OPTIMIZING CONTAINER UTILIZATION

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ABSTRACT

With the continuing globalization of the economy, the volume of container shipments by sea has significantly increased. A key concern in the transportation industry is to design efficient and effective loading schemes for maximizing container space utilization, thereby reducing the container shipment volume, and saving logistics costs and delivery time. Therefore this research seeks to find a method for an optimal number of cartons, and for arranging a loading plan. to achieve container space utilization by introducing optimization computer software.

This is a case study of an export company in Thailand. Solving the company's problems reduces transportation cost and reduces order cycle time by applying logistics and supply chain strategies such as eliminating waste time in the process, and improving supply chain collaboration to increase effectiveness and efficiency by all the parties concerned. This will also enhance customer satisfaction and enable the company to become more competitive in the market.

INTRODUCTION

International trade markets have been changing rapidly, and as a result many factors have affected Thailand's export sector. According to research by the University of the Thai Chamber of Commerce, it was expected that the Thai export value in 2008 would be US$161,169 millions, equivalent to 10.37% growth. Vietnam, China and India offer commodities at lower prices to the world markets, and have become strong competitors of Thai exporters (www.thannews.th.com, 2008). These reasons affect the higher total expenses of Thai exporters, and directly impact on competitiveness.

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In international trade, ocean transportation is the most important channel and most frequently used when compared with other modes of transportation due to water being one of the least expensive carriers of bulk commodities over long distances and in substantial volume (Coyle et al., 2003). Containerization has gained notable acceptance in international distribution because it saves transportation costs, yet has increased accessibility via connections with other modes and reduced risk of loss and damage. Some firms containerizing their shipments to foreign markets have reduced costs by 10-20% and have increased the service level they provide to these markets (Coyle et al., 2003). A key concern in the container transportation industry is to design efficient and effective loading schemes for maximizing the container space utilization, thereby reducing the container shipment volume and saving logistics costs (Zhou-jing and Kevin, 2007). Normally calculation of cartons volumes and a loading plan for a container depend on the operator's experience. Optimum loading solutions are often not achieved. To arrange effective and efficient container loading is a complex problem, and it may be difficult to rely only on the operator's experience to achieve good utilization of space, which will affect the company cost and profit. In order to maximize space utilization, highly sophisticated optimization techniques are required. (Chua et al., 1998).

Container loading is the core of many problems in distribution and logistics. Therefore this research will seek to find a method for an optimized number of cartons and loading plan, to achieve container space utilization, by introducing optimization computer software. The expected benefits should be minimized wasted space, reduced transportation cost per unit, reduced wasted time, and increased company efficiency to become more competitive.

Background of the project. This project uses information from a case study of an export trading company which is a small-medium enterprise (SME) in Thailand. It has been growing steadily in foreign trade as an intermediary without having its own plant or products. Its major functions are to find required products from domestic manufacturers, consolidate the shipment, and export these products to various destinations such as Dominican Republic, USA, and Taiwan. The company's main products are the export of motorcycle spare parts, canned foods, canned coconut milk, herbs, and other products, depending on each customer's enquiry. The value-added activities that the company provides to customers include trade negotiation, product sourcing, consolidating the shipment, sending specification and sample, quotation, export arrangement including documents, transportation, and foreign government requirements. The company's profit comes from commissions as a percentage of each product's value. That mean that the more sales volumes increase, the more profits increase.

The company transports products in containers by sea, usually on full container load (FCL) terms. The sizes of containers used are subject to the requirement of customers such as 20', 40' or 40' Hi-cube. Normally the Company calculates the volume and weight of products to fully fill the container, and designs loading plans by manual calculation and space planning using decisions based on staff experience. The company has no problem in loading standard size packages to the container, such as canned coconut milk. However, motorcycle spare part products are of different packaging sizes which makes it difficult to use container space to full capacity. The Company's problems can be listed as follows:

Unutilized container space

There are no standards of packages, or space planning of the container, because motor cycle spare parts consist of more than 1,000 types from many manufacturers, differing in volume and weight, and are packed in boxes of different sizes. The more box size variety then the more difficult it is for staff to arrange all cartons in the container. Normally customer orders in each shipment are not the same. So space planning cannot be standardised. Staff have to recalculate space for cartons in the container, shipment by shipment.

The products plan for loading a container is calculated manually by using Excel spreadsheet, which can calculate roughly the volume and weight of container restrictions without a load plan. It often causes space underutilization (volumes of total cartons are less than the volume of the container) and the actual loading of cartons into a containers relies on trial and error based on staff experience and their common sense. So, the capacity of the container is usually assumed to be 84-87% of the actual capacity, as shown in the Table below:

Table: Used container space of motor cycle spare parts shipments in 2007

Shipment	CB.M	% Volume utilization
1	64.20	85.17%
2	63.92	84.80%
3	65.01	86.24%
4	65.08	86.34%
5	64.94	86.15%
6	63.83	84.68%

*full capacity of 40'HQ is 75.38 CBM.

Increased transportation cost

Maximized container space utilization in each shipment is at the heart of the company's transportation. For instance, when the customer's order has been completed and is ready for loading but the whole lot cannot be put into a container, the company has to try loading again, repackaging from the wrongly estimated quantity or leaving the surplus for the next shipment, which causes delay and excessive time. This causes increased transportation costs such as labor cost and container loading yard cost. In addition to this causing an idle money cycle, it also risks damage to the products from loading-unloading and short shipment when it cannot fulfill the order as the customer requires. On the contrary, the ordered quantities are not enough to fully fill the container, and to deliver empty space is a waste. Freight cost over a long distance to deliver wasted container space increases the transportation cost. Furthermore, the company has to employ more staff to expedite loading, or pay more rental to a container loading yard to finish the loading.

Long total order cycle time

Most customers' orders are make-to-order products. The time the company takes to send the procurement to suppliers, wait for their production and for the company to deliver the finished products to a customer, is longer than the time the customer is prepared to wait. Normally the total customer order cycle time for a motor cycle spare parts shipment is about three to four months, which is too long. This long customer order cycle time is a cost to the company and reveals a slow response which makes customers unsatisfied and affects the business through lost sales.

Research objectives

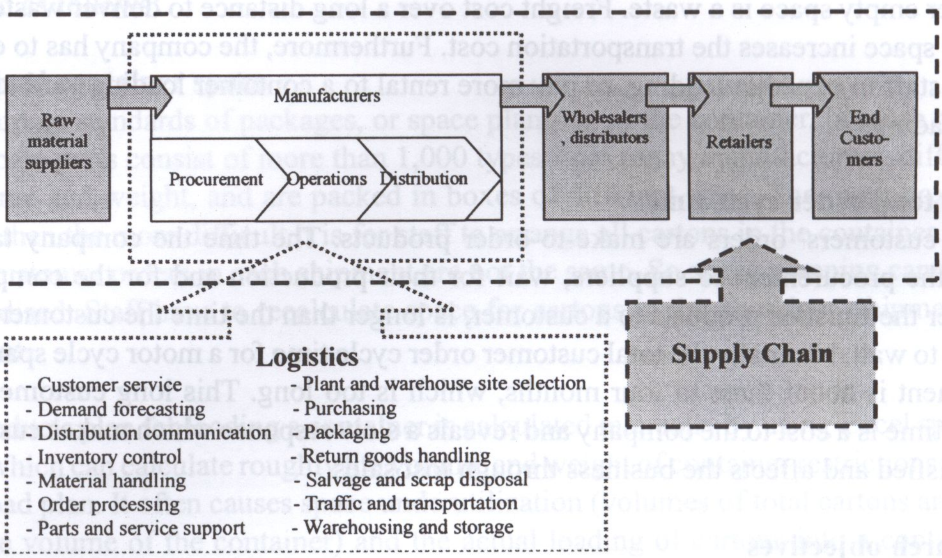
The main objectives of this projects are to optimize container space utilization, to reduce transportation cost, and to reduce total order cycle time. To achieve these, many applications are required: to introduce and apply optimization computer software decision support systems to solve container loading problems; to apply logistics and supply chain strategy; to improve supply chain collaboration.

The Company expects to be able to solve container loading problems by using the application of optimization computer software for calculating carton volumes and loading plans. By this method, the company can increase loading volume to utilize the container. It will also apply logistics and supply chain management strategy to save transportation costs by cutting unnecessary expenses and reducing the loading time for stuffing the product into a container, and produce a quick response to customers' requirements. In addition, it will promote all parties in the supply chain to increase opportunities for manufacturer's sale volumes, and customers will gain benefits from reduced freight cost per unit, get the right goods and services at the right place, at the right time, and in the desired condition, while making the greatest contribution to the firm. Also, it can introduce the use of optimization computer software to other interested companies.

LITERATURE REVIEW

Logistics is only part of the supply chain as the Figure below showns.

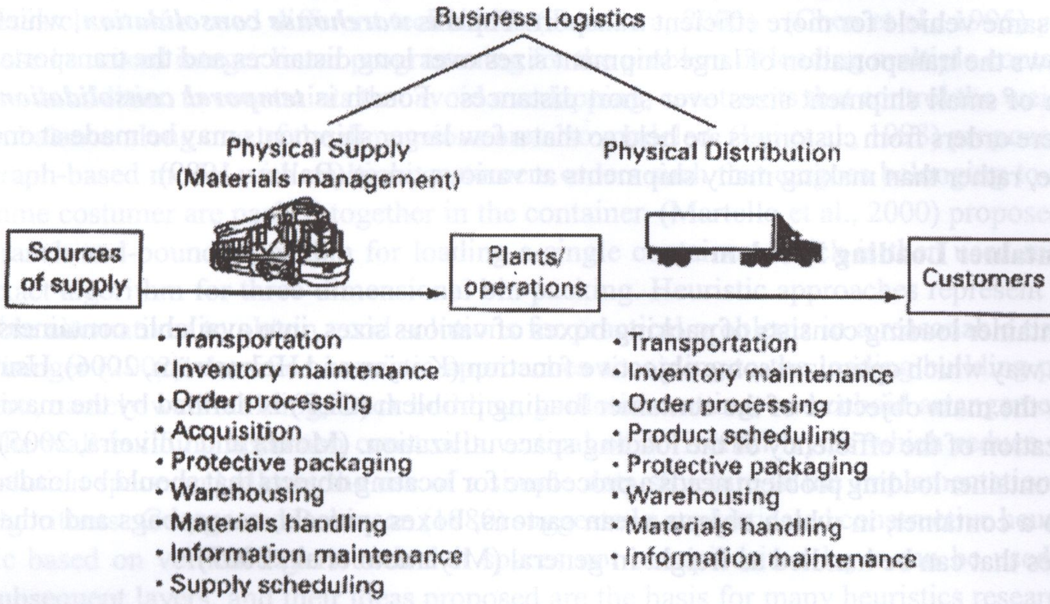
Logistics and Supply Chain



Source: *Thai National Shippers' Council, 2004*

A single firm is not generally able to control its entire product flow channel from raw material source to points of final consumption, although this is an emerging opportunity. So the business logistics for the individual firm has a narrower scope, and the maximal managerial control that can be expected is over the immediate physical supply and physical distribution channels. The next Figure summarises this:

Logistics Activities in a Firm's Immediate Supply Chain



Source: (Ballou, 1999)

Some Factors Influencing Transportation Costs/Pricing

Lambert and Stock (1993) grouped factors influencing transportation costs/pricing into two major categories: product-related and market-related. In Product-Related the significant factors are density, stowability, ease or difficulty of handling and liability. Low-**density** products those with low weight-to-volume ratios (such as clothing, toys) tend to cost more to transport, on a per-pound (kilo) basis than high-density products (such as steel or canned food). ***Stowability*** is the degree to which a product can fill the available space in a transport vehicle. Grain in bulk has excellent stowability because it can completely fill a container, while items such as automobiles have poor stowability. Related to stowability is the ***ease or difficulty of handling the product***. Items that are not easily handled are more costly to transport. Regarding ***liability***, this refers to products with high value-to-weight ratios, those that are easily damaged, and those are subject to higher rates of theft or pilferage and cost more to transport.

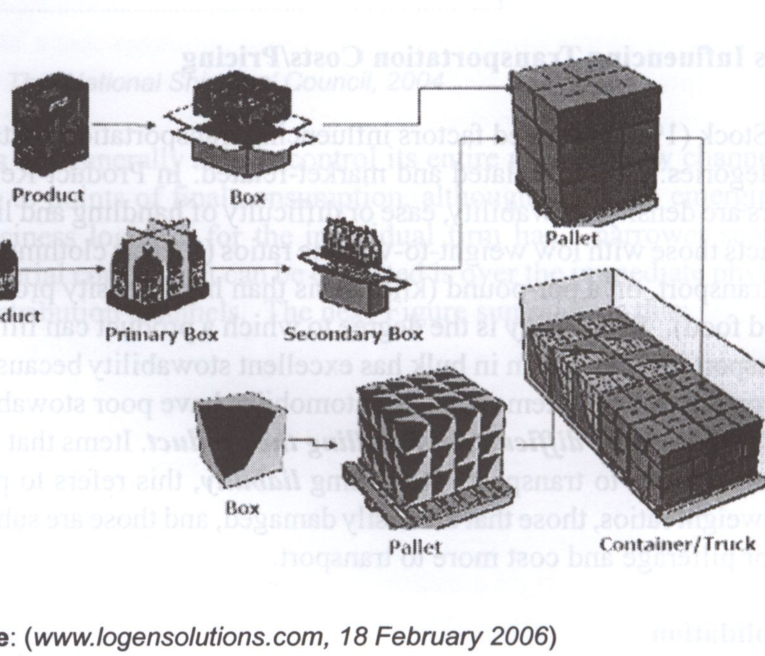
Freight consolidation

Reduced rates for large shipment sizes encourage shipment in large quantities. Consolidating small shipments into large ones is the primary way to achieve this. Consolidation is usually achieved in four ways. First is ***inventory consolidation***. An inventory of items is created from: this allows large and even full vehicle load shipments to be made into the inventory. Second is ***vehicle consolidation***. Where pickups and deliveries involve less than vehicle-load quantities, more than one pickup or delivery is placed on the same vehicle for more efficient transport. Third is ***warehouse consolidation***, which allows the transportation of large shipment sizes over long distances and the transportation of small shipment sizes over short distances. Fourth is ***temporal consolidation***, where orders from customers are held so that a few larger shipments may be made at one time, rather than making many shipments at various times (Ballou, 1999).

Container Loading Problem

Container loading consists of packing boxes of various sizes, into available containers, in a way which optimizes some objective function (Kocjan and Holmström, 2006). Usually the main objective of the container loading problem (CLP) is defined by the maximization of the efficiency of the loading space utilization. (Moura and Oliveira, 2005). A container loading problem needs a procedure for locating objects that should be loaded into a container, in which objects mean cartons, boxes, parcels, cases, bags and other types that can be handled as freight in general (Miyamoto et al., 2007).

Conceptual view of packing and loading



Source: (*www.logensolutions.com, 18 February 2006*)

Review of existing research

Container loading problems are important and have been investigated by a number of researchers who used different techniques (Takahara, 2006). (Chen et al., 1995) proposed a mixed integer linear programming for the problem of loading multiple containers. In addition to constraints that avoid overlapping, constraints that control the weight imbalance along one of the dimensions are also modeled. (Lai et al., 1998) proposed a graph-based model with multiple costumers orders such that cargoes belonging to the same costumer are packed together in the container. (Martello et al., 2000) proposed a branch-and-bound algorithm for loading a single container, which is then used in an exact algorithm for three-dimensional bin packing. Heuristic approaches represent viable alternatives to obtain good solutions for practical problems in a reasonable time. Pisinger (2002) classified heuristic approaches according to the loading building pattern, namely wall building, stack building, guillotine cutting, and cuboid arrangement. The wall building approach constructs vertical or horizontal layers which reduce the solution space and allows the use of a simple data structure in the implementation of algorithms. George and Robinson (1980) suggested a sophisticated constructive heuristic based on vertical layers such that spaces not occupied in a layer can be used in subsequent layers, and their ideas proposed are the basis for many heuristics researchers.

The stack building approach allows the decomposition of the original problem into two sub-problems: the three-dimensional problem of packing the boxes into suitable stacks and the two dimensional problem of locating the stacks on the floor of the container (Haessler and Talbot, 1990). Morabito and Arenales, (1994) proposed a heuristic which makes use of guillotine cuts as a strategy to obtain competitive results compared to non-guillotine cuts. In the cuboid arrangement, the container is filled by homogeneous blocks made up of boxes of the same type and with identical orientation (Bortfeldt and Gehring, (2003).

Optimization computer software

Container loading problems are complex. Providing technological assistance in the form of computers or other equipment to service company personnel can make improvements (Wisner et al., 2005). Optimization software calculates optimum solutions (least cost/best packing/highest profit). Some companies try to develop computer software to optimize container utilization. *AutoLoadPro* is an automatic 3D Palletizing and Loading optimization software solution. *MaxLoad®Pro* is a cargo load planning, container loading, freight calculation and cube optimization software. *CubeMaster* is a cost-effective cargo load planning software to optimize the load on trucks, air & sea containers, pallets and totes. It reduces shipping and transport costs through intelligent loading and optimal space utilization (www.logensolutions.com, 19 February2008). *Cargo Optimizer* is optimization software in Thailand for Exporters/ Importers, packaging, manufacturers and logistics which handle regularly shaped containers such as ocean containers, trucks and refrigerated units. It offers several advanced options such as loading by sequence, loading by FILO (First In Last Out), multiple container sizes per shipment (no limit), multiple package sizes per shipment (no limit), manual optimization over-ride, calculate costing and cost per package being shipped (www.cargooptimizer.com, 19, February 2008).

METHODOLOGY

Information was collected from January to May 2008 of motorcycle spare parts products of the company. The information consisted of the container database (dimensions), data on shipments of motorcycle spare parts, financial database of transport costs, and a cartons database.

Finding and Selecting Alternative Solutions

To optimize container utilization. The company is seeking a cost saving solution for solutions within a reasonable amount of computational time. Hence optimization computer software is used as a tool in this study. The price of computer software can be very high, because most software is imported from abroad which causes the entrepreneurs to bear an increased cost. So, local optimization software "*Cargo Optimizer 4.27*" was selected. The results of this software are not the best but they are acceptable.

To reduce transportation cost. The company is seeking ways to drive down transportation costs by improving operating strategies for transport optimization. This strategy consists of three components: people, process, and technology. For process, operating strategies such as optimal product mix to maximize capacity utilization, change in transport items to better fill up the vehicles, and consolidation to improve capacity utilization. For technology, the company applies optimization computer software for support in efficient loading. For people, assign a number of suitable staffs to job and staff development.

To reduce order cycle time. Managing order cycle time is a fundamental activity with a direct bearing on competitive advantage. A number of causes of long process cycle times can be found in a supply chain environment. Typically one or more of the following causes will be present: *Waiting, Non-value-added-activities, Serial versus Parallel Operations, Repeating Process Activities, Batching, and Lack of Synchronization in Materials Movement.*

Implementation and evaluation

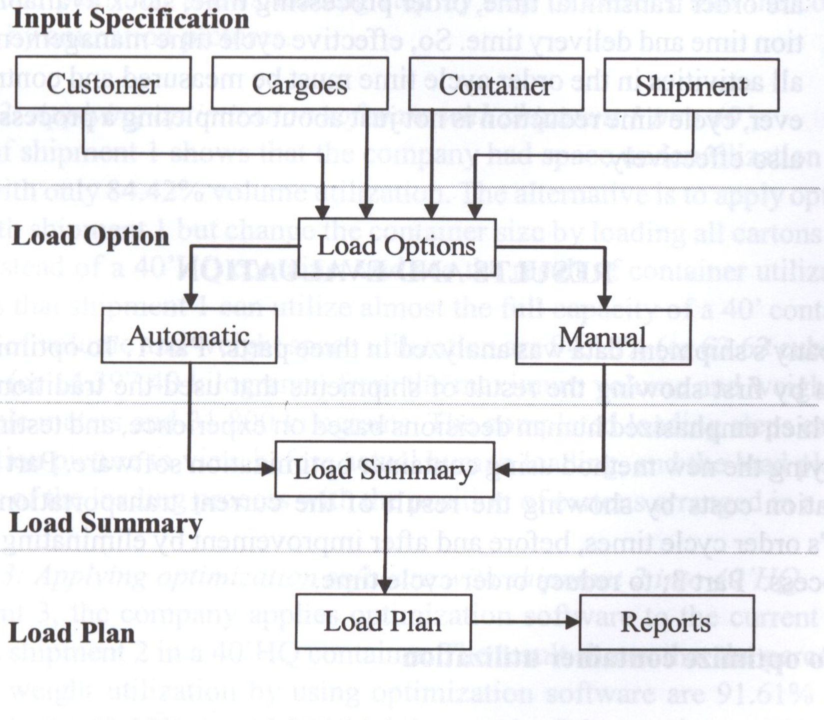
The company tested the selected solution using past data and implemented it in the current shipment to utilize container space by comparison of performance with manual calculations. It used Excel spreadsheet and optimization computer software (‘*cargo optimizer 4.27*’) with the company data. The testing of the new solution with experiments for utilizing container space, were as follows:

Experiment 1: Applying optimization software with shipment 1 into 40’HQ
Experiment 2: Applying optimization software with shipment 1 into 40’
Experiment 3: Applying optimization software with shipment 2 into 40’HQ

Calculation steps of manual calculation using Excel spreadsheet:

1) Prepare product list and packing dimensions
2) Identify the container size for loading
3) Add product list to full container load. Stop adding more items when those reach the number of volume or weight constraints of the container
4) Arrange the product into the container based on staff experience

Calculation steps of loading flow of *Cargo optimizer 4.27*



For implementation of reducing transportation cost and order cycle time, the company compared improvement results with the original data. It then analyzed and evaluated the result, before and after applying the selected solution, in terms of cost and time.

Improvement Indicators. To prove validity after implementation, that the selected solutions are workable, the company has key improvement indicators to analyze the result, as follows:

1) *Volume utilization.* The efficiency of container packing can be measured in the percentage of volume utilization (Thapatsuwan et al., 2007). The formula for calculating volume utilization is below.

$$\text{Volume utilization} = \frac{\text{Volume of boxes packed}}{\text{Container volume}} \times 100\%$$

2) *Transportation cost per unit.* Using the company's financial data, especially transportation costs which directly affect container utilization of the company, can show the changed cost resulting from applying the new method. Transportation benefits are often measured in terms of reduced transportation cost. It can help to measure the performance of efficient loading, so that the more the volume increases the more transportation cost per unit will decrease.
3) *Order cycle time.* It can be viewed as the accumulation of time, as an order passes through each step in the order cycle. The order cycle time elements are order transmittal time, order processing time, stock availability, production time and delivery time. So, effective cycle time management means that all activities in the order cycle time must be measured and controlled. However, cycle time reduction is not just about completing a process quickly, but also effectively.

RESULTS AND EVALUATION

The company's shipment data was analyzed in three parts. Part 1: To optimize container utilization by first showing the result of shipments that used the traditional operating method which emphasized human decisions based on experience, and testing the results after applying the new method using container optimization software. Part 2: To reduce transportation costs by showing the result of the current transportation cost of the company's order cycle times, before and after improvement by eliminating wasted time in the process. Part 3; to reduce order cycle time.

Part 1: To optimize container utilization

The data used was motorcycle spare parts of shipment 1 which the Company had al-ready shipped as Full container load (FCL) in a 40' High cube container to one overseas customer. The company used traditional manual calculations by Excel spreadsheet to calculate optimizing container utilization of shipment 1. The calculation method continues by adding products from the customer inquiry until it reaches the volume or weight capacity of the container. The result shows that the company could not utilize the 40'HQ container because shipment 1 used volume utilization of only 63.63 cubic meters or 84.42%, and weight utilization of only 14,397 kilograms or 45.88%, while the volume and weight capacity of 40'HQ container was 75.38 cubic meters and 31,380.00 kilograms. This result always occurred in past motorcycle spare part shipments. Hence, the company selected optimization software *'cargo optimizer 4.27'*, as a tool to solve the problem. The experiments tested the company shipments and showed alternative solution.

Experiment1: Applying optimization software with shipment 1 into 40'HQ
The calculation method starts with inputting the customer, cargo, and container database of shipment 1. The result shows underutilization of shipment 1 in both volume and weight capacity, which are 63.63 cubic metres or 84.42% and 14,397 kilograms or 45.88%. Next, the load option is selected by automatic calculation. Then the load summary shows load statistics as amounts of used container space, and the number of loaded and left cartons. This shows the arranged result, that 100% was loaded which means all 2,236 cartons of shipment 1 can be loaded into a 40' High cube container. The software also has a load plan that shows loading step by step of cartons into the container of shipment 1, by animation pictures.

Experiment2: Applying optimization software with shipment 1 into 40'
The result of shipment 1 shows that the company had space underutilization in 40'HQ container, with only 84.42% volume utilization. The alternative is to apply optimization software with shipment 1 but change the container size by loading all cartons into a 40' container instead of a 40'HQ container and see the result of container utilization. The result shows that shipment 1 can utilize almost the full capacity of a 40' container. The percentages of volume and weight space utilization are 94.18% (or 63.63 cubic meters) and 45.27% (or 14.397.40 kilograms) from the maximum volume and weight capacity of 67.57 cubic meters and 31,800 kilograms. The completed loading steps can be seen in an animation picture to view before actual human loading, and the load plan reports show results of the loading process with the position of cartons arranged in a container.

Experiment 3: Applying optimization software with shipment 2 into 40'HQ
In experiment 3, the company applies optimization software to the current customer order, that is shipment 2 in a 40'HQ container. The result shows that the percentages of volume and weight utilization by using optimization software are 91.61% (or 96.06 cubic meters) and 63.68% (or 19,984.10 kilograms) of the maximum 40' high cube

capacity. It has increased, because past manual calculations of the company assumed only 84%-87% of capacity before the actual loading decision. After automatic calculation, the arranged result of load summary shows unloaded cartons as zero, which means all products, amounting to 55,900 pieces in 2,424 cartons, can be loaded into a 40' high cube container.

Part 2: To reduce transportation cost

The company improves its operating strategies for transport optimization in people, process and technology, and gains benefit from applying optimization software. Total transportation cost of shipment 1 represents traditional operation, and shipment 2 shows the resulting total transportation cost after the improvement.

According to the traditional operation, the result shows increased total transportation cost of shipment 1, resulting from unutilized container loading problem. The company's staffs wasted time in trial loading and unloading all products into the container for two days. The reasons are that each motorcycle spare parts shipment contains a variety of products and different sizes of packaging, and is difficult to load. There is no fixed loading plan to guide staffs arranging cartons into the container. Staff skills in loading are based on their own experience, which is time-consuming. The company has to use many staffs for one shipment. At present there is one supervisor to check the number of cartons and control staffs and, five staffs for actual loading. This affects the company by increasing total transportation expenses to 23,425 baht per shipment. Main transportation costs comes from variable cost of rent for a loading yard for two days (which is 2,000 baht) and the labor cost is 7,000 baht.

Shipment 2 used optimization computer software to help in arranging cartons into a container. The company staffs load cartons by following the automatic load plan report. It can reduce loading time from two days to only one day. Besides minimized loading time, this also reduces transportation costs. The company can reduce its rental of a loading yard by one day, to 1,000 baht. It can reduce labor costs by 3,000 baht: for the supervisor by 1,000 per day; the number of loading staffs reduces from five persons to four persons, which saves 500 baht per day. So, the total transportation cost of one day's loading is only 18,425 baht per shipment.

Part 3: To reduce order cycle time

The customer order cycle of shipment 1 contains all the time-related events that make up the total time required for a customer to receive an order. The order cycle time elements are: order transmittal time, order processing time, stock availability, production time, and delivery time. For shipment 1 the order transmittal time begins with the customer sending inquiries by email or fax to the company. The process is then as shown in the next Figure.

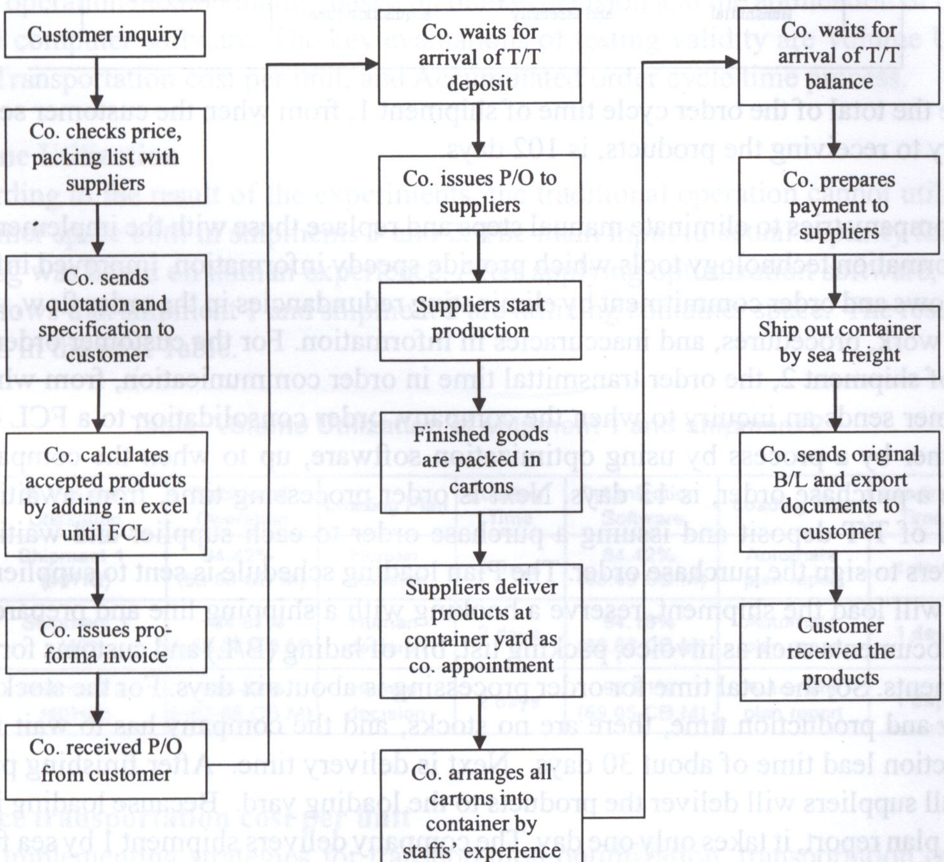
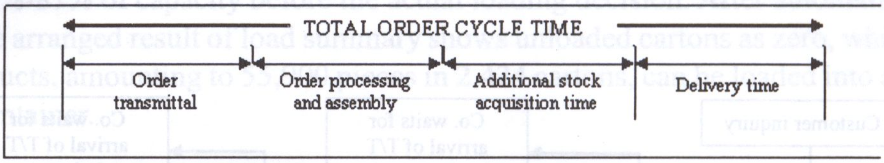


Figure: The customer order process flow of shipment 1

The total order time to consolidate an order from a customer takes about 18 days. Total time for order processing is about seven days. For stock availability and production time, normally customer products are made to order (MTO). Manufacturers do not keep stock, so the company has to wait for production processes with a lead time of about 30 to 45 days. On loading day, the staffs have to use their own experiences in trial loading all the finished products into the container. Because loading is without a plan, it takes two days. The mode of transportation for shipment 1 is sea freight, and the transport lead time from port of origin to customer destination take about 45 days. Total delivery time is about 47 days. The total customer order cycle time of shipment 1 is shown in the next Figure.

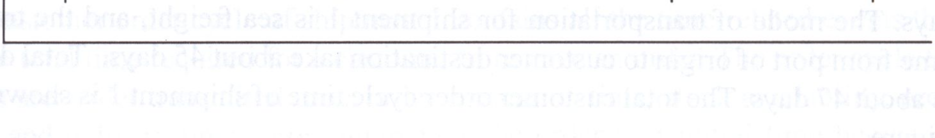
Figure: Customer order cycle time of shipment 1



Hence the total of the order cycle time of shipment 1, from when the customer sends an inquiry to receiving the products, is 102 days.

The company tries to eliminate manual steps and replace these with the implementation of information technology tools which provide speedy information, improved information flows and order commitment by eliminating redundancies in the order flow, useless paper work, procedures, and inaccuracies in information. For the customer order cycle time of shipment 2, the order transmittal time in order communication, from when the customer sends an inquiry to when the company, order consolidation to a FCL 40'HQ container by a process by using optimization software, up to when the company receives a purchase order, is 13 days. Next is order processing time, from awaiting the arrival of T/T deposit and issuing a purchase order to each supplier and waiting for suppliers to sign the purchase order. The Plan loading schedule is sent to suppliers who when will load the shipment, reserve a booking with a shipping line and prepare shipping documents such as invoice, packing list, bill of lading (B/L) and customs formality documents. So, the total time for order processing is about six days. For the stock availability and production time, there are no stocks, and the company has to wait for the production lead time of about 30 days. Next is delivery time. After finishing production, all suppliers will deliver the products to the loading yard. Because loading is with a load plan report, it takes only one day. The company delivers shipment 1 by sea freight, and the transport lead time to customer destination takes about 45 days. After loading, the company will collect the T/T balance from the customer and prepare payment to suppliers. Bill of Lading (B/L) and export documents are also sent to the customer. So, total delivery time is about 46 days. The total customer order cycle time of shipment 2 is 95 days as shown in the next Figure.

Figure: Customer order cycle time of shipment 2



Data Evaluation

This section presents the comparison result of container utilization, between the traditional operation method mainly based on human decision and the application of optimization computer software. The key evaluations of testing validity are Volume Utilization, Transportation cost per unit, and Accumulated order cycle time process.

Volume Utilization

According to the result of the experiments, the traditional operation cannot utilize the container space both in shipments 1 and 2. The main input to actual capacity for cargo loading was based on human experience. After applying optimization software, the result shows that shipment 1 and shipment 2 are utilizing container space. The results are shown in the next Table.

Table: Volume Utilization of shipment 1 and shipment 2

% Volume Utilization	Traditional Operation	Loading Plan	Loading Time	Optimization Software	Loading Plan	Loading Time
Shipment 1 (40'HQ)	84.42% (63.63 CB.M)	Human decision	2 days	84.42% (63.63 CB.M)	Automate plan report	1 day
Shipment 1 (40')	~84-87% (~56-58 CB.M)	Human decision	2 days	94.18% (63.63 CB.M)	Automate plan report	1 day
Shipment 2 (40'HQ)	~84-87% (~63-66 CB.M)	Human decision	2 days	91.61% (69.05 CB.M)	Automate plan report	1 day

Reduce transportation cost per unit

After implementing strategies for transportation optimization, transportation cost per unit decreases from 0.59 baht / unit to 0.33 baht / unit. In addition, shipment 1 took two days to finish loading. After using optimization software, shipment 2 can finish loading within only one day with less loading staffs and rent. The company can save 5,000 baht per shipment. As average orders are 8 to 12 shipments per year, the company can save transportation expenses by from 40,000 baht to 60,000 baht per year.

Order cycle time reduction

The cumulative cycle time of the traditional operation of all sub-processes (which are *order transmittal*, order processing, production time and delivery time) for shipment 1 is 102 days, and after improving the process the total order cycle time of shipment 2 is decreased to 95 days. Implementing optimization software automatically calculates optimal quantities instead of manual calculation, and also shares information so that a customer can participate in consolidating their order. *Prroduction time* does not reduce after improving the process as the customer's order is for make-to-order products, so all this process depends on the supplier's production plan, normally estimated at about 30 days. To reduce this process the company has to carrying inventory or gain earlier warning of requirements through improved visibility of demand. The *delivery time* shows a reduction of one day from the loading activity, with the company being able to eliminate rework from staff experience of trail loading all products into a contain, by replacing that with automatically generated 3D graphics loading plan reports.

Table: Total Customer order cycle time before and after software application

Total Order Cycle Time			
Activities	**Before**	**After**	**Improve**
Order transmittal	18 days	13 days	5 days
Order processing	7 days	6 days	1 day
Production time	30 days	30 days	0 day
Delivery time	47 days	46 days	1 day
Total order cycle	102 days	95 days	7 days

Remark: Time before and after improvement

CONCLUSION AND RECOMMENDATIONS

In the continuing economic globalization, the volume of container shipments has greatly increased. Efficient loading of these containers minimizes empty space inside. Using optimization computer software, the improvement results show that:

1) the company can optimize container utilization by automated calculation of optimal quantities matched to the best container type for utilization of container space.
2) increased loading volume space utilization from 84-87% to more than 90%;
3) increased customer satisfaction by reducing customer complaints about delivery of waste space (container underutilization);
4) shorter order cycle time from 102 days to 95 days by streamlining the processes, reduced process redundancies, improved communications along the supply chain, and improved delivery time such as reducing the loading time from two days manual loading to only one day loading;
5) transportation cost reduction, by reducing variable costs such as labor cost and rental for a container yard which saves transportation cost of 5,000 baht per shipment. For this improvement, the company invested 13,910 baht in information technology optimization software. With an average of 6 to 8 shipments per year, the company can save 30,000 to 40,000 baht per year - a worthwhile investment.

In addition, customers achieve benefits from: 1) reduced freight cost per unit by increased loading volumes; 2) the customer can be assured that orders can be delivered with right quality, quantity at the right time; 3) quick response to customer requirements. Suppliers gain more profit from increased sales opportunities of about 3 to 6% as customer orders increase.

However, there are some limitations to this study. *Cargo optimizer 4.27* is powerful optimization software, but it has limitations. Carton shapes: the stuffing products are not only packed in rectangular shaped cartons but also packed in rolls or irregular shapes such as sacks. Such furniture products and textile products are beyond the scope of the software's function. The software can solve optimizing problems with rectangular cartons loading, but some other businesses may require mixed loading of rectangular and rolls cartons. Also, usually sea freight containers are rectangular in shape. But in other transportation modes, containers may not be rectangular, such as air freight containers that are trapezoid in shape. The software cannot work at present, and has to be further developed.

The result of automatic calculation for optimal quantities and loading plans is an optimized solution which provides a good solution but not the best answer (optimum solution). This software can produce an optimum solution, given rectangular containers of fixed dimensions. These limitations are not problems for the case study Company because all its products are stuffed in rectangular shaped cartons and transported by sea freight containers to overseas customers, but they do affect the generalisability of the research findings.

To achieve mutual benefits and optimization in container utilization, collaboration with all parties is most important. The following recommendations should be adopted by suppliers, the company and customers, to reach the objective.

Recommendation for Suppliers. Motorcycle spare parts have components of more than one thousand pieces: each part has different sizes, and these are packed in various carton types. Some item are packed in unsuitable cartons, sometime cartons are oversized, and some are tightly packed. These are difficult for arranging a loading plan for the container. The company needs suppliers' collaboration to standardize the packaging as much as possible in order to increase loaded volumes and utilize the space more efficiently, such that the same product sizes should be packed in similar size cartons. Suppliers have to send to the company a packing list describing volumes, weight, and number packed in cartons.

There are many suppliers in one shipment who supply small quantities. They are in the same area or on the same route, and should join to deliver in one truck. As the company has to arrange cartons according to the automated loading report, each supplier should deliver cargo on time as scheduled to expedite smooth loading according to the load plan.

Recommendation for the Company. The company acts as the intermediary between foreign buyers and local product suppliers. It should collaborate with key suppliers and service providers. Working together as partners, being open to mutual exchange, sharing information between buyer and suppliers, so that they can anticipate the buyers' needs, and reduce response time and its variability.

Recommendation for Customers. A customer should send its order plan in advance, at least three months, so that suppliers have time to prepare materials and finish production on time. Order cycle time will also reduce. The customer will get a discount from lot-batch buying and a reduction in delayed shipments.

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