planner was developed internally nearly six years ago for quicker calculations of labor distribution and has been

updated to address process changes at the FC. The inputs into the planner were headcounts at start of shift from each outbound department and the workable backlog data by process from an internal website. Here, the workable backlog data refers to orders in Condition 4 that refers to orders that can be picked and packaged. Aside from workable backlog, there is additional backlog that sits in a filter for different reasons. In regards to headcount, it is very important that each department figures out the total available labor and communicates these counts as soon as possible.

The flow planner has different field for variable and fixed inputs. For instance, the rates from all outbound functions are programmed in the template. Based on the current workable backlog input and the labor rates, the planner figures out how much labor and where it is needed to process the backlog during the shift. This labor calculation may be higher or lower than the actual labor available. Next, based on the current labor in different departments, the planner figures out how this labor should be used in each direct and indirect function to work down the volume. If the workable volume is higher than volume that can be processed by the available labor, the planner scales down the work by portion of available labor. On the other hand, if the available labor is higher than the needed labor, the planner predicts that new order charge throughout the shift will be in the same proportion by process as current workable volume, and allocates labor accordingly. Based on the planner output and flow manager's own experience, the flow operations manager notifies the department managers and process assistants on how labor should be moved around. This information is usually communicated to the departments within 30 minutes of start of shift, at which time the labor is moved.

After the flow operations manager starts the shift, flow management is handed over to an area manager (based on pre-selected schedule shown in the appendix Figure 24) until late afternoon about 1 pm. At that time, the flow operation manager takes took over flow and manages it through the end of the shift. Thus, after SOS, the area manager's responsibility is to observe the flow screens, assess rates, and make changes on the flow console settings or move labor to keep balance.

4.4 Passive Flow Management Levers

The various levers used in Flow management can be separated into Passive and Active levers. The passive levers merely provide information to aid in decision making, such as: Shipment conditions, Shipment Priorities, Chute Utilization, Flow Console page, etc. Whereas the active levers are user inputs in flow management; these are discussed in the next section. Some of this information was acquired through reading existing materials on flow management, while most of it was obtained through interviews, shadowing flow managers, and managing flow myself.

4.4.1 Shipment Priorities

Every customer order is categorized by a shipment option, which is the basis for how an order must be delivered to a customer. Super Saver shipping is the lowest shipment priority whereas Same/Next Day delivery has higher priority. The Flow Manager doesn't usually make a distinction between the shipment priorities, but they become very important when the fulfillment center has to prioritize orders in the risk of missing shipments. Generally, the system will automatically upgrade the shipment method to a higher method if the system knows that the item will not be delivered on-time to meet customer expectations. By the same token, if the system knows that a shipment can be delivered through a less expensive method and still meet customer promise, then the system will downgrade the shipment priority. When the shipment method is upgraded to a higher priority, the company has to absorb this extra cost. Thus, it's important for the flow manager to monitor order fulfillment status due on the closest CPT and make sure they are processed in time to avoid the risk of upgrades. Flow Manager has to know the various Truck pull times, keep an eye on the order status in the fulfillment process, and know when to add resources to chase a package.

4.4.2 Shipment Conditions

As a customer shipment moves through the order, finance approval, and fulfillment process, it is assigned different conditions that vary based on the status. While there is tens of shipment conditions associated with an order depending on its current status in the system, the flow manager only needs to be

aware of some conditions that are directly relevant to flow management. The amount of volume in each condition is monitored incessantly to make sure the orders get processed in time to meet their critical pull time (CPT), referring to the expected shipment time and the delivery method. Moreover, the flow manager can use the dwell times from a condition to initiate investigation for lost or out of order items.

Some of the relevant conditions are discussed. An item with Condition 29 (C29) means that it has been assigned to the FC, but it is not pickable by a picker until the volume is collated into Condition 4. The Collating process will be discussed in further detail later in the Flow Management section. The next shipment condition is Condition 4 (C4) which can mean either of the following: item is pickable but not yet picked, item has been picked into a tote, or item has been inducted in Crisplant but has not packed into a box. Once an item(s) is packed but has not received a shipping level, its status changes to Condition 7 (C7) in the system. After the manifest label is applied, this status switches to Condition 13, which is generally an indication that the item will be shipped on time. Another important condition that is closely monitored is Condition 15, which means that the item has been assigned to a problem solver.

4.4.3 Crisplant Chute Utilization

Chute utilization is the most frequently used metric to make flow decisions for Crisplant. Figure

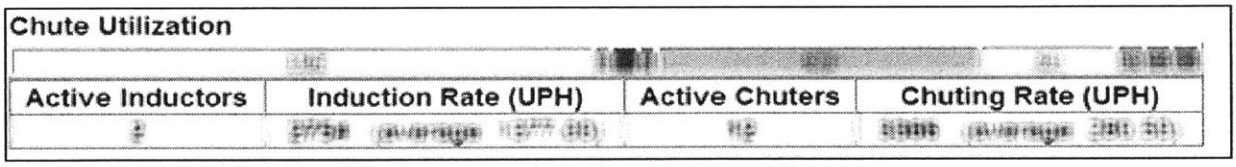


Figure 10: Crisplant Chute Utilization and Labor Rates

10 shows Crisplant Utilization: chute status, number of active inductors and chuters, as well as their rates.

Incomplete chutes (yellow): Chutes that contain some but not all of the units for an order

Complete chutes (green): Chutes that contain a completed order and are ready to be packaged.

Open chutes (white): Chutes that contain no units.

4.4.3.1 Decisions on number of Inductors and Chuters

In an ideal circumstance, induct rates will match chute rates. Maintenance of induct rates is dependent on keeping a backlog at induct (a sufficient supply of totes at induct stations). This is ensured by supplying an adequate number of pickers to the path to provide a backlog of totes at induct. Maintenance of chute rates is dependent on providing a sufficient number of complete chutes ("green lights"), as well as boxes in which to pack units in the completed chutes.

As shown in Figure 10, the green lights are high. This means that inductors are inducting more than the chuters are chuting (packing out a completed chute). In this case, an inductor will have to be "dropped" or taken down, to allow chuters to work down lights, as they will normally, at that point, be out-chuting the inductors (as in the case above). In the opposite scenario, an additional inductor can be "put up" or added to facilitate the building of lights. The typical range for completed chutes (green lights) is 400-600. The optimal number of completed chutes within this range is based on the number of chuters.

4.4.3.2 Shipment Limit Decision

Shipment Limit is determined based on the number of actual incomplete chutes, as shown in Figure 10. The number of chutes occupied by incomplete orders increases proportionate to the number of orders that can be picked simultaneously. The typical range for incompletes is 40% - 50% of total chutes available. Thus, the shipment limit is adjusted to keep incompletes in this range. Maximum chute utilization is desirable, so it is appropriate to run at the higher end of this range so long as there is not a risk of maxing the sorter.

4.4.4 Picking Flow Console

Picking Flow Console is the most used screen in flow management; a cropped section of the process paths and their respective metrics are shown in Figure 11. The chute Utilization in Figure 10 is part of the flow console, but the sections are split for ease of understanding. This page is used in conjunction with supplemental console sites as well as real-time information from the shop floor to make labor and work assignment decisions. The first column in the figure shows the process paths while the second column shows the status of that process path.

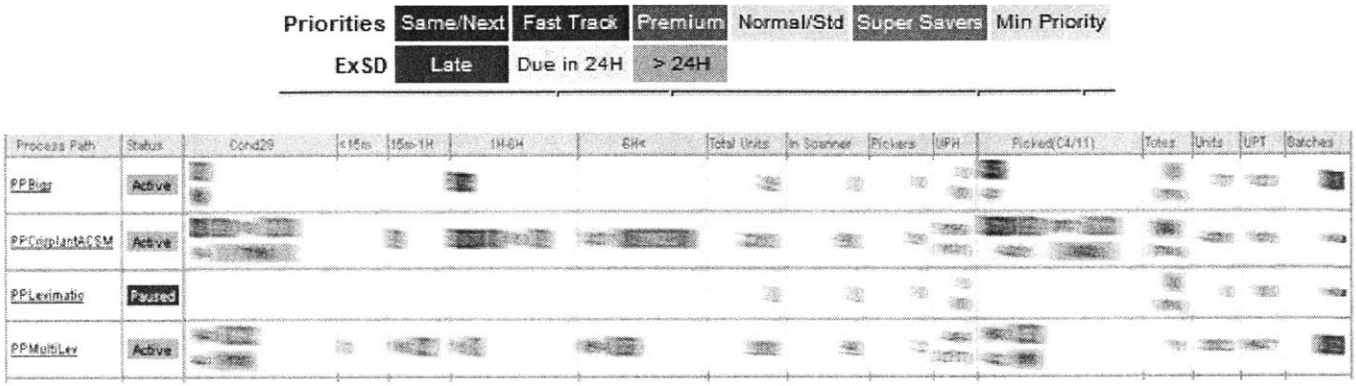


Figure 11: RNO1 Picking Flow Console

Status: The status of the process paths can be changed by the flow manager. Here, the Status shows *Flow Paused or % Flow Paused,* which implies that the path is approaching the tote limit established for the path by the flow manager. This function is automatically managed by the flow console based on how fast the actual totes are being picked versus being consumed by the process path. When a path begins to *Flow Pause,* the pickers in that path get routed by the console to other paths that are *Active.* This status must be watched in conjunction with actual number of Totes (4th column from the right) since *Flow Pause* status is an indication of an imbalance of labor or concerns in the conveyance system for that process.

Cond 29: The volume shown in this column is "Ready to Pick" for that path, but it is not actually pickable until it is collated into pickable condition C4. Furthermore, the volume shown in Cond 29 and C4/C11on the console is distinguished by both shipment priority (top row) and ExSD (bottom row) where the colors can be matched with the index (shown in Figure 11). Important thing to note is that the numbers in both rows total to the same number. The Flow manager keeps an eye on this volume in comparison to actual units in the system (total units column) before making a decision to collate. For instance, if the total units for a process path are low, then the pick density is low and the picking efficiency would be lower; thus, the units from C29 should be collated in. However, at the same time, the flow manager should be aware of new volume that will be charged and automatically drop into Total Units volume based on the current Collate filter.

At minimum, the collate "window" for a given path will be set out far enough to accommodate a shift's ExSD volume, however, it is desirable to keep a minimum amount of pickable volume available to stay in front of customer demand (pick future volume) and maximize pick efficiency. A larger workforce can accommodate more work in progress. However, too much C4 volume can neglect sooner ExSDs, as *all* future volume that has not hit its pad time is treated with the same priority. Likewise, too little C4 volume can compromise pick efficiency, as pickers may be "chasing" these units.

<15m, 15m-1H, 1H-6H, 6H<: These four columns are referred to as Priority Tiers and show all *unpicked* volume in Condition 4, categorized by its priority in terms of its ExSD. This priority is determined by the process pad time for a given pick path. The smaller the time value of the tier, the higher the priority assigned to the volume in it by the picking console; thus, units in a higher priority tier will be picked more immediately than units in the latter tiers.

The first two columns (<15m, 15m-1H) columns are watched very closely to ensure these units are picked in time to reach the pack stations and get processed to meet their expected ship time. If these units are not clearing off the system, the flow managers needs to analyze the rest of the system for balance: whether the path is flow paused which will cause pickers to leave that path, the amount of pack labor, the amount of work in progress (totes in the system) compared to the tote setting, or if there is a lack of overall pick labor and most of the pick labor is tied up in another path.

Units per Hour (UPH): This value indicates the total number of units being picked per hour by the pickers in the path (global pick rate). The number in parentheses is the average pick rate of each picker.
Number of Totes: This value indicates the combined number of finished totes for given path that is either on pickers' carts or in conveyance.
Units: The total number of units in the totes included in the "Totes" column. This is essentially the work in progress (WIP) for the process path.
Units per tote: The average number of units per tote from the totes included in the "Totes" column.

In addition to the picking console, flow manager uses supplemental internal webpages to understand the status of the shipments that are due by certain Critical Pull Time (CPT). Every order in the system is

WorkItemPoolId	Total	01/04/2008 17:30:00	01/07/2008 16:00:00	01/07/2008 17:00:00	01/07/2008 17:30:00
Total	514	22	63	39	390
Picking-Not Yet Picked	439	0	56	33	350
Picking-Picked	22	0	3	6	13
Sorted	14	0	1	0	13
Giftwrap	7	0	1	0	6
Scanned	6	0	1	0	5
Manifest Pending	22	22	0	0	0
Problem Solving	4	0	1	0	3

Figure 12: Status of Truck Shipments

assigned a CPT referring to the time the order must be shipped by to meet customer promise. As shown in Figure 12, this page shows units for an upcoming shipment that have not yet received a shipping label. Thus, it's a very important page to monitor closer to CPT and follow through on outstanding orders.

4.5 Active Flow Management Levers

The flow manager uses several process path properties as well as labor moves to keep flow management in balance. Specifically, there are user-input properties for a process path that can be modified real-time in the Picking Console. Figure 13 shows the process path properties for Crisplant, for

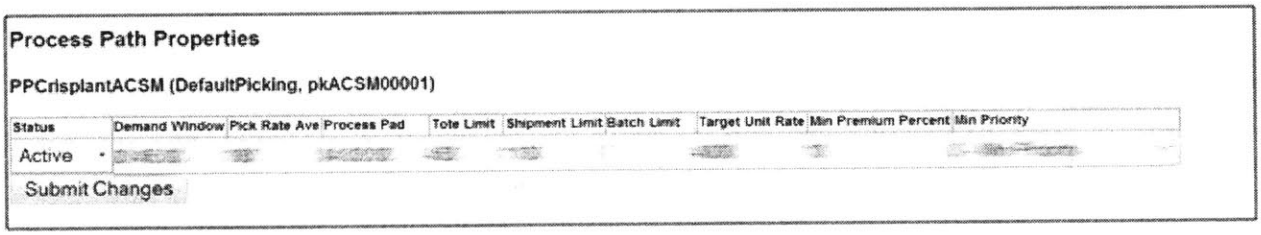


Figure 13: Process Path Properties Dialog Box

instance. Please note that the actual data has been blurred for data integrity. The Process Path Properties screen looks the same for the remaining paths. Flow manager simply clicks on the process path from the picking flow console to see the current settings and make changes. Next, each of these process path properties will be discussed as well as their impact on managing flow.

4.5.1 Process Path Status

The Status of a process path can be *Active, Paused or Halted.* An *Active* path implies that this path is open for pickers to pick volume in this path as long as there is volume available to pick for the

path. When a path is switched to *Paused*, the pickers are allowed to pick units remaining in their scanners for the process path and then moved into another path. The last option *Halt* is detrimental to the picking productivity as it will kick pickers out of the process path immediately.

4.5.2 Demand Window

The demand window refers to the maximum amount of time allowed within which a multi-unit order must be completely picked. The default setting for the demand window is 45 minutes and is rarely ever changed. In theory, reducing the demand window will result in lower pick efficiency as the system would force all items from an order be picked in a shorter time interval. At the same time, if the order is picked earlier, then it will also reach the downstream Crisplant processes earlier. The Demand Window time applies to Crisplant only because that is the only path that process multiple unit orders at RNO1 fulfillment center.

4.5.3 Pick Rate Ave

This is a value that the picking console uses to determine the number of pickers to send to a given path, relative to the path Target Unit Rate (discussed later) and number of available pickers. It is a baseline pick rate that implies the number of picks that must be made per hour per picker for that path. The standard range for all process paths is usually between 1.4n and 2n, although a transshipment path may see actual pick rates above 3n, where n is a unit of measure, so a higher pick rate average is typically used there.

4.5.4 Process Pad Time

Process pad time is used to determine the pick-need-by time for an order, as shown below:

Pick Need by Time = EXSD – Pick travel time – ***Process pad time***

EXSD = Expected ship date and time

Pick travel time = time required for an item to reach its process path after being picked

As seen from the formula, EXSD and Pick travel time are constant inputs, whereas Process Pad Time can be used as a lever to control when items for a particular path will be picked by APS. Here, lowering the

process pad time will result in APS waiting until closer to EXSD to pick the items. This allows for better pick productivity, but increases the risk of missing the customer order shipment time. Whereas, raising the process pad time results in lowered pick productivity since APS will pick the order earlier, however the risk of not picking the order in time is decreased. The Process Pad Times vary by process and can be changed by the flow manager to control the flow of work.

Essentially, the process pad time forces an unpicked unit into higher priority tiers. The calculation behind the process pad time was beyond the scope of the project, it was explained as a plug for calculating the Pick Need by Time. However, it should be noted that the Singles paths are set between 1 and 1.25x the Crisplant time. When ExSD demand is high and the workforce is large (e.g., during Peak), tighter WIP (work in progress) is desirable to prevent intermixing of later units with sooner ExSDs. Therefore, a shorter the pad time should be used.

4.5.5 Tote Limit

Tote Limit is a very important tool used in flow management to control the maximum number of totes for a process path in the system, in other words, this refers to the number of totes that have been picked for a process path but have not been processed, basically the amount of WIP in the system. Tote limit represents the cap value upon which the flow console will determine how aggressively to pick a process path and how long to keep pickers in the path. This setting works as a feedback loop to prevent maxing out the system. As the actual number of totes approach the tote limit, the path will begin to flow pause and start to kick pickers out of the path. Once the total totes in the path reach 90% of the tote limit, the path will become completely flow paused.

4.5.6 Shipment Limiter

The shipment limiter is a tool in the Amazon Picking System (APS) to maximize pick productivity where the shipment limit refers to the number of open orders that can be picked simultaneously. For example, if the shipment limiter is set to 700, then APS is allowed to work on 700 orders at a time. An order is considered closed in APS when picking picks the last item needed for that

order. Therefore, the higher the shipment limiter, the better Total Picks per Hour (TPH) as the pick path will be denser. Furthermore, incomplete chutes on the Crisplant Sorter are related to the shipment limiter by the cycle time for a complete order to be picked. For example, if the first pick in an order arrives at the sorter at 12:00PM, there will be a certain amount of time before the closing pick for that order is picked and then travels to the chute. Thus, the number of incompletes in CP remains at some level above what the shipment limiter.

The Shipment Limit is a picking constraint and must be monitored very closely to prevent maxing out Crisplant. Shipment limit can increase the risk of maxing out the Crisplant sorter, which can have ripple effect on labor in the plant where inductors will have to stop inducting to allow chuters to pack out chutes, and a halt in induct can lead to increased WIP from picking, resulting in Picking labor to stop picking for Crisplant. This is especially dangerous when there is a jam on conveyance and totes are delayed to the Crisplant. When there is a jam, APS continues to allow picking to open more orders thus increasing the amount of work in progress between picking and Crisplant. Thus, it is vital that the shipment limit is lowered until the jam has been cleared.

The shipment limit is a constraint for multi-shipments only. A single item order is in a sense both an opener and a closer. The process path properties page allows the flow manager to edit the shipment limit.

4.5.7 Batch Limit

This is a batch-pick path only setting, such as Smols process path, and represents the number of batches that "ready to pick" volume can be collated into. A batch can be picked by one picker at a time.

4.5.8 Target Unit Rate (TUR)

This is a frequently used lever and refers to the desired number of units to be picked per hour for a given pick path. TUR is critical in determining the number of pickers and packers. Generally, TUR is calculated based on the pack labor times their average pack rate. However, TUR further determines the number of pickers needed to keep up with the number of packing associates. The Flow Manager has to

constantly monitor the pack and pick rates to ensure a balance; otherwise the system will either end up with too much WIP in terms of totes or insufficient WIP where pack labor will be starved for totes.

4.5.9 Min Premium Percent

The Min Premium Percent requires the pick system to schedule a certain number of premium and fastrack picks regardless of their EXSD. This tool is useful when there are a high number of premiums to pick. The pick system only follows the premium percent with regards to openers. It will still schedule middle and closing picks for multi-unit orders that are on the sorter. The system allows pickers to pick these items to close out incomplete chutes and open them for new fast-track and premium shipments.

4.5.10 Min Priority

This setting determines the lowest shipment priority category that can be considered pickable by the picking console. The default is 'Zero' such that all volume is available to pick. This setting can be modified to 'Super Savers,' 'Normal/Standard,' 'Premium', or 'Fast-track', depending on the order volume that needs to be prioritized.

4.5.11 Collate Settings

In addition to process path properties, Collate Setting is another lever used in flow management with manual input from the flow manager. Collate settings control what work will be moved from Condition 29 to Condition 4 in the Picking Flow Console. As noted before, C29 volume is "Ready to Pick" volume but it is not available for picking until it moves in pickable condition C4. It is made pickable when it is collated into C4 by the Flow Manager. For example, if the collate settings for

Profile	Type	Active	Collated ExSDs	Interval Minutes	Update
CPBigs	Batchy	☑	between NOW and 18:00 in 14 days	N/A	Update
CPBigsPremium	Batchy	☑	between NOW and 18:00 Tomorrow	N/A	Update
CPCrisplant	Batchless	☑	between NOW and midnight in 14 days	5	Update
CPFracsSingles	Batchless	☑	between NOW and 18:00 in 14 days	5	Update

Figure 14: Example of Collate Window on the Picking Console

Crisplant are set at midnight tomorrow, all orders for Crisplant with an Expected Ship Date (EXSD) before midnight tomorrow will drop into the pick scheduler. An example of the Collate Window is shown in Figure 14 for illustration purposes.

As a general principle, collate settings should be rolled out together for each process path. If Crisplant is at 2 days out, then VDF should also be set to the same time. This ensures that FC is working on the nearest EXSDs in all paths and not neglecting a process path. If all paths are collated out to the same day and the volume in one path grows faster than another path, the flow manager should rebalance labor among the outbound departments and restrict collate settings to limit pickable volume until the process paths are in balance. Tracking the volume in each path and collating each path out at the same time allows the fulfillment center to prioritize work based on EXSD. This is especially important with the singles process paths (VDF and Tekho) where the capacity is significantly lower than the Crisplant. Neglecting proper staffing in these paths can result in a situation where there isn't sufficient capacity to complete all customer shipments for a given shift. This can result in chasing orders and require out of standard processes that are difficult to manager.

Auto-collate works slightly differently for batch processes, where orders will not move from C29 to C4 until the batch is ready to be made active. If the batch limit is set to 5 and 5 batches are being worked on, another batch will not move to C4 until one of the active batches is completed.

4.6 Summary of Managing Flow

Overall, flow management is very complicated with a broad set of objectives and actions required. Flow management is controlled manually through limited tools, but has large implications on outbound performance, costs, and on-time shipment processing. Flow Manager has to be able to process large amounts of information in dynamic and stressful situations, make quick decisions with outlook into the remaining shift, and ensure the decisions are followed throughout the outbound processes. Moreover, the Flow Manager must have deep knowledge of outbound functions, labor requirements, flow console

tools, flow levers, and diverse experiences in flow management. Diverse experiences imply running flow on different times of the day and different days of the week under different scenarios, for instance peak versus off-peak. It's difficult to predict how flow will be managed by the minute as there are too many inputs into the system and they're ever dynamic.

5 Project Findings & Changes Implemented

There were major concerns found with the complex process of flow management at RNO1. The findings are detailed in this section along with the changes made to address the concerns, their impact, and how the change will be sustained at RNO1 fulfillment center.

5.1 Flow Management Structure

The Flow operations manager started the shift with balanced labor and then turned flow over to an Area Managers (AMs) to lunch based on a daily flow coverage schedule (Figure 24). After lunch, the flow operations manager took over flow until EOS to focus on the heavier premium pulls. There were fundamental issues with this approach as shown below.

- The AMs ran flow for an average of 13 hours per week while managing their own department area. This not only limited their attention to flow, but also took time away from their associates.
- The approach to making flow decisions varied vastly from one manager to another. For instance, one manager could run the tote limits much higher than another manager. The difference in outcome is the amount of work in progress that could accrue in front of a path. A high tote limit can get the outbound fulfillment processes in trouble during late afternoons as orders due may be stuck behind a large WIP. This results in out of standard processes to scan every tote on the line to locate ones that are due and bring them to packaging associates. In essence, there were no set criteria on how to manage some of the important settings.
- The number of templates used for reporting shift performance and flow decisions varied. Managers tended to download the templates onto their desktops and keep using that copy. Each manager also

had come up with their own modifications to make it more convenient for him/her to prepare the reports. During my interviews, I came across over 5 different templates on preparing just the shift.

- Based on my observations, the AMs' focus was to keep the process paths balanced and get customer orders shipped on time that were due during their flow schedule, and did not include proactive labor planning to fulfill afternoon premium volume. They hardly evaluated the labor before heading to lunch and communicated the essential labor moves. The approach to make labor moves was rather reactive and costly, where more than ¾ of labor moves were made after returning from breaks.
- When the flow operations manager took over flow after lunch, he evaluated the situation and made drastic labor moves and changed process path properties based on his preference to run flow for the remaining of the shift. These dynamic changes have a rough effect on the flow of labor and work.
- There was hardly any communication between managers at Start of Shift (SOS) or after lunch when flow managers shifted hands. It was expected that the new managers evaluates the situation and makes changes as he/she sees fit for the rest of the shift.
- Lastly, yet importantly, the management at Amazon.com rotates frequently with RNO1 as well as within the network of fulfillment centers. Thus, it's difficult to provide the needed training to new managers; instead the new managers received a few hours of training on the tools and were expected to learn on the job.

5.1.1 Improvement to the Flow Management Structure

During interviews of flow managers, flow operations manager, there was an obvious concern with the flow management structure. The area managers expressed concerns with running flow while managing their own departments, resulting in split attention to the two roles. When asked the change they would like in flow management, their first answer was to have a dedicated person managing flow. I confirmed this hypothesis by managing flow myself throughout the shift which resulted in less chasing after orders and smoother communication to the departments as there was only one point of contact. The next decision was whether the flow management should be given to a manager level or a level below.

After much discussion about advantages and disadvantages of the two options, the general management level at RNO1 decided to hire a dedicated tier III flow-lead on every shift. Tier III simply refers to a hiring tier where the level of these personnel would be one step lower than an Area Manager. The Flow leads report to the shift operations manager. This change allowed the shift operations manager to hold sync-up and production strategy meetings with the area managers and the Flow lead twice daily.

5.1.2 Impact of Change

The flow lead structure is projected to save $141K annually compared to the cost of AMs and flow Ops manager running flow, as shown in Figure 15. Even though the cost of training was a one-time

Savings from the Flow Lead Structure						
	#	Hours/ wk	Total hours/wk	Payrate	cost per week	cost per year
Ams	10	13	130	$ 36	$ 4,680	$ 243,360
Ops Mgrs	2	25	50	$ 50	$ 2,500	$ 130,000
Flow Leads	4	45	180	$ 24	$ 4,320	$ (224,640)
Cost of training the flow leads:						$ (7,680)
Savings						**$ 141,040**

Figure 15: Savings from the new Flow Lead Structure

cost, it was added to account for follow-up annual trainings or cost of hiring a new flow lead, if necessary. The flow operations manager structure was eliminated and the flow leads on each shift reported directly to their shift operations manager. The Assistant Manager positions were not eliminated, but their time could be used for implementing change projects that would result in future savings to the company. RNO1 agreed that $141k was a conservative estimate for expected cost savings from the Flow Lead Structure program.

Moreover, a survey was given to all AMs and Operations Managers to get feedback on the new structure. A summary of the responses is shown in Figure 16. 100% of the managers agreed that it's a good idea to keep the Flow Lead structure. Managers reported spending 9 more hours per week walking the floor and talking to associates instead of working on their computers. Managers reported spending more time in understanding their hourly metrics and giving higher quality feedback to their associates.

AM/Ops Feedback on Flow Lead Structure	Before	After	Δ
Hours spent running flow per week	13	0	-13
Hours spent on computer weekly	29.4	20	-9.4
Hours spent working from home per week	4.4	1.9	-2.5
Hours worked per week	50.6	50.4	-0.2
Sync meetings on the floor with managers	0.6	8	7.4
Hours spent on the floor and talking to associates weekly	4.7	13.9	9.2
Hours of training to run flow	14	80	66

Figure 16: Manager Feedback on new Flow Lead Structure

All AMs also reported that they feel less hurried and more eager to look for continuous improvement. Lastly, managers have more time to implement quick Kaizen projects, while some AMs have been able to work on major projects: Radio deployment and Pack at Chute project with savings of $300k annually. This was largely attributed to having more time to plan and implement projects.

5.1.3 Sustaining the change

The flow lead structure is in line with flow management at other FCs. RNO1 plans to continue to use flow leads as it frees up managers to focus on associate development and Kaizen activities. This change combined with countermeasures discussed next helped optimize flow management significantly.

5.2 Flow training and Management guidelines

As mentioned in the last section, the training given to AMs to run flow lacked standardization and was insufficient. Based on a survey of the AMs, their training involved shadowing another AM or Ops for an average of 14 hours total, which is clearly not sufficient in understanding the complex flow levers, lever usage techniques during different times of the week, personnel involvement, ensuring order fulfillment, etc. There was a 60 page Flow Handbook that existed however to my surprise only 1 manager was aware of this resource and had not used it. Furthermore, RNO1 facility did not have a tool to assess the flow managers' knowledge of basic flow concepts. Flow management was also not tied into the facility's performance, even though flow management had a significant impact on order fulfillment and balance of labor and work. Essentially, as long as all the orders due were fulfilled on time, flow management job was not questioned.

Flow management lacked standard in many aspects – reporting, training, managing labor, and managing work in progress throughout the shift and amongst the four shifts. The ranges for Work in Progress (totes/chutes) varied substantially based on the flow manager. For instance, some AMs preferred keeping the Induct backlog at 40 minutes, while others ran it lean at 10 minutes. There were also no handoff guidelines between shifts and between flow managers. As a result, the next shift could walk into extremes of WIP in various paths, requiring immediate labor moves. On average, each shift ended up moving an average of 4-5 associates for up to 45 minutes until the system balanced. In summary, the flow managers were overburdened to make flow decisions without the right tools and training.

5.2.1 Process Improvement

The changes were carefully chosen to get the highest leverage and ensure they could be implemented in the timeframe of the internship. Moreover, it was very important to gain buy-in from flow managers on all shifts and determine how the changes will help them manage flow easier. The most prominent changes implemented were: standardized flow training module, optimal WIP settings for all process paths, quick-reference guide, flow assessment questionnaire, and shift-hand off guidelines.

Using intrinsic knowledge of flow management and feedback from managers about best practices, I prepared a standardized flow training module. It included review of flow tools, theory, hands-on training in various departments, time to shadow all involved personnel (PAs, problem solvers, AMs, dock clerks), and actual flow management for 2 weeks with guidance. In addition, I trained the four flow leads using this flow training module and made changes according to their direct feedback. This document is now a living document at the flow management desk and can be easily updated. As a supplement to the actual training, standardized documents were created for future flow training, as shown in the Appendix. In addition, clear guidelines were set for flow lead responsibilities as well as a list of tasks that the flow lead must be able to do independently, which is a good proxy to confirm proper training was given.

It was important to derive local optimal ranges for work in progress for the various processes. These units were determined based on empirical data and averages of work in progress used by managers using the formula: WIP = # of packers * pack RE * minutes of WIP/60. Next, the idea was to have a higher backlog in the mornings (~35 minutes) and reduce it in the afternoon during premium CPTs (~15 minutes). Please note that the range of units has been blurred to protect Amazon's proprietary data. There are notes below the units in Crisplant table for more details about how the units were determined. The same strategy was used for Tekho and VDF. These tables and the methodology were also shared for best practices with two other sortable fulfillment centers: TUL1 and SDF1 that use the Crisplant equipment to sort multiple unit orders.

Units in Crisplant (based on open inducts and time of the day)								
	3 inducts	4 inducts	5 inducts	6 inducts	7 inducts	8 inducts	9 inducts	10 inducts
Morning								
11:30								
Early Afternoon								
14:30								
15:30-16:30								
EOS								

Notes to explain the above table:

- Mornings: Higher unit count will allow for a buffer if software/ mechanical issues arise.
- Afternoons: Pick rates run lower in the afternoon as software chases after premium and fast-track units. In order to reduce the amount of time units spend at induct stations, the unit count is managed to low levels in the afternoon. This minimizes the time to process these units.
- EOS: Units in CP should be higher to leave sufficient volume for nightshift startup in Crisplant.

Figure 17: Optimal WIP at Induct based on time of the day and number of inducts open

In addition, a one-page quick reference to necessary information was developed, eliminating muda which is time wasted in looking for basic information. This is used frequently when managing workflow. Given the sensitivity of the information on this reference guide, it is not shared in my thesis. Another important change implemented was a standardized 65 question assessment to test all flow managers on flow concepts. The questionnaire was finalized after feedback from the Operations

managers, Senior Operations manager, and General Manager at RNO1. All current AMs and flow leads were tested using the assessment. The content of the assessment are confidential however the assessment methodology was vetted prior to administering.

5.2.2 Impact of Change

The implemented countermeasures provided a standardized approach to training and evaluating flow concepts. See Flow Assessment results in Figure 18. While this may not guarantee that the new trainees will manage flow optimally, but it does set them up for success. Furthermore, the dayshift AMs

Flow Assessment Results			
AM 1	75%	Flow Lead 1 (before)	55%
AM 2	59%	Flow Lead 1 (after)	92%
AM 3	72%	Flow Lead 2 (before)	56%
AM 4	56%	Flow Lead 2 (after)	97%
AM 5	65%	Flow Lead 3 (before)	72%
AM 6	75%	Flow Lead 3 (after)	90%
AM 7	75%	Flow Lead 4 (before)	47%
AM 8	72%	Flow Lead 4 (after)	93%
Average	69%	Average (after)	93%

Figure 18: Results of the Flow Assessment Questionnaire

reported that labor planning is more consistent and have noticed more than 25% reduction in labor moves into and out of their departments after breaks. Each labor move after break costs the FC approximately 6 minutes. See next section for cost savings in planning labor moves. Lastly, the standardized guidelines reduce the waste of muri, mura and muda from flow management. The WIP ranges have been successful in improving Customer Experience by running the system leaner during the afternoons, especially in fulfilling fast-track orders. Similarly, the shift hand-off standards allow the next shift to plan proactively instead of reacting to extreme amounts of work, causing pick and pack labor moves. This saves nearly 14k in annual savings based on 4 associates moved back and forth within 1 hour on each shift daily.

5.2.3 Sustaining the change

The facility plans to use the training to train all new AMs in outbound on flow principles. The quick reference guide that includes all the standards is a live document and will be updated by dayshift operations managers to address changes.

5.3 Customer Order Charge Forecast

Customer orders allocate to different fulfillment centers throughout the day depending on distance to customer and inventory location. This order charge varies throughout the time, thus it's difficult to plan labor to a consistent order change. RNO1 fulfillment center like other FCs did not have a tool to capture this order charge real-time. There was a lack of understanding of charge pattern, especially by process path, and what percentage of the new charge is due on Truck CPTs on the same shift. Furthermore, the FC was unable to differentiate that day's EXSD volume from units shipped early for pick efficiency sake out of the total volume shipped in a day. Most importantly, the shift was not planned on forecasted volume. Instead, labor was moved around based on real-time evaluation of the flow as new charge due same day was allocated to the facility.

5.3.1 Process Improvement

An Excel-based macro was implemented that pulls order charge data from Amazon's internal website every hour. This data was further analyzed automatically to calculate units by process path and differentiate units due same day versus one due in the future. Figure 19 shows outbound charge trend for a random week. The macro is incorporated in a Windows based program 'Task Scheduler,' which runs automatically every hour.

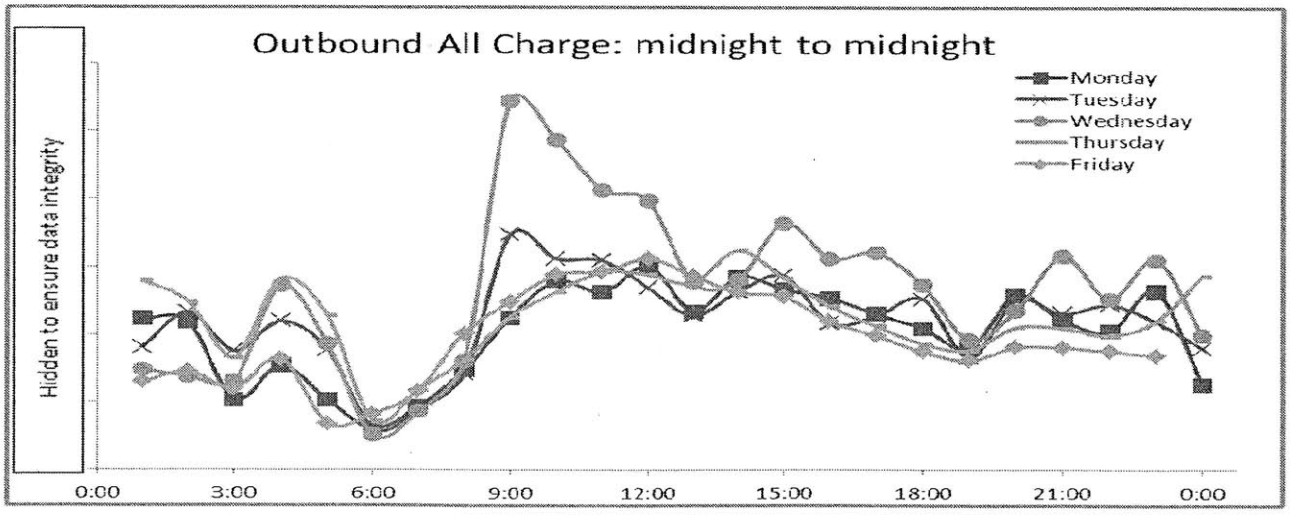


Figure 19: RNO1 Outbound Charge for a random week

5.3.2 Impact of Change

With the customer order charge data, the fulfillment center has a better understanding of charge patterns by process and time of the day. This data is further broken down by types of customer orders: Same day, next day, 2nd day, or supersaver, which can be used to prioritize planning. Some of the immediate impacts have already been incorporated. Further, this data was used to predict the hourly order charge for each weekday and incorporated into the Flow Planner to plan labor. The charge data was also used to test the effectiveness of the Min Percent Premium lever, discussed in a later section.

5.3.3 Sustaining the change

Understanding the nature of new processes being introduced, the macro has a built in feature that looks for unique process paths every time it's run and adds a new row if it recognizes data for a new process. Furthermore, the macro was programmed in such a way that it can be easily replicated to download charge data for any FC. It had already been customized for use at TUL1, LAS2, DFW1, and PHX3 before end of internship. Lastly, I have trained all the flow leads and one Ops manager on how to run the flow manually in case the automatic feature has issues. The Ops manager has also reviewed the code for basic understanding. In the near future, it'll be beneficial to get support from Seattle to build an intra-website that captures this data.

5.4 Incremental changes to make Flow Planner Accurate

Outbound flow planner is a tool designed to aid in planning labor for a given shift based on the following inputs: available labor and backlog by process path. Labor should be allocated to direct and indirect functions in each department based upon the labor recommendations from the planner. However, there were a number of concerns with the current planner. As the issues were fixed, I continued to evaluate the planner effectiveness using PDCA cycle and identify new areas of opportunities.

5.4.1 First Iteration of Change

The flow planner's recommendation for labor was inaccurate and usually not followed at Start of Shift by the area managers. When followed, the flow AMs soon realized that the pack labor in Tekho and

overall pick labor was insufficient. This required the manager running flow to make labor moves within one hour of shift start time to keep the paths balanced.

Why: The flow planner was built nearly 3 years ago and not updated to do labor calculations on new process attributes, i.e. Tekho Premiums and Levimatic Premiums and increase in Transship volume. For example, Transship volume has increased by 40% over previous year. Thus this volume not being able to take into account in the planner caused the flow manager to make extra moves.

Fix: The first step was to understand how the flow planner works and allocates labor. Then, the planner was modified to include Premium volume and raise the volume constraint in Transship. This resulted on average a 15% increase in labor allocation to Tekho and Picking (~2 more packers, 1 more picker), thus reducing the need for these labor moves later in the day. This is a minimal saving of $7k/year based on 6 minutes to make labor move on each shift.

5.4.2 2nd Iteration of Change

The labor planning was purely based on the workable backlog and did not take into account the units in the Filter. Therefore, the pack labor was not balanced to reduce the backlog in each path at

Process Paths	Current Backlog (units)	Actual RE (7 day avg* TPH)	Pack Labor	Through put (Units)	Backlog (labor hours)	Backlog hours (based on current labor)
Crisplant	58285	[illegible]	34	9180	216	6
VDF	19719	[illegible]	9	1305	136	15
Tekho	12622	[illegible]	11	660	210	19
Levimatic	1138	[illegible]	1	180	4	6

Figure 20: Backlog hours by path (before change)

approximately the same rate. Figure 20 was a typical representation of backlog hours by path with the current planner.

Why: This type of analysis was conducted at Senior Operations Manager level on an ad-hoc basis.

Fix: New tool was developed to use workable and filtered backlog along with current labor to determine the backlog hours. This was incorporated into the planner and labor was allocated to balance the backlog

hours. Now, the flow leads can use this tool to quickly evaluate how change in labor would impact the balance in backlog hours for the various process paths.

5.4.3 3rd Iteration of Change

The labor and volume goals for each process path were determined based on the workable units, such that EXSDs beyond the shift were equivalent of new charge that will be due during that shift.

Why: RNO1 FC, like the rest of the FCs, did not track cumulative charge, especially by path, thus it was difficult to know whether this approach was sufficient.

Fix: The availability of charge data made it possible to trend and forecast charge by process path and how much of that charge is due on the same shift. Figure 21 below shows process path capability before and after charge forecast is incorporated into the planner for a random day at RNO1 FC.

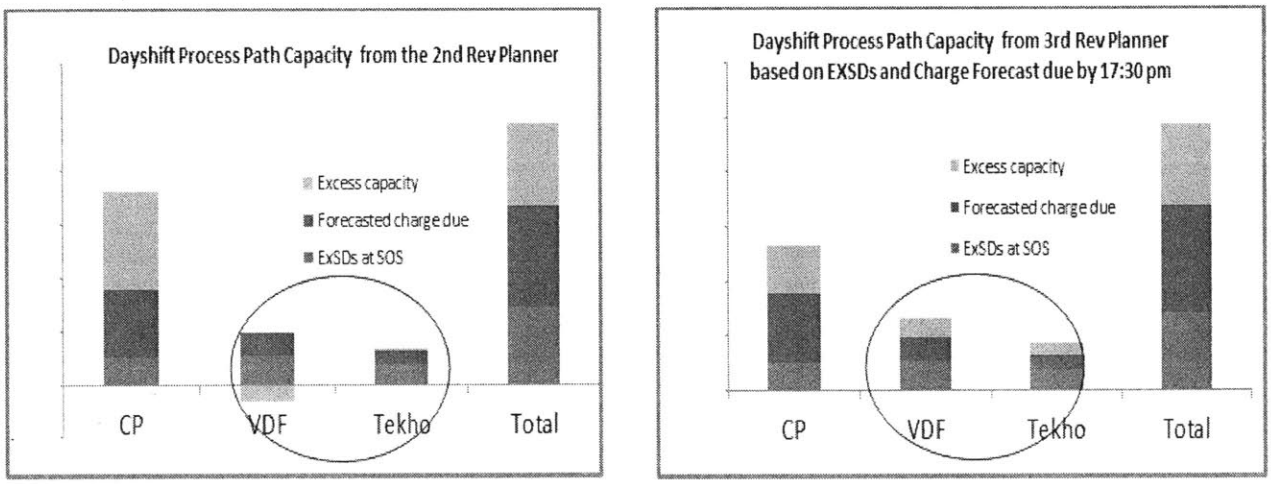


Figure 21: Process Path Capability Comparison before (left) & after change (right)

The graphical comparison for process path capability before change shows that the labor in VDF was not even planned to fulfill the expected ship volume at SOS and new charge that will be due by the last premium pull. Similarly, Tekho labor was barely planned for EXSDs and the new charge. Furthermore, using charge data for 10 random days in July 2010, I was able to determine that approximately **50%** of total units shipped had EXSDs beyond that day. Thus, the pack labor should be planned to take into account the extra shipments that will picked out by the picking algorithm in addition to total units that are due.

The cost and Customer Experience impact is quite significant in this case. On this particular day, there were 15 labor moves made into Tekho and VDF after lunch, where 6 of the associates were brought in from the Inbound department. Because labor was not planned properly, RNO1 had to upgrade 27 shipments to a higher shipment method and 6 shipments missed their expected CPT. In addition this caused a lot of out of standard work and cost to the fulfillment center.

To reduce the chances of a scenario as above from recurring, the planner has been modified to switch labor planning focus to EXSDs and new charge that is forecasted to be due on that shift. The remaining labor is allocated evenly amongst the paths based on the workable backlog due beyond that shift's EXSDs. Also, the graphical representation of process path capacity has been added to the planner preparation as a standard.

After the new planner was implemented, the labor moves decreased dramatically over the next ten days, based on feedback from the flow lead and shift ops, however it's difficult to compare the difference based on the previous planner as labor move data was not collected historically. Although, a qualitative survey of all managers shows that majority of the labor moves are planned prior to going to a break, thus reducing the travel time of 6 minutes average per person after break. Based on AMs and Flow leads' feedback, labor moves have been cut down by more than 25%. Thus, it's a minimum of $10k in labor savings. As RNO1 refines the forecast and take data on the impact of lesser labor moves, higher savings are bound to be realized.

5.4.4 Sustaining the change:

The facility sees its ability to track customer order charge at process level as a big win over the previous planner. The forecast in the planner will be continually revised every 2-3 weeks based on the latest charge data. Also, the flow leads have been instructed to verify the daily forecast with actual charge by process to understand the discrepancies in forecasting.

5.5 Leverage Nightshift to process more Premium volume

The pick rates begin to drop as the picking software is in chase mode during the afternoon to pick premium and FT volume. While it's difficult to plan for the exact fast-track charge, there was an opportunity to leverage nightshift to pick higher overall premium volume. Based on Charge tracking, on average, of dayshift's premium volume charges between 16:00 pm and 4:00 am, of which a percentage is due by next day's last premium pull. However, nightshift only picked out a lower percentage of the opportunity of VDF, Tekho, and CP Premium volume based on calculations from tracking database.

5.5.1 Min Percent Premium Test

The Min Percent Premium picking lever was tested on nightshift in three major paths: Crisplant, Tekho, and VDF. The test was conducted from July 9th through July 26th. The range of Min Percent Premium tested was Crisplant: 10% - 30%, Tekho: 15% - 40%, and VDF: 15% - 40%.

The results of Min Percent Premium test are in Figure 22 by process path and impact to each shift, where

EPPH **Before**: refers to Jan-June data by process path and overall picking EPPH

EPPH **After**: refers to average of EPPH from dates the test was conducted in July.

	% prem units picked			Nightshift EPPH			Dayshift EPPH		
Path	Before	After	% change	Before	After	% change	Before	After	% change
Crisplant	76%	93%	23%	[illegible]	[illegible]	2%	[illegible]	[illegible]	1%
Tekho	48%	74%	55%	[illegible]	[illegible]	-2%	[illegible]	[illegible]	-2%
VDF	43%	78%	81%	[illegible]	[illegible]	9%	[illegible]	[illegible]	10%
Overall Impact on EPPH				[illegible]	[illegible]	-1%	[illegible]	[illegible]	6.9%

Figure 22: Impact of Min Percent Premium on Pick Performance

5.5.2 Impact of change:

This lever had a surprisingly significant impact on RNO1's pick productivity as displayed in the figure above. Using the min percent premium test on nightshift helped process a larger premium volume on nights in all three processes, with significantly better results in Tekho and VDF. For CP, setting of merely 10% min percent premium allowed the system to pick over 90% of premium volume. In comparison, the setting of 30% was needed to pick higher premium volume in VDF and Tekho.

Nightshift EPPH showed a 1% decrease, while dayshift experienced a 6.9% increase compared to the previous six months. Statistically speaking, it's difficult to compare the average and confidence interval from 6 months to 1 data point in July. Thus, Statistical Paired test-statistic was used to compare data for every hour of the week in July with every hour of the week in June for dayshift and nightshift. This removed most variation in the test, thus showing the impact of min percent premium test. More detailed analysis in shown in Appendix. The impact on picking is a saving of 0.9 to 3.1 pickers per labor hour. The cost impact to RNO1 ranges from $74.8k to $263.4K, with an average saving of **$169.1k** annually during ***off-peak*** months. RNO1 will continue to run this test and do more statistical studies with a large sample size to confirm effectiveness.

The impact on the ease of shipping customer orders on dayshift is difficult to measure as a % change. However, here are verbatim comments from both of the dayshift Operations Managers at RNO1.

"Picking the additional premium picks during nightshift has helped alleviate the stress of large volumes in every process path while allowing us to meet our goals and establish a more efficient overall customer experience."
RNO1 Outbound Operations Manager

"It has increased the flexibility of dayshift pick power to focus on the increased transship and fast-track charge, instead of scrambling to make our earlier pulls. I think this is a better way to leverage nightshift resources, which in the past have not been used strategically to help customer experience."
RNO1 Outbound Operations Manager

5.5.3 Sustaining the change:

Based on data collection for 3 weeks, it was recommended that RNO1 continue to test min percent premium lever as 10%, 30%, and 30% in CP, VDF, and Tekho respectively. The availability of order charge data will help understand impact in terms of % premium units picked.

5.6 Visibility into Hourly Outbound Performance

The outbound shift performance was tracked through different avenues and lacked a cohesive and standardized tracking. Other metrics such as Safety, Quality, and backlog were also reported separately. Each department evaluated its performance and bridged hours at the End of the Shift. In addition, the flow manager sent out separate overall Outbound performance updates quarterly and at EOS, with references

to the departmental washes. Since the departments only reported their performance once a day, the area managers did not consistently track their metrics on a more frequent basis and take proactive steps to improve. Lastly, the plan and commit rates were based on the annual FC goals, and did not account for reduced rates of new hires or volume fluctuations due to projects.

RNO1's hourly shift tracker was modeled after the shift trackers used at LEX1, another Amazon.com sortable fulfillment center in Lexington, Kentucky. See Appendix for the new End of Shift report. The one recap email has replaced 5 departmental washes and 3 quarterly flow updates for each shift, reduction of 14 emails a day. In respect to cost, the PAs are able to save 7 minutes on average after EOS from not doing their separate departmental washes. There are certainly incremental benefits of a more proactive approach to improving performance, which are difficult to measure.

5.6.1 Impact of Change

The one recap email has replaced 5 departmental washes and 3 quarterly flow updates for each shift, reduction of 14 emails a day. The report-out structure is standardized between the 4 shifts. The hourly tracking of performance by sub-department allows the AMs to review their metrics and devote a good portion of their team to drive performance. This reduces focus on reactive bridging at EOS and encourages focus on proactive tactical improvements. Additionally, each shift meets with their team for sync up twice a day to review performance. This is a complete change from the previous structure where the AMs did not meet together. The hourly shift tracker has resulted in annual saving of $10,220.

5.6.2 Sustaining the change

RNO1 facility continues to use this format for hourly tracking and EOS report-out. The flow leads and one dayshift Ops manager were trained on how to make changes to the template. Continuous improvement is ingrained in Amazon culture, thus this document was developed to be easily customized.

6 Summary & Conclusion

Major changes implemented to improve RNO1 Flow Management as well as the type of waste the change reduced are listed below. Overall, these changes allow for a more proactive Flow Management instead of reacting and chasing after orders and labor movement.

- Shift flow management from Managers to dedicated Tier III leads on all shifts (Muri, Mura).
- Standardize all aspects of flow from training to running flow, and from shift handoff to reporting guidelines. Determine local optimum settings for work in progress. (Muri, Mura and Muda).
- Develop a system to track hourly charge, with further analysis by premium units versus all charge, by process path, and by the expected ship dates. Use this data to forecast volume and plan labor. (Muda)
- Sequential improvements to optimize the Shift flow planner using EXSDs and charge forecast, thus reducing labor moves in between breaks. (Muda)
- Leverage nightshift to process higher premium volume with the Min Percent Premium lever. (Muri)
- Visual management tools to track hourly performance and reduce dwells (Muri, Muda)

The cost impact of the projected annual savings at RNO1 is charted below:

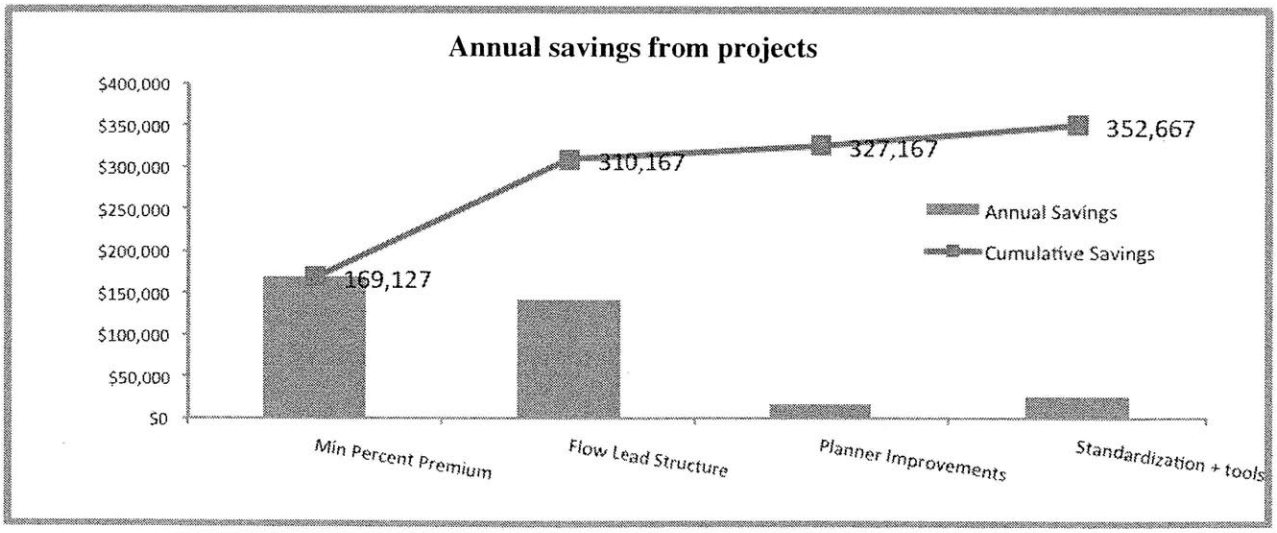


Figure 23: Projected Savings from the Internship

This 6 month project was a great learning experience and gave me ample opportunities to practice leadership, change management, and influence day to day decisions on the floor.

6.1 Future Opportunities for Improvement

While Amazon.com continues to improve its operations, below are further improvement suggestions:

- Amazon.com should invest into an algorithm that makes the flow decisions automatically, using queuing theory and optimization. This functionality can be built into the Flow Console where the various flow levers will adjust automatically based on changes in the plant such as labor, equipment breakdown, labor rate fluctuations, as well as order pattern change.
- Emphasize the PDCA methodology to review the impact of Kaizen activities. Moreover, Kaizen should extend beyond one week and the team should continue to seek feedback from the associates and make incremental improvements.
- As managers are rotated, there should be a standardized handoff including essential documents.
- There is room for more appreciation for workforce and for managers to spend more time alongside associates.
- Associates shouldn't need use an Andon[11] to ask for supplies, instead they should always be supplied ample amounts in order to hit their RE's. Also, the Andon sounds are very unfriendly.
- There are opportunities to stop defects in process and give associates feedback real-time about errors.

[11] "Andon is manufacturing term for referring to a system to notify management, maintenance, and other workers of a quality or process problem. Associates use a pull cord or a button to get the management's attention."

7 Appendix

7.1 Flow Management Schedule

Example of March 2010 Flow coverage schedule showing Area Manager assignments to managing flow.

Dayshift 7am - 12 pm Flow Coverage Schedule					
Day	**Date**	**Name**	**Day**	**Date**	**Name**
Monday	1-Mar	Mgr 1	Wednesday	17-Mar	Mgr 1
Tuesday	2-Mar	Mgr 2	Thursday	18-Mar	Mgr 4
Wednesday	3-Mar	Mgr 1	Friday	19-Mar	Mgr 5
Thursday	4-Mar	Mgr 4	Saturday	20-Mar	Mgr 3
Friday	5-Mar	Mgr 3	Sunday	21-Mar	Mgr 2
Saturday	6-Mar	Mgr 3	Monday	22-Mar	Mgr 2
Sunday	7-Mar	Mgr 2	Tuesday	23-Mar	Mgr 4
Monday	8-Mar	Mgr 1	Wednesday	24-Mar	Mgr 3
Tuesday	9-Mar	Mgr 2	Thursday	25-Mar	Mgr 6
Wednesday	10-Mar	Mgr 5	Friday	26-Mar	Mgr 5
Thursday	11-Mar	Mgr 3	Saturday	27-Mar	Mgr 3
Friday	12-Mar	Mgr 5	Sunday	28-Mar	Mgr 1
Saturday	13-Mar	Mgr 4	Monday	29-Mar	Mgr 2
Sunday	14-Mar	Mgr 2	Tuesday	30-Mar	Mgr 4
Monday	15-Mar	Mgr 1	Wednesday	31-Mar	Mgr 5
Tuesday	16-Mar	Mgr 2			

Figure 24: Example of Flow Management Schedule for Area Managers

7.2 Critical Pull Time Schedule

Below is the Critical Pull Time (CPT) schedule for dayshift at RNO1. This schedule shows the major times when trucks leave the fulfillment center. Every order shipment is tied to a CPT.

7.3 Impact of Flow Leads: Survey Results

O/B AM and Ops Manager Survey Results: Impact of Flow Lead Structure									
Before Flow Leads + Flow related improvements	**Average**	**Mgr 1**	**Mgr 2**	**Mgr 3**	**Mgr 4**	**Mgr 5**	**Mgr 6**	**Mgr 7**	**Mgr 8**
How many hours did you spend running flow per week?	13	7	10	15	15	8	10	15	27
# of Hours of training received to run flow?	14	0.25	0.75	1	60	0.5	18	2	30
How long did it take to prepare planner and washes per week?	4	0.75	3	1.5	3	1	0.75	2	17.5
How often did you meet with the other AMs for a sync-up	0.6	0	0	0	1	0	1	3	0
How much time did you spend walking the floor and talking to your associates per week?	4.7	0	8	12.5	8	2	0	10	5
Time spent on projects per week?	5.8	4	10	8	8	4	3	4	5
How much time did you spend at your PC?	29.4	35	38	20	32	25	25	25	35
Number of hours you spend working per week?	50.6	48	48	47.5	50	52	48	46	65
Hours spend working at home per week?	4.4	7	6	2	2	6	2	0	10
After Flow Leads + Flow related improvements	**Average**	**Mgr 1**	**Mgr 2**	**Mgr 3**	**Mgr 4**	**Mgr 5**	**Mgr 6**	**Mgr 7**	**Mgr 8**
Overall, do you think it's a good idea to keep the Flow Lead and Shift Ops Structure?	Yes	yes	yes	yes	yes	yes	no	yes	yes
Are you able to spend more quality time with associates?	yes	yes	yes	yes	yes	yes	yes	yes	yes
How much time do you spend walking the floor and talking to your associates per week?	13.9	5	18	22.5	16	10	10	23	15
Are you able to work on more projects since Flow Leads?	yes	yes	yes	yes	yes	yes	yes	yes	yes
How much time do you spend at your PC now?	20.0	28	26	14	25	12	20	15	20
Do you feel less hurried and more eager to look for continuous improvement rather than fire-fighting?	yes	yes	yes	yes	yes	yes	no	yes	yes
Number of hours you spend working per week?	50.4	55	48	55.5	50	48	46	46	55
Do you feel your Ops manager has more time to mentor and develop your leadership potential?	Y/N	No	No	Yes	yes	yes	No	yes	yes
Do you spend time reviewing the hourly data from the shift tracker and take proactive steps to improve your department metrics?	yes	yes	yes	not yet	yes	yes	yes	yes	yes
Do you believe Sync up meetings are effective?	yes	yes	yes	yes	yes	yes	yes	no	yes
How much time do you spend after work on work-related activities?	1.9	5	0	5	0	0	0	0	5

Figure 25: Results of Survey after Flow Lead Structure

A survey was given to majority of the Area Managers and Operation Managers to understand the impact of the flow lead structure. The results are shown in the table above.

7.4 Flow Lead Training Schedule

FLOW LEAD Training – Week 1 Schedule

Monday:

10:00 am – 10:15 am	Meet and Greet. Review Agenda for the week
10:15 am – 11:45 am	Baseline Flow Assessment Questionnaire
11:45 am – 12:00 pm	Break. Confirm access to laptops and email
12:00 pm – 01:00 pm	What does Flow Management mean to you? to RNO1? Overview of RNO1 Order Fulfillment Your Roles & Responsibilities when managing workflow
01:00 pm – 02:00 pm	Review Picking Flow Console Fields
02:00 pm – 02:45 pm	Lunch Served. Q&A.
02:45 pm – 03:45 pm	Walk the Shop Floor • Overview of Outbound Processes • Meet AMs, PAs, Manifest Clerks, DCAs, and Problem Solvers
03:45 pm – 04:30 pm	Picking Process Path Configuration Settings (Pick Average Rate, TUR, Tote Limit, Shipment Limiters, etc.)
04:30 pm – 04:45 pm	Break
04:45 pm – 05:00 pm	Short Quiz
05:00 pm – 05:30 pm	Discuss Quiz Answers, Overview of learnings, Q&A
05:30 pm – 06:00 pm	Meet Nightshift Sr Ops and Shift Ops

Tuesday:

10:00 am – 10:30 am	Agenda for the day, Access Flow websites Review Results of the baseline assessment
10:30 am – 12:00 pm	Picking Flow Console Website – Analysis How the system determines # of pickers in each path? FC WorkFlow – most relevant sites
12:00 pm – 12:30 pm	Coffee Break. Walk to Picking desk
12:30 pm – 01:30 pm	Picking Hands On Floor Training (with Laurie Wachenfield)
01:30 pm – 02:00 pm	Role of Picking PA & AM when managing OB workflow
02:00 pm – 02:45 pm	Lunch Served. Q&A.
02:45 pm – 04:30 pm	Using Workflow sites & Picking Flow Console together
04:30 pm – 04:45 pm	Break
04:45 pm – 05:15 pm	Short Quiz
05:30 pm – 06:00 pm	Discuss Quiz Answers, Overview of Learnings, Q&A

Wednesday:

10:00 am - 10:30 am	Agenda for the day, Access Flow websites Visit by Shift 3 Ops Manager
10:30 am - 12:00 pm	RNO1 Flow Macro file versus data on Flow websites Walk to Crisplant Trainer
12:00 pm – 01:30 pm	Crisplant & Slam Hands On Floor Training (with Sarah Long) Get Access to Collate Settings Configuration and Giftwrap tool
2:00 pm – 2:45 pm	Lunch Served. Q&A
2:45 pm – 3:15 pm	Role of Crisplant PAs & AM when managing OB workflow

3:15 pm – 4:30 pm	Review of the Sortation & Routing links on Flow Console
4:30 pm - 4:45 pm	Break
4:45 pm – 5:15 pm	Short Quiz
5:30 pm – 6:00 pm	Discuss Quiz Answers, Overview of Learning, Q&A

Thursday:

10:00 am - 10:30 am	Agenda for the day, Access Flow websites
10:30 am - 12:00 pm	How to Collate in work?
	Collate settings for Premiums and Standards
	Managing workflow in Singles Paths
12:00 pm – 12:30 pm	Break. Walk to Shipping
12:30 pm – 01:30 pm	Shipping Hands On Floor Training (with Diane Gordon)
1:30 pm – 2:00 pm	Role of Shipping PA and AM when managing OB workflow
2:00 pm – 2:45 pm	Lunch Served. Q&A. Visit by Ship SME
2:45 pm – 4:30 pm	Ship dock and Jack Pot with Manifest Clerk.
	Role of Manifest Clerk in Flow
	Meet DCAs and their interaction with Flow Management
4:30 pm - 4:45 pm	Break
4:45 pm – 5:15 pm	Short Quiz
5:30 pm – 6:00 pm	Discuss Quiz Answers, Overview of learning, Q&A

Friday:

10:00 am - 10:30 am	Agenda for the day, Access Flow websites
10:30 am - 12:00 pm	How the current Flow planner works/how to prepare it?
	Hourly tracking & Recap Report
12:00 pm – 12:45 pm	Break
12:45 pm – 02:00 pm	Watch Flow Management, Anticipate actions to take, Q&A
	Preparing EOS Wash E-mail
2:00 pm – 2:45 pm	Lunch Served. Q&A. Visit by Ship SME
2:45 pm – 4:30 pm	Shadow Ops Manager running Flow
4:30 pm - 4:45 pm	Break
4:45 pm – 5:45 pm	Flow Management Best Practices
	Flow Quick Reference Sheet
5:45 pm – 6:00 pm	Overview of Flow Learnings
	Next week schedule

FLOW LEAD Training – Week 2

Monday- Thursday:
Hands on Flow Management
Overview of leanings at 5:30 pm
Q & A

Friday:
Hands on Flow Management (until 3:30 pm)
Flow Management Assessment Quiz (3:30 – 5:30 pm)

7.5 Flow Management Training Records

Trainee Name: _____

Trainer Name: _____

Training Dates (2 weeks min): _____

#	Description	Trainee able to explain/perform on their own (initials)	Date
1	RNO1 Outbound Order fulfillment – sub-departments, process paths, pick categories, and indirect labor		
2	Understand the Picking Flow Console Fields		
3	Flow Configuration levers and their impact		
4	Workflow ExSDs current status		
5	Check C7, FC backlog, Induct backlog, totes on Single lanes		
6	Camera locations, equipment breakdown notifications, filing a ticket		
7	Determine Collate Settings and make changes accordingly		
8	How the current flow planner works?		
9	Prepare SOS flow planner		
10	Calculate backlog hours by process path		
11	Route tote(s) to a particular induct station		
12	Making labor move decisions		
13	Balancing Crisplant Induct backlog		
14	Work Pool Today, OMA, and Skeds		
15	Find lost totes- virtually and physically + IdPremiums tool		
16	Filling out the hourly tracker and how it works		
17	Top flow mgmt situations, reasons, & corrective steps		
18	Complete the EOS hourly recap		

19	Score 95%+ on the Flow Assessment Questionnaire		

Figure 26: Flow Management Training Records

7.6 Standardized guidelines on Flow lead responsibilities

Flow Lead Responsibilities:

- Prepare the shift Flow Planner at SOS and email it out within 30 minutes of SOS.
- Create the Daily Outbound Recap file at SOS.
- Revise the flow-planner before lunch and before 2nd break to plan labor changes. Coordinate labor moves within outbound departments before going to break.
- Evaluate Outbound Flow status and make moves after breaks as necessary.
- Keep the various process paths balanced in respect to backlog.
- Update the following Flow settings: TUR, Pick-Average Rate, Tote Limit.
- Manage future ExSDs:
    - Ensure sufficient labor in paths to fulfill ExSDs.
    - Keep an eye on dwelling units in condition 4 and condition 7.
    - Coordinate with Manifest Clerk to confirm all units in condition 13 manifest on time.
- Watch the various camera links and notify appropriate personnel of equipment breakdowns.
- Identify shipments that are not processed within 30 minutes of the Critical Pull Time and escalate to Shift Ops.
- Manage Collate Settings to keep units in path within the pre-defined range.
- Use the EOS handoff guidelines for proper handoff to next shift.
- Coordinate VTO plans once decisions are finalized.
- Update the Daily Recap file at EOS. The Ops Manager has responsibility for sending the EOS Wash.
- Coordinate with the impacted department to submit SEV3 tickets for equipment breakdown.

Flow Leads need permission from the Shift Ops Manager to do the following:

- Make VTO decisions.
- Make more than 3 labor moves at a time.
- Move labor to/from departments outside of Outbound.
- Change the following settings: MinPremium, Min Priority, Process Pad time.
- Submit a SEV2 ticket.

7.7 RNO1 Outbound Charge Trends

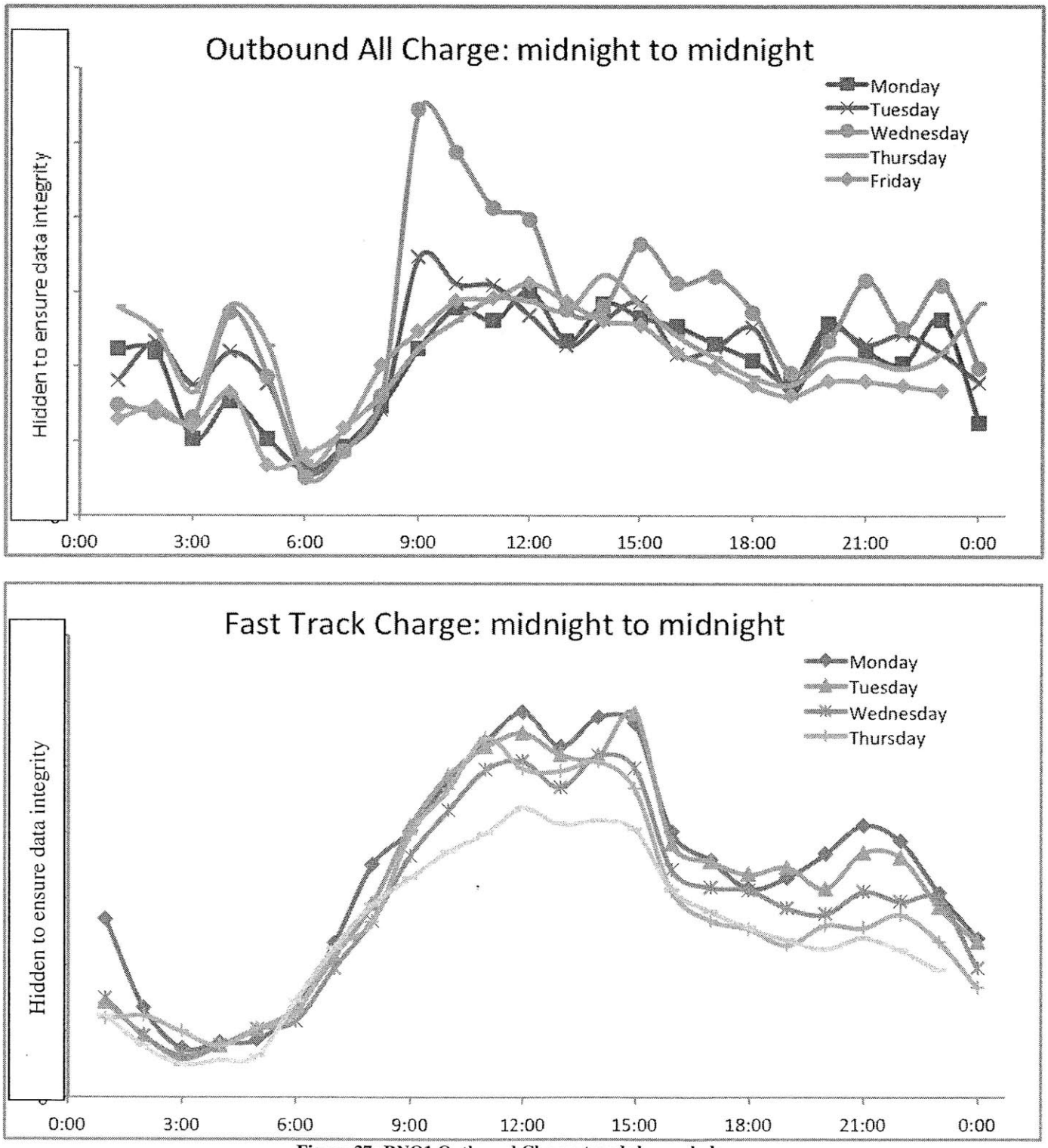


Figure 27: RNO1 Outbound Charge trends by week day

7.8 Min Percent Premium Charge: Statistical Analysis

Justification for Statistical Analysis:

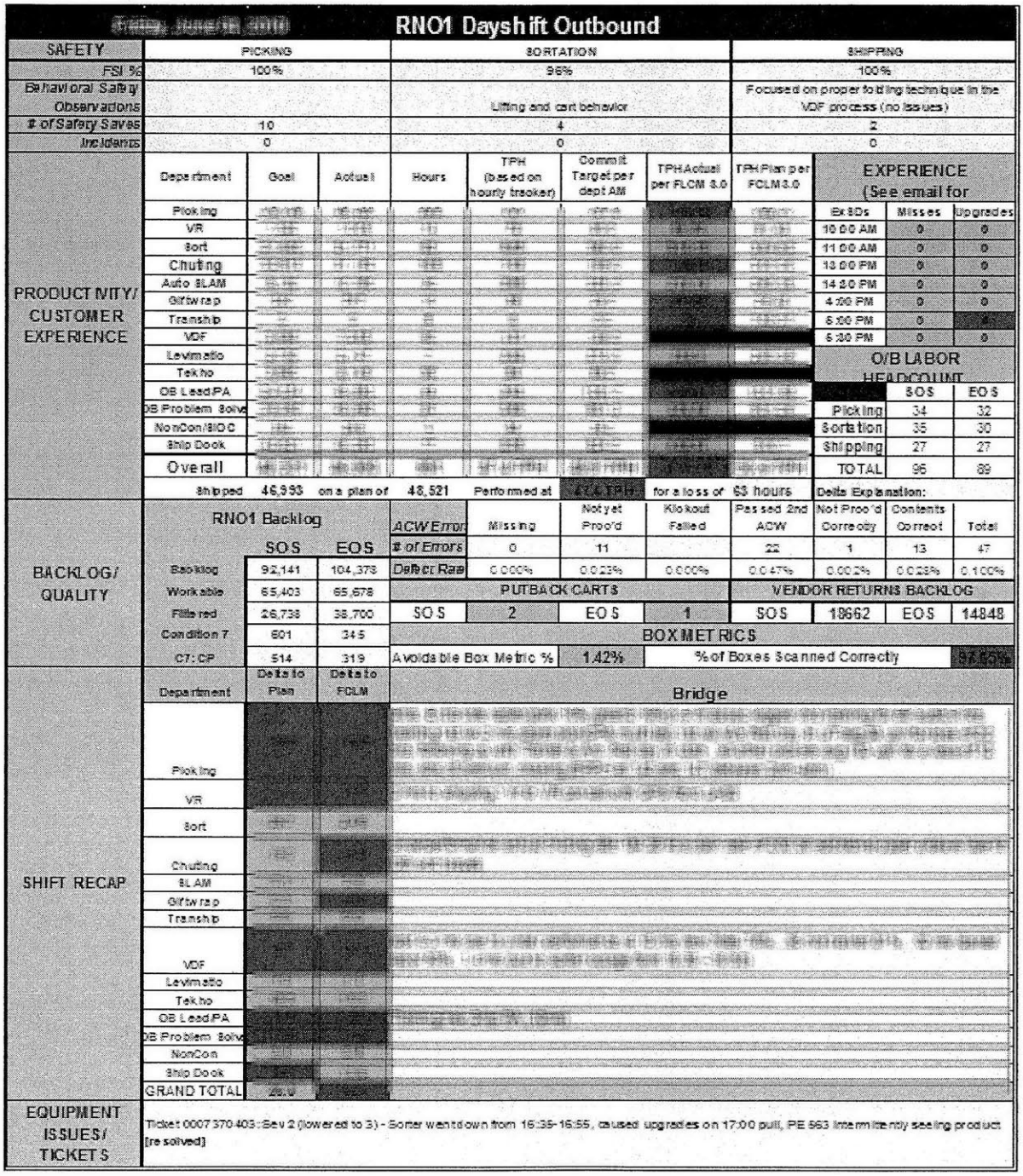
Different ways the data was examined:
1. Compare the data from Jan through June with July – entirely based on averages and 95% confidence interval. This showed that July definitely had nearly 14 pph increase. There were a few concerns with this approach:
   - Cannot simply compare a straight up average from 6 months to 1 month of data. The sample size comparison was 6 to 1. The variation in Jan-June data was high due to the high sample size.
   - The likelihood of Jan-June data to be similar to July was low.
   - 7 am is different 12 pm which is different from 4 pm, thus I couldn't take a simple average.
2. Do a paired test statistic test. Here's the definition and example of a paired t-test:

   Dependent samples (or "paired") *t-tests* typically consist of a sample of matched pairs of similar units where one group of units that has been tested twice (a "repeated measures" *t*-test). A typical example of the repeated measures *t*-test would be where subjects are tested prior to a treatment, say for high blood pressure, and the same subjects are tested again after treatment with a blood-pressure lowering medication.

   Thus hourly data for each weekday in June was compared with each weekday in July. Since July is expected to be more similar to June this year than any other month this year or even July of last year. The way I did the paired test was compare the average of 7 am (i.e.) on all Mondays in June to the average of EPPH at 7 am on all Mondays in July. I repeated this test for every hour of each weekday day for the two months for dayshift and nightshift. Doing this ensures to a high degree that the variation is low for each equal hour, i.e.:
   - The charge pattern should be equivalent at each similar hour of the week (7 am on Monday for example)
   - The person making flow decisions is the same
   - The facility tote travel map is the same (on any day between June and July)
   - The labor allocation is approximately the same

Statistical significance testing:
The **p-value** is the probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that the null hypothesis is true. The **null hypothesis** typically proposes a general or default position, such as that there is no relationship between two measured phenomena. The *lower* the p-value, the *less* likely the result is if the null hypothesis is true, and consequently the *more* "significant" the result is, in the sense of statistical significance.

7.9 Example of New End of Shift Performance Report



RNO1 Dayshift Outbound

	PICKING	SORTATION	SHIPPING
FSI %	100%	96%	100%
Behavioral Safety Observations		Lifting and cart behavior	Focused on proper totting technique in the VDF process (no issues)
# of Safety Saves	10	4	2
Incidents	0	0	0

Department	Goal	Actual	Hours	TPH (based on hourly tracker)	Commit Target per dept AM	TPH Actual per FLCM 3.0	TPH Plan per FCLM 3.0
Picking							
VR							
Sort							
Chuting							
Auto SLAM							
Giftwrap							
Transhlp							
VDF							
Levimatic							
Tekno							
OB Lead PA							
OB Problem Solve							
NonCon/BIOC							
Ship Dock							
Overall							

EXPERIENCE (See email for

Ex SDs	Misses	Upgrades
10:00 AM	0	0
11:00 AM	0	0
13:00 PM	0	0
14:30 PM	0	0
4:00 PM	0	0
5:00 PM	0	0
5:30 PM	0	0

O/B LABOR HEADCOUNT

	SOS	EOS
Picking	34	32
Sortation	35	30
Shipping	27	27
TOTAL	96	89

Shipped 46,993 on a plan of 48,521 Performed at [redacted] TPH for a loss of 63 hours

Delta Explanation:

RNO1 Backlog

	SOS	EOS
Backlog	92,141	104,378
Workable	65,403	65,678
Filtered	26,738	38,700
Condition 7	601	345
C7: CP	514	319

ACW Error	Missing	Not yet Proo'd	Kickout Failed	Passed 2nd ACW	Not Proo'd Correctly	Contents Correct	Total
# of Errors	0	11		22	1	13	47
Defect Rate	0.000%	0.023%	0.000%	0.047%	0.002%	0.028%	0.100%

PUTBACK CARTS

SOS	2	EOS	1

VENDOR RETURNS BACKLOG

SOS	18662	EOS	14848

BOX METRICS

Avoidable Box Metric %	1.42%	% of Boxes Scanned Correctly	[redacted]

Department	Delta to Plan	Delta to FCLM
Picking		
VR		
Sort		
Chuting		
SLAM		
Giftwrap		
Transhlp		
VDF		
Levimatic		
Tekno		
OB Lead PA		
OB Problem Solve		
NonCon		
Ship Dock		
GRAND TOTAL		

Bridge

[redacted]

EQUIPMENT ISSUES/ TICKETS: Ticket 0007370403: Sev 2 (lowered to 3) - Sorter went down from 16:35-16:55, caused upgrades on 17:00 pull, PE 963 intermittently seeing product [resolved]

Figure 28: Revised End of Shift Performance Report

7.10 Glossary of terms

AMs: Area Managers

APPH: Actual picks per hour also defined as picks/actual time picking.

APS: Amazon Picking System

CP: Crisplant

CPT: Critical Pull Times showing ship methods and time of expected ship time

EOS: End of shift

EPPH: Expected picks per hour. Expected pick rate is based on the evaluated picks and the warehouse map. The warehouse map will determine based on historical performance and the pick path the picker took during the time, how long the picker should have taken.

Fast-track: A premium shipment that Amazon guarantees same day shipping.

Flow: Processing work in a balanced manner

Kaizen: is a daily activity, the purpose of which goes beyond simple productivity improvement. It is also a process that, when done correctly, humanizes the workplace, eliminates overly hard work ("muri"), and teaches people how to perform experiments on their work using the scientific method and how to learn to spot and eliminate waste in business processes.

Min Priority: is a setting allowing to specify that only shipments of certain priority or higher will be picked in this process path.

Maxed Crisplant Sorter: The sorter is considered at full capacity when open chutes reach 100.

PA: Process Assistant

Percent to goal: Actual pick rate/expected pick rate. This reduces to expected time/actual time.

Process Path: is used to group picks according to the unique destination paths those shipments must follow after Picking to be properly sorted, packed, and shipped.

Ship Methods: The type of service the customer order is being shipped: next day, second day, ground, etc.

Sortable: Term used to describe items that can be processed through the crisplant sorter, smaller than 8" x 14" x 18".

Sortation: A process path, also known as crisplant, where multi item shipments are combined for shipment.

SOS: Start of shift

Tekho: Process path that is located in Shipping and handles items with dimensions large than a VDF size folder.

Tote Limit: Setting on the configuration tab of picking console, limits the amount of totes in process for a specific process path. If actual tote count rises above the number the tote limit, the system will not assign work to pickers in that particular path.

TUR: Target unit rate

VDF: Variable Depth Folder, used to contain and ship single item orders, majority books.

Workable Backlog: The volume in total units assigned to an FC that can be processed.

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