A STUDY OF LEAN DISTRIBUTION IN MOTOR MANUFACTURING

by

Ms. Chomjinda Khummuangploek

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of Master of Science
in Supply Chain Management
Assumption University

November 2006
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ABAC School of Management
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This project is concerned with designing the distribution processes to improve the company operation and performance in supply chain functions. It focuses on FUSA (FASCO USA) customer, 78 and 85 lam production line of FASCOMotors (Thailand) Co.,Ltd. by using the principle of the Lean concept. Thus, this becomes increasingly competitive in delivering value to the customer on price, quality, and on-time delivery.

This paper simulates the process design of lean thinking on one of the core support functions in supply chain, the distribution processes, by focusing on removing waste from the processes dependency on the reliable performance of assets (people, method, and fixed assets) dramatically increases. Reliable assets become an absolute prerequisite for running the business.

The results from the simulation provide the optimal solution before the actual implementation that will impact on the flow efficiency of the distribution and it can be seen that there has been considerable saving of resources and creation of value in the supply chain.

In summary, the new proposed distribution processes will be designed to replace the existing process. With lean distribution it will reduce the number of administrative staffs, solve the problem of redundant functions, decrease waste time & waiting time, and make better cost reductions.
ACKNOWLEDGEMENTS

In the completion of this project, I would like to take this opportunity to give particular recognition and thanks to all the following people.

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I. INTRODUCTION

1.1 Introduction

How do we survive in the global market of rapid change? Most of manufacturers in Thailand are still hard put to answer this question. This is because the market area has been changed from the local to be global market, so that the customer can find its sourcing from anywhere through the Internet technology. Furthermore, this also makes the competition in the market harder and harder in the current situation. For example, we cannot respond to the customers as quickly as they want. Lack of cash liquidity is the main problem of the company. To survive in the current market situation, the company should have lower prices of products, less inventory, quick response to the customer and good quality of products. Finding the non-added value activities in all sections of the organization and eliminating them has been the strategy to meet customer satisfaction and survive in the market now.

Manufacturers are continuing to become more customer-centric in their approach to the market. This philosophy and lean manufacturing go hand in hand. In order to meet customer demands manufacturers not only have to concentrate on taking out non-value-added processes internally but they also must ensure they know exactly what their customer wants and when they want it. Manufacturers are widening the scope and focus of lean manufacturing to encompass all processes that contribute to the bottom line. Lean manufacturing is the result of manufacturing system design which produces products with the highest quality, shortest response time, predictable output and greater variety. Lean thinking is now increasingly being applied to all areas within the organization from sales and marketing to engineering and production through to finance and post-sale service. The Lean Distribution approach is the one focused area for this situation, which is a major innovation created and cited by the automotive industry for
its ability to cut warehousing costs at the same time as it improves flexibility and
simplicity and thus reduces the reliance on forecasts and optimized plans to achieve
results. This is a management philosophy that strives to focus on reducing lead time,
reducing lot sizes, and increasing reliability, yielding the flexibility and simplicity
required to achieve consistent results. Lean Distribution takes a very different approach
from an optimization and planning approach that is based on fixed lead times and lot
sizes. Lean Distribution provides capabilities that address a variety of business
situations and challenges. Lean Distribution is not necessarily a 'solution' to these
business issues, but it can provide the necessary responsiveness and cost reduction to
address the underlying issues driving many current topics on executive agendas. From
customer-driven cost reduction to considering the implementation of new technologies,
Lean can provide a framework to assess the benefits and construct approaches for
success. Lean Distribution practices link the operational cycle times and variability to
all aspects of process, enabling a clearer link between operations and results. As various
initiatives alter operations or customer demand characteristics, the benefits and
implications become more readily apparent and easier to deliver.

"How do we simulate the design of Lean Distribution to FASCO Motors"

In this project, the simulation will be applied for designing new processes by
using Igrax program, particularly distribution area of FASCO Motors (Thailand); the
motor manufacturer which is the supplier of motors for air conditioners on both fan coil
and condensing. The current FASCO system is the batch production and MRP system
that allows many work in process (WIP) around the factory, long lead time and slow
response to the customer. There are too many redundant processes in the flow of
distribution area leading to much waste in each process.
1.2 Problem Statement

Currently there are many steps in the process flow in the distribution area from delivery schedule plan until distributing the products to the customer, which cause the company to face the following problems:

- Long process time: 2 days in providing all documents per one shipment.
- Late delivery to the customer: the Company cannot catch the vessel within the cut off time, so the company can only ship the product to the customer in the following week (1 week delay).
- Error loading: Short time for finished goods staff to prepare shipment causes wrong product loading.
- High cost of loading truck overnight: the Company cannot load the products within a loading day, so the company has to pay an extra charge to the forwarding agent for allowing the truck to stay overnight.

1.3 Objective of the Project

To design and analyze new processes for the distribution activities of organization that will result in better customer satisfaction leading to better business with the customer.

1.4 Scope of the Project

This project will focus on only FUSA (FASCO USA) customer, 78 and 85 lam production line. In this project, it is to improve efficiency and effectiveness of the distribution system by developing new design and simulation with the lean concept, which cover the major parts of whole processes as follows:

- Distribution processes.
- Internal information flow between customer service and distribution center.
1.5 Deliverable

The deliverable of the project is a new distribution process design as a Lean concept to improve current performance for FASCO Motors (Thailand) Ltd.

1.6 Methodology

The methodologies of the project are as follows:

- Data collection and analysis of the current processes.
- Design modeling and simulation of a new process.
- Evaluation from simulation.
H. COMPANY PROFILE

2.1 Company Background

FASCO Motors (Thailand) Limited was formed in 1999 with a registered capital of 828 million baht. The company is an affiliate of FASCO Motors Group, the world's leading manufacturer of specialty fractional horse-power electric motors. FASCO Motors (Thailand) Limited serves as a manufacturing base to respond to the demand of the Asia Pacific market. The company specializes in the design and manufacture of electric motors and blowers. Single-and three-phase motor with output between 5-3,800 watts in different frame sizes are available to facilitate various industrial needs such as refrigeration, air conditioning and ventilation, farming equipment, swimming pool and spa pumps, and household electrical appliances. The company also provides design and custom-made services to ensure optimal customer satisfaction. With the commitment to enhance the operational efficiency relentlessly to meet international standards in terms of both quality and environment, the company decided to implement the ISO 9001:2000 and ISO 14001 international standard systems. With the close collaboration of all management and staff, Fasco were certified by BVQI in 2004, attesting to the company's professionalism, leadership and environmental responsibility.

2.2 Historical Background

➢ 1997  Fasco acquired Yamabishi Electric
➢ 1999  Fasco acquired TC Motors and the two companies merge to become Fasco Motors Thailand
➢ 2002  Tecumseh acquired Fasco Group

2.3 Fasco Vision

To be the leading designer and supplier of innovative, competitive electric motor solutions and motor driven products to selected worldwide markets.
Fast: 1 day process lead time, 5 day dock-to-dock time, 50+ inventory turns, single piece flow, management by sight, simple and robust systems

Agile: Build to customer Takt (flexible processes staffing, skills, equipment, supply-base, ...), changeover within Takt time

Superior: Quality (zero-defects), Delivery (100%), product performance, customer support and responsiveness, product launches

Competitive: Low cost manufacturing footprint, reliable, capable and productive processes, low cost/high value supply base

Outstanding: Continuous improvement culture, performance driven, employee involvement and engagement, data driven decision-making and problem resolution

2.4 Fasco Mission

To be the first choice for worldwide users of electric motor solutions.

To achieve this we will:

• Ensure a high level of customer satisfaction
• Commit to 6 Sigma Quality standards
• Develop innovative products
• Keep our promises
• Act with honest and integrity
• Meet expectations of growth and profitability
• Train and develop competent and responsive people
• Use teamwork to continuously improve
• Be socially and environmentally responsible
• Maintain a safe work place
2.5 **Fasco** Product Range

- Fan & Pump Motors
- Motors for Air-Conditioner
- General Purpose Motors
- Exhaust Fan Motors
- Appliance Motors & Blower
- Aqua Drive 6, 7 & 8 Series Pump Motor

2.6 Organization Structure

The organization structure of the company is divided into 7 departments with different functions and responsibilities. The following describes the details of each department. The organization chart is illustrated in Figure 2.1.

2.6.1 Production Department

There are 4 main functions in this department: issuing a weekly production plan, preparing components for final assembly, producing goods, maintaining all machines to create efficient and effective production, improving productivity, controlling quality of product and controlling raw material inventory in work processes.

2.6.2 Supply Chain Department

There are 3 major functions in this department: purchasing raw materials and facilities according to the production plans, improving & developing supplier selection, issuing weekly and monthly production plans, receiving and storing materials/finished goods, taking care of customer orders, receiving complaints from customers and declaring to related department, delivering goods, and controlling inventory both materials and finished goods products.
2.6.3 Business Development Department

In this department there are 4 functions: selling and providing goods for customer, collecting important marketing information, updating unit price, creating new product design, improving current product design, and finding new customers & markets.

2.6.4 Finance Department

Financial activities are the major tasks in this department, and they have to record all transactions, which take place both inside and outside the company. Its duty is to prepare the financial and accounting report for the outside section and the company's executive report as well as to manage and control all the company's budgets. IT (Information Technology) is another activity in this department, managing all data bases of users in the company, controlling the computer system and creating new programs for users.

2.6.5 Human Resources Department

There are 3 main functions in this department: recruiting & selecting new employees, controlling the company rules, recording the employees' personal records, issuing all announcements and declaring to all related parties, preparing training for all employees depending on the level & job, and providing a safety environment for the company.

2.6.6 QS & 6 Sigma Department

There are main 2 functions in this department: doing 6 Sigma projects to improve quality, improving production processes, controlling processes, updating & controlling procedure profiles, leading cost reduction, and identifying & eliminating waste in the processes.
2.6.7 QA Department

There are main 3 functions in this department: inspecting the quality of raw material, work in process and finished goods, controlling the quality of product in processes, and controlling the quality of finished goods.
Figure 2.1. Organization chart of FASCO Motors (Thailand)
LITERATURE REVIEW

3.1 Introduction

The function of a supply chain is essentially a process involving the flow and conversion of materials and other resources into products and services that match demands of the ultimate consumer in globalized markets. As supply chains are characterized by dynamic relationships, companies also need to contend with communicating rapidly changing demand. As supply chains make global competition much more possible than it has ever been, it is important to know the supply chain process. Understanding the implications of the proposed future state in term of supply chain flows and supply chain activities (plan, source, make and deliver) leads the company to be quick and highly efficient so as to improve revenues and profit margins in a climate of intense competition and constant pressure.

This chapter describes the principle of the distribution process, lean concept, and a business process simulation and modeling that consists of much information to support each topic for a better understanding and improvement. These concepts will lead a distribution process based on lean principles to attain very high levels of efficiency, competitiveness and flexibility in the distribution process.

3.2 Distribution processes

The role of distribution in the supply chain management model has extended considerably from the conventional view of the activity as being concerned solely with transport and warehousing. The distribution function takes on a wider role as the provider of the final added value. Distribution in the integrated supply chain has now become a value-added activity, providing a critical link between the customer and the factory. — (Kirk D. Zylstra, 2006)
The distribution process shoulders responsibility for successful customer service while continually being under pressure to reduce costs, lead time, and inventory. It can be an awesome responsibility that only gets more difficult and complicated as the supply chain spans the globe. Distribution processes are particularly susceptible to globalization trends due to the direct linkage to customer service, the limited value added, and the high levels of cost across distribution. Changes in distribution process quickly impact customer service and costs. Only well-optimized processes that are flawlessly executed meet distribution's exceedingly stringent standards for both service and low cost. The distribution process changes challenge distribution optimization and the organization's ability to meet performance objectives.

Distribution strategies, warehouse locations, service levels, and operations were built around this role, resulting in many of the facilities, business process, technologies, and policies that are utilized today. Traditional distribution functions have fallen under attack as the business environment and competition are changing. Sales channels have expanded with the addition of online merchants, and other direct shipping channels have increased order rates, reduced quantities per order, and changed the mix of outbound transportation. Competition is changing the traditional role of distribution as customers are having more success reducing prices and obtaining more stringent service policies. Improving distribution processes is now a necessary requirement to survive in the current business market.

3.3 SCOR model — (Supply Chain Council, Inc 2005)

The Supply-Chain Operations Reference-model (SCOR) is a process reference model that has been developed and endorsed by the Supply-Chain Council as the cross-industry standard diagnostic tool for supply-chain management. SCOR enables users to
address, improve, and communicate supply-chain management practices within and
between all interested parties.

SCOR is a management tool. It is a process reference model for supply-chain
management, spanning from the supplier's supplier to the customer's customer. The
SCOR-model has been developed to describe the business activities associated with all
phases of satisfying a customer's demand. By describing supply chains using process
building blocks, the Model can be used to describe supply chains that are very simple or
very complex using a common set of definitions. As a result, disparate industries can be
linked to describe the depth and breadth of virtually any supply chain. The Model has
been able to successfully describe and provide a basis for supply chain improvement for
global projects as well as site-specific projects.

3.3.1 SCOR Model Level 0:
Identifies collaboration points and defines a network where consortiums,
enterprises, divisions or corporate functions collaborate.

3.3.2 SCOR Model Level 1: Process-Type Level
Defines five management processes where the company creates its competitive
position and operations strategy.

1. Plan: Defining resources and demand, planning inventory, distribution,
   production and rough-cut capacity planning.

2. Source: Acquiring raw materials, qualifying and certifying suppliers,
   monitoring quality, negotiating vendor contracts and receiving materials.

3. Make: Making the end product: manufacturing, testing, packaging,
   engineering changes, holding and releasing products.
4. **Deliver**: Managing orders and credit, managing the warehouse and transportation, delivery inventory and quality. Creating databases for customers, products and prices.

5. **Return**: Returning raw materials and finished goods, maintenance, repair and overhaul.

### 3.3.3 SCOR Model Level 2: Configuration Level

SCOR defines process categories that may be supply chain components. Organizations configure operations using these processes, going into detail to uncover inefficiencies and flatten the chain, doing "what-if" analyses to evaluate the impact of potential improvements.

![SCOR Level 2 Diagram](image)

Figure 3.1. SCOR Model Level 2

### 3.3.4 SCOR Model Level 3: Process Element Level

Uses information gathered to set supply-chain improvement goals, define process elements, inputs and outputs, create performance metrics, investigating best practices and creating systems to support them.
3.3.5 **SCOR** Model Level 4: Implementation Level

Implementation is company-specific, focusing on putting improvements into action.

3.3.6 **SCOR** Model Analyzes Processes

The **SCOR** model is a process reference model that expands to analyze processes involving cross-functional activity. For instance, the Plan process involves sales, marketing, manufacturing, finance, logistics and others. It draws attention to process gaps rather pointing to specific departments' performance which can help the company communicate without ambiguity and help measure, manage and refine processes.

The **SCOR** Model helps companies capture "as-is" processes, define and achieve a desired "to-be" future state. It also helps the organization quantify operational performance and set improvement targets based on best practices in similar companies.

Metrics can include a wide variety of performance measures: delivery (in-full, on-time, in-specification), order fulfillment, fill rate (for make-to-stock), lead time or supply-chain response time, production flexibility, total cost, realized margin, warranty costs, returns processing costs and more.

A company is not likely to meet best practice norms in all metrics, so the ones a company picks should reflect its customer needs and market realities, rather than a "do-all, be-all" approach.

3.3.7 **SCOR** Model Gaps

The **SCOR** model excludes sales and marketing, research and technology development, product development and some elements of post-delivery customer support. All of these impact and influence supply chains, and may be included as modeling evolves.
Product development, especially in short life cycle industries such as fashion has always been collaborative and across companies. This high degree of "product decay" is now occurring in most other sectors. To create a super-responsive supply chain in this marketplace, companies need to adopt a concurrent engineering approach, simultaneously designing a product, its specifications, associated manufacturing processes and the supply chain. As Level 0 evolves, the SCOR model should start to address supply chain effectiveness with product development as an integral part.

3.4 Lean Principle

'Lean' operating principles began in manufacturing environments and are known by a variety of synonyms; Lean Manufacturing, Lean Production, Toyota Production System, etc. It is commonly believed that Lean started in Japan (Toyota, specifically), but Henry Ford had been using parts of Lean as early as the 1920's, as evidenced by the following quote:

"One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost." — (Henry Ford, 1926)

3.4.1 Lean definition

In order to set the groundwork of this paper, it should begin with lean distribution.

"A systematic approach to identifying and eliminating waste through continuous improvement, flowing the product at the pull of the customer in pursuit of perfection." - (National Institute of Standards and Technology Manufacturing Extension Partnership's Lean Network, 2003)
The term 'lean' was popularized by Womack et al. (1990) as a system that uses less of all inputs to create outputs similar to the mass production system but offering an increased choice to the end customer. The logic behind lean thinking is that companies jointly identify the value stream for each product from concept to consumption and optimize this value stream regardless of traditional functional or corporate boundaries. In order to facilitate this change process it is necessary to define corporate strategy and to identify key customer-facing processes such as order fulfillment and new product development together with key non-customer-facing processes such as supplier integration of environmental control. Once this is complete, roles and responsibilities can be defined and appropriate structures for improvement put in place. Although the lean approach was developed through the study of the Japanese automotive industry, it is claimed that its approaches and way of thinking can transcend cultural and industrial divides (Womack and Jones, 1996).

Lean thinking brings together several stands of process improvement. It starts by defining the purpose of the process (value for the customer), then redesigns the process to deliver this value within wasted time, effort and cost. It then organizes people and organizations to manage this value delivery process. So the first step in lean thinking is to understand what value is and what activities and resources are absolutely necessary to create that value. Once this is understood, everything else is waste. Since no one wants to consider what they do as waste, the job of determining what value is and what adds value is something that needs to be done at a fairly high level. In short, lean thinking is lean because it provides a way to do more and more with less and less human effort, less equipment, less time, and less space while coming closer and closer to providing customers with exactly what they want. Lean thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert waste into
value. And, in striking contrast with the recent craze for process reengineering, it provides a way to create new work rather than simply destroying jobs in the name of efficiency. Lean thinking can be summarized in five principles: precisely specify value by specific product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection.

3.4.2 Five Principles in Lean Thinking — (Womack, 1990)

1. Specify what does and does not create value from the customer’s perspective and not from the perspective of individual firms, functions and departments.
2. Identify all the steps necessary to design, order and produce the product across the whole value stream to highlight non value-adding waste.
3. Make those actions that create value flow without interruption, detours, backflows, waiting or scrap.
4. Only make what is pulled by the customer.
5. Strive for perfection by continually removing successive layers of waste as they are uncovered.

These principles are fundamental to the elimination of waste. They are easy to remember and should be a guide for everyone in the organization who becomes involved in the lean transformation.
Lean Thinking Model – *(Lean Enterprise Research Centre, 2002)*

**1. Understanding value and waste**

The rationale behind lean centers on creating value and removing waste both inside and between companies. This is fundamental to a lean value stream. Improved customer focus and productivity gains lead to leaner operations, which in turn help to expose further waste and quality problems in the system. The systematic attack on waste is also a systematic assault on the factors underlying poor quality and fundamental management problems.

*What is value?* *(Value Stream Management, 2002)*

Value is what customers want. It consists of their articulated and latent needs and may be expressed as a perception rather than in facts and figures. In general there will be a number of key dimensions of customer value; we can call these value attributes. Examples of value attributes include tangible elements such as product features, quality and delivery times, as well as more intangible such as service and
relationship. Each customer will have their own set of value attributes for different products and services, although groups of customer may be clustered into distinct market segments.

It is important to start by gaining an external view of value, as a company’s view of what is valuable for their customers is very often wrong or distorted. The description of the customers’ value profile become strategic, as it is the basis of understanding how to create competitive advantage. It involves the direct participation of the management, but most of all, of the customers.

What is waste? — (Taiichi Ohno, 1988)

The wastes are commonly referred to as non-valued-added activities, and are known to Lean practitioners as the Eight Wastes. Taiichi Ohno (co-developer of the Toyota Production System) suggests that these account for up to 95% of all costs in non-Lean manufacturing environments. These wastes are:

- **Overproduction** — Producing more than the customer demands. The corresponding Lean principle is to manufacture based upon a pull system, or producing products just as customers order them. Anything produced beyond this (buffer or safety stocks, work-in-process inventories, etc.) ties up valuable labor and material resources that might otherwise be used to respond to customer demand.

- **Waiting** — This includes waiting for material, information, equipment, tools, etc. Lean demands that all resources are provided on a just-in-time (JIT) basis — not too soon, pot too late.

- **Transportation** — Material should be delivered to its point of use. Instead of raw materials being shipped from the vendor to a receiving location, processed, moved into a warehouse, and then transported to the assembly line, Lean
demands that the material be shipped directly from the vendor to the location in
the assembly line where it will be used. The Lean term for this technique is
called point-of-use-storage (POUS).

• Non-Value-Added-Processing – Some of the more common examples of this
are reworking (the product or service which should have been done correctly the
first time), deburring (parts should have been produced without burrs, with
properly designed and maintained tooling), and inspecting (parts should have
been produced using statistical process control techniques to eliminate or
minimize the amount of inspection required). A technique called Value Stream
Mapping is frequently used to help identify non-valued-added steps in the
process (for both manufacturers and service organizations).

• Excess Inventory – Related to Overproduction, inventory beyond that needed
to meet customer demands negatively impacts cash flow and uses valuable floor
space. One of the most important benefits for implementing Lean Principles in
manufacturing organizations is the elimination or postponement of plans for
expansion of warehouse space.

• Defects – Production defects and service errors waste resources in four ways.
First, materials are consumed. Second, the labor used to produce the part (or
provide the service) the first time cannot be recovered. Third, labor is required to
rework the product (or redo the service). Fourth, labor is required to address any
forthcoming customer complaints.

• Excess Motion – Unnecessary motion is caused by poor workflow, poor
layout, housekeeping, and inconsistent or undocumented work methods. Value
Stream Mapping (see above) is also used to identify this type of waste.
• Underutilized People – This includes underutilization of mental, creative, and physical skills and abilities, where non-Lean environments only recognize underutilization of physical attributes. Some of the more common causes for this waste include – poor workflow, organizational culture, inadequate hiring practices, poor or non-existent training, and high employee turnover.

Getting the balance right

Clearly the organization needs to balance customer value with the cost of generating it, in order to provide a competitive offering. This is true whether organization seeks to offer a premium, standard or budget product/service.

Four types of activity – (Lean Enterprise Research Center, 2002)

When thinking about waste, it is useful to define the four different types of activity within the organization:

1 Value adding (VA) activity: those activities that, in the eyes of the customer, make a product or service more valuable. Examples would include converting iron ore into cars, or mending a broken down car on a motorway.

A value adding activity is simple to define: just ask yourself if you as a customer would be happy to pay for it.

2 Future value adding (FVA) activity: those activities that, in the eyes of the customer, make a product or service valuable in some future time period. Examples would include providing marketing information about a product that a customer was not presently aware of, or developing a new product or service.

3 Support activity (SA) or Business value adding activity (BVA), necessary non value adding activity: those activities that, in the eyes of the customer, do not make a product or service more valuable but are necessary unless the
existing process is radically changed. Such activities are often difficult to remove in the short term and should be a target for longer term or radical change. An example would be: inspecting every product at the end of a manufacturing line because the firm uses old machinery which is known to be unreliable.

4 Waste (W) or non value adding activity (NVA): those activities that, in the eyes of the customer, do not make a product or service more valuable and are not necessary even under present circumstances. These activities are clearly wasteful and should therefore be the target of immediate or short term removal. An example of non value adding activity would be transferring a product from one sized container to another so that it can be moved around factory.

2. Setting the direction

Developing critical success factors

Critical success factors are a limited number of key areas where 'things must go right' for the business to succeed and flourish. They should be directly linked to, and influenced by, the specific factors impacting company or value stream.

Establish the key forces impacting the business or wider value streams. Divide them into categories, such as:

- general business environment
- industry specific
- customer specific
- company specific

Reviewing and modifying appropriate key performance indicators
Most organizations already have a set of top level (often finance-based) business measures. However, these may not be aligned to the critical success factors. This alignment is very important as existing measures will drive aspirations and ultimately performance. Organizations must check that they are compatible with what is critical in business environment.

Targeting improvement for each key performance indicator

The next stage is to create targets for each business measure. The following steps may help:

- establish the current position
- develop a long term vision of what the company would ideally like the measure to look like (say 5 years away)
- develop sensible intermediate targets bearing in mind that some measures may not improve in a straight line

Defining key value streams of business processes

A key business process can be defined as:

Patterns of interconnected value-adding relationships designed to meet business goals and objectives.

All business processes have a series of inputs and a number of steps, tasks or activities that convert these inputs into a number of outputs. They typically run across several departments in a business (or businesses) and encourage and support inter-departmental communication and co-operation throughout the company or value stream.

What is a Value Stream? – *(Value Stream Management, 2002)*

Value stream mapping is a picture of the process or what is used as a process. The lack of a real process can create waste, or non-value-added activity. Identifying the entire value stream for each product (or in some cases for each product family) is the
next step in lean thinking, a step which firms have rarely attempted but which almost always exposes enormous, indeed staggering, amounts of waste. Value Stream is the set of all the specific actions required to bring a specific product (whether a good; a service, or, increasingly, a combination of the two) through the following three critical management tasks of any business:

1. The problem-solving task running from concept through detailed design and engineering to production launch.
2. The information management task running from order-taking through detailed scheduling to delivery.
3. The physical transformation task proceeding from raw materials to a finished product in the hands of the customer.

Why use Value Stream Management?

Value stream mapping has become the latest craze in manufacturing improvement. This is exciting, because value stream maps are an important part of what makes the storyboard and exceptional form of visual management. However, it is not enough to perform mapping in isolation. Without a good understanding of lean manufacturing principles, mapping will bring organizations no closer to minimizing wastes and achieving excellence than kaizen workshops did in the early-to mid-nineties. While manufacturers have been quick to acknowledge the benefits of becoming lean, relatively few truly understand what such an effort entails.

Deciding which key value streams or business processes to focus on

To decide which key business process area is likely to give the company the targeted improvements, just ask if the business process is likely to yield benefit in each target area if improved. The company can then decide which process or processes need detailed mapping.
To help identify which processes to focus on, try dividing them into

- strategic processes: processes focusing overall direction but not directly impacting on targets
- core processes: processes directly impacting on targets
- support processes: processes indirectly impacting on targets

3. Understanding customer value

The critical starting point for lean thinking is value. It can only be defined by the ultimate customer. And it is only meaningful when expressed in term of a specific product (a good or a service, and often both at once) which meets the customer's needs at a specific price at a specific time. Value is created by the producer from the customer’s standpoint. As beginning to track the flow of work, it soon becomes obvious that some of the activities add value in the eyes of customers (and hence is called value-added work). Another way to look at value-added work is to look at the company position whether customers would be willing to pay for it if they were given the option of whether to pay for it if they knew it was part of their purchase price. If they would likely refuse to pay if given the choice, or would take their business elsewhere to find another supplier who did not have those costs, then that work is non-value-added. Lean thinking therefore must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers.

4. Understanding the big picture

Before starting detailed mapping of any core process it is useful to develop an overview of the key features of that entire process. To some degree the company has already achieved this by using the value stream interaction map. However, in most cases the company will need more detail in order to:
- help the organization visualize the flows
- help the organization see where waste is
- pull together the lean thinking principles
- help the organization decide who should be in the implementation teams
- show relationships between information and physical flows
- create buy-in from the senior team undertaking the big picture mapping

5. Detail Mapping

Up to this point company has only involved the senior or line managers, and lean change will not happen unless the company involves the wider workforce. By now the senior team will have a pretty good idea of the direction and possible areas that could be addressed. However, this information has not come from the 'doers' in the organization. The bottom-up detailed mapping should, therefore, be done by a team of doers, led by a senior or line manager who has participated in the earlier activities.

Process activity mapping

This is the key tool for the detailed mapping of the order fulfillment process. It is an engineering-derived approach that has traditionally only been used for the shop floor of manufacturing companies. However, most companies use it more widely to identify lead time and productivity opportunities for both physical product flows and information flows, not only in the factory but also in other areas of the supply chain. The idea is to map out every step of activity that occurs throughout a process. There may be more wastes in the information flow than on the shop floor, so map the information flows as well as any physical flows.

The idea of flow is fundamental to lean production. If the company does nothing but add value, then the company should add value in as rapid a flow as possible. If this is not the case, then waste builds up in the form of inventory or transportation or extra
steps or wasted motion. The idea that flow should be pulled from demand is also fundamental to lean production. Flow thinking is easiest to see in conventional, discrete-product manufacturing, which is where flow techniques were pioneered. However, once the company learns to see it, it is possible to introduce flow in any activity and the principles are in every case the same: Concentrate on managing the value stream for the specific service or good, eliminate organizational barriers by creating a lean enterprise, relocate and right-size tools, and apply the full complement of lean techniques so that value can flow continuously.

Quality filter mapping

This approach is a new tool designed to identify quality problems in the order fulfillment process or the wider supply chain. The map shows where three different types of quality defects occur in the value stream:

1. Product defects: defects in physical goods that are not caught by in-line or end-of-line inspection and are therefore passed on to customers. In a few cases companies have found faulty product that was detected but still passed to customers; this would also fall into this category.

2. Scrap defects: defects that have been caught by in-line or end-of-line inspection. The in-line inspection methods will vary and can consist of traditional product inspection, statistical process control or poke yoke devices.

3. Service defects: problems given to a customer that are not directly related to the goods themselves, but due to the accompanying level of service. The most important of these service defects is inappropriate delivery (late or early). Others include incorrect paperwork or documentation, incorrect packaging or labeling, incorrect quantity and incorrect invoicing.
The approach integrates quality and logistics performance measures. It is designed to establish both internal and external quality levels as well as levels of customer service.

Process costing

An effective lean profit requires proper cost information, such as the critical process costs and the amount of the current value adding, future value adding, support activity and waste costs inside each key process.

Cost data are necessary to:

- identify priorities (which key process should I focus on first?)
- estimate potential benefits of lean initiatives (what is the lean profit potential?)
- set management control systems (what are the links with the budgeting, reporting and incentive systems?)

6. Checking the plan & its profit potential

Developing a set of appropriate projects

At this point the company will have gathered a great deal of information. They will then need to turn this into a workable plan over a sensible time frame.

Developing project potential

A lean transformation will take time and commitment to achieve, but if properly designed and executed, it will be worth the effort.

Every step in a value stream can be improved in isolation to good effect. And there is rarely any ground for concern about investing to improve an activity which will soon be replaced together. At every step we have noted the need for the top management to determine how important to learn to see: to see the value stream, to see the flow of value, to see value being pulled by the customer. The final form of seeing is
to bring perfection into clear view so the objective of improvement is visible and real to the whole enterprise.

Once companies have implemented all of the above lean principles, it often dawns on those involved that there is no end to the process of reducing effort, time, space, cost and mistakes while offering a product which is ever more close to what the customer actually wants. Striving for perfection can drive additional rounds of improvement.

3.4.3 Lean Distribution

Lean Distribution is the natural extension for companies using Lean practices within their own operations or that have customers that embrace Lean. Lean works to systematically improve the parameters that drive performance across the entire supply chain rather than to take independent actions seeking to improve departmental costs, service levels, and inventory. The main levers of a Lean Distribution approach are cycle time, variation, and flexibility. These parameters become the drivers for inventory levels, cost profiles, and other aspects of the distribution chain so the relationships and interactions are readily apparent. Lean takes the approach that markets move and the supply must move quickly with them; it is not a forecast-and-plan-based approach that attempts to optimize and execute a frozen plan. With Lean, market shifts are expected and taken in stride because variability and flexibility are built in. A forecast and plan approach resists market changes, because changes upset the plan and all of the actions being taken to optimize and execute. — (Kirk D. Zylstra, 2006)

3.4.4 Lean Distribution Benefits

The lean distribution approach provides an operational foundation for service excellence and low total costs. A combination of service and cost performance is what differentiates how a Lean approach both simplifies the business and delivers results.
Service and cost are typically considered to be conflicting objectives where trade-offs must be made, but Lean focuses efforts on changing the dynamics of this trade-off by reducing cycle time, improving reliability, and increasing flexibility. These changes deliver benefits in customer service, total costs, and asset utilization. Customer service benefits accrue from improvements in service policies and value provided to customers with Pull. As service policies are formalized and segmented with the Lean Distribution approach benefits relate to service delivery for customers grouped into segments with various levels of service. By formalizing service policies, improvements result from:

- Providing differentiated levels of customer service
- Improving execution of service delivery
- Examining and segmenting customers for price/value
- Directly linking (Pull) with customer usage to improve the customer’s material flows

Within Distribution processes, Lean improves the flow of business processes to mitigate wastes in distribution area. Benefits also accrue across downstream operations both internally and with suppliers, Lean further improves flexibility, reliability, and costs without the distractions of daily disruptions to meet spikes in demand. These and other benefits can be linked back to key operational parameters and improvements. Cycle time is an example parameter that improves with lean and can be related to distribution lead time. As cycle time is reduced, the improvements in lead time are readily apparent. These relationships make Lean benefits more transparent and linked with day-to-day operational improvement efforts and measures. — (Kirk D.Zylstra, 2006)

Benefits of Implementing Lean
The benefits of implementing Lean can be broken down into three broad categories; Operational, Administrative, and Strategic Improvements. Even to this day, most organizations that implement Lean do so for the operational improvements, primarily because of the perception that Lean only applies to the operations side of the business. However, from the data from website, Lean's administrative and strategic benefits are equally impressive. Some of Lean's benefits are summarized below—(Jerry Kilpatrick, 2003).

Operational Improvements

The NIST Manufacturing Extension Partnership recently surveyed forty of their clients who had implemented Lean Manufacturing. Typical improvements were reported as follows:

- Lead Time (Cycle Time) reduced by 90%
- Productivity increased by 50%
- Work-In-Process Inventory reduced by 80%
- Quality improved by 80%
- Space Utilization reduced by 75%

Administrative Improvements

A small sample of specific improvements in administrative functions is (based on www.mep.org):

- Reduction in order processing errors
- Streamlining of customer service functions so that customers are no longer placed on hold
- Reduction of paperwork in office areas
- Reduced staffing demands, allowing the same number of office staff to handle larger numbers of orders
• Documentation and streamlining of processing steps enables the outsourcing of non-critical functions, allowing the company to focus their efforts on customers’ needs

• Reduction of turnover and the resulting attrition costs

• The implementation of job standards and pre-employment profiling ensures the hiring of only "above average" performers — envision the benefit to the organization if everyone performs as well as the top 20%.

Strategic Improvements

Many companies who implement Lean do not adequately take advantage of the improvements. Highly successful companies will learn how to market these new benefits and turn them into increased market share. One specific example involves a midwestern manufacturer of a common health care product. Of approximately forty U.S. competitors, the third largest company in the industry decided to implement Lean manufacturing principles. The industry average lead-time was fifteen days, and this company was no different. At the end of the project, Company #3’s average lead-time was four days, with no products shipped in less than seven days. In order to capitalize upon these improvements, the company began a marketing campaign, advertising that customers would receive the product in ten days, or the order would be free. Sales volume increased by 20% almost immediately. After making the appropriate improvements to handle the new demand, they company initiated another marketing campaign; for only a 10% premium, they would ship within seven days. Again, sales volume increased (by only 5%). because new customers wanted the product within seven days, but more than 30% of existing customers also paid the premium, even they were already receiving the product in less than seven days. The end result was that the company increased revenues by almost 40% with no increase in labor or overhead costs.
Another key benefit was that the company was able to invoice customers eleven days sooner than before, greatly improving cash flow.

3.4.5 Barriers to Successful Implementation

Many of the companies that attempt to implement Lean experience difficulties and/or are not able to achieve the anticipated benefits - (Jeri Kilpatrick, 2003).

- The company fails to tie the improvement metrics to financial statements. In other words, the company only reports the percent improvement and does not convert this to a monetary measure. By not communicating in the same language as management, the department or function implementing Lean does not get the support needed to continue the efforts.

- Choosing a difficult or low-impact project as the first one. Lean is not difficult, but can be complicated because of all the variables and communication involved. If the first Lean project is not successful or generates little return on investment, cooperation and support for future projects will fade.

- Overlooking administrative areas. Some manufacturing environments, especially continuous processes (e.g., high-volume chemical manufacturers) have only small or insignificant opportunities in the production or operations areas. Implementing Lean there will provide little impact.

- The company spends too much time on training and not "doing," or they start at the wrong place.

- Failing to expand lean implementation to the supply chain. Because of the need for just-in-time delivery of materials, minimization of inventories and Lean's dependence upon high quality products and services, companies need to bring suppliers into the improvement efforts. If critical suppliers cannot deliver on time, and in smaller quantities, the benefits of Lean will be greatly
diminished or even non-existent. The development of a lean supply chain is probably one of the most difficult, but more financially rewarding, aspects of implementing Lean.

- Lean radically impacts every person in every function of an organization, and literally changes the organizational culture. The change causes discomfort, and many companies are not able to cope with this magnitude of change.

3.5 Business Process Simulation & Modeling – *(H. James Harrington, 2000)*

**What is Simulation?**

"Simulation is a means of experimenting with a detailed model of a real system to determine how the system will respond to changes in its structure, or underlying assumptions". (Charles Harrell and Kerim Tumay, *Simulation Made Easy: A manager's Guide*).

Simulation, by definition, allows for experimenting with a model of the system to better understand processes, with a goal of improving performance. Simulation modeling incorporates various inputs to a system and provides a means to evaluate, redesign, and measure or quantify customer satisfaction, resource utilization, process streamlining, and time spent.

Process simulation is a technique that helps organizations predict, compare, or optimize the performance of a process without the cost and risk of disrupting existing operations or implementing a new process. Process simulation is a technique that allows representation of processes, resources, products, and services in a dynamic computer model. A model, when simulated, mimics the operations of the business: it steps through the events in compressed time while displaying an animated picture of the work flow. Because simulation software keeps track of statistics about model elements, performance metrics can be evaluated by analyzing the model output data.
Business processes such as supply chain, customer service, and new product development are too much complex and dynamic to be understood and analyzed by flowcharting and spreadsheet technique. The interactions of resources with processes, products, and services over time result in a large number of scenarios and outcomes that are impossible to comprehend and evaluate without the help of a computer simulation model. Although flowcharts and spreadsheets are adequate in answering "what" questions, they are in adequate for answering "how", "when", and "what if" questions. Business process improvement approaches such as process reengineering, process design, and benchmarking are often unsuccessful if the present-and future-state solutions are not proven out in a simulation model. It is often impossible to understand the as-is process through simple flowcharting techniques, due to the number of dissection points and variation of cost and time required to process individual items through a simple point on the flowchart.

What is a Process?

Process: A logical, related, sequential (connected) set of activities that takes an input from a supplier, adds value to it, and produces an output for a customer.

Defining the terms Process Simulation & Modeling

Major Process: A process that usually involves more than one function within the organizational structure and that has a significant impact on the way the organization functions. When a major process is too complex to be flowcharted at the activity level, it is often divided into subprocesses.

Subprocess: A portion of a major process that achieves a specific objective in support of the major process.

Hierarchical process modeling: The ability to decompose a process onto layers.
Transaction: Any entity that flows through a process simulation model. Transactions represent physical objects, such as orders or other paperwork, or informational objects, such as triggers, signals, or flags.

Activity object: Symbol used for modeling unique dynamic behavior of a process. Examples of activity objects would be Batch and Delay.

Batch: An activity object that holds a specified number of transactions until a batch is formed and then releases the batch to the next activity.

Delay: An activity object that holds a transaction for a specified period of time before releasing it to the next activity.

Branch: An activity object that holds a transaction for a specified period of time before releasing it to the next activity.

Assemble: An activity object that puts components together.

Transformation: An activity object that accepts an input and produces a different output.

Full-time equivalent: The number of hours that an individual would work in a given time period (without overtime).

Trigger: The input that starts a transaction through a process or activity.

Process analysis: A statistical analysis of model input data, such as customer demand and resource capacity, and model output data, such as cycle time and process cost.

Effectiveness: The extent to which the output of a process or activity meets the needs and expectations of its customers. Effectiveness is having the right output at the right place, at the right time, and for the right price.
Efficiency: A measure of the resources (human, money, cycle time, etc.) that are used by a process in order to produce its output. A close synonym to efficiency is productivity.

Adaptability: The ability of a process or activity to handle the fluctuations in its output and still meet its effectiveness and efficiency requirements or objectives. It is a measure of the process's ability to handle future, changing customer expectations and today's individual, special customer requests.

Throughput: The number of transactions that traverse the process.

Queue: The status of a transaction when it has completed one activity and cannot continue because the next activity cannot start processing for some reason (e.g., all the resources are busy, all the parts are not ready to be assembled, or the equipment is being prepared).

Process Simulation at Work

Organizations use process simulation as part of their approach to business process innovation and performance improvement. Simulation is used to understand and analyze the current state of a system as well as to vision the future state of the reengineering system. Simulation provides a powerful means of generating suggestions for improving or innovating systems. In each situation, process simulation provided a means to analyze the system and allowed for an innovative approach to arriving at better solutions.

What is the difference between a process and an activity?

Processes use an organization's resources to provide definitive results. Activities are things that go on within all processes. An activity may consist of one task or many.

In process modeling, a process object allows company to represent several subprocesses and activities in multiple levels of detail. The ability to decompose a
process into layers is called hierarchical process modeling. For example, purchasing or product development can be modeled as hierarchical processes, with the actual process behaviors defined at lower levels.

In process simulation, the company uses activity objects to model the unique behavior or behaviors of a process. Activities are not decomposable. A delay activity is the most commonly used activity type in process modeling. It has at least an activity time and sometimes a resource requirement. For example, processing a claim or delivering a shipment can be modeled as delay activities.

In a process, there may be several activities such as Branch, Batch, Assemble, or Transformation that accept an input and produce an output. For example, triggering of an order by a customer or final testing of the developed product is modeled using unique activity objects. - (H. James Harrington, 2000)

Why Simulate?

Simulation can assist in creative problem solving: Fear of failure prevents people from coming up with ideas. Simulation will allow creative experimentation and testing and then selling the idea to management, thus encouraging an optimistic "Let's try it" attitude. Thus simulation provides a means for creative problem solving.

Simulation can predict outcomes: Management is prediction. Simulation educates people on how a system might respond to changes. For example, simulation could help in predicting response to market demands placed on the business system. This allows for analyzing whether the existing infrastructure can handle the new demand placed on it. Simulation can thus help determine how resources may be efficiently utilized. Simulation thus helps in predicting outcomes for various changes to system inputs.
Simulation can account for system variances: Conventional analytical methods, such as static mathematical models, do not effectively address variance as calculations are derived from constant values. Simulation looks at variance, in a system incorporating interdependence, interaction among components, and time. This approach allows for examining variation in a broader perspective.

Simulation promotes total solutions: Simulation allows modeling entire systems, therefore promoting total solutions. Simulation models provide insight into the impact that process changes will have on input to and output from the system as well as system capabilities. Simulation models can be designed to provide an understanding of the system-wide impact of various process changes. Thus simulation provides a means of examining total system-wide solutions.

Simulation can be cost-effective: As organizations try to respond quickly to changes in their markets, a validated simulation model can be an excellent tool for evaluating rapid responses. For example, a sudden change in market demand for a product can be modeled using a validated system model to determine whether the existing system can cater to this need. Additionally, simulation modeling allows for experimenting with system parameters without having to tamper with the real system. Simulation provides more alternatives, lowers the risks, increases the probability of success, and provides information for decision support without the cost of experimenting with the real system. Simulation thus provides a cost-effective way to rapidly test and evaluate various solutions to respond to market demands.

Simulation can help quantify performance metrics: Simulation can help quantify performance measures for a system. For example, the aim of a system may be to satisfy the customer. Using a simulation model, this requirement could be translated into time to respond to a customer's request, which can then be designated as the
performance measure for customer satisfaction. Simulation can help measure trade-offs associated with process designs and allow for further analysis on parameters such as time to market, service levels, market requirements, carrying costs, SKU levels, and so forth. Simulation thus provides a quantitative approach to measuring performance.

Simulation serves as a means of communications: Simulation is an effective communication tool. A simulation model can be used to communicate the new or reengineered process in dynamic and animated fashion. This provides a powerful means of communicating the function of various components to those who will use the new system, helping them understand how it works.

Modeling

A parallel activity to mapping is simulation modeling, the process of building a computer simulation of the manufacturing process. Modeling is an optional and not essential part of the analysis phase. But there are two strong reasons to consider modeling:

1. To confirm understanding of the process.
2. To play "what if" about the future.

Static Versus Dynamic Activity Modeling

Activity modeling for process simulation is somewhat different than it is for static process modeling and analysis. In static modeling, the user simply defines the effects—activity cycle time and activity cost. On the other hand, in process simulation, the user defines the cause of delay (e.g., random arrivals, random activity times, resource unavailability, random equipment failures) and analyzes the effects of these factors on cycle time and activity cost.

For static process modeling and analysis purposes, activities can be classified into three categories:
Real-value-added (RVA) activities: Activities that, when viewed by the external customer, are required to provide the output that the customer is expecting.

Business-value-added (BVA) activities: Activities that add no value from the customer's point of view, but are essential for the business.

Non-value-added (NVA) activities: Activities that are not required by either the customer or the business.

Resource Modeling

Resources are the agents that are required to perform an activity. The performance of a dynamic process is usually constrained by the limited availability of resources or by resource interdependencies, which result in queuing for transactions. Process simulation allows you to model capacity, cost, schedule, and allocation for resources. During the simulation, the model automatically keeps track of the utilization of resources, the queuing delays, and the costs incurred by activities and transactions using the resources.

Typically examples of resources are:

- Customer representative
- Engineer
- Supervisor
- Department
- Equipment
- Money
- Materials

Human resources are typically defined in term of full-time equivalents. Other resources may be defined in term of capacity or number of units. A full-time equivalent may be an individual resource as well as part of a work group. Work groups may consist
of group of resources that may be required to perform a specific activity, a department, or a group of resources that share the same job function. A resource may belong to multiple work groups.

Transaction Modeling

Transactions are the entities that flow through a process simulation model. Transaction can be used to represent physical objects, such as orders or other paperwork, or information objects, such as triggers, signals. They may be assigned attributes to define such characteristics as order size, customer size, and priority.

For static process modeling purposes, products and services produced by each activity are defined as outputs of that activity and inputs into the next activity. In fact, definition of inputs and outputs is an integrated step within an activity modeling session. However, for dynamic process modeling purposes this approach needs to be enhanced, because it does not take into account two very important dynamic transaction modeling concepts.

The activity time of a transaction may be dependent on the type of the transaction. For example, a credit check activity may take longer for a customer with a long credit history than for a recent college graduate with little credit history. The activity time of a transaction may also be dependent on the state of the transaction, that is, it may vary according to circumstances. For example, an investment transaction may take longer while trading is heavy.

Thus, for process simulation modeling purposes, the inputs and outputs of the activities need to be defined in term of types of transactions and group them into three classes, say A, B, and C. These classifications are based on a criterion that is significant in term of the nature of the business.
For example, this technique has been used for inventory-analysis purposes for many decades. A very large number of inventory items can be grouped into tree types:

- Type A: High-turnover items
- Type B: Medium-turnover items
- Type C: Low-turnover items

Model Performance Measurements

Measurements are the key. If the company cannot measure it, company cannot control it. If the company cannot control it, company cannot manage it. If the company cannot manage it, the company cannot improve it. It is as simple as that. Measurements may be focused on finances, quality, resources, or investors. Process simulation aids in the improvement of quality-driven measurements, such as service level and waiting time, and resource-driven measurements, such as cycle time and activity cost.

In order to improve a process, the company needs to develop critical effectiveness, efficiency, and adaptability measurements and targets for the process. Process effectiveness is how well the process meets the requirements of its end customers. Process efficiency is the output per unit of input. It is a measure of how many resources the process uses to provide the output. Efficiency is for the benefit of the process owner whereas effectiveness is for the benefit of the customer. Process adaptability is the flexibility of the process to handle future, changing customer expectations and today's special customer requests. Although process simulation focuses on analysis and improvement of efficiency measurements, it also provides indirect benefits for process effectiveness and adaptability measurements. It is very important to realize that if company considers only efficiency in his future-state solution, it often will result in negative impacts on both effectiveness and adaptability, so that the new process will be less acceptable and valuable than the old process. It is a
lot like putting on a clean shirt and a new tie to go to a formal dinner, but going
unshaved, unwashed, and in a suit that's old, dirty, ripped, and wrinkled.

Specially, process simulation provides key performance measurements such as:

- Cycle time
- Activity cost
- Transaction throughput
- Resource utilization
- Wait time
- Inventory level

Most process simulation tools automatically provide statistics on these
performance measures. However, some performance measurements need to be
customized. For example, service level is a custom performance measure because its
definition varies by industry or by organization. Measurement of service level for a call
center is different than measurement of service level for a supply chain. Only the
powerful process simulation tools provide the flexibility define custom performance
measurements, collect statistics, and provide output analysis with custom performance
measures.

Cycle Time

Cycle time is the total time spends traversing a process. The means cycle time
includes value-added process time, waiting time for resources, and waiting time for
conditions. Reducing total cycle time is a key issue in almost all critical business
processes. Reducing total cycle time may reduce cost and improve the quality of the
output; it can even increase sales.

Transaction Count
Transaction count measurement provides throughput information. Throughput is the number of transactions that traversed the process. At the end of simulation period, some transactions may still be in process; they are not counted as throughput. Each time a transaction departs from the model through a dispose activity, the throughput count is incremented.

Activity Cost

When defining a resource in a process model, have to define it in terms of the number of available units, usage costs, setup costs, and fixed costs. When defining an activity, have to assign the resources required to perform it, the duration for the activity, and the transaction that it processes.

Resource Utilization

Resource utilization statistics are time persistent statistics. During a simulation, resources change states from busy to idle, from unavailable to reserved. Resource utilization defines the percentage of time that a resource spends in each state. The availability and assignment of resource dictate the allocation of resources to activities in a model. So, the resource utilization results provide useful statistics in measuring and analyzing underutilization or over utilization of resources.

Wait Time

When designing a process or improving a process, reducing wait time should be given the utmost priority because it always reduces total cycle time and increases customer satisfaction. Wait time can be attributed to understaffing, unreliable equipment, or large fluctuations in demand. In any case, analysis of the wait time measurements can pinpoint the causes and evaluate alternative ways to minimize wait time.
Queue Length

This measurement is also a very useful performance indicator because it helps company to identify the location of bottleneck resources in the process. For production processes, queue length represents inventory levels. For a service process, queue length represents customers waiting for service.

3.6 Weighted Scoring Matrix – [www.asq.org]

A decision matrix allows decision makers to structure, then solve their problem by:

1. Specifying and prioritizing their needs with a list a criteria.
2. Evaluating, rating, and comparing the different solutions.

Decision matrix activity – [www.rfp-templates.com]

Use the COWS method, shown below, that describes all the information comes up with in order to make an impartial decision:

C (Criteria): Develop a hierarchy of decision criteria, also known as a decision model.

O (Options): Identify option, also called solutions or alternatives.

W (Weights): Assign a weight to each criterion based on its importance in the final decision.

S (Scores): Rate each option on a ration scale by assigning it a score or rating against each criterion.

Decision matrix method

Method 1: Establish a rating scale for each criterion. Some options are:

1, 2, 3: 1 = slight extent, 2 = some extent, 3 = great extent

1, 2, 3: 1 = low, 2 = medium, 3 = great extent
1, 2, 3, 4, 5: 1 = little to 5 = great

1, 4, 9: 1 = low, 4 = moderate, 9 = high

Make sure that rating scales are consistent. Word criteria and set the scales so that
the high end of the scale (5 or 3) is always the rating that would tend to make company
select that option: most impact on customers, greatest importance, least difficulty,
greatest likelihood of success.

Method 2: For each criterion, rank-order all options according to how well each meets
the criterion. Number them with 1 being the option that is least desirable according to
that criterion.

Method 3, Pugh matrix: Establish a baseline, which may be one of the alternatives or
the current product or service. For each criterion, rate each other alternative in
comparison to the baseline, using scores of worse (-1), same (0), or better (+1). Finer
rating scales can be used, such as 2, 1, 0, —1, —2 for a five-point scale or 3, 2, 1, 0, —1, —2, —3 for a seven-point scale. Again, be sure that positive numbers reflect desirable
ratings.
IV. PROJECT METHODOLOGY AND ANALYSIS

4.1. Project Methodology

Applying Lean concept to the distribution processes

Although applying lean is very young in Thailand especially in administrative processes, it is widespread in Japanese and American organizations. Perhaps this is because the idea is so simple and so appealing. In short, lean is to find and eliminate all non value-adding activities from the processes to improve their efficiency and effectiveness.

This project will design the new processes through the following steps;

- Collect and analyze the current processes:
  1. Describe the current resource of each department, cost structure, working hours and over time structure.
  2. Create the current model and run the simulation by using Igrafx program version 2006.
  3. Analyze current result from the Igrafx program.
  4. Identify waste in the current processes.

Brainstorming for the action support: this is to find the alternative to improve the non-value-adding processes through brainstorming with a team, and then using the weighted scoring method to conclude the actions.

Develop the new processes: this is to develop the new distribution processes by changing the processes and running the simulation to get the optimal benefits.

Analyze the new process design and compare to the current processes: running the simulation of new process design modeling in Igrafx program,
and then analyze the result as the same figure as current process to find the benefit improvement.

**Create the implementation plan:** this is to estimate the timeline for implementation from all supporting actions.

**What will be analyzed?**

After completing the simulation, the following key measurements will be used for evaluating the efficiency and effectiveness of each process.

- **Cycle times** – the total time spent traversing a process.
- **Activity cost** – number of available units, usage cost, labor cost, and fixed cost.
- **Transaction throughput/lead time** – total elapsed, or ‘wall-clock’, simulated time.
- **Headcount** – number of resources required for running the process.
- **Wait Time** – Amount of time transactions spent waiting at the activity. Includes inactive, blocked and resource wait time.
- **Queue length** – location of bottleneck (highest cycle time) and inventory level (number of document pending at each process).

**VA/BVA/NVA** – value added, business value added, and non-value added work.

Waste identification – identify waste on the process for improvement.
4.2 The Current Processes

In the current process, there are 43 process steps crossing 2 external and 4 external parties as shown in figure 4.1. The process starts from the customer service department and then goes to the other departments such as Sale, Finance, FG warehouse, Freight Forwarder, and Customer. On operating this process, the following current resources and their cost are assigned to handle the processes in table 4.1.

Table 4.1. Resource and cost structure of each department

<table>
<thead>
<tr>
<th>Department</th>
<th>No of Operator</th>
<th>Labor cost per hour</th>
<th>OT cost per hour</th>
<th>Working hour per day</th>
<th>OT limit per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer service</td>
<td>6</td>
<td>83.33</td>
<td>125</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Finance</td>
<td>2</td>
<td>83.33</td>
<td>125</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Freight Forwarder Agent (FFA)</td>
<td>1</td>
<td>Paid by customer</td>
<td>8</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Sale</td>
<td>1</td>
<td>83.33</td>
<td>125</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>FG warehouse</td>
<td>4</td>
<td>37.5</td>
<td>56.25</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
The current process flow of distribution process is shown as figure 4.1.

Figure 4.1: current process flow of distribution process
4.2.1 The analysis of current processes

Analyzing the performance of the current processes, the modeling and simulation method will be used for evaluating the process performance. Running the current process model as figure 4.1: it will be run as one-piece flow for the first two processes and then accumulated as the batch of five for the rest.

**Time study – Work time and wait time**

![Time consumption at each department](image)

As shown in figure 4.2 and table 4.2, after running the simulation of current modeling in batch of five documents, the total cycle time is 100.45 hours or 9 days running 11 working hours a day. Considering the total average cycle time of all departments the percentage of work time is approximately only 36% or 3.26 days comparing to the rest waiting time at 64% or 5.74 days. Looking in detail at two internal departments and four external departments in the current modeling, the major work time or highest work time is in Customer service department with 41.47% from 24 process steps of the whole processes, and the second higher work time is at customer side that is
22.27%. This process is very interesting on studying the time reduction; however, this project will focus only on the internal processes. For FG warehouse department the work time is 16.70% from 6 process steps, mainly the activities of product shipment. For Finance and sale department, they consume the work time 15.86% and 2.31% accordingly. Main activities of these departments are to check and confirm the customers' credit and price change. The last part of this process is Freight forwarder agent, which is the external department that spends work time less than the other departments - only 1.39% from the whole process. Although this is an external party the new process design also improves the method of reserving the container as a time reduction in the whole processes.
### Table 4.2: Time consumption at each department of the current process

<table>
<thead>
<tr>
<th>Activity Statistics (Hours)</th>
<th>Avg Cycle</th>
<th>Avg Work</th>
<th>Avg Wait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Service - Check delivery schedule</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Due?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inven?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Check product info</td>
<td>2.77</td>
<td>.50</td>
<td>2.27</td>
</tr>
<tr>
<td>Customer Service - Consolidate order</td>
<td>1.00</td>
<td>1.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform shipment &amp; value to FN</td>
<td>.25</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Contact Freight Forwarder Agent</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Receive booking detail</td>
<td>.08</td>
<td>.08</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Build load</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Generate commercial invoice</td>
<td>2.50</td>
<td>2.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Issue Pick slip</td>
<td>1.83</td>
<td>.83</td>
<td>1.00</td>
</tr>
<tr>
<td>Customer Service - OK?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Recheck qty/model</td>
<td>.25</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Delay to FG</td>
<td>.20</td>
<td>.00</td>
<td>.20</td>
</tr>
<tr>
<td>Customer Service - Pick confirm and find PO</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Send all documents to FN</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Prepare packing list</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Submit shipping doc to FFA</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Prepare shipping mark</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform loading detail and shipping mark to FG</td>
<td>.33</td>
<td>.33</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform customer</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform shipment detail to customer</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Submit ship docs to customer</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform planning</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Finance - OK?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Finance - Check credit hold/limit</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Finance - Release account</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Finance - Issue invoice</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Finance - Send invoice to CS</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Finance - Hold shipment</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Finance - Delay account release</td>
<td>.93</td>
<td>.00</td>
<td>.93</td>
</tr>
<tr>
<td>Finance - Delay doc return</td>
<td>15.65</td>
<td>3.65</td>
<td>12.00</td>
</tr>
<tr>
<td>Sale - Confirm price</td>
<td>1.83</td>
<td>.83</td>
<td>1.00</td>
</tr>
<tr>
<td>Sale - Delay to CS</td>
<td>.20</td>
<td>.00</td>
<td>.20</td>
</tr>
<tr>
<td>FG Warehouse - Signed and send back to CS</td>
<td>.44</td>
<td>.00</td>
<td>.44</td>
</tr>
<tr>
<td>FG Warehouse - Confirm Qty on Pick slip</td>
<td>.08</td>
<td>.08</td>
<td>.00</td>
</tr>
<tr>
<td>FG Warehouse - Pick Products to loading area</td>
<td>3.50</td>
<td>2.50</td>
<td>1.00</td>
</tr>
<tr>
<td>FG Warehouse - Identify shipping mark</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>FG Warehouse - Product loading</td>
<td>2.50</td>
<td>2.50</td>
<td>.00</td>
</tr>
<tr>
<td>FG Warehouse - Product shipment</td>
<td>14.91</td>
<td>.08</td>
<td>14.83</td>
</tr>
<tr>
<td>Freight Forwarder Agent - Check container available</td>
<td>14.52</td>
<td>.50</td>
<td>14.02</td>
</tr>
<tr>
<td>Freight Forwarder Agent - Delay from FFA</td>
<td>.63</td>
<td>.00</td>
<td>.63</td>
</tr>
<tr>
<td>Customer - Customer feedback</td>
<td>24.00</td>
<td>8.00</td>
<td>16.00</td>
</tr>
</tbody>
</table>
Investigating in detail the waiting time from the simulation of current modeling, the highest waiting time is 25.22% from the processes located at FG warehouse department as this activity is assigned to check the real product instead of checking from the system. A warehouse supervisor has to assign his staff to check the quantity of products of each invoice to assure that the quantities are correct. Then the warehouse supervisor rechecks and confirms the quantity back to customer service. These redundant activities definitely cause process waiting for each other due to the limited resource.

The second highest, 24.8% is from receiving the confirmation from the customer in the United States (FUSA), which time zone is different from Thailand by 12 hours. The third one, 22.71% is waiting for the freight forwarder agent to confirm the booking. At present, FASCO never sends the forecasting information to the freight forwarder agents that they have to plan themselves, submit the booking requirement to the vessel to check container available, and wait to receive booking details. Then the freight forwarder agent can send the booking details to customer service.

The other major waiting time is 20.04% at the Finance department as there is a long lead-time on issuing the invoice and sending it to the customer. Time constraint and limit over time at finance effects this process. For example, if customer service submits the pick slip to finance in the afternoon, the invoice will be issued in the morning of the next and lead to late delivery to the customer. In turn, if submitting in the morning, they will issue the invoice that same day's afternoon. Next is at customer service activity with 5.38% for the function of product information checking. Lastly, 1.86% of waiting time is from the selling price's confirmation from Sales department. This is the only activity from this department, so the waiting time is less than the other departments.
The activities in the current processes can be categorized into three groups — Value adding (VA) activity, Business value adding (BVA) activity, and Non value-adding (NVA) activity. As shown in the figure 4.3, the biggest time is value-adding activities at 48%; 23% is business value-adding activities; the last 29% is non value-adding activities, which is the big challenge for improvement to eliminate delay and redundant processes from the current processes.

![Pie chart showing VA/BVA/NVA percentages](image)

Figure 4.3. The percentage of VA/BVA/NVA in the current process

An analysis of these 3 types of activity of each process for the 6 departments: Customer, Customer Service, FG Warehouse, Finance, Freight Forwarder Agent, Sales, can be identified based on the SCOR model—Deliver-Make-to-Order Product, and Lean thinking concept.

Customer Department (External department)

There is only one activity in this department that was identified as Value adding (VA) activity.

Value adding (VA) activity: 1 activity
Customer feedback

Customer Service Department (Internal department)

There are 24 activities in Customer service department that were identified: 9 activities for Value adding (VA) activity, 9 activities for Business value adding (BVA) activity, and 6 activities for Non value adding (NVA) activity.

Value adding (VA) activity: 9 activities

• Check delivery
• Due date for delivery? — Decision
• Inventory level? — Decision
• Inform planning
• Consolidate order
• Build load
• Contact Freight forwarder agent
• Issue pick slip
• Inform to FG

Business value adding (BVA) activity: 8 activities

• Inform customer
• Receive booking detail
• Send all documents to Finance department
• Prepare packing list
• Submit shipping documents
• Prepare shipping mark
• Inform shipment detail
• Submit documents to customer
• Pick confirm
Non value adding (NVA) activity: 7 activities

- Check product information
  Inform shipment to Finance department
- Generate commercial invoice
- Recheck quantity
- Quantity OK? - Decision
- Delay to FG

**FG Warehouse Department (Internal department)**

In FG warehouse department there are 6 activities that were identified: 2 activities for Value adding (VA) activity, 3 activities for Business value adding (BVA) activity, and 1 activity for Non value adding (NVA) activity.

**Value adding (VA) activity: 2 activities**
- Product loading to temp area
- Product shipment

**Business value adding (BVA) activity: 3 activities**
- Confirm quantity
- Pick product
- Identify shipping mark

**Non value adding (NVA) activity: 1 activity**
- Sign and send back to Customer service

**Finance Department (Internal department)**

There are 8 activities in this department that were identified: 3 activities for Value adding (VA) activity, 2 activities for Business value adding (BVA) activity, and 3 activities for Non value adding (NVA) activity.

**Value adding (VA) activity: 3 activities**
• OK for credit term? – Decision
• Hold shipment
• Issue invoice
  Business value adding (BVA) activity: 2 activities
• Check credit term
• Release customer account
  Non value adding (NVA) activity: 3 activities
• Delay account release
• Send invoice to Customer service
• Delay documents return
  Freight Forwarder Agent (External department)
  For Freight forwarder agent there are 2 activities in this kind of external
  department, Business value adding (BVA) activity and Non value adding (NVA)
  activity.
  Business value adding (BVA) activity: 1 activity
• Check container available
  Non value adding (NVA) activity: 1 activity
• Delay from Freight forwarder agent to Customer service
  Sale Department (Internal department)
  In this department there are 2 activities, and they are Non value adding (NVA)
  activity.
• Confirm price
• Delay to Customer service
Activity cost — current process

![Activity Based On Department](image)

From the figure 4.4, the activity cost based on department consists of two costs; the total of standard cost and over time (OT) cost. The cost shown in the figure is the processing cost of five documents as set out in the simulation criteria. To summarize the activity cost of each department the chart shows that there is no activity cost both in total standard cost and total over time cost for two departments, customer department and freight forwarder department, as they are external departments. Furthermore, there is no over time cost at sale department due to its only one activity in the process, so the resource has the time enough to support all documents that flow to the process itself.

Firstly, considering the total standard cost, the customer service department takes the highest cost with the total amount of 16,207.69 baht per 5 documents. This is because the customer service department handles 24 processes from the whole 44 processes, which is higher activities than the other departments. On the other hand, the only one process in sale department lead it to the lowest cost of 2,701.28 baht per 5
documents. For the other departments, Finance department takes 5,402.56 baht of standard cost, and FG warehouse department takes 4,862.50 baht respectively.

Considering the over time cost, this figure is the number identifying the adequacy of the resource in each department. The highest over time cost means inadequate resources and the company has to pay this cost for each department in order to complete their tasks, and zero over time cost means adequate resources or there are many idle times in that particular area. To solve the problem of inadequate resources does not mean to increase the resources at particular departments. But it is required to investigate the process in detail to find out why the current resource cannot support the current work in the normal working time. As in the previous section, there is 29% for improvement that can fill in the excess time. As shown in figure 5, the highest cost is in finance, customer service, and FG warehouse department: 375, 122.93 and 9.69 Thai baht respectively. This means that the resources of two major departments are inadequate to support the current activities in their department.

![Activity Cost Based On Department](image)

Figure 4.5. Activity cost based on transaction cost at each department of the current process

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Considering the transaction cost of each department based on their working type, Business Value Adding (BVA) cost, Value Adding (VA) cost, Non Value Adding (NVA) cost. As shown in figure 4.5, it shows that there is no activity cost concerning to two external departments, customer and freight forwarder agent because this project will focus only on internal processes. The external cost is disregarded. For all internal departments, the non value-adding transaction cost is the higher of other types, that means many redundancies and wastes in the processes. However, with positive thinking, this is the big opportunity for improvement, which leads to administrative's cost reduction.

Customer Service Department

- The ratio of transaction cost in this department, VA:BVA:NVA is 28.46%, 43.91%, and 27.63% respectively. The highest one is from business value-adding activities, especially in the process of checking product information, which cycle time is 4.7 hours or 26.5% of all average cycle time in customer service department. The other major driver is the process of issuing pick slip as value-adding activities and preparing commercial invoice as non value-adding activities.

FG Warehouse Department

- The ratio of transaction cost in this department, VA:BVA:NVA is 40.88%, 52.32%, and 6.81% respectively. Most of the transaction costs in this department are from value-adding and business value-adding activities, which is concerning with shipping the products to the customer. So, the non value-adding activities in this department are a minor focus.
Finance Department

- The ratio of transaction cost in this department, VA:NVA is 10.32%, 77.29% respectively. The figure in this department is much different from the other departments as most of its activities are non value-adding activities from the process of checking credit terms and issuing invoices.

Sale Department

- There is totally 100 % of Non value adding (NVA) cost in this department.

Resource analysis

Table 4.3. The resource statistic of each department in the current process

<table>
<thead>
<tr>
<th>Department</th>
<th>Count</th>
<th>Tag UI</th>
<th>AvgBuy</th>
<th>AgIdle</th>
<th>AvgIncr</th>
<th>AvgCOS</th>
<th>Avg OT</th>
<th>AvgCost</th>
<th>TagNVA</th>
<th>Agast</th>
<th>Td Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>1</td>
<td>24.42</td>
<td>24.42</td>
<td>60.00</td>
<td>4.00</td>
<td>0.00</td>
<td>24.42</td>
<td>24.42</td>
<td>0.00</td>
<td>24.42</td>
<td>24.42</td>
</tr>
<tr>
<td>Customer Service</td>
<td>6</td>
<td>635.00</td>
<td>635.00</td>
<td>635.00</td>
<td>1.00</td>
<td>0.16</td>
<td>635.00</td>
<td>635.00</td>
<td>0.16</td>
<td>635.00</td>
<td>635.00</td>
</tr>
<tr>
<td>FG Warehouse</td>
<td>4</td>
<td>484.00</td>
<td>484.00</td>
<td>484.00</td>
<td>4.00</td>
<td>0.04</td>
<td>484.00</td>
<td>484.00</td>
<td>0.04</td>
<td>484.00</td>
<td>484.00</td>
</tr>
<tr>
<td>Finance</td>
<td>2</td>
<td>551.00</td>
<td>551.00</td>
<td>551.00</td>
<td>4.00</td>
<td>1.50</td>
<td>551.00</td>
<td>551.00</td>
<td>1.50</td>
<td>551.00</td>
<td>551.00</td>
</tr>
<tr>
<td>Freight/Receive Agent</td>
<td>1</td>
<td>348.00</td>
<td>348.00</td>
<td>348.00</td>
<td>4.00</td>
<td>0.00</td>
<td>348.00</td>
<td>348.00</td>
<td>0.00</td>
<td>348.00</td>
<td>348.00</td>
</tr>
<tr>
<td>Sale</td>
<td>1</td>
<td>32.00</td>
<td>32.00</td>
<td>32.00</td>
<td>4.00</td>
<td>0.00</td>
<td>32.00</td>
<td>32.00</td>
<td>0.00</td>
<td>32.00</td>
<td>32.00</td>
</tr>
</tbody>
</table>

The resource statistics are used to analyze the data and has been collected about the resources. As the table 4.3, much information is available with the following meaning:

**Total(Tot)** - For time and cost statistics, the total is the sum of time or costs accrued by the resource.

**Average (Avg or Tavg)** - For time and cost statistics, the average (Avg) is the total time or costs divided by the count of resources. Count and utilization statistics are Avg and Tavg.

- Avg is the observation-based average. This is the sum of the value of the statistic, when observed, divided by the number of observations taken.
Tavg is the time-weighted average. This is the average after weighting each count or utilization based on the amount of time that the observed count or resource usage occurred.

- **Workers (Count)** - The total number of workers for one or all departments. During simulation, a resource can always be classified as busy, out of service, idle, or inactive. You set how a resource "spends" its time when you specify how activities acquire and use it, for how long, and by its schedule. The sum of a resource's time equals the total elapsed time of the simulation.

- **Busy Time (Avg Busy, Tot Busy)** - The time that a resource spends working, i.e., processing a transaction. This time is paid. Also see the following discussion on the two subsets of busy time: waiting versus non-waiting time, and standard time versus overtime.

- **Out of Service Time (Avg OOS, Tot OOS)** - The time that a resource is active but unavailable to process transactions. A resource can also be acquired by an activity as out of service. Out of service time can be paid or unpaid, depending on how the time span is defined in the resource's schedule.

- **Idle Time (Avg Idle, Tot Idle)** - The time that a resource spends available for use but not currently processing a transaction. This time is paid.

- **Inactive Time** - The remaining time when a resource is out of schedule. This time is unpaid.

- **Resource Waiting Time and Non-Waiting Time (Avg Res Wait, Tot Res Wait)** - The time that a resource spends waiting. This occurs when an activity processing a transaction acquires a resource with the Wait option, and the transaction must wait for some reason (for example, waiting for another resource, or the transaction incurs blocked or inactive time).
\[ \text{Tot Busy} = \text{Tot Res Wait} + (\text{Total resource non-waiting time}) \]

- Resource Standard Time and Resource Overtime (Avg OT, Tot OT)-The time that a resource spends in standard time or overtime.

\[ \text{Tot Busy} = (\text{Resource standard time}) + \text{Tot OT} \]

- Resource Utilization (Res Util\%)-The percentage of scheduled active time that a resource is busy but not out of service:

\[ \text{Res Util}\% = \frac{\text{Tot Busy}}{(\text{Tot Sched}) - (\text{Tot OOS})} \]

The total scheduled active time is calculated by figuring the total number of hours during which the resource is scheduled to be active during the entire simulation.

- Non-Waiting Resource Utilization (NW Util\%)-The percentage of scheduled active time (when a resource should be in schedule) that a resource is busy but not waiting or out of service.

\[ \text{NW Util}\% = \frac{(\text{Tot Busy}) - (\text{Tot Res Wait})}{(\text{Tot Sched}) - (\text{Tot OOS})} \]

Time weighted average of utilization

Figure 4.6. The utilization time at each department of current process
As figure 4.6, it shows the percentage of time the resources of each department are on schedule. Actually, this figure is to identify the utilization of the resources at each department. The highest percentage is at the customer side, 24.68 hours or 24.5% comparing to the lowest department at sale department 3.2 hours or 3.2%. This means that the number of the resources at each department is still over the requirement or less busy time as shown in figure 4.7 and high idle time as shown in figure 4.8.

Figure 4.7. The busy time at each department of the current process

Figure 4.8. The idle time at each department of the current process
To summarize from the above charts for the average idle hours and busy time of each department. The figure of busy time is in the same direction as the utilization as its formula. The higher utilization, the resource at a particular department is busier. In the other hand, the busy time is always the opposite figure to idle time. So as in figures 4.7 and 4.8, the opportunity to improve or increase the utilization is in the internal departments: customer service, finance, FG warehouse and sale department. Especially the customer service department, where there are currently 6 staffs to support the processes. Comparing their work, this number should be reduced by half or more than 30%.

![Out of Service time at each department](image)

Figure 4.9. Out of service time at each department

The other figure of concern is the out of service time, which is the time that resources are not available or busy with the other activities. As figure 4.9 shows, the out of service times in both external and internal department are not much different except Customer service department. In customer service, time is slightly higher than the other departments: it differs by only 0.58%. This is caused by unbalance of time between the resources.
Customer department: Total average out of service is 4 hours, 16.57%.

Finance department: Total average out of service is 4 hours, 16.57%.

FG warehouse department: Total average out of service is 4 hours, 16.57%.

Freight forwarder agent: Total average out of service is 4 hours, 16.57%.

Sale department: Total average out of service is 4 hours, 16.57%.

Customer service department: Total average out of service is 4.14 hours, 17.15%.

4.2.2. Waste identification

From the current analysis, the long cycle time and higher cost in the current processes are from the redundant and wasting activities. With the reference to FASCO SCOR model in figure 4.10, the identification of wasting activities is shown in the figure 4.11 for further improvement.

For Fasco SCOR in level 2, it starts from source stocked product (S1) and source make-to-order product (S2) from both oversea and local raw material suppliers. In FASCO
operation process, the policy is make-to-order (M2), and then deliver make-to-order product (D2) to the customer, FUSA.

Figure 4.11. Waste identification of the current distribution processes
4.3 Brainstorming for action support

From the analysis and waste identification of the current processes, it shows that there are many wastes in the current process that causes long cycle time and high cost. To develop and design the new processes, the weighted scoring matrix is applied on identifying the non value-adding activities and finds the alternative solutions to improve each issue.

In the process of developing the processes, it follows by;

1. Identifying the non value-adding activities: with refer to SCOR model, there are 14 of non value-adding activities, which they can be grouped into major 8 items as shown in table 4.4.

2. Specifying and prioritizing their needs with a list of criteria: as this project is a simulation on developing the new process design to find the maximum benefits that can be gained from it, all non value-adding activities are all focused in this project. Anyway, the prioritizing the actions and needs would be considered in the actual implementation.

3. Evaluating, rating, and comparing the different solutions: after listing the non value-adding activities, the brainstorming process is applied to find the alternative solutions for each item with a ranking number. Then evaluating and rating the alternatives are taken with the following criteria and shown in table 4.4:

   Compact: This criteria is to evaluate the alternatives for how many benefits can be gained. In this project, there are three levels with its rating values;

   - High = 3, Med = 2, Low = 1
Table 4.4. The table of all supporting actions from brainstorming.

<table>
<thead>
<tr>
<th>No.</th>
<th>Waste identification</th>
<th>Department</th>
<th>Alternative</th>
<th>Ranking no</th>
<th>Compact</th>
<th>Invest</th>
<th>Weight score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Confirm price -&gt; Delay to CS</td>
<td>Sale</td>
<td>Price update on system by sale that allow CS to check</td>
<td>A</td>
<td>High</td>
<td>Low</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Customer service print out the selling price &amp; credit term and confirm back by sale.</td>
<td>B</td>
<td>Med</td>
<td>Med</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Confirm price through e-mail</td>
<td>C</td>
<td>Low</td>
<td>Low</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Inform shipment to FN -&gt; Delay &amp; release</td>
<td>Customer service</td>
<td>Credit limit update on system by FN that allow CS to check</td>
<td>D</td>
<td>High</td>
<td>Low</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Update credit term weekly</td>
<td>E</td>
<td>Med</td>
<td>Low</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Automatic block the system if credit term is on hold by FN</td>
<td>F</td>
<td>High</td>
<td>Med</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Delay from FFA</td>
<td>Freight Forwarder Agent</td>
<td>Send forecast to FFA monthly and update weekly to reserve container</td>
<td>G</td>
<td>High</td>
<td>Low</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Request for vessel schedule</td>
<td>H</td>
<td>Med</td>
<td>Low</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Find the other quicker supplier</td>
<td>I</td>
<td>Low</td>
<td>High</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Generate commercial invoice</td>
<td>Customer service</td>
<td>Combine commercial and actual invoice to be one form and use multi layer copy</td>
<td>J</td>
<td>High</td>
<td>Med</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Print out from the system</td>
<td>K</td>
<td>High</td>
<td>Med</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Develop excel file to be easier, just click and check</td>
<td>L</td>
<td>Med</td>
<td>Med</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Recheck qty -&gt; Ok? - Decision, delay at FG</td>
<td>Customer service</td>
<td>Check qty in the step of check product info</td>
<td>M</td>
<td>Med</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Automatic link data between invoice and pick slip</td>
<td>N</td>
<td>High</td>
<td>Med</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Combine pick slip and pick confirm to be one step</td>
<td>O</td>
<td>High</td>
<td>Med</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reprocess to reduce redundancy steps</td>
<td>P</td>
<td>Med</td>
<td>Med</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Signed and sent back to CS</td>
<td>FG warehouse</td>
<td>Stock update on system</td>
<td>Q</td>
<td>High</td>
<td>Low</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Call to confirm qty</td>
<td>R</td>
<td>Low</td>
<td>Low</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Check qty in the step of check product info</td>
<td>S</td>
<td>High</td>
<td>Low</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>Pick confirm</td>
<td>Customer service</td>
<td>Pick slip to use as order slip and gate pass.</td>
<td>T</td>
<td>Med</td>
<td>Med</td>
<td>4</td>
</tr>
<tr>
<td>8</td>
<td>Send all documents to FN -&gt; issue invoice</td>
<td>Customer service</td>
<td>Customer service issue the invoice instead Finance. only Finished product &amp; Cancel the sale order format.</td>
<td>U</td>
<td>High</td>
<td>Med</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fix time on sending document to FN to avoid waiting time &amp; delay</td>
<td>V</td>
<td>Med</td>
<td>Low</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Automatic generate invoice since pick confirm</td>
<td>W</td>
<td>Med</td>
<td>Med</td>
<td>4</td>
</tr>
</tbody>
</table>
Cost: This criteria is to evaluate the alternatives how much of cost or investment are required for. In this project, there are three levels with its rating values:

High = 1, Med = 2, Low = 3

Then plot the activities into the weighted scoring matrix chart as shown in the figure 4.12.

![Weighted scoring matrix chart of the current processes](image)

Figure 4.12. Weighted scoring matrix chart of the current processes

4. Selecting the best matching solution: The last step is to select the optimal alternatives and develop the new process design. Selecting the optimal alternatives can be done by two methods;

- Selecting from a weighted scoring matrix chart: this is a visual method that can select the alternatives from the chart. The left-top section of the matrix chart is always the first selection and the middle-top or left-middle top section is the second selection accordingly.
- Calculating from the rating score: this method is to select the alternative from the highest score, which can be calculated from the following formula:

\[
\text{Score} = \text{Compact rating} \times \text{Cost rating}
\]

As shown in table 4.4, there are three alternatives for the item 1 of ‘confirm price -> delay to CS’ process.

- Alternative A: Impact = high or 3, Cost = low or 3, the rating \(\rightarrow\) \(3 \times 3 = 9\).
- Alternative B: Impact = med or 2, Cost = low or 3, the rating \(\rightarrow\) \(2 \times 3 = 6\).
- Alternative C: Impact = high or 3, Cost = med or 2, the rating \(\rightarrow\) \(3 \times 2 = 6\).

So, the selected alternative is alternative A as the highest score.

After selecting the alternative solutions for each item, the new processes will develop according to the selected alternatives and adjust all parameter to get the optimal outputs.
4.4 New proposed processes

As the alternative actions in table 4.4, the new proposed process flow is designed as figure 4.13 that is developed and different from the current process, as in the following details;

- Confirm price -> delay to CS: This process in the current process will be eliminated by having a price update by sale on the system that allows the customer service staff directly check once the delivery schedule is reached.

- Finance department: customer service department to remove the delay time and redundant process between the departments, and will handle the processes of checking credit term and issuing invoice that are handled by finance processes in the current process. From the data analysis of the current process, it shows that the utilization of customer service staffs is only 6.35% that means it has room enough to handle the other jobs. Furthermore, the IT will allow customer service to check credit terms as updated daily by finance department.

- Delay from FFA: this is the wasting time occurred at the external side effecting to the whole process. Normally, the outside process will not be focused on this project; however, it can be improved by giving the forecast to the FFA and updating it weekly.

The other IT help is to have an automatic data link between invoice and pick slip that allows combining pick slip and pick confirm to be one step by the customer service. Furthermore, it will help to remove delay time at FG warehouse by having stock update on the system and check quantity in the step of check product information at the first stage.
The last action is to reduce the process of pick confirmation by combining it with the process of picking slip. Furthermore, it also use pick slip as order slip and gate pass when shipping the products out of factory.

Figure 4.13. The proposed process flow of distribution process
From developing the new process design as figure 4.13, the process step is reduced from 43 to 29 process steps with the actions support this according to table 4.5 and the total number of departments is reduced from six departments to four departments. There are two internal departments and two external departments in this new process modeling. The processes are mainly handled by customer service department and then go to the other departments such as FG warehouse, Freight Forwarder, and Customer. From the current modeling, it shows that the percentage of utilization is very little compared to its full time, so when running the simulation of the new process design, the resources at each department will be reduced with the same cost rate as shown in table 4.5.

Table 4.5. Resource and cost structure of each department

<table>
<thead>
<tr>
<th>Department</th>
<th>No of operator</th>
<th>Labor cost per hour</th>
<th>OT cost per hour</th>
<th>Working hour per day</th>
<th>OT limit per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer service</td>
<td>2</td>
<td>83.33</td>
<td>125</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Freight Forwarder Agent (FFA)</td>
<td>1</td>
<td>Paid by customer</td>
<td></td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>FG warehouse</td>
<td>4</td>
<td>37.5</td>
<td>56.25</td>
<td>8</td>
<td>3</td>
</tr>
</tbody>
</table>
4.5 The analysis of new proposed processes

Figure 4.14. Time consumption at each department of new process design

As shown in figure 4.14, after identifying waste of the current processes and running the simulation of new process design modeling, the total cycle time is 53.32 hours or 4.84 days running 11 working hours, which reduce by 46.92% from the current model. This reduction is from the reallocation of work handled by Sale department and Finance department in the current process to be handled by customer service in the proposed processes, as they are redundant work creating more Non Value Adding (NVA) activity in the distribution function. However, there is only one party, the customer side, that is still running in the current process model. This is because the time zone is limited by time zone difference between USA and Thailand.

For work time, the new process modeling is sharply decreased from the current of 3.26 days to the new process design of 2 days or 38.7% reduction, in turn, the wait time for new process is very different from the current that reduced from 5.74 to be 2.84 days or 50.5% reduction. Looking in detail, the work time in customer service department is reduced from 14.9 to 6.76 hours or 54.6% reduction, caused by reducing
non value-adding activities of the current process. For the FG warehouse, the work
time is increased from 6 hours to 6.75 hours or 12.5% increase, caused by reallocating
the process of preparing shipping mark from the customer service in the current model
to be handled by FG in the new modeling to reduce the redundant processes between the
departments. This will allow the FG warehouse preparing and identifying shipping mark
directly without any waiting time. Lastly, the working time at freight forwarder agent
will be same as the current process due to the new process model improvement to
reduce the waiting time only.

Looking in detail of waiting time, the customer’s waiting time is reduced from
the current 3.47 to 1.66 hours or 52% reduction. As shown in table 7, the new process
design based on lean tries to minimize the redundancy functions, waiting time. There
are some functions transferred from Sale and Finance department to try to increase the
speed of flow by eliminating wait time for returned documents from both departments.
Therefore, customer service department has to perform the tasks instead of sale and
finance department in checking the unit prices, issuing invoices, checking credit limits
and releasing customer accounts, which causes a reduction in wait time and better
process flow in this area. Some tasks in customer service department are eliminated in
order to reduce the redundant work, i.e. recheck quantity and model process.
Table 4.6. Time consumption at each department of the new process model

<table>
<thead>
<tr>
<th>Activity Statistics (Hours)</th>
<th>Avg Cycle</th>
<th>Avg Work</th>
<th>Avg Wait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Service - Build load</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Freight Forwarder Agent - Check container available</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Check credit hold/limit</td>
<td>1.83</td>
<td>.83</td>
<td>1.00</td>
</tr>
<tr>
<td>Customer Service - Check delivery schedule</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Check product info</td>
<td>2.77</td>
<td>.50</td>
<td>2.27</td>
</tr>
<tr>
<td>Customer Service - Consolidate order</td>
<td>1.00</td>
<td>1.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Contact Freight Forwarder Agent</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer - Customer feedback</td>
<td>24.00</td>
<td>8.00</td>
<td>16.00</td>
</tr>
<tr>
<td>Freight Forwarder Agent - Delay from FFA</td>
<td>.63</td>
<td>.00</td>
<td>.63</td>
</tr>
<tr>
<td>Customer Service - Delay?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Hold shipment</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>FG Warehouse - Identify shipping mark</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform customer</td>
<td>.50</td>
<td>.50</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform loading detail and shipping mark to FG</td>
<td>.33</td>
<td>.33</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform planning</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Inform shipment detail to customer</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - new?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Issue Invoice</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Issue Pick slip/confirm</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - OK?</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>FG Warehouse - Pick Products to loading area</td>
<td>3.50</td>
<td>2.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Customer Service - Prepare packing list</td>
<td>.83</td>
<td>.83</td>
<td>.00</td>
</tr>
<tr>
<td>FG Warehouse - Prepare shipping mark</td>
<td>12.85</td>
<td>.83</td>
<td>12.02</td>
</tr>
<tr>
<td>FG Warehouse - Product loading</td>
<td>2.50</td>
<td>2.50</td>
<td>.00</td>
</tr>
<tr>
<td>FG Warehouse - Product shipment</td>
<td>.08</td>
<td>.08</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Receive booking detail</td>
<td>.08</td>
<td>.08</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Release account</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Submit ship docs to customer</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>Customer Service - Submit shipping doc to FFA</td>
<td>.17</td>
<td>.17</td>
<td>.00</td>
</tr>
</tbody>
</table>

In FG warehouse department, the waiting will be reduced from the current 16.27 to 13.02 hours or 19.9% reduction. The new model design will reallocate customer service department to perform the process of picking slip confirmation instead of FG warehouse to reduce the delay time on waiting for confirmation from FG as normal in the current process. Further, another work relocation, preparing shipping mark, that was mentioned on working time analysis, will improve the process to run faster with less
waiting time. The other department that the new process design can greatly improve its performance is freight forwarder agent. Its waiting time is reduced from the current 14.65 to 0.63 hours or 95.6% reduction. This is because by good planning and forecasting that FFA can reserve the container in advance with the less waste of time.

Lastly, external departments: in customer department there are no changes in the activity as the feedback to confirm the shipment will be returned to Customer service department in the following day after sending the information to customer (as already mentioned the reason is because of different time zones).

Comparing the percentage of VA/BVA/NVA between the current process and new process design, it will shows that the percentage of value-adding activities will increase from the current 48% to be 62% and the percentage of business value-adding adding activities also increases from the current 23% to be 32% as shown in figure 4.15. On the other hand, the percentage of non value-adding activities will reduce from 29% to 6%.

![Figure 4.15. The percentage of VA/BVA/NVA in the new process design](image)
**Activity cost – New process design**

As well as the current process, the new process design is still using the same cost structure as current process, as shown in table 6. The cost shown in the figure is the processing cost of five documents as set in the simulation criteria. To summarize the activity cost of each department, the chart shows that there is no activity cost both in total standard cost and total over time cost for two departments, customer department and freight forwarder department, as they are external departments. Furthermore, there is no over time cost at sale department due to its only one activity in the process, so the resource has the time enough to support all documents that flow to the process itself.

![Graph showing activity cost based on department](image)

**Figure 4.16.** Activity cost based on resource cost at each department of new process design.

Comparing to the current process, the total activity cost is sharply reduced from the current 29,681.65 to 7,580.40 Thai baht or a cost reduction of 75% per five documents or per week, as shown in figure 4.16. The activity cost of new process design is from the two main departments, customer service and FG warehouse respectively. Comparing the percentage of overtime cost over the total cost, the new process design will slightly increase from 1.7% to 3.6%. This is because of the reduction of resources at both departments to increase the percentage of utilization.
Following Lean thinking, the new process is designed to eliminate non value-adding (NVA) cost from the activity of each department, which can reduce the cost of non value-adding activities from the current of 43% to zero. Comparing VA and BVA costs with the current model, they will increase from 23% and 34% to 43% and 57% respectively, which means the new design can make the activity of more value as shown in figure 4.17.

![Activity Cost Based on Department](image)

**Figure 4.17.** Activity cost based on transaction cost at each department of the new process design

Looking at the details, the most significant benefit for this new process design is the VA cost of Customer service department which increases 32% from the current. Although the VA cost of FG warehouse department decreases by 3.22%, this is a small figure compared with the activities that are minimized from this department. As BVA cost comes from the activity necessary to perform the task, these are all tasks from sale and finance department transferred to customer service department. So, although the BVA cost in Customer service department slightly increases for new process design, it is only 7.7%. As well as FG warehouse department, this department has transferred to it some tasks from customer service function to flow in the warehousing function to
minimize wait time, make it easy to control and make it more convenient to perform the job in order to avoid any errors. Thus, the BVA cost of this department increases by 21.9% from the current process.

Resources analysis – New process design

Table 4.7. The resource statistic of each department in the new process design

<table>
<thead>
<tr>
<th>Worker</th>
<th>Count</th>
<th>Tag Util</th>
<th>AvgBusy</th>
<th>AvgIdle</th>
<th>Avg Incr</th>
<th>Avg CCS</th>
<th>Avg Cr</th>
<th>Avg Res W</th>
<th>Tag NW</th>
<th>Ag Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>1</td>
<td>3466</td>
<td>6.00</td>
<td>15.60</td>
<td>31.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>34.65</td>
<td>6.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Customer Service</td>
<td>2</td>
<td>17.16</td>
<td>5.04</td>
<td>19.12</td>
<td>28.51</td>
<td>3.42</td>
<td>1.49</td>
<td>0.00</td>
<td>17.16</td>
<td>8.05</td>
<td>8.42</td>
</tr>
<tr>
<td>FG Warehouse</td>
<td>4</td>
<td>7.31</td>
<td>1.99</td>
<td>21.40</td>
<td>30.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>7.31</td>
<td>8.05</td>
<td>8.42</td>
</tr>
<tr>
<td>Freight Forwarder Agent</td>
<td>1</td>
<td>483</td>
<td>1.13</td>
<td>21.83</td>
<td>30.00</td>
<td>3.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4.86</td>
<td>500</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Figure 4.18. Utilization time at each department of new process design

As shown in figure 4.18, there are four departments utilization in new design, customer department, customer service department, FG warehouse department, freight forwarder agent department. meaning that there is no utilization from sale and finance department in the new design. Comparing the average of utilization, the highest is in customer department, which increases from the current 24.68 hours to 34.6 hours or 24.5% to 64.89% improvement. Apparently most utilization time is still acquired by the customer, and it is unchanged as this activity has to be performed by the customer in the
United States (FUSA). Even though there are some tasks transferred to customer service department, the utilization increases from 6.35 hours to 17.16 hours or 6.3% to 32% improvement. This results from some functions being transferred to another department and some are eliminated for speeding the response and improving the flow process with the reduction of the resources in the department from 6 to be 2 people. Actually, it can be reduced to only those people handling all processes in customer service department, but this would be the risky in the new process design when he or she is absent or assign to a further job in the future. For new process design, FG warehouse is a lower utilization than the others, anyway it will increase from 4.84 hours to 7.31 hours or 4.8% to 13.7% improvement if running as new process design, which lets this department continue to perform their tasks without any interruptions or delays. To flow all processes starting from shipping mark preparation until finish production shipment of each invoice. There is a small portion of utilization in freight forwarder department and it is same process with the current process that this department performs a check on the availability of containers and confirms back to Customer service department. However, the new design will find the solution to decrease wait time and improve the speed of flow within the process of this department.
Busy time and idle time are shown as figure 4.19 and 4.20 respectively. The busy time of customer service department greatly increases from the current 2.2% to 9.4% in the new design. Absolutely, this is from the re-allocation of work and the reduction of resources at this department as well as FG department that also increases from 1.1% to 40.1% for the same reason. For idle time, the figure obviously shows that the new process design reduces the idle time of each department to perform the work by over 50% from the current process. As the current model it represents the total hours in
idle time for all departments; these are all wastes in processes. Based on lean concept, new process design proposes to minimize all wastes in the process that means eliminating the idle time of each task to be better process flow. The highest percentage in reduction of idle time is in Customer service department: it is a 38.25% reduction. Although from new process design many tasks are transferred into this department, it shows that in customer service processes there is less idle time and more value adding activity. So the idle time is absolutely reduced from the current by the new process design. It can be said that the new process makes the functions to be more effective and efficient as there are less wastes in its function compared to the current model. Furthermore, it would be observed that the amount of idle time in each department is quite close to each time that means to the balancing of the processes.

![Figure 4.21. Out of service time at each department of new process design](image)

Comparing the current process as shown in figure 21, this chart represents that the Out Of Service (OOS) hour is reduced by new processes by nearly 50% from the current, even though the ratio of each department is similarly to current processes. The figure of Customer service department is still the highest with 26.29%, but it is slightly different from the other departments only 6.5%. This means that the portion of OOS
time of each department is not too much between the current process and the new process design, but the figure of total 00S time of new process is less than the current, meaning that it is better in the new process design.
4.6 The implementation plan

After the data analysis of the new proposed processes, the process flow and its parameters are confirmed so that the optimal benefits will be gained from this change. Therefore, the implementation plan and the person who will be responsible for each item, with a maximum lead time of 4 weeks, is shown in Table 4.8.

Table 4.8. Actions support for new proposed distribution process

<table>
<thead>
<tr>
<th>No.</th>
<th>Waste identification</th>
<th>Department</th>
<th>Action</th>
<th>Who</th>
<th>Time estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Confirm price -&gt; Delay to CS</td>
<td>Sale</td>
<td>Price update on system by sale that allow CS to check</td>
<td>Sale/CS/IT</td>
<td>1 week</td>
</tr>
<tr>
<td>2</td>
<td>Inform shipment to FN -&gt; Delay acc release</td>
<td>Customer service</td>
<td>Credit limit update on system by FN that allow CS to check</td>
<td>FN/CS/IT</td>
<td>2 weeks</td>
</tr>
<tr>
<td>3</td>
<td>Delay from FFA</td>
<td>Freight Forwarder Agent</td>
<td>Send forecast to FFA monthly and update weekly to reserve container</td>
<td>CS</td>
<td>2 weeks</td>
</tr>
<tr>
<td>4</td>
<td>Generate commercial invoice</td>
<td>Customer service</td>
<td>Combine commercial and actual invoice to be one form and use multi layer copy</td>
<td>CS</td>
<td>3 weeks</td>
</tr>
<tr>
<td>5</td>
<td>Recheck qty -&gt; Ok? - Decision, delay at FG</td>
<td>Customer service</td>
<td>Automatic link data between invoice and pick slip and combine pick slip and pick confirm to be one step</td>
<td>CS/FG</td>
<td>1 week</td>
</tr>
<tr>
<td>6</td>
<td>Signed and sent back to CS</td>
<td>FG warehouse</td>
<td>Stock update on system and check qty in the step of check product info</td>
<td>FG</td>
<td>2 weeks</td>
</tr>
<tr>
<td>7</td>
<td>Pick confirm</td>
<td>Customer service</td>
<td>Pick slip to use as order slip and gate pass.</td>
<td>CS</td>
<td>2 weeks</td>
</tr>
<tr>
<td>8</td>
<td>Send all documents to FN -&gt; issue invoice</td>
<td>Customer service</td>
<td>Customer service issue the invoice instead Finance. (only Finished product) &amp; Cancel the sale order format.</td>
<td>CS/FN/IT</td>
<td>4 weeks</td>
</tr>
</tbody>
</table>
V. CONCLUSION AND RECOMMENDATION

5.1 Conclusions

At this present time of fierce competition, there is an urgent requirement for timely and improved business processes. The study in this project is to design a new distribution process flow, and therefore the lean approach is the tool to drive the distribution process enabling better improvement, faster processing, lower costs, and greater profitability. With lean thinking concepts, it is possible to eliminate waste and manage a streamlined flow of value to customers as well as removing non-value adding activities from the chain.

The new proposed lean distribution processes are designed to replace the existing distribution processes. The new design aims to improve, eliminate waste, and maximize business flow with less time, resources, human effort, and costs, while meeting customer requirements. The major problems in distribution processes are time consumption in processing, redundancy of functions across departments and the information flow among several sections that cause long lead times in the distribution processes. Lean distribution will help to increase the speed of flow and reduce costs much more than the existing model in distribution. New process design based on lean thinking concept provides several benefits with more utilization as shown in table 5.1.

The main benefits are:

1. Reduce process step and redundant functions.
2. Reduce headcount requirement as well as increasing utilization.
3. Increase speed of flow as shown in cycle time improvement.
4. Reduce total costs of the company.
5. Greater flexibility.
7. Better cooperation with the customer through quick response.

Table 5.1. The benefits from the new process design comparing to current process.

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Description</th>
<th>Current process</th>
<th>New process design</th>
<th>Benefit gain</th>
<th>Percentage of gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Process</td>
<td>Process step</td>
<td>43</td>
<td>29</td>
<td>14</td>
<td>32.5</td>
</tr>
<tr>
<td>2</td>
<td>No of VA activities</td>
<td>16</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>No of BVA activities</td>
<td>13</td>
<td>11</td>
<td>2</td>
<td>15.4</td>
<td>15.4</td>
</tr>
<tr>
<td>4</td>
<td>No of NVA activities</td>
<td>14</td>
<td>2</td>
<td>12</td>
<td>85.7</td>
<td>85.7</td>
</tr>
<tr>
<td>5</td>
<td>Time</td>
<td>Total cycle time (days)</td>
<td>9</td>
<td>4.84</td>
<td>4.16</td>
<td>46.2</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Total working time</td>
<td>3.26</td>
<td>2</td>
<td>1.26</td>
<td>38.7</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Total waiting time</td>
<td>5.74</td>
<td>2.84</td>
<td>2.9</td>
<td>50.5</td>
</tr>
<tr>
<td>8</td>
<td>Cost</td>
<td>Total cost (THB)</td>
<td>29,681.65</td>
<td>7,580.40</td>
<td>22,101.25</td>
<td>74.5</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Total Standard cost (THB)</td>
<td>29,174.03</td>
<td>7,309.57</td>
<td>21,864.46</td>
<td>74.9</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Total OT cost (THB)</td>
<td>507.62</td>
<td>270.83</td>
<td>236.79</td>
<td>46.6</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Total VA cost (%)</td>
<td>23</td>
<td>43</td>
<td>-20</td>
<td>-20.0</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Total BVA cost (%)</td>
<td>34</td>
<td>57</td>
<td>-23</td>
<td>-23.0</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Total NVA cost (%)</td>
<td>43</td>
<td>0</td>
<td>43</td>
<td>43.0</td>
</tr>
<tr>
<td>14</td>
<td>Resources</td>
<td>Utilization time (%)</td>
<td>6.6</td>
<td>24</td>
<td>-17.4</td>
<td>-17.4</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Busy time (%)</td>
<td>8.8</td>
<td>77.56</td>
<td>-68.76</td>
<td>-68.8</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Idle time (%)</td>
<td>91.2</td>
<td>15.86</td>
<td>75.34</td>
<td>75.3</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Out of service time</td>
<td>24.14</td>
<td>12.42</td>
<td>11.72</td>
<td>48.6</td>
</tr>
<tr>
<td>18</td>
<td>Department</td>
<td>No of headcount</td>
<td>14</td>
<td>7</td>
<td>7</td>
<td>50.0</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>No of department concern</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>33.3</td>
</tr>
</tbody>
</table>

However, the methods of getting the benefits as proposed in the new process design are not easy to deal with, as there are many barriers along the way such as:

**IT support:** currently there is only one IT engineer to support, the whole company. On requesting him to help, sometimes there is a slow response: It is better if the company makes the decision to hire outsourcing to help case by case.
**Human conflict:** as seen in this project, there are many wasting activities along the processes. The new design is proposed to improve the company performance that will affect current functions such as the finance department. The new design is proposed to reallocate the finance function to be handled by customer service, which means the current operator who handles this function will be free. Job rotation would be required to reduce the conflict from negative thinking by the operator.

**Top management support:** It is absolutely essential for support from the top management to drive any changes in the organization.

**Training:** There are two issues for training. One is to train the operator to understand lean concepts that will help the company to get the better performance and enhance its competitiveness in the global business. The other is to train for re-allocation of processes. Re-allocation of the processes will not succeed if there is a lack of training from the previous department.

**Supporting actions for changes:** The quicker process can be changed to the new proposed process, the quicker completion of supporting actions would be required.

**Cooperation and trust between people:** Good collaboration across functional teams would be definitely required to run the improvement process smoothly.

### 5.2 Recommendations

This new process design might not be the best design but its objective is to create a modeling design to be the most valuable process in distribution in accordance with the concept of lean by simulating the modeling before the actual implementation, which it cannot be run as easily as in the past trial and error process. However, the
benefits revealed by the simulation are not exactly the benefits that will be gained when actually implementing, slightly differences should be realized.

After the proposed new distribution modeling has been implemented, it requires deep study and a well planned implementation, as lean principles are not a one day job. The new distribution model performance has to be evaluated to identify the difficulties that occur during the operation. The evaluation should be discussed among the members of the top management for lean distribution enhancement.

One of the major contributors to the success of lean distribution implementation is the acceptance by the employees, the support and willingness to change. Company culture, discipline and team work also seem to have effects on the success of implementation. In addition, some training courses for the employees may be introduced, for example Just-In-Time. The Information Technology (IT) department seems to have important roles linked with lean distribution as it is required to modify and update the database for supporting the solutions in the new distribution process. Furthermore, computer and information technology will help the operator to work easier not only eliminating non value-adding activities but also including both business value-adding and value adding activities in the organization.

This proposed model is the first step to apply lean thinking concepts in the distribution process. In the future it would be greatly advisable for all types of organizations to study lean principles, and apply some of the principles that are suitable in the business environment to smooth the process flow.
APPENDIX A

IGRAFX PROCESS SIMULATION PROGRAM
**Igrafx Introduction**

iGrafx 2006 is a software environment for process mapping, process modeling, and process simulation. iGrafx 2006, an intelligent business diagramming and modeling solution designed for knowledge workers, managers, and IT professionals. With the intuitive ease of use of iGrafx 2006, it has never been easier to create process, free-form, structured, software, presentation, and network diagrams. iGrafx 2006 provides flowcharting and modeling capabilities to help on draw, analyze, and improve processes, with what-if scenarios. The results provide statistical data for in-depth analysis of the work flow in an organization.

**Describing the Behavior of Each Shape/Activity**

Most shapes represent activities and contain behavioral information. You enter or define the behavioral information for each activity using the **Properties** dialog box.

The **Properties** dialog box contains pages for each category of activity behavior. The most commonly used pages are **Inputs, Resources, Task, and Outputs**.

To use the Process Guide:

1. Double-click a shape, or right-click a shape, and click **Properties** on the context menu.
2. Select the **Process** from the **Guide** category. The **Process** page appears.
Figure A.1. The Window of Process guide

The Start Point specifies an entry point for transactions into the process. The transactions may arrive to the process from a Generator or another process. To specify a start point:

1. In the Properties dialog box, select the Process page.

2. In the Process page, select the Process start point check box.

The Process page provides a quick start to specifying modeling properties for an activity, such as the duration, cost and capacity of a task defined on the Step tab of the Task page. The Process page also defines the basic type of activity:

- **Work**- Usually uses a resource to work on a transaction for the duration of the Task.

- **Decision**- Transactions leave an activity following one or more output paths based on certain decision criteria.

- **Delay**- Blocks the transaction for the duration of the Task. Delay tasks do not usually use a resource.
Subprocess- Links to a process. During simulation, the transaction moves from this activity to a start activity on another diagram (process). The transaction returns to this activity when it completes the process.

Defining Process Behavior

The process model consists of a set of activities that process transactions. Transactions can be a person performing a task or an object moving through a process, such as a loan application in a bank loan process. These transactions flow from activity to activity through the directed connector lines that create a path through the process.

Defining Activity Inputs

Every transaction entering an activity is an input to that activity. Transactions enter an activity in one of three ways:

1. by way of incoming connector lines;
2. by start point (either a generator is assigned to a start point name, or a parent process sends transactions to an activity with the start point name in the child process);
3. or by generating transactions using the current shape.

Figure A.2. The properties of inputs
Defining Activity Resources Requirements

A resource is labor, equipment, or other assets used at an activity to process a transaction.

At each activity it specify the number, or count, of each resource that is required. For each transaction that enters the activity, these resources are subtracted from the total number of available resources for as long as the transaction uses them. The count can be an expression.

iGrafx 2006 includes a predefined labor resource type called Worker. By default, every activity in a process is assigned the Worker resource. Therefore, your model automatically has one worker resource defined. If an activity needs additional types of resources, you must first define the resource and then assign it to the activity. You define resources using the Define Resources dialog box available by clicking Resources on the Model menu.

Figure A.3. The window of resource activities
Defining Tasks

Task data describes how an activity processes transactions. You define task data using the Task page in the Properties dialog box.

Defining Activity Outputs

Activity outputs are concerned with the output path, which is a directed connector line which a transaction follows when leaving an activity. An output path usually leads to another activity at which point it becomes an input path and the transaction becomes an input to the new activity.

Process Mapping, Modeling, and Simulation

The mapping, modeling, and simulation features of iGrafx 2006 let us draw a process diagram, create a process model, define one or more simulation scenarios, simulate the process, and then review the process results in a simulation report.

Five Step Process to Simulation Analysis

The methodology covered in this chapter consists of the following five steps:

1. Identifying Goals
2. Gathering Data
3. Building a Model
4. Performing Simulation (What If?) Analysis
5. Presenting Results

Figure A.5. Process modeling and simulation

The Modeling and Simulation Environment

The interface to the iGrafx 2006 mapping, modeling, and simulation facilities is through three main windows:

- The Process window
- The Scenario window
- The Report window
The relationship between these three windows is shown in the following diagram:

![Diagram showing the relationship between Process, Scenario, and Report windows]

Figure A.6. The relationship between each window of iGrafx program

When you run a simulation, iGrafx 2006 takes as input, the information you define through the Process and Scenario windows, executes a simulation and displays the results in the Report window.

![Image of the Process and Scenario windows]

![Image of the Report window]

Figure A.7. All windows of iGrafx program

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Executing the Simulation and Analyzing Results in the Report

It can execute and trace simulations using the Model toolbar and the Model menu.

Executing a Simulation

On the Model toolbar, click the Start/Resume tool, or on the Model menu, point to Run, and then click Start.

Entering Trace Mode

It can trace a simulation by first entering Trace mode, and then running the simulation. On the Model toolbar, click the Trace tool, or on the Model menu, point to Run, and then click Trace. After entering Trace mode, click Trace Colors on the Control menu to show the meanings of the colors used for the simulation run. After the simulation is complete, a Report is presented for review.

Figure A.8. The window of reports
APPENDIX B

SCENARIO INFORMATION OF CURRENT PROCESSES
Run Setup

Create: Report1

Simulation Time: Calendar - Standard
Simulation Start Time: "Nd/A": 8:00
Simulation End: Transactions Complete
Warmup Time: None

Hours/Day: 24
Days/Week: 7
Sequence: 1
Active Limit: 5000

Generators

Process1
Generator1 - Active
Start
Generator Type: Interarrival
Schedule: Always
Start: Simulation Start
End: Simulation End
Initial Count: 1
Subsequent Count: 1
Max: 6
Interarrival: BetweenNorm(25,30) Minutes
Spread: All at Start

Resources

Worker (Labor)
Customer
Count: 1
Schedule: Default

Customer Service
Count: 6
Schedule: Default
Hourly Rate: R83.33
Hourly O/T Rate: R125.00
Max O/T Hours per Day: 3

FG Warehouse
Count: 4
Schedule: Default
Hourly Rate: R37.50
Hourly O/T Rate: R125.00
Max O/T Hours per Day: 3

Finance
Count: 2
Schedule: Default
Hourly Rate: R83.33
Hourly O/T Rate: R125.00
Max O/T Hours per Day: 3

Freight Forwarder Agent
Count: 1
Schedule: Default

Sale
Count: 1
Schedule: Default
Hourly Rate: R83.33
Hourly O/T Rate: R125.00
Max O/T Hours per Day: 3

-1 Calendars
APPENDIX C

SCENARIO INFORMATION OF NEW PROCESS DESIGN
Run Setup

Create: Report1

Simulation Time: Calendar - Standard
Simulation Start Time: 8:00
Simulation End: Transactions Complete
Warmup Time: None

Hours/Day: 24
Days/Week: 7
Sequence: 1

Active Limit: 5000

Generators

Process1
Generator - Active
Start
Generator Type: Interarrival
Schedule: Always
Start: Simulation Start
End: Simulation End
Initial Count: 1
Subsequent Count: 1
Max: 6
Interarrival: BetweenNorm(25,30) Minutes
Spread: All at Start

Resources
Worker (Labor)
Customer Count: 1
Schedule: Default
Customer Service Count: 2
Schedule: Default
Hourly Rate: 683.33
Hourly O/T Rate: $125.00
Max O/T Hours per Day: 3

FG Warehouse Count: 4
Schedule: Default
Hourly Rate: 637.50
Hourly O/T Rate: $656.25
Max O/T Hours per Day: 3

Finance Count: 0
Schedule: Default
Hourly Rate: 683.33
Hourly O/T Rate: $125.00
Max O/T Hours per Day: 3

Freight Forwarder Agent Count: 1
Schedule: Default

Sale Count: 1
Schedule: Default

- 1 Calendars
BIBLIOGRAPHY


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