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A research of logistics company's warehouse cost reduction and optimization design

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World Maritime University

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Abstract

As we all know, a warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. It is not only a place for goods storage and flow, but also the enterprise's cash flow zone. In today's globalization world, every logistics companies are trying to reduce their cost in every logistics link. And as an important part of the supply chain, warehouse cost reduction is concerned by the enterprisers more and more.

This essay mainly talks about some methods to cut down the logistics cost, which are more focus on the warehousing cost. To find out the possibility of the methods used, some mathematical models will be constructed to calculate the actual cost reduction. Then according to the calculation results, some discussion will be given out, but also many other probably ways to reduce the warehousing cost.

KEYWORDS: Warehouse, Inventory, Labors Efficiency, Logistics Cost, Information Systems, Shelves Utilization, Warehouse Optimization.

Chapter 1 Introduction

1.1 Background

In China, many companies don't pay attention to the warehousing management. And there are some enterprises, they have noticed that they should try to control inventory and speed up the turnover of goods to reduce logistics cost. However, they only know what should do other than how to do the best to improve the situation.

According to statistics, even in developed countries, the circulation cost accounted for 10% of GDP. In China, due to the low level of technology in circulation, low circulation efficiency, and high logistics cost, an annual circulation cost was about 20% of GDP, which got to 1.788 trillion RMB.

Thomas W. Speh said that:" Warehousing is nothing more than the management of space and time." Only when we make full use of the limited space, and enhance the logistics efficiency, the cost would be reduced. And that's our main issue to be considered. Both space and time management are important and they will influence each other.

To improve warehousing efficiency and reduce cost, many experts and professors have already given out different useful ideas. Above all, the most popular used method is controlling inventory. Lowing the inventory means increase inventory turnover, so that the cash turnover is increased. For example, the famous enterprise APPLE and DELL, their inventory operating time are only 6 to 8 days, the corresponding turnover frequency are 61 and 46 times. Controlling inventory will bring more benefit, and more and more western and native companies began to use this method to reduce their warehouse cost.

Another way which can low the time cost is to optimize the warehouse layout. We

can adjust the shelves of the cargo and then scientifically use the information system to arrange the warehouse area and shelves positions. Now many western enterprises are emphasizing enhance labors efficiency, shorten the working time. First, we need to calculate which good is the most frequently flow out. Then according to the result, put the higher rate goods in the nearer position. When the right goods are placed on the right shelf, the workers' efficiency must be higher. And the corporation could hire less labor to do the same work.

Besides above two common ways, many experts have put out other available methods to cut down the warehouse cost. Firstly, we need to determine the utilization of warehouse equipment, and check it often to make sure whether they have been fully used, which makes it possible to reduce storage devices. Secondly, the improvement of inventory software systems is also important. Using the computer system to control materials and logistics can greatly improve the efficiency. But there is one thing must be paid attention to, that is, to strengthen the timeliness of the systems. Thirdly, packaging improved may be a proper solution. Because when goods are stored and turnover, large amounts of waste packaging come out. The enterprises should consider whether to adopt recyclable packaging instead. And for those not recyclable packaging items, they should try to find ways to use. Last but not least, that's performance reporting. There is an old adage of "You can't improve what you don't measure" is certainly true. An effective measurement and reporting process can improve performance and lower costs.

In addition, as long as the enterprises pay attention to warehouses, can they dig out a lot of potential cost reduction. Not only the internal warehouse, but also the external warehousing should be paid attention. If the warehouse can take various cost reduction measures, it will certainly gain economic benefits. At the same time lowering costs at the warehouse, enterprise supply chain will be improved.

1.2 Research Purpose

In 21st Century, efficiency perhaps is the most valuable thing. Obviously, the cost reduction has direct connection with the efficiency enhanced. Currently, the logistics management in all industries is concerned widely. As every link of the supply chain is important and warehouse cost is totally not a small number. It concerns both supply enterprises and logistics companies. Achieving warehouse cost reduction has significantly meanings. This essay mainly focuses on the efficiency improvement to obtain cost reduction. As is suggested above, there are so many ways can be used to enhance warehouse condition. However, without careful survey and calculation, we cannot get to know the practicality of each method, and its actual cost reduction.

As is known to all, the experts have proposed many methods, but mostly are about generalities. And a variety of methods haven't been repeated demonstrated. And there are not many individuals analyzing the relationship between different methods. This essay not only studies the inventory controlling model and shelves allocation method in mathematical models, but also gives out discussion about relationship of different ways. What's more, the essay gives some illustration and analysis about that through reasonable warehousing management would make third-party logistics companies and manufacturing enterprises to achieve win-win state.

1.3 Research Methods

Firstly, according to the experts' literatures, through analyzing the different methods, choosing a common way, we are able to enhance efficiency and reduce cost. That is inventory management and classification. And among all the possible methods, we choose the ABC classification model.

The research of inventory classification and stock position layout are constantly going on by the experts. No the ABC classification is used more and more in both western countries and eastern countries. The main progress is as follows. Above all, input the inventory data to the Excel sheet, and sort out the data based on time (a week, two weeks, a month, out of three weeks, etc). Then input the result to Access, to get the different periods' goods outflow frequency. Generally speaking, we should put the most frequent cargo on the shelf which is nearest to the door. However, to make full use of the shelf and space is also important. Thus, measuring the volume of goods is very necessary. When finishing calculating all the data, we can find out the best way to allocate the shelves to different goods. In addition, setting safe inventory is also needed. We use the computer software to make an information system, that is, once the inventory is lower than the safe inventory, the computer will remind to give replenishment. After all the design is completed, we can do the layout of the new warehouse, choosing a way to move the cargo from old warehouse to the new one. Then arrange the workers to achieve the program.

1.4 Literature Review

(1) Warehouse Management

Many people say that, warehouse management is to move from managing overhead to creating a competitive advantage. Warehouses have a lot of useful functions for both customers and enterprises. For example, with warehouse management, we can track inventory items by bins and containers, designating the items that move in and out of inventory. Also it is possible to prepare pick lists for items that need to be picked for sales orders, transfers, material requisitions and other transaction types and so on (TRAVERSE, 2007).

A warehouse cannot live without information systems. Warehouse management systems often utilize Auto ID Data Capture (AIDC) technology, such as barcode scanners, mobile computers, wireless LANs and potentially Radio-frequency identification (RFID) to efficiently monitor the flow of products. Once data has been collected, there is either a batch synchronization with, or a real-time wireless transmission to a central database. The database can then provide useful reports about the status of goods in the warehouse (Wikipedia).

Thomas W. Speh once said that, warehousing is nothing more than the management of space and time. The space management portion, storage, has a cost per month, because there is a monthly cost for warehouse space. The time management component includes labor involved in handling materials as they move in and out of the warehouse. (Thomas W. Speh, 2009)

From the experts ideas we can see that, warehouse is not only a place for goods storage and flow, but also an important link of the supply chain. It can be seen as the enterprise's cash flow zone.

(2) **Warehousing Cost**

Cutting down warehousing cost is very necessary for both logistics companies and supply enterprises. As is known to everyone, warehousing cost accounts for an important element of supply chain cost, which is 2.09% of sales dollars and 25% of all logistics cost (Tom Speh and Bob Murray, 2009).

Tom Speh and Bob Murray also told us that: Warehousing is frequently outsourced. Both parties must know the costs and agree on which costs to include. Cost is an important floor against which profits are established. In addition, warehousing is often benchmarked, a target for cost improvement or charged to another function. So that, warehousing cost reduction is very important.

How to reduce the warehousing cost gradually became a hot topic in the logistics researchers. And they have put forward their point of view. Mikko Varila, Marko Seppanen and Petri Suomala proposed that cost reduction first needed to increase the visibility of logistics cost. Proper cost control requires sufficiently accurate monitoring of logistics processes. Reaching this level of accuracy will largely depend on the ability of the firm's cost accounting system to trace costs to cost objects (Pohlen and La Londe, 1994). Today's information technology provides a variety of means for replacing manual data collection with automatic applications. Advanced identification methods, e.g. bar codes and RFID, have been important landmarks in a relationship for recording even the smallest phases of the processes (Mikko Varila, Marko Seppanen and Petri Suomala, 2007).

There are some other people perceive that new technologies should be used to enhance the current systems, raise efficiency by improving the management information system. Every warehouse, large and small, performs four basic functions: receiving and put away, picking and packing, shipping and inventory control. Only with a perfect system can it reach the best efficiency. However, now in China, some enterprises' warehousing systems are not timeliness, this is also a serious problem must be solved (Henan Logistics Vol.79, 2009).

(3) **Optimize the Warehouse**

Besides inventory controlling, there are many other solutions to optimize the warehouse working progress, so as to enhance efficiency and reduce cost, for example, goods classification method and shelves allocation method.

Some other experts thought that the ABC and XYZ method was also very good. As Miroljub Kljajic etc. said that, products stored in a warehouse belong to different categories according to ABC and XYZ classification. ABC classification divides

products into three categories according to their value (Silver et al., 1998; Ljubic, 2000), while XYZ classification divides products into three categories according to the dynamics of their consumption. The dynamics of products consumption and products value must be taken into consideration in order to improve the warehousing processes. We believe that there is a lack of optimization technology in use and there are a number of possibilities of how to improve the warehousing processes (Miroljub Kljajic, Davorin Kofjac, etc, 2004).

The ABC model is useful in warehouse management, and there is a similar method to ABC model that is also used widely. We can use the data of outflow of products, and then divide the goods according to their flow frequency. This method will be discussed carefully in the essay. Apart from the above, there are a lot of other available and simple ways can be used. Just like packaging changing and using recyclable packaging to save warehouse space, determining the utilization of warehouse equipment and checking often to make sure whether they have been fully used, developing new and intelligent information system to remind products replenish, etc (Henan Logistics Vol.79, 2009).

Chapter 2 Methods of reducing warehousing cost

2.1 Introduction of warehouse management

Warehouse management is to meet the needs of the whole supply chain, which makes full use of modern technology to manage the inventory, sorting, package, distribution, in and out of goods in certain tangible or intangible place.

Through this concept we can see that, warehouse management have 5 basic meanings as follows:

1. Warehouse management is one form of logistics activities. In other words, logistics activity is essential attribute of a warehouse. It is not a kind of manufacture or trade, but a part of logistics activity for production and trade. And it must be linked and coordinated with other logistics processes.

2. Warehouse activities consist of the turnover, inventory, sorting, package, distribution, information processing of goods and so on. Among these aspects, the turnover and inventory management are the most important and fundamental. As the improving of warehouse management, nowadays, the sorting and package of goods are more accurate and precise than before. In addition, many of the management practices combine the turnover and inventory management together. What's more, why we consider "distribution" as one of the warehouse activities is that distribution is not a kind of transport generally, but the natural extension of the warehouse management. It has an inherent requirement that the warehouse should become a distribution centre. Last but not least, warehouse cannot live without information processing as information can be commonly found in today's economic activities. Modern warehouse management needs the help of information service and systems.

3. As we all know, the purpose of warehouse management is to meet the needs of the supply chain. In the past, people though that warehouse management was just to meet the demand of customers. However, customers do not equal to the final buyers. Customers could be manufacturers, retailers, and even the internal of the enterprise. Warehouse management should not only meet the needs of direct customers, but also meet the needs of indirect customers, then make the service into the entire supply chain.

4. A warehouse requires certain tangible or intangible places and technologies. As enterprise's supply chain is specific, of course, the place of storage is a particular

place. Moreover, in the modern economic society, in order to make warehouse management occur in both tangible and tangible places, obviously we need the technology support.

5. The level of warehouse management shows in effective planning, running and controlling. As modern management comprises planning, organizing, staffing, leading and directing.

The target of warehouse management is using the most appropriate cost to make service reach the greatest customer satisfaction. To achieve this target, careful planning and strategic means should be used in both forward and reverse of logistics progress. As the work of warehouse is expanding continuously, the function of a warehouse is not only the goods storage. It includes the factors as follows:

Table 1: Contents of Warehouse Management

Basic Contents	Specific Performance
1) Problems of warehouse site selection and construction	The principal of warehouse site selection, the determination of warehouse construction area, transport bank road in the warehouse and the arrangement of working areas.
2) Problems of warehouse machinery operation choosing and configuration-related	How to choose machines and equipments according to the features of warehouse working and types of storage goods; and how to manage the machines and equipments.
3) Warehouse business management and running issues	How to organize the goods in and out of warehouse; how to store and protect the goods in the warehouse; how to sort, order, flow and process the materials in the warehouse.

4) Inventory management issues in the warehouse	Methods of inventory management.
5) Other problems, for example, business appraisal, new technology applications in warehouse management, warehouse safety and fire prevention and so on.	The assessment standard and methods of warehouse business; the promotion, training and utilization of warehouse business; the specific requirements and operating of warehouse safety and fire control and so on.

Modern warehouse management has 7 main tasks: the first of all is to utilize market economy to make the most perfect warehouse resources configuration. Second, warehouse management needs to have the highest efficient administrative organization. Third, the commercial activities of a warehouse should be for the customers' requirements. Fourth, warehouse must have the principle that manufacture with high efficiency and low cost. Fifth is to make full use of scientific and advanced methods so as to make management better. Sixth, quality of the staff has very important significance. The quality of staff determines the quality of service. Seventh, we should provide excellent service and be honest to establish a good impression to the customers.

All in all, the ultimate purpose of warehouse management is to achieve the optimization and rationalization of the warehouse, which is to help the enterprise offer better service. In order to make this target come true, we need to do systematic planning and designing to the warehouse. There are many factors that influence warehouse optimization such as actual condition of the site, nature and scale of the warehouse, features of items in store, and its technology conditions. Only when doing the planning and designing with consideration of all the elements, can we make maximum use of the storage and operation capacity of the warehouse. At the same time the operating costs would be cut down, that is to let warehouse play a more important role in the logistics process.

2.2 Methods that reduce logistics cost of the warehouses

Many scholars and experts are considering that, how to optimize the warehouse and how to minimized the warehouse costs? For the enterprises, there are a lot of ways to cut down the cost and expenses during the warehouse running. And they are as follows:

1. Inventory controlling. This method is mainly for the warehouses of production companies. Because decreasing inventory means to increase the inventory turnover, which also increases the cash flow. This has significant effect to the running of enterprises. As is known to all, in the 21st Century market is changing constantly. The inventory strategies of the warehouse must response and be adjusted quickly. First of all, we should make an inventory of the goods in storage, and we are able to know the actual stock clearly. Next, safety stock quantity could be adjusted according to actual inventory and demand. Of course, the transport frequency is increased obviously. Besides, purchase amount should also be adjusted. Every week we need to do some analysis and predict to the market orders. After complete the analysis can we decide the inventory, safety stock and purchase amount. Generally speaking, the best way is keeping appropriate inventory to cut down purchasing fund and accelerate the capital turnover.

2. Inventory and report every day to let the enterprise know the real and credible inventory data. Only when knowing the real data, the decision-makers of the enterprise can draw up appropriate strategies. The company's logistics department needs to clearly know what goods are flowing according to the plan, what goods' flowing speed is slowing down and what goods have been obsolete items. Then the company should handle these goods in time. In particularly when dealing with obsolete goods, the company must take action immediately, other than not willing to handle them. Because the obsolete goods will cost management and storage fees,

that is increasing the warehouse cost. So it is very necessary to inventory and report every day. What's more, it is necessary that placing the goods by type, by variety and by package.

3. Adjusting the layout of warehouse. As we know that, a warehouse is generally divided into three parts: production and work area, support work area and management area. The warehouse layout should be adjusted with the changing of market and inventory. In my opinion the most important is that to improve the utilization of warehouse space. It is wrong to think that, the extra space of warehouse can be used to add more inventories, or store obsolete goods. The right method is that we suitably arrange the cargo area and allocate the shelves, so as to search for the optimal balance between the inventory disposal cost and the warehouse space. By analyzing the perpendicular layout, tilted layout and other layout arrangement, we could find out a most appropriate way of layout.

4. Measuring the standard operating time of the warehouse work. In the manufacture companies, the production workers' standard operating time is always measured. However, the warehouse workers' standard operating time is seldom measured. For my part, I insist that the time in the warehouse such as inventory time, handling time and packaging time should be measured. Only in this way, can the logistics engineers give an analysis of the worker whether their working process is suitable. And then the improvements will be proposed. Finally, the workers can operate according to the standard optimized process to do their work. In addition, the optimization of the warehouse such as inventory controlling, cargo deposition scientifically will enhance the workers' efficiency, so that both of the number of labor and commission can be cut down.

5. Measuring the utilization of warehouse equipment and the use of resources. First of all, for those often used forklifts, stackers, manual or electric hydraulic trucks and

other equipment, we should clearly know all of their utilizations. Check time to time to see whether they are fully used. This makes it possible to reduce warehouse devices. Secondly, the water, electricity, gasoline, diesel and some other energy used should be controlled. Through a separate measure, the enterprise can see whether these resources and energy are necessary or reasonable, and whether there is a potential improvement for them.

6. Improving the packaging. When goods are stored in the warehouse or turnover, they will produce large amounts of waste packaging. In order to solve this problem, enterprises should consider whether they can make use of recyclable packaging instead. For those goods whose packaging cannot be recycled, we should also find ways to use them. In addition, there are some particular goods in the warehouse. We can remove the external packaging to save the space of shelves.

7. Improving the warehouse management software system. Now it is the technological age. The use of various software systems to manage logistics and materials is very common. We believe that manage the warehouse with computer system will make the management better. For example, when the inventory is shortage, the computer will immediately send a replenishment reminder. Frequency of each cargo's in and out of warehouse can also be recorded. But now, many companies show their shortcoming in the management information software. That is mainly reflected in the information lag, which affected the warehouse efficiency enhancing deeply. So enterprises should take measures to improve the timeliness of the computer system, to reduce the risk of cost increasing.

Of course, the ways to reduce the enterprise's warehouse cost are not only the above points. Overall, as long as the enterprise is willing to pay attention to its warehouses, they can explore a lot of possibilities of cost reduction. So we can get a conclusion that the enterprise must not only focus on its internal warehouses, but also not ignore the external warehouse and supplier's warehouse. If each warehouse

can have initiative of reducing cost, the enterprise may have great economic benefits. Since the warehouse cost is reduced, the supply chain can also be improved.

2.3 ABC Inventory Management Model

There is no enterprise that has no-limited resources. Every company, every warehouse has certain amount of resources and devices. So when we are doing inventory management, we'd better more pay attention to the important goods. And we should distinguish them and administrate separately according to their importance. This is the gist of ABC classification management.

ABC classification is derived from the Pareto curve. When economist Pareto studied the social distribution of wealth, he had drawn an important conclusion: 80% of the wealth is in the hands of 20% people, that is "less critical and more minor" rule, the rule exists in all areas of society. Of course, there is no exception for the warehouse, which has a wide range of various inventories. Moreover, the price and value of each products is different, the stock number is also not equal. So we need to use the specific data based on company, and divide the products into A, B, C class.

As for the ABC classification standards, there are many different types. We can classify according to the value of the goods, which is dividing them into high-priced, medium-priced, and low-priced categories. But also they can be classified according to their actual sales. In addition, we can classify them according to their frequency of turnover of the warehouse and so on. Through the classification of goods, and making rational use and distribution of shelves, we are then able to design appropriate operational procedures to achieve the effect of warehouse optimization. In this article, I would like to classify the cargo into A, B, C three categories according to their frequency that they are in and out of the warehouse. Therefore, a new optimization program is designed.

Because A type of goods' in and out of warehouse is the most frequent, whose influence from labor cost impact and warehouse operation efficiency is the largest. We should seriously deal with the A type of goods. On one hand, a corresponding manpower and material resources should be put into the management. On the other hand, we'd better place the goods at the places that have the shortest distance to the warehouse exit. These are all to speed up the working of in and out of warehouse. As for these goods, they should be strictly checked and controlled. The stock amount should also be regularly checked. Then we can set the most appropriate amount of safety stock.

B type of goods is relatively not very frequent to the warehouse running. Generally speaking, B type does not have a big impact to the organization and delivery of goods. Therefore, we can arrange their shelves location secondarily. For the actual position methods and safe stock can be decided according to actual situations.

C type of goods takes up much more yard and resources, making the management cost and expenses increase significantly. So that the management of C type cargo should be mainly focus on simplifying management. To those little use of the goods may set a minimum turnover amount to reduce the processing times, etc. But the stock number should be enough.

Nowadays many companies are beginning to adopt ABC classification method to manage their warehouses, such as large supermarkets and retailers and so on. Because the modern warehouse management method has not been common yet. Many logistics companies will give programs to their customers to optimize warehouses. No I will help the *Shanghai Shine-Link International Logistics Co., Ltd*, to design a warehouse optimization program for their customer *Mitsubishi.*

Chapter 3 Location of the New Warehouse and Layout Design

Shanghai Shine-Link International Logistics Co., Ltd (after referred to SLC) which locates in Shanghai Waigaoqiao Free Trade Zone, is a supplier of professional import and export service and bonded logistics. It provides all-round and high quality 3PL service, integrated logistics solution and package service of cargo flow, information flow and cash flow. Possessing modern professional logistics facilities and lots of logistics talents, the company has become one of the most powerful and the biggest 3PL companies. Since 2004, in order to satisfy the customers, SLC is trying its best to layout and build the bonded logistics network of the country. Warehouse is an important part of the logistics procedure. Cutting down its cost can effectively decrease the logistics cost. Therefore, how to minimize the warehouse operation cost, and not influence the quality of customer service, has become many logistics companies' concerning problem.

So as to improve the utilization of warehouses, and speed up the turnover in the warehouse, but also save time cost and labor cost, I have designed a warehouse optimization program for the SLC. This is to help them to reduce the cost and improve the service to their important customer Mitsubishi.

The inventory of Mitsubishi is mainly situated on the 4th floor of Warehouse No.1 and the 2nd floor of Warehouse No.2. According to the agreement with the customer, we could move the inventory to the new warehouse in late April. We place the inventory in the warehouse No.5 instead. After that, we can refer to the previous data, and do some adjustment and optimization to the inventory mode. The number of labors will not increase. We should allocate all the resources legitimately to reduce the stock area and enhance working efficiency.

3.1 The Calculation of Area Required After Integration

Here we need to make sure that how much area do we need? Apparently, we must try to increase warehouse utilization, but also ensure that the warehouse operation space is enough. In addition, the situation of volume's sudden increase might happen. Actions should be taken to solve all of these cases.

The original warehouse position of Mitsubishi was on the 4th floor of Warehouse No.1 and the east of the 2nd floor of Warehouse No.2. And plus the releasing and operation area, the total area is about 6500 m^2 (stack limit is 3.8 to 4.2 m). Now the vacant Warehouse No.5 has an area of 3000 m^2. As Warehouse No.5 is a single storey, the height of storey is a little higher (stack limit is 5.6 to 6.5 m), we can calculate that the equivalent area to Warehouse No.1 and No.2 is 4500m^2, that is 69% of the original size.

In early March, we had estimated and calculated the utilization of large stock position in Warehouse No.1 and No.2. And we get to know that Warehouse No.1 has a higher utilization in the east, which is above 90%. However, there are some shelves idle in the west of Warehouse No.1 and east of Warehouse No.2, whose utilization is only 70%.

From the above data we can see that, if we put all of the cargo in the Warehouse No.5, even we all use the double stretch racks, the area is not enough. Considering that among all the cargo, the Fx Department's goods are independent in and out, we should place the Fx cargo on two idle shelves of Warehouse No.7.

Mitsubishi Warehouse is a kind of circulation-type warehouse, which has a very frequent in and out business. And the cargo in the warehouse is also frequently turnover. Generally, this type of cargo is distributed as follows: 40% to 50% in the storage area, 8% to 12% in the channel, 40% to 50% is in the operation area.

Warehouse No.1 and No.2's area estimation and calculation is also like that. However, the storey height of the new warehouse is higher than the original ones. If we take all use of ground facilities in the operation area, it will occupy a large amount of storage capacity. So it is very necessary for us to beyond the old limitations when designing racking and layout, to let the operation area as compact as possible and make use of the space of high effectively. Besides, there is a 400 m^2 open yard outside the Warehouse No.5 which can be used to piling up goods temporarily or operating.

3.2 Overall Layout of the Warehouse

In designing the Warehouse No.5, we decide to use tandem arrangement. The advantage of tandem arrangement is that we can arrange the cargo space according to different cargo's different time in the storage. The goods which have a short in-storage time and frequently in and out of warehouse would be put on both sides of the main channel.

As for this racking layout of the warehouse, we need to do some innovation based on the original tandem arrangement, considering of adding the pickticket consolidations to the whole optimization project. So when designing the shelves location of the Warehouse No.5, we should take this into account, making it possible that the trucks drive S-type forward. In addition, a design of "middle stock position" is put up, to divide the stock positions into 4 types.

Owing to reduce the proportion of the operation area, we have designed a half-storage and half-operating "temporary area" for the cargo in and out of warehouse. The gate-like area which is next to the wall will be all double stretch racks. And the bottom part is planned as the cargo temporary storage area. Thus, in order to give priority to the out of warehouse, if there is some cargo occupied the operation area,

the cargo that is into the warehouse can be put in the temporary area. After the cargo that is out of warehouse finishes operating, the cargo which is into the warehouse is able to be handled. Moreover, once there are large amount of goods flowing into the warehouse, we might not have the time to open the boxes. Therefore the boxes can also be placed in the temporary area to prevent blocking the channels, and to avoid obstructing other operations. The temporary area has a height of 2m. Mitsubishi's daily cargo that flows in is about 1.4 TEU. The temporary area can hold 6 TEU totally, which means that it is able to manage the cargo increasing for 4 or 5days. In fact, when it is sunny, the operation is much easier. Part of the cargo can be positioned on the yard outside the warehouse.

As the temporary area takes up a large area, we design that the Warehouse No.5 adopts the double stretch racks to enhance the utilization of the warehouse. The cargo which has big volume and does not flow in and out frequently will be put inside of the double stretch racks.

For the cargo which is medium volume but has high flowing frequency, we have added a "Middle Stock Position", which originates from the replenishment setting of supermarket management. Middle stock position is located at the bottom of single-storey shelf. We set that it can contain the cargo amount of half a month. Thus, the cargo can be placed inside the shelves. We are able to replenish half a month to the middle stock position. And we can depend on the inventory of the middle stock to make cargo flow out in the ordinary days. It not only reduces the use of forklifts, but also save energy and time.

The small shelves are located at the bottom of the double stretch shelves. Here we adopt the vertical layout to the big shelves. And its function is similar to the one of the Warehouse No.2, which is to store the small goods.

The operation area is near to the gate. In the area there are many double stretch racks to place the pallets and empty boxes. We also need to divide the ground into a few parts. One batch of cargo can be handled in one part of the area.

Support work area and the management area are in the near-gate place. That is to make people and trucks in and out more convenient. It can also help to prevent obstructing the route of the vehicles. The support work area can hold 4 forklifts.

3.3 The Detailed Design of the Shelves

(1) The height of into-warehouse temporary area

The into-warehouse temporary area is used to store the cargo that has no time to be unboxed. After measure the height of original not open cargo, we get the data that the maximum height of cargo is 1.8 m. In addition, in order to make the workers' operation more convenient, we set the stock positions' net height as 2 m, which fully meet the needs of both workers and cargo, but also avoid the situation that influence other work.

(2) The storey height of shelves in big stock position

Among all the stock positions of Warehouse No.5, the space of big stock positions has taken a big proportion, which has determined function to the enhance of warehouse area utilization. As in known to all, dividing the height of the big stock positions means a lot to the warehouse area utilization. So we have done a complete measurement to all the 1800 batches of cargo in Warehouse No.2. Finally, according to the height statistics, each height of the shelves can be decided.

(3) The height of picking stock position

The picking stock position is following the supermarket management mode of shelves. There are some goods stored in the picking stock position. When the cargo

amount there is not enough, we should replenish to it from the big stock positions. So that this enables a height that will makes the workers easy to reach. Then, the 2 meters of the bottom storey can be divided into three, which is 0.8m of the bottom, 0.6m of the middle and 0.5m of the above. In this way we can put some big-volume cargo, some heavy cargo at the bottom. The height of middle or above will both easy for the workers to reach. Then the working intensity is being reduced.

(4) The shelves design of small stock position

Because the position of small goods is more flexible, we can rely more on human intervention to determine the places. In the end, the arrangement basically remains the same with the original program that of the previous warehouse. The storey number is still four, with each storey 0.5m. We have just done some adjustment only on the order of position number. In particular, as the small shelves are below the large shelves, we have some limitations in the height of the top. That is to avoid small cargo contacting with the upper pallets.

(5) The width of big shelves

After measuring the pallets of Warehouse No.1 and No.2, we have found that there are mainly two kinds of pallets, whose width are 0.75m and 1.1m. Only a little of the cargo's is larger than the width. So we decided to use the 2.4m and 2.7m shelves together. The 2.4m shelves are used to place two batches of 1.1m cargo. The 2.7m shelves are used to place three batches of o.75m cargo. Of course, the shelves can also be used to place 1.4m cargo and 1.1m pallets, or 1.8m cargo and 0.75m pallets.

Table 1： Cargo's width and height

Stock Position	Width	Height	Notes
0140101B10			None
0140101B30	0.75	1.3	
0140102A10	1.4	1.4	
0140102B20	0.75	0.7	

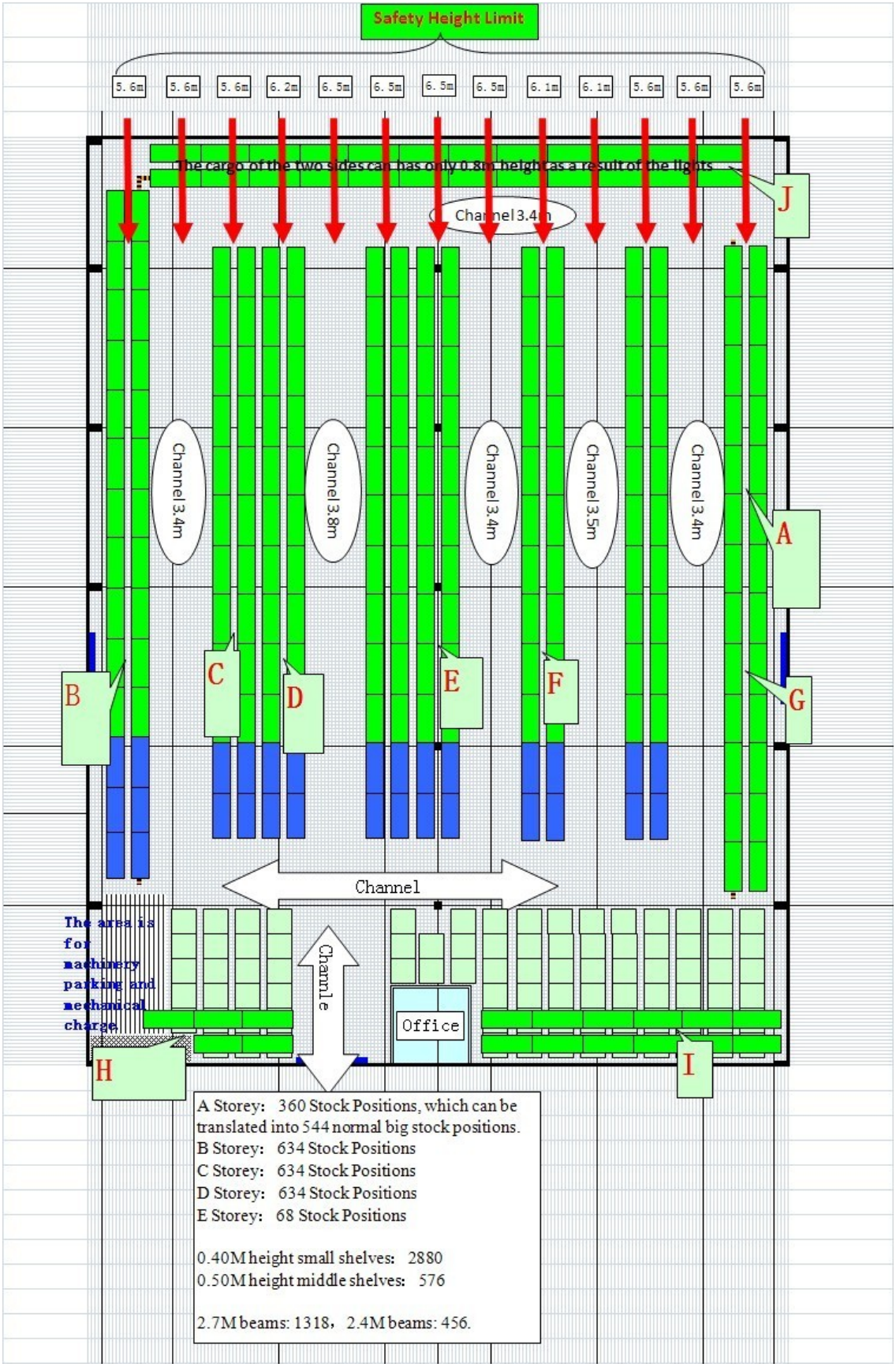
0140105C10	1.1	1	
0140109A10	1.4	1.4	

(6) The detailed design of operation area

The operation area is near to the gate, which includes empty pallets and packaging shelves, and the ground working area. So as to make operation more convenient, the bottom height of shelves is also 2m. Then we collected the statistics of the businesses of the half year, finding that there were about 30 orders of cargo everyday to both the inside city and outside city. The top was 38 orders. And the average volume of the cargo was about 2 pallets' volume.

That is why we divide the operation area into 16 rows. Each row has 2 to 4 blocks. Thus, we can operate 16 orders at the same time. Daily flowing-out cargo can be completed in two operations. After the cargo flowing out of the warehouse, we can move the other cargo of the temporary area to the operation area.

Figure 1: Design of Warehouse No.5


Safety Height Limit
5.6m
5.6m
5.6m
6.2m
6.5m
6.5m
6.5m
6.5m
6.1m
6.1m
5.6m
5.6m
5.6m
The cargo of the two sides can has only 0.8m height as a result of the lights
J
Channel 3.4m
Channel 3.4m
Channel 3.8m
Channel 3.4m
Channel 3.5m
Channel 3.4m
A
B
C
D
E
F
G
Channel
The area is for machinery parking and mechanical charge
Channle
Office
H
I
A Storey: 360 Stock Positions, which can be translated into 544 normal big stock positions.
B Storey: 634 Stock Positions
C Storey: 634 Stock Positions
D Storey: 634 Stock Positions
E Storey: 68 Stock Positions
0.40M height small shelves: 2880
0.50M height middle shelves: 576
2.7M beams: 1318, 2.4M beams: 456.

A	A:2m×78 Batches B:1.2m×78 Batches C:1.2m×78 Batches D:0.8m×78 Batches Double Stretch Racks Total：312 Total Height：5.5m Plus 3 bars of 0.3m 156 beams of 2.7	**B**	A:2m×78 Batches B:1.2m×78 Batches C:1.2m×78 Batches D:0.8m×78 Batches Double Stretch Racks Total：312 Plus 3 bars of 0.3m Total：5.5m 132 beams of 2.7 36 beams of 2.4
C	A:2.3m B:1.2m×68 Batches C:1.2m×68 Batches D:0.5m×68 Batches Double Stretch Racks Total：204s Plus 3 bars of 0.3m Total Height：5.5m 120 beams of 2.7 24 beams of 2.4	**D**	A:2.3m B:1.2m×68 Batches C:1.2m×68 Batches D:1.2m×68 Batches Double Stretch Racks Total：204 Plus 3 bars of 0.3m Total Height：6.2m 120 beams of 2.7 24 beams of 2.4
E	A:2.3m B:1.2m×136 Batches C:1.2m×136 Batches D:1.5m×136 Batches Double Stretch Racks Total：408 Plus 3 beams of 0.3m Total Height：6.5m 240 beams of 2.7 48 beams of 2.4	**F**	A:0.88m×68 Batches B:0.56m C:0.56m B:0.88m×68 Batches C:0.88m×68 Batches D:0.88m×68 Batches E:0.88m×68 Batches Single Stretch Racks Total：340 Plus 6 bars of 0.6m

			Total Height：6.12m 240 beams of 2.7 48 beams of 2.4
G	A:0.88m×64 Batches B:0.56m C:0.56m B:1.05m×64 Batches C:1.05m×64 Batches D:1.05m×64 Batches Single Stretch Racks Total：256 Plus 5 bars of 0.5m Total height：5.65m 60 of 2.7 beams 40 of 2.4 beams	H	A:2m B:1.2m×10 Batches C:1.2m×10 Batches D:1.0m×10 Batches Double Stretch Racks Total：36 Plus 3 bars of 0.3m Total Height：5.7m 30 beams of 2.7
I	A:2m B:1.2m×24 Batches C:1.2m×24 Batches D:1.0m×24 Batches Double Stretch Racks Total：72 Plus 3 bars of 0.3m Total Height：5.7m 60 beams of 2.7	J	A:2m×72 Batches B:1.2m×72 Batches C:1.2m×72 Batches D:1.0m×72 Batches Double Stretch Racks Total：288 Plus 3 bars of 0.3m Total：5.7m 144 beams of 2.7

Chapter 4 Optimization of Operation Procedure

However, this is our first time to design a warehouse optimization program that the experience is not enough. There must be some problems. First, picking consolidation will reduce the picking time. But it increases the sorting time and difficulty of

checking. So we should consider that does it really save the flow-out time? Second, changing the operation practices needs high management cost, and in the next few months, do we ensure the working efficiency and working accuracy?

About the first question, we had searched for the flow-out record of the last 30 days. In these days, the repetition rate of goods (Total operation lines / Number of Goods Names) is about 40%. It is too low. Considering that after picking consolidation, the sorting and checking time will go up substantially, we could not save much time in picking process. Besides, as for the machines utilization, we estimated and calculated the distance of machines that had running in 30 days. In contrast of the data before, we have found that in this way we can save about 60% of the running distance. But in the actual operation, a forklift cannot carry down all the goods for only once. And it is possible that a forklift would go back to the flow-out area halfway to unload the cargo. So we can see that the real distance saved is very limited.

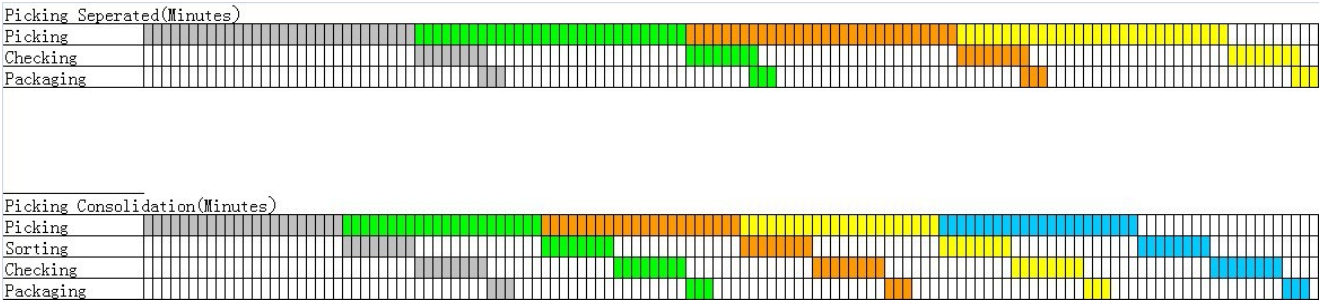
Table 2: Distance calculation of using the original picking method

SO Number	The distance of big stock position	The distance of small stock position	Warehouse No.
SI00137344	188		1
SI00137520	630		1
SI00137521	26	4	1
SI00138076	76		1
SI00139033	150		1
SI00139059	111		1
SI00139063	71	83	1

So this optimization is mainly showing its advantage of reducing time for what the workers wait for the machine. The good effect is reflected in the order of working time. After optimization, we can achieve the multiple machines operating at the same time. Meanwhile, other workers can begin to sort the cargo and tally. We don't forget to measure the time of that from picking to finishing packaging and flowing-out cargo. A time table is drawn to show the time order before and after the optimization. In theory, it will increase the efficiency by 25%.

For the second problem, we should consider more about increasing labors to assist the operation, to make sure the good efficiency and accuracy.

Figure 2: The contrast of optimization before and after



4.1 Sorting the cargo and collecting data

There are more than 3800 SKU (Part Number) of Mitsubishi goods. We have collected the inventory report of the last 6 months, which involved more than 3000 SKU. According to the frequency of cargo flow-out, we classify the goods with the ABC model. But we have classified 4 categories. The A type of goods is which has over 1000 flow-out in a month. The B type of goods refers to the ones who have more than 400 in a month. Then the C type is the ones who have about 900 in three months, and D is 700 in three months.

Table 3: The classification of cargo flow-out frequency

Time Period	SKU	Flow-out orders	Average flow-out amount for once				Top flow-out amount for once			
			0-50	50-100	100-500	500+	0-50	50-100	100-500	500+
two weeks	41.006.381	1	3				3			

two weeks	41.006.384	1	2				2			
two weeks	41.006.776	10	4.1				14			
two weeks	41.006.894	1	1				1			
two weeks	41.006.895	1	1				1			
two weeks	41.007.104	1	1				1			
two weeks	41.007.300	1	5				5			
two weeks	41.007.301	1	50				50			

The medium or small size of goods will be located in the picking stock position meanwhile they must be the high frequent cargo. We have collected the data of length, width, height of the over2400 SKU cargo in the warehouse, calculating their volume. At the same time, according to the number shown in the report, we can get to know the total volume of cargo flow-out in each month. The data collection has lasted for about 25 days, with the working of data maintenance and processing.

Figure 3: Measurement data (Part)

sku	No.	Stock Positior	Length(	Width(m	Height(m	Small pieces Contain	Volume(cm^3	Stock Size
41.035.075	AE2000-SW 4P 2000A D/O MOTOR (UVT)	0140102A30	830	590	600	1	293820	110*85*135
41.035.118	UVT-A460-W(05)	0140103C10	380	180	200	1	13680	110*85*90
41.035.079	AE4000-SWA 4P 4000A D/O MOTOR (UVT)	0140107A30	830	680	610	1	344284	110*85*135
41.035.804	AE2000-SW 3P 2000A D/O MANUAL(W/O SHT)	0140107B30	710	610	620	1	268522	110*85*135
41.035.247	AE3200-SW 3P 3200A D/O MOTOR(W/O UVT	0140202A30	710	610	620	1	268522	110*85*135
41.035.882	AE2000-SWA 3P 2000A D/O MOTOR(UVT)VT TTC	0140203A20	580	560	590	1	191632	110*85*135
41.035.025	AE2000-SW 3P 2000A FIX MOTOR (UVT)	0140204A10	710	510	580	1	210018	110*85*135
41.035.056	AE2500-SW 4P 2500A FIX MOTOR (UVT)	0140205B30	850	610	620	1	321470	110*85*135
41.035.018	AE2000-SWA 3P 2000A D/O MANUAL	0140206B10	570	570	580	1	188442	110*85*135
41.035.074	AE1600-SW 4P 1600A D/O MOTOR (UVT)	0140208A30	570	570	580	1	188442	110*85*135
41.035.880	AE1600-SW 3P 1443A D/O MOTOR(UVT)HV WM1	0140301A20	570	570	580	1	188442	110*85*135
41.035.883	AE1600-SW 3P 1082A D/O MOTOR(UVT)WM	0140304A10	570	570	580	1	188442	110*85*135
41.010.080	S-N600 AC200V MAG. CONTACTOR	0140306C10	410	410	340	1	57154	110*85*90
41.010.074	S-N125 AC200V MAG. CONTACTOR	0140308C30	230	170	170	1	6647	110*85*90
41.017.163	NF63-CW 3P 25A W BREAKER	0140309C30	140	90	100	1	1260	110*85*90
41.035.243	AE1000-SW 3P 656A D/O MOTOR(UVT)	0140401A30	600	600	600	1	216000	110*85*135
41.009.001	UN-CZ2200	0140401C30	140	60	100	1	840	110*85*90
41.035.207	AE2000-SW 3P 2000A D/O MOTOR (	0140402A10	680	580	600	1	236640	110*85*135
41.035.007	AE3200-SW 3P 3200A FIX MANUAL	0140403A30	740	530	600	1	235320	110*85*135
41.035.030	AE4000-SWA 3P 4000A D/O MOTOR	0140404A10	680	680	610	1	282064	110*85*135
41.035.217	AE2500-SW 3P 2500A D/O MOTOR(W	0140405B10	710	610	620	1	268522	110*85*135
41.035.114	AE2000-SW 3P 2000A D/O MOTOR(W/O PW)	0140406B10	710	610	620	1	268522	110*85*135
41.035.048	AE2000-SWA 4P 2000A FIX MANUAL	0140407B10	610	670	620	1	253394	110*85*135
41.017.303	NF400-SW 3P 350A BREAKER	0140408C30	400	200	200	1	16000	110*85*90
41.035.069	AE4000-SWA 4P 4000A D/O MANUAL	0140409B30	810	680	600	1	330480	110*85*135
41.017.737	NF630-SEW 3P 300-630A PM	0140409C30	250	170	170	1	7225	110*85*90
41.035.037	AE3200-SW 3P 3200A D/O MOTOR (UVT)	0140502A20	680	590	590	1	236708	110*85*135
41.035.077	AE3200-SW 4P 3200A D/O MOTOR (UVT)	0140502B20	570	565	580	1	186789	110*85*135

4.2 The distribution design of the cargo in the warehouse

First, as the goods of Fx department placed in the Warehouse No.7 separately, it can be excluded. And then through calculation, we discover that the stock position in Warehouse No.5 is very tight. Once there is sudden situation happening, perhaps we have not got enough space to place the cargo. So we decide to place the low frequent goods on the spare shelves of the Warehouse No.7. As a result of that, the space is enough for Warehouse No.5 when emergency happens.

After that, we can sort the goods according to their flowing frequency. The goods with the lowest frequency are put inside the double stretch racks. Part of the others are the goods with high frequency, put on the shelves that near the gate. The goods with general frequency will be positioned in the deep of the warehouse.
For the goods with the highest frequency, we have calculated the average once flow-out volume and average flow-out volume monthly. Sorting the cargo which suits to

use for replenishment, put them at the middle stock position.

And for the small shelves, its goods do not have big volume, and are flexible. When moving to the new warehouse, their positions are determined by actual situation.

4.3 Optimization of picking consolidation

There are more than 10 orders of Mitsubishi every day. If we choose to pick consolidation manually, it will cost too many labors. So we cooperate with the information department of the company, optimizing the picktickets. And then classify the tickets into two kinds: inside city and outside city. After that, we can do the consolidation. The tickets after consolidation will show that each SKU are in which orders. As a result, the sorting will be much more convenient when the machine does the picking. The change of checking tickets is not many. Check one order, check one ticket.

Chapter 5 Design of Program Implementation

5.1 Moving to another warehouse

As there are goods in and out of the warehouse every day, it is hard to have one or two days to do the moving work. So we must divide the cargo into some categories, and move one batch by one batch. We all know that the goods of Fx Department have strong independence, which is not able to pack with other cargo. We can move them first.

Besides, most goods of the Mitsubishi are electrical products. The goods which have not flow in or out can be seen as slack goods. The possibility of flowing is almost

zero. These goods can be moved, too.

We have completed the above goods moving to Warehouse No.7 in the weekends of April.

Table 4: Slack Goods

SKU	LOC	qty	Width	Height
41.035.629	0140101A10	2	1.2	1.4
41.035.629	0140106A10	2	1.2	1.4
41.035.804	0140107B30	2	0.75	0.7
41.035.629	0140108A10	1	1.2	1.4
41.035.018	0140108B20	3	0.75	1.3
41.035.018	0140206B10	4	0.75	1.3
41.035.207	0140206B30	1	0.75	0.7

The main cargo will begin to be moved on April 23rd. In the week before, we have finished the classification and allocated them into different areas. In addition, daily record and data maintenance is necessary. All the cargo will be marked the original stock position and the new position.

As the layout of the new warehouse is tight, we need to move the cargo of the double stretch racks first, to prevent accumulation.

In fact, the tight layout of the new warehouse increases the difficulty of moving work. But we have discovered that, the temporary area has helped a lot just like imagination. At last, we finished the moving on time.

5.2 Adjustment in later stage

(1) Distinguishing misplaced goods

Since goods need to be delivered on Monday as clients required, the first step has to ensure all the goods can be found after goods relocation, in order to avoid delivery delay.

Actually due to large amount of goods, crowded warehouse layout, and tight time schedule, many goods cannot be shelved as planned on Sunday, some goods are even misplaced in the temporary storage area or other empty stock positions; thus some goods are hard to find on Monday when they need to be delivered.

Therefore, from Monday to Wednesday, the quality control team of the warehouse storage department needs to transfer all the staff to arrange and manage all the goods in warehouse 5, and locate each good in the appropriate position. The rest few mismatched goods should be disposed differently. Besides some goods' packages are damaged during goods relocation, these goods should be placed into frozen stock positions, and wait for client's check on qualification.

(2) Adjusting inner and outer detailed layout of the warehouse

Due to the rainy weather after goods relocation, goods placed outdoor were under the risk of wet by rain, and they cannot be removed in the short time period; hence the outdoor stock spaces cannot be exploited effectively. This induces a shortage of operating spaces, which also became the bottleneck of actual operations after goods relocation. A fieldwork was conducted and resulted that, the middle part of the outdoor stock space can be heightened, and erect a rain proof shed, which allows goods loading and unloading, and other operations during rainy days.

Inside the warehouse, because of the middle stock position, the availability of the small stock position in the large rack bottom is not that high. Hence, according to the stock change of Mitsubishi, we can then flexibly demolish or erect small racks near the door. During the period of high goods flowing amount, the stock rate will accordingly decrease, then the small racks can be demolished, and this 2 meters high space can be used as temporary stock area or operating area; whereas during the period of low goods flowing amount, the stock rate will accordingly rise, at this time the space can be used as stock positions.

(3)The workers allocation

The moving work has taken up the weekends of workers, and the efficiency of warehouse is a little lower after moving complete. So we have to let the workers work overtime to ensure the accuracy of operating. Therefore, we need to adjust the workers, to give them appropriate rest.

According to the statistics of March and April, we get the follow report:

Table 5: 3/4 Report

3/4 Statistics	PL Department	HC Department
Orders	200	775
ITEM Number	6672	3466
Workers Number	5	7
Working Days	41	41
ITEM/day	32.54634	12.07666

Thus, in the evening of the first day, head of the warehouse can predict the next day's flow-in amount according to the report offered by the customers. And then he can do the workers arrangement. If the flowing amount is not much on that day, the head can let the workers rest in turn. The situation that nobody has work to do will not happen.

5.3 The Specific Operation

Table 6: Picking Consolidation (Part)

Order Date	sku	SO No.	Total Flow-out
2009-9-1	42.039.087	SI00108034	10
2009-9-1	42.039.089	SI00108034	3
2009-9-1	42.039.109	SI00108034	1
2009-9-1	42.039.113	SI00108034	5
2009-9-1	42.039.126	SI00108034	10
2009-9-1	42.039.127	SI00108034	10
2009-9-1	42.039.128	SI00108034	10
2009-9-1	42.039.129	SI00108034	25
2009-9-1	42.039.130	SI00108034	5
2009-9-1	42.039.248	SI00108034	10

2009-9-1	42.042.203	SI00108032	54
2009-9-1	42.042.404	SI00108033	3
2009-9-1	42.042.458	SI00108032	27
2009-9-1	42.048.300	SI00108032	12
2009-9-1	42.048.300	SI00108033	24
2009-9-1	42.048.305	SI00108033	9
2009-9-1	42.048.326	SI00108033	14
2009-9-1	42.048.450	SI00108033	6
2009-9-1	42.049.980	SI00108033	3
2009-9-1	48.035.047	SI00108036	20
2009-9-1	48.035.048	SI00108036	1
2009-9-1	48.035.501	SI00108037	40
2009-9-1	48.035.508	SI00108037	13
2009-9-1	48.035.515	SI00108037	60
2009-9-1	48.035.516	SI00108046	6
2009-9-1	48.035.551	SI00108037	40
2009-9-1	48.035.552	SI00108046	30

1. Do the flow-out tickets consolidation for the customers
2. Classify the tickets after consolidation
3. Sorting and tally managing the goods
4. Distinguish the cargo that is fit to pick consolidation
5. Data maintenance, picking and replenishment

Table 7: Replenishment Analysis (Part)

SKU	Volume	Stock Position	Volume of Stock Position	Minimum Picking	Average Flow-out	Flow-out Period	Replenishment Period	Rate (FP/RP)
41.006.009	0.000092	1	792	198	25.5	83.0	1932.7	23.3
41.006.067	0.000958	1	76	19	2.0	166.0	4717.0	28.4
41.006.089	0.000505	1	144	36	10.4	25.8	267.4	10.4
41.006.278	0.000986	1	74	18	4.0	166.0	2291.8	13.8
41.006.321	0.000227	1	320	80	1.0	83.0	19896.5	239.7
41.006.381	0.000279	1	260	65	6.0	23.7	772.1	32.6
41.006.384	0.000279	1	260	65	1.5	83.0	10809.5	130.2
41.006.407	0.001319	1	55	14	2.0	166.0	3425.4	20.6
41.006.642	0.000183	1	396	99	2.0	83.0	12320.7	148.4
41.006.776	0.000188	1	387	97	8.6	11.9	397.7	33.5
41.006.778	0.000188	1	387	97	5.5	83.0	4375.0	52.7
41.006.779	0.000183	1	396	99	17.0	166.0	2899.0	17.5
41.006.894	0.000061	1	1188	297	12.0	55.3	4106.9	74.2
41.006.895	0.000061	1	1188	297	13.1	9.2	626.5	67.9
41.006.957	0.001530	1	47	12	8.0	55.3	246.0	4.4
41.007.035	0.001355	1	54	13	4.0	166.0	1667.4	10.0
41.007.036	0.001028	1	71	18	2.0	83.0	2196.4	26.5
41.007.300	0.000484	1	150	37	8.5	27.7	366.0	13.2
41.007.301	0.000260	1	279	70	25.7	7.5	61.4	8.1
41.007.302	0.000270	1	269	67	31.4	6.1	39.5	6.4
41.007.303	0.000262	1	277	69	14.2	5.7	83.4	14.6
41.007.306	0.000266	1	273	68	27.2	16.6	124.8	7.5
41.007.310	0.000262	1	277	69	21.4	7.9	76.8	9.7
41.007.311	0.000261	1	278	69	29.9	5.0	35.0	7.0
41.007.312	0.000968	1	75	19	13.8	15.1	61.4	4.1
41.007.319	0.001139	1	64	16	1.1	20.8	881.7	42.5
41.007.325	0.001680	1	43	11	15.0	47.3	102.2	2.2
41.007.326	0.002760	1	26	7	2.0	166.0	1636.6	9.9
41.007.370	0.000259	1	280	70	3.0	166.0	11617.5	70.0
41.007.374	0.000262	1	277	69	201.0	166.0	171.9	1.0
41.007.464	0.000261	1	278	70	2.2	33.2	3150.5	94.9
41.007.518	0.002844	1	26	6	2.5	83.0	635.4	7.7
41.007.539	0.000269	1	270	67	2.0	55.3	5593.3	101.1
41.007.540	0.000214	1	339	85	9.5	41.5	1110.2	26.8
41.007.546	0.001260	1	58	14	5.0	131.0	1131.6	8.6
41.007.548	0.005590	1	13	3	4.0	55.3	134.7	2.4
41.007.550	0.000315	1	230	58	1.7	53.0	5489.0	103.6
41.007.553	0.000484	1	150	37	3.5	83.0	2666.5	32.1
41.007.556	0.000255	1	285	71	2.0	54.0	5773.5	106.9
41.007.584	0.004840	1	15	4	2.0	166.0	933.3	5.6
41.007.586	0.001101	1	66	16	13.3	41.5	154.8	3.7
41.007.596	0.001143	1	63	16	2.6	17.7	329.1	18.6
41.007.611	0.001811	1	40	10	1.4	33.2	712.5	21.5
41.007.612	0.001815	1	40	10	4.0	166.0	1244.4	7.5
41.007.627	0.000367	1	198	49	6.6	11.9	264.7	22.3
41.007.632	0.000299	1	243	61	17.5	15.1	156.7	10.4
41.007.633	0.001126	1	64	16	4.0	166.0	2005.1	12.1
41.007.643	0.002285	1	32	8	5.5	83.0	359.5	4.3
41.007.648	0.000261	1	278	70	29.5	27.7	195.8	7.1
41.007.654	0.002145	1	34	8	1.3	27.7	526.5	19.0
41.007.868	0.000012	1	5956	1489	31.8	27.7	3882.2	140.3
41.007.872	0.000474	1	153	38	3.0	166.0	6348.8	38.2
41.007.873	0.000484	1	150	37	5.0	166.0	3733.1	22.5
41.007.878	0.001144	1	63	16	14.0	166.0	564.3	3.4
41.007.884	0.000403	1	180	45	1.6	33.2	2800.7	84.4
41.007.989	0.000258	1	282	70	15.3	41.5	574.7	13.8
41.008.083	0.000621	1	117	29	4.0	166.0	3637.3	21.9
41.008.131	0.002070	1	35	9	4.0	166.0	1091.1	6.6
41.008.147	0.005580	1	13	3	4.0	166.0	404.8	2.4

Chapter 6 Actual Effect of the Program

6.1 Reduction of the warehouse equipment costs

The most direct profit is earned from reduced warehouse spaces. Double stretch racks can substantially save the warehouse space. Theoretically a double stretch rack can increase the warehouse availability to approximately 150% of a sing stretch rack, whereas the double stretch forklift truck is fairly large in size, which needs a larger turning radius, accordingly the gap between racks will also need to be enlarged, thus the actual increased availability is about 30%. Moreover, the inner side of a double stretch rack is placed with goods which are moved not so frequently. Refer to the measured data after cargo relocation, it takes about 20 seconds to grab a good from a 3 m high single stretch rack, and it takes approximately 1.5 minutes to grab a good from the inner side of a 3 m high double stretch rack. However the frequency of getting goods from inner side is quite low, averagely it takes less than half an hour to do so in a day, thus the disadvantage of a double stretch rack can be ignored.

On the other hand, the former warehouse 1 and 2 had multiple layers, thus freight elevator was used every time a good needs to be moved; but the elevator is no longer needed since all the cargo have relocated into the new warehouse. Furthermore, the new single layer warehouse is much higher than the former multilayer warehouse; the lighting condition is also improved, most racks do not need all-weather illumination. The former warehouse used to spend more than 0.1 million RMB on electricity bill, now up to 50,000 RMB can be saved on electricity usage since the cargo are relocated in Warehouse No.5.

6.2 Improved loading and unloading efficiency

The former freight elevator used to take approximately 2 minutes for one round of

up and down, besides each elevator can only carry one batch of cargo. Due to the limitation of the freight elevator, the former warehouse needs around 1.5 hours to load and unload 1TEU of goods. However the new warehouse enables unloading goods without unpacking them but place them in the temporary storage area, which saves the time on waiting for transportation, and substantially improves loading and unloading efficiency. Loading and unloading 1TEU of goods can be finished in 15 minutes.

After practical measurement and calculation, due to the above advantage, the daily maximum loading and unloading rate of new warehouse is 4TEU, which is 1.5TEU more than the former warehouse; this high rate can conquer the operational pressure from greatly increased goods flowing amount after economic resurgence.

6.3 Saving on human resources

The picking process used to be the operational bottleneck of the former warehouse, as labors always spent a lot of time on waiting; an example of this situation would be that while two forklift trucks are lifting goods, other operatives can do nothing but waiting in the tallying area only. By way of the optimization of picking consolidation, the pointless waiting time has reduced for labors, they are allowed to simultaneously operate and accomplish their own job.

Since the new operational procedure is not very proficient, the number of labors was not reduced during the first period of goods relocating. However due to the utilization of picking stock position, and reasonable optimization of goods locating in the warehouse, hence result in the reduction of labors' intensity on physical work, and their dependency on vehicles. These changes decrease the usage of operational machines in the warehouse in certain extent, and saves cost simultaneously.

After labors get used to the new operational procedures, according to the new employee distribution mentioned above, the warehouse manager will make flexible rotation plans for labors. The design of middle stock position reduces the usage of forklifts, which leads to decreased labor intensity of forklift operator, they are ensured to have sufficient stamina due to reasonable rest time, which also avoids operational accidents in the warehouse in certain extent. Other operators' working rotation is depended on cargo amount, in order to avoid low efficiency which caused by old operating approaches of overtime working, meanwhile ensures accuracy of work. When there are not that many goods, the spare labor can be adjusted to assist on other projects, hence more sensibly distributing the human resources.

Chapter 7 Conclusion

Time-saving and efficiency are essential during the operations in logistic centers. On the other hand, due to safety and humanity concerns, labor saving is also required while employees move goods. Therefore, in order to achieve high efficiency, short time-consuming, and labor-saving, it is necessary to have reasonable goods locating and optimized information system, thereby using spaces more wisely and increasing performance efficiency, which will result in cost reduction.

This warehouse optimization procedure indicated such comprehensive process: Warehouse layout planning – Shelf size designing – Procedure optimization – Goods moving – Implementing optimization. These steps are interdependent rather than independent with each other; every step can only be proceeded while the previous one is entirely completed, and they all have impact on the final outcome, such as reduced management cost, human resources etc.

Meanwhile the cost of each component in warehouse logistic can have impact on each other. The cost reduction on a certain aspect will surely affect the expense on

other aspects. For instance, economizing warehouse space will not only increase management income by providing spare spaces to other clients, but also accelerate the operation of warehouse, improve labors' efficiency, and reduce labor cost. This procedure will achieve multiple purposes.

In sum, corporations should have the courage to reject past warehouse management schemes, and have the insight on discovering new management approaches, utilizing computer information systems to assist the operation and management of the warehouse. Strictly control every component, exploit the current resources to accomplish maximum tasks; hence decrease costs of warehouse, which will lead to the cost reduction of whole logistic chain, and optimize all the logistical activities.

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