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Supply Chain Management in the Logistics Industry

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Abstract

The goal of this Major Qualifying Project was to analyze the performance of warehouse operations relating to the client LG Electronics at AGUNSA's Distribution Center in Santiago. By gathering information from REPORT warehouse documents, meetings with the various warehouse departments, observational analysis of the processes, and time-data collection of these operations, I was able to assemble a general overview of LG operations and identify the weaknesses and wastes within these. Through the analysis of incoming shipment timed data, I was able to present the current performance of Reception operations and make recommendations to diminish costs incurred within this process, which could potentially increase capacity of warehouse operations by 20%.

Acknowledgements

I would like to thank AGUNSA and REPORT for sponsoring my Major Qualifying Project. Specifically, I would like to thank Rodrigo Jimenez for presenting me with the opportunity to complete this project at AGUNSA's Distribution Center in Santiago. Within REPORT, I would like to thank Gaston Oyarzun for the opportunity to work with him to improve warehouse operations and for the guidance he provided throughout the project. Within the Planning and Control department, I would specially like to thank Claudio Marin and Ismael Vial for their support and assistance during the project. I would like to thank Maria Jose Hernandez and Felipe Huerta from Human Resources for providing data relevant to the project and guiding me through the labor-related aspects of the project. My appreciation goes to all individuals of REPORT, AGUNSA, and MTO who were part of the distribution center. Thank you for integrating me into the organization for the 2 months this project encompassed.

Without the support and commitment of the mentioned individuals, this project would not have been able to be completed and produce significant information.

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1 Introduction

In today's industries, companies are consistently looking for improvement within their operations. The search for competitive advantage and differentiation has been more critical than ever before as the number of competitors in the various industries continues to grow. Integration of the supply chain has become an important way for companies to gain competitive advantage[1].

Supply chains are responsible for the movement of a product or service from supplier to customer, and through the various networks within them, involved in adding value to the final customer. They include vendors, producers, intermediaries, and logistics service providers, all working together to create more value than competitors[2]. According to the principles of supply chain management, modern companies attempt to achieve high-volume production and distribution using minimal inventories throughout the logistics chain that are to be delivered within short response times[3]. These objectives have placed a great deal of responsibility on the logistics system to achieve smooth and efficient operations. The growing emphasis on logistics operations is due to the important role logistics costs have in the overall production costs.

[1] Hertz, S., & Alfredsson, M. (2003). Strategic development of third pardy logistics providers. *Industrial Marketing Management , 32*, 139-149.
[2] Gourdin, K. N. (2006). *Global Logistics Management* (2nd Edition ed.). Oxford, UK: Blackwell Publishing.
[3] van den Berg, J., & Zijm, W. (1999). Moderls for warehouse management: Classification and examples. *International Journal of Production Economics , 59*, 519-528.

Implementing an efficient logistics system can be difficult for many companies. As a result, they have turned to third-party logistics providers (3PLs) in order to reduce the risks of managing logistics operations. A 3PL provider is an external service provider who manages, controls, and delivers logistics activities on behalf of a shipper[4]. The decision to outsource logistics activities depends on a multitude of variables: centrality of the logistics function, risk and control, cost/service trade-offs, information technologies, and relationships with logistics providers[5]. Throughout the years, 3PL companies have expanded and created networks that have become beneficial to many companies. Their specialization in this supply chain activity has made them key players in the improvement of customer satisfaction. At the same time, the distribution networks 3PLs have established have provided access to international distribution opportunities that individual companies could not create by themselves due to high risks and costs[6].

Within these networks, the logistics activities require that at least management and the execution of transport and warehousing be involved. In fact, the efficiency and effectiveness of these distribution networks in turn is largely determined by the operation of the nodes in such a network, i.e. the warehouses[7]. As a result, warehouse management has become an important component of the supply chain. And companies all around the world are trying to minimize waste and costs within these warehouse operations.

[4] Hertz 2003
[5] Selviaridis, K., & Spring, M. (2007). Third party logistics: a literature review and research agenda. *The International Journal of Logistics Management , 18* (1), 125-150.
[6] Bask, A. H. (2001). Relationships among TPL providers and members of supply chains - a strategic perspective. *Journal of Business & Industrial Marketing , 16* (6), 470-486.
[7] Rouwnhorst, B., Reuter, B., Stockrahm, V., Houtum, G. v., Mantel, R., & Zijm, W. (2000). Warehouse design and control: Framework and literature review. *European Journal of Operational Research , 122*, 515-533.

2 Background & Literary Review

2.1 History

Since its foundation in 1960, Agencias Universales S.A., globally known as AGUNSA, has grown to be one of the leading maritime port agencies, primarily operating in Latin America. Through the decades, AGUNSA's expertise has rapidly grown through the integration of new technology, new services, and new investments around the world.

As the 20th century came to an end, the growing export markets around the globe (see examples in Table 1) aided AGUNSA's expansion through the increasing demand for its services. In 1994, Empresas Navieras S.A. became aware of AGUNSA's critical role in South American agency services and acquired a substantial portion of the company's stocks, boosting AGUNSA's available capital. As well as a financial asset, ENSA further extended AGUNSA's network. ENSA is the majority stockowner of Compañía Chilena de Navegación Interoceánica S.A. or CCNI (69.73%), Portuaria Cabo Froward S.A. (69.83%), and AGUNSA (66.00%). This allowed for AGUNSA to offer all of the services it offers today, ensuring a wide range of resources through this agency network.[8]

AGUNSA continues to improve its services, fulfilling their mission to empower and expand the service to cargoes, passengers, means of transportation and terminals networks, with an effective offer adding value to clients, vendors, employees and

[8] Empresas Navieras S.A. (2006). *Historia*. Retrieved April 2, 2009, from Grupo Naviera Web Site: http://www.empresasnavieras.com/index.php?option=com_content&task=view&id=8&Itemid=10&bloqueo=1

shareholders[9]. AGUNSA's high level of service is demonstrated through its membership in the S5 Agency Organization – the association for the leading service agencies worldwide.

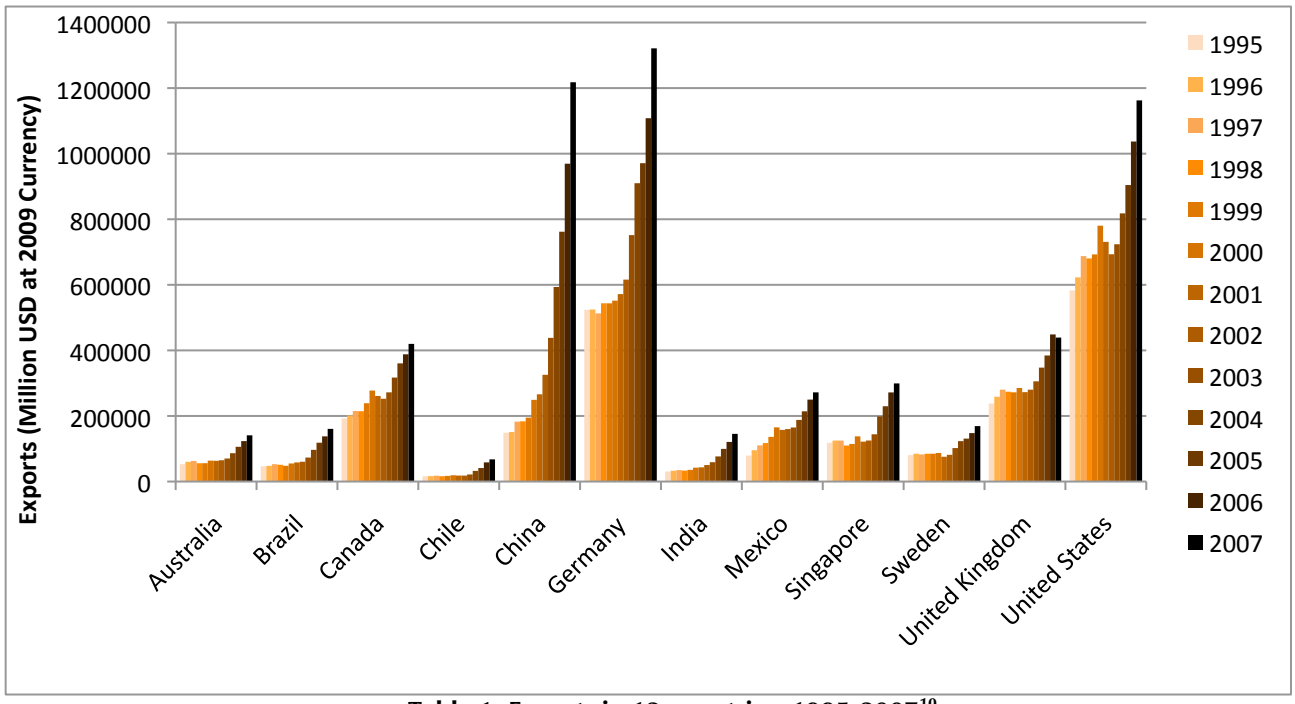


Table 1: Exports in 12 countries: 1995-2007[10]

2.2 AGUNSA Worldwide

The Chilean company has been primarily operating in South America since the 1960's. As the demand for agency services grew around the world through the growing export markets, AGUNSA became a multinational corporation with offices around the world. The holding Empresas Navieras S.A. opened many opportunities in the 1990's for AGUNSA to further expand internationally. As a result, AGUNSA manages offices in Asia, Europe,

[9] AGUNSA. (2006). *About AGUNSA: Mission*. Retrieved March 22, 2009, from AGUNSA Web Site: http://www.agunsa.com/eng/index.php?option=com_content&task=view&id=25&Itemid=26

[10] World Trade Organization. (2008). *CDS Time Series Selection*. Retrieved April 17, 2009, from The Inter Agency Task Force on International Merchandise Trade Statistics: http://imts.wto.org/CDS/gp/tsselection.aspx

North America and South America, with headquarters in Santiago, Chile. Figure 1 displays the different locations where AGUNSA is currently stationed. All locations guarantee the primary service AGUNSA offers: ship agency services. All other nine areas of service are offered respectively (see Table 2).

2.3 AGUNSA Services

This leading service agency offers a variety of services and solutions besides their maritime agency services. Under their current operation, AGUNSA offers ten areas of service: (1) ship agency services, (2) airline agency services, (3) transportation services, (4) operation and administration of terminals, (5) stevedoring services, (6) pilot boat services, (7) container depot and services, (8) freight forwarding, (9) bunkering and (10) logistics and distribution[11].

2.3.1 Ship Agency Services

As a ship agency, AGUNSA offers a variety of services to be handled for the clients in order to achieve the most efficient and effective results. AGUNSA acts a global commercial representative for all clients, ensuring the clients have accessibility to the entire AGUNSA network. AGUNSA administers the sale of freight and space booking for their clients and all financial services related with these shipments. In order to make the process as smooth as possible, AGUNSA also manages the legal procedures, inventory, and the overall port-to-port administration. Navigation assistance is also available.

[11] AGUNSA. (2006). *Services and Solutions: Ship Agency Services*. Retrieved March 22, 2009, from AGUNSA Corporation Web Site: http://www.agunsa.com/eng/index.php?option=com_content&task=view&id=84&Itemid=94

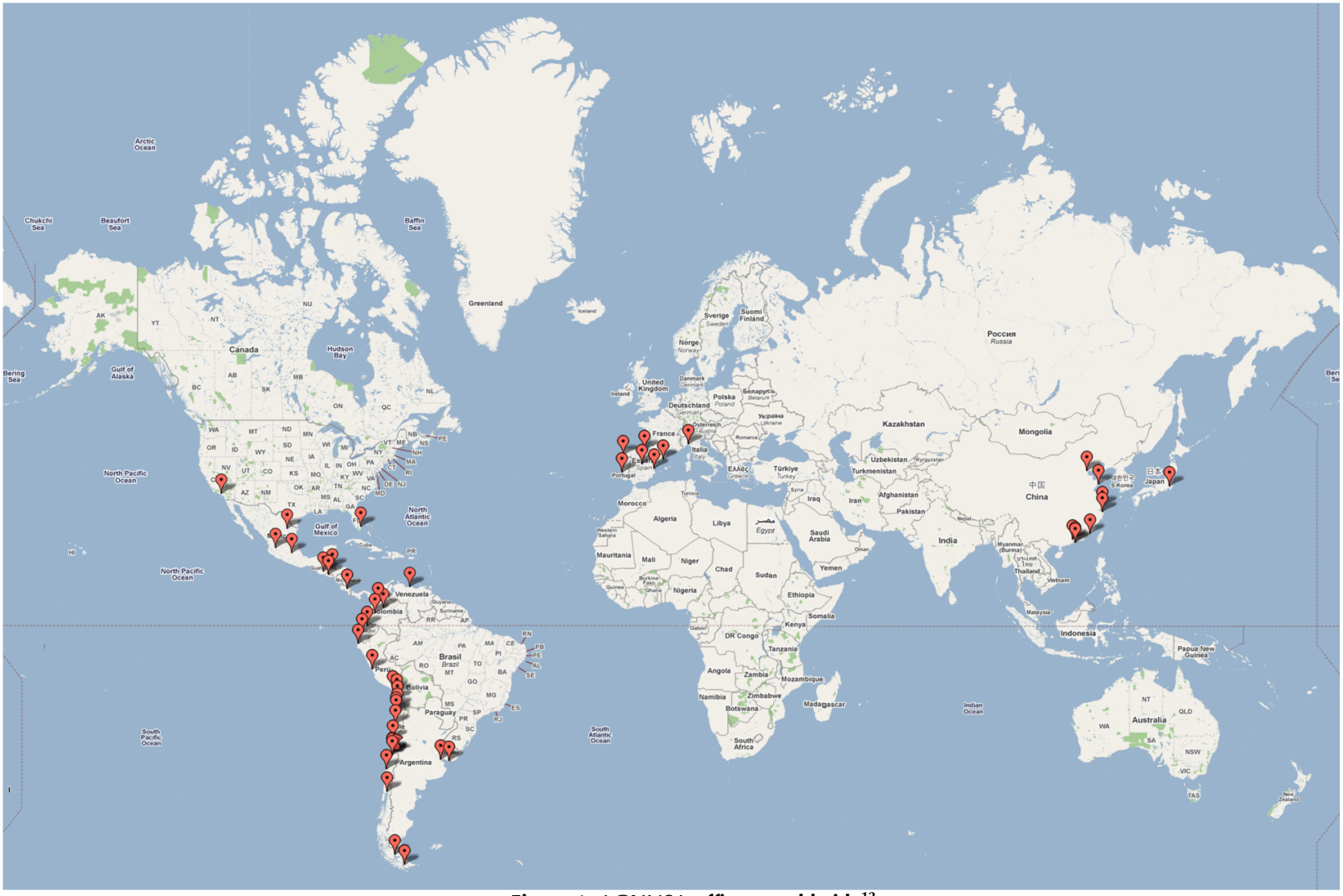


Figure 1: AGUNSA offices worldwide[12]

[12] AGUNSA. (2006). *About AGUNSA: AGUNSA worldwide*. Retrieved March 22, 2009, from AGUNSA Web Site: http://www.agunsa.com/eng/index.php?option=com_content&task=view&id=116&Itemid=137

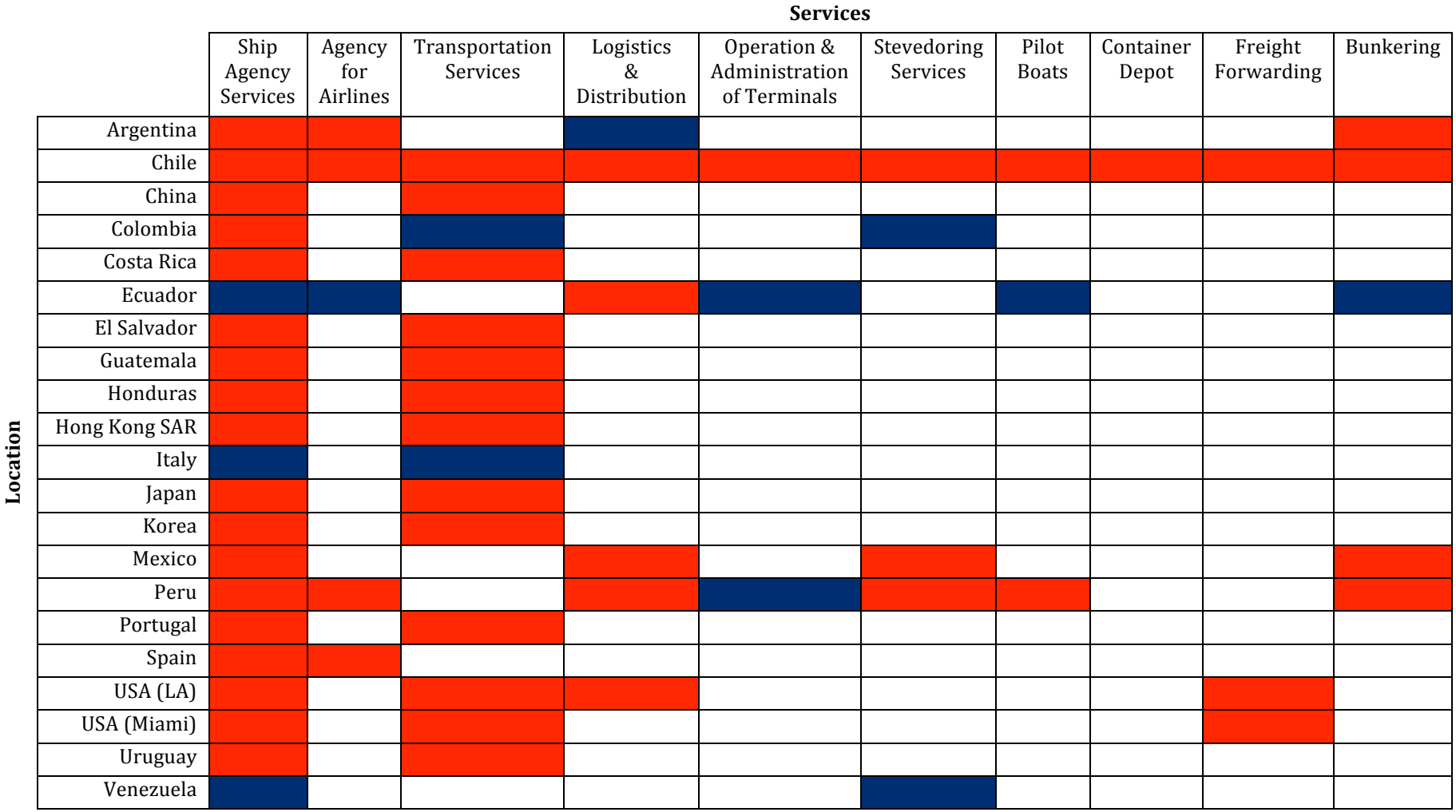


Table 2: AGUNSA services worldwide[13]

[13] AGUNSA Service and Solutions 2006

AGUNSA's ship agency services have acquired a tremendous amount of influence over South America, and continue to grow around the world.

2.3.2 Agency for Airlines

One of AGUNSA's newest services is the operation of agency services for airlines. AGUNSA offers legal representation and consultancy, marketing, and financial management to clients. In addition, many airport services are offered such as sales counter operation, customer service assistance, and all operative requirements for airplanes such as fuel supply. AGUNSA is currently administrating these airline agency services for Air Canada (Chile, Ecuador, Peru), United Airlines (Chile), and Emirates Airlines (Chile).

2.3.3 Transportation Services

Another core service area offered by AGUNSA is transportation for national and international cargo. These services include customs representation and consultancy, cargo insurance, and the entire shipment administration. AGUNSA's extensive network allows for one of the most reputable transportation operations.

2.3.4 Operation & Administration of Terminals

AGUNSA controls the core services of terminals for clients. The four areas required to run an efficient terminal – administration, maintenance, operations, and commercial management – are offered to clients.

2.3.5 Stevedoring Services

AGUNSA operates the loading and unloading of cargo for clients. AGUNSA manages general orders with the mainstream teams and offers their Project Cargo team for more complex cargo transportation.

2.3.6 Pilot Boats

The embarking and disembarking of vessels, as well as at-port assistance and maintenance, is also offered to clients.

2.3.6 Container Depot

With the high demand of import and export cargo, AGUNSA offers container warehousing as well as the retail of containers and accessories for these.

2.3.7 Freight Forwarding

Many of the services previously mentioned are combined together to offer freight forwarding to small and medium size clients. Everything from shipping, transportation, logistics and distribution are offered to clients through AGUNSA, corporations within the AGUNSA network, or through qualified third-party operators.

2.3.8 Bunkering

AGUNSA acts as a supplier of all fuel and lubricants needed for vessels and ports.

And the final service AGUNSA offers is logistics and distribution.

2.4 Logistics & Distribution

Globalization, market pressures, and growing competitors have driven companies to find areas to differentiate themselves in, in order to gain competitive advantages and expand their market share[14]. Enhancing supply chain management has been a key area for this restructuring process. Apart from a financial incentive to enhance these, logistics & distribution are key processes connected with customer satisfaction – today's new high-value corporate objective – as customers are continuously demanding greater value from the supply chain[15]. As a result 3PLs – third party logistics providers – have become increasingly popular around the world. They have been attractive logistics alternatives to both large and smaller enterprises as they deliver the complex services required by large enterprises, and aid small companies to enter other domestic and international markets through services that, if handled by the enterprises themselves, could pose higher risks. The high customer adaptation and problem solving abilities of 3PLs have made them more

[14] Hertz 2003
[15] Gourdin 2006

appealing than other logistics service providers (see Figure 2). The 3PL market has grown over USD$10 billion in just a year, from USD$187.4 in 2007 to USD$199.7 billion in 2008[16].

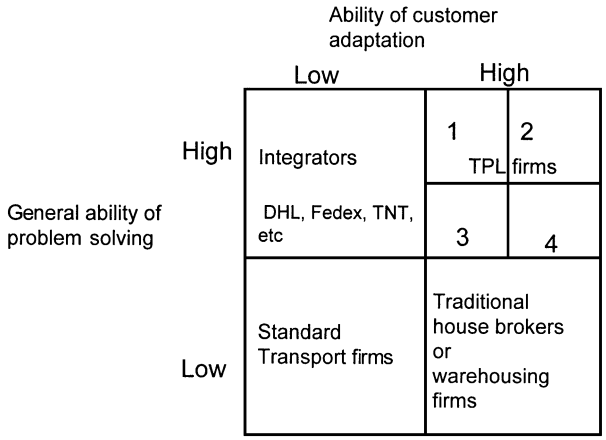


Figure 2: Logistic Provider Abilities – Third Party Logistics (TPL) Provider Position[17]

Chile's capital is not only home to AGUNSA's headquarters, but also home to AGUNSA's first warehouse. Beginning in 1996, AGUNSA launched its logistics and distribution service division with a 300 m^2 warehouse in the outskirts of Santiago in Lampa. Today, the Santiago L&D division operates an 80,000 m^2 warehouse, resulting in 126,000 m^2 of warehousing operated by AGUNSA worldwide. These warehouses offer reception, storage, added value, and distribution services. Although the warehouse is owned by AGUNSA, the warehouse is operated and administered by one of AGUNSA's daughter companies – REPORT (see Figure 3).

[16] Armstrong, R. (2009, January 28). *3PL Customers Report Identifies Service Trends, 3PL Market Segment Sizes and Growth...* Retrieved March 23, 2009, from Thomson Reuters Web Site: http://www.reuters.com/article/pressRelease/idUS213963+28-Jan-2009+PRN20090128
[17] Hertz 2003

2.4.1 REPORT Ltd.

Originating in one of Chile's busiest and most popular ports, Recursos Portuarios y Estibas Ltda, known as REPORT Ltd., began operating in Valparaiso as a stevedoring service provider. Today, REPORT operates 12 offices throughout Chile. It offers a variety of services, mainly focusing on warehouse operations and stevedoring. These services have become crucial to AGUNSA's Distribution Center in Santiago (DCS).

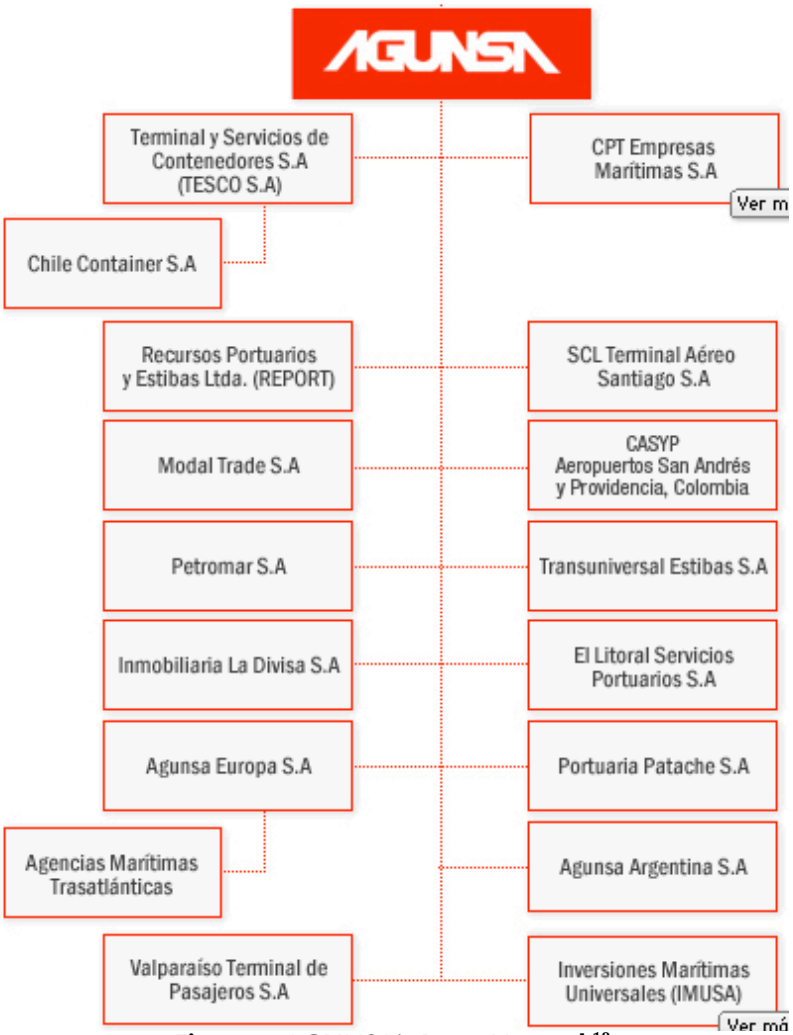


Figure 3: AGUNSA's Inner Network[18]

[18] AGUNSA. (2006). *About AGUNSA: Group structure*. Retrieved March 22, 2009, from AGUNSA Web Site: http://www.agunsa.com/eng/index.php?option=com_content&task=view&id=26&Itemid=27

The 80,000 m^2 distribution center is divided into 5 warehouse buildings as seen in the figure below. The clients shown are the majority occupants of the warehouse, but not the sole clients stationed there. Module D is currently the largest warehouse in the distribution

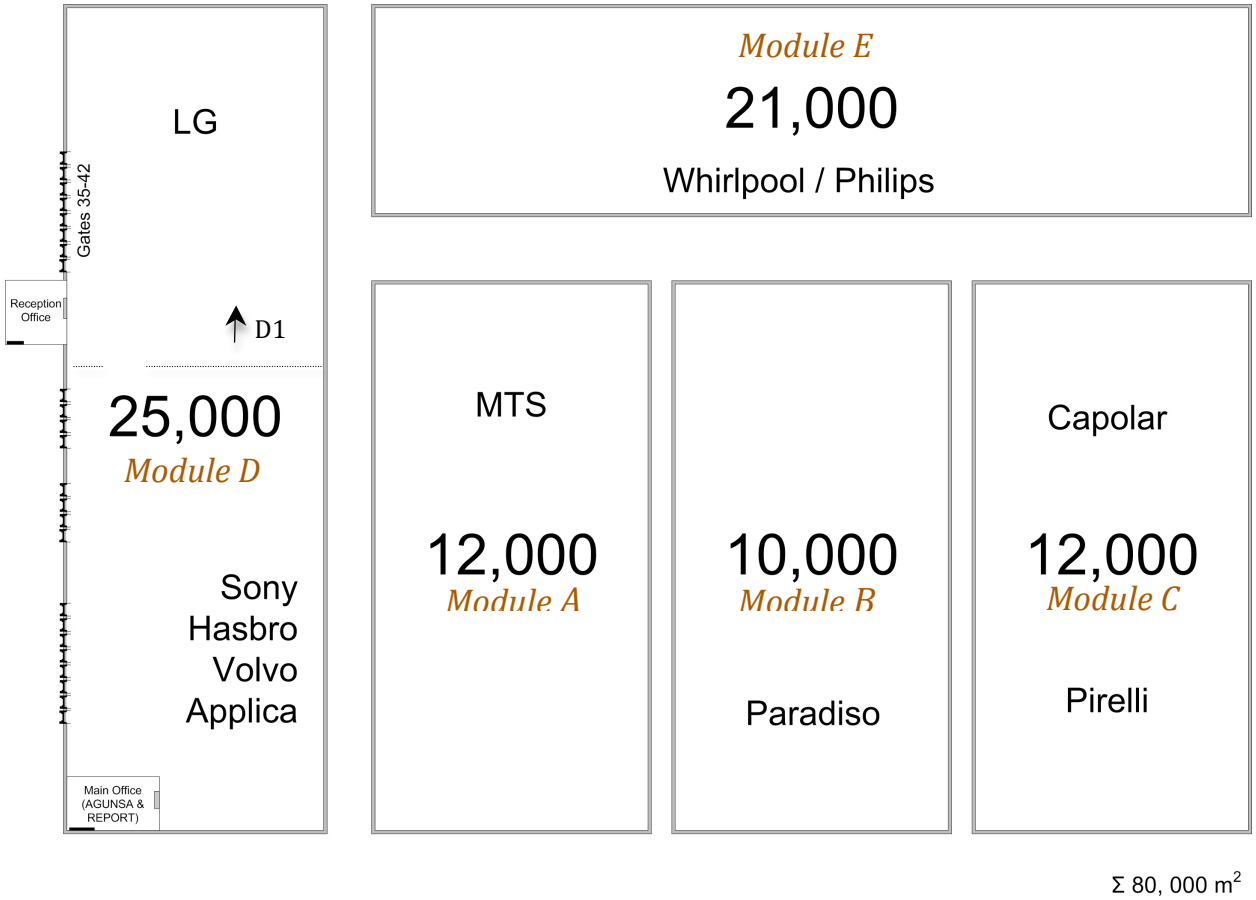


Figure 4: AGUNSA's Distribution Center in Santiago (DCS)

center. It recently received Sony as the newest client during Q3'09. But the biggest client in the entire DCS is LG, situated in this module. The expansion of module D, D1 (finished in 2007), currently holds only LG products, mostly White Line and Air Conditioning products. The Electronics Line is situated in racks in module D. LG relies on quality performance by REPORT's warehouse operations in order to expand its business in Chile.

2.5 Warehouse Operations

Within a logistics network, warehouses act as critical nodes with the primary function of storage. Market competition requires continuous improvement in the operation of distribution networks, which in turn requires higher performance from warehouses[19]. Distribution warehouses collect products from different suppliers and deliver these to a number of customers. Regardless of the type of warehouse – distribution, production, or contract – these facilities perform a variety of important functions such as:

- Providing temporary storage of goods
- Consolidating products for customer orders
- Serving as a customer service facility (after sales services, etc…)
- Protecting goods
- Performing added value services
- and Inventory (Facility Design)[20]

Warehouses fulfill these functions through 5 main processes: reception, storage, order picking, added value services, and dispatch.

[19] Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on warehouse operation: A comprehensive review. *European Journal of Operaitonal Research , 177* (1), 1-21.
[20] Heragu, S. S. (2006). *Facilities Design* (2nd Edition ed.). Lincoln, NE, USA: iUniverse Inc.

2.5.1 Reception

Reception is the first process encountered by an incoming shipment. The Logistics Planning and Control department assigns instructions for the incoming transportation (such as docking gate assignment) and will provide the necessary equipment required to unload the shipment[21]. Products will arrive at a receiving dock and be unloaded. These will be checked and transformed if necessary (repacked into pallets) until storage personnel carries on with the next step[22].

2.5.2 Storage

Storage is the second process that encounters an incoming shipment. Three fundamental decisions must be made in order to fulfill the function of storage – how much inventory should be kept in the warehouse for a stock keeping unit (SKU), how frequently and at what time should the inventory for an SKU be replenished, and where should the SKU be stored in the warehouse. This information is processed and communicated between 3PL provider and supplier. Once a shipment has arrived, storage personnel, mostly operating warehouse vehicles, transport the SKUs to their assigned location within the warehouse. Warehouses may have a variety of physical storage layouts employing racks, storage areas, and so on, depending on the physical characteristics of the goods (pallet storage vs. case storage)[23].

[21] Gu 2007
[22] Rouwenhorst 2000
[23] Gu 2007

2.5.3 Order Picking

Order picking, as seen in Figure 5, is the most expensive process of all. There is a variety of order picking methods, which include a combination of batching, zoning, and picking practices[24]. Regardless of the combination, the purpose of order picking is to retrieve items from their storage location and be transported to their sorting, consolidating, and/or added value processes[25].

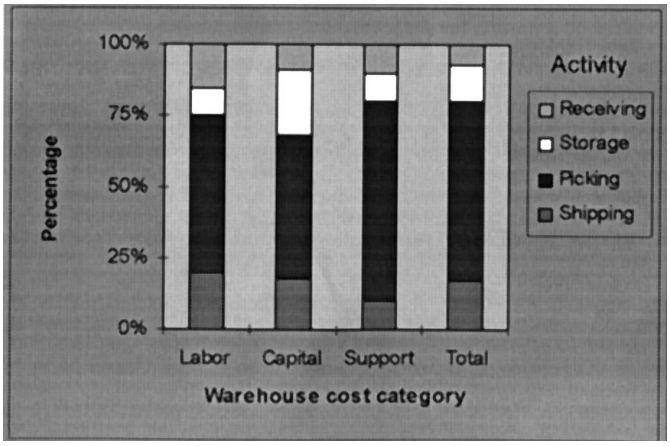


Figure 5: Warehouse Cost Category[26]

2.5.4 Added Value Services

Although not necessarily part of the standard warehouse operations, added value services follow order-specific instructions to enhance the products to be shipped. For example, many customers ask for 3PL providers to place pricing tags and other stamps on products in order to arrive at their final location ready to be sold.

[24] Gu 2007
[25] Rouwenhorst 2000
[26] Van den Berg 1999

2.5.5 Dispatch

Once an order's items have been sorted, processed through added value services (when required), and consolidated, they are placed at the designated loading dock gate. Shipping personnel will load these onto the respective carriers and be sent to customers (retail stores, personal venues, other distribution centers, etc…)[27].

[27] Rouwenhorst 2000

3 Methodology

The central goal of this project was to investigate the degree of efficiency within the logistics cycle of warehouse operations for the client LG, at AGUNSA's Distribution Center in Santiago (DCS), to identify processes requiring improvement. AGUNSA's Senior VP of Commercial Logistics noticed a growth in the latest warehouse operations costs at the DCS, specifically relating to labor costs. Today's logistics research offers a variety of approaches to audit warehouse performance, such as that of AGUNSA's DCS.

Warehouse operations depend on three key components: space, people, and equipment[28]. By quantifying the allocation, productivity, and utilization of each, respectively, warehouse performance can be analyzed. Since AGUNSA's DCS does not seek to make any physical rearrangement to its space allocation, it will be excluded from the warehouse performance analysis.

The quantification of people's productivity has led to a multitude of performance metrics. Since 1997, a common warehouse performance metric has been the pallet-per-hour ratio for each employee. This measure is collected for all employees each month over a period of time (≥year), and a quality control analysis is performed in order to establish benchmarks. Performance is thereon based on these standards[29].

[28] Ackerman, K.B. (1997). *Practical Handbook of Warehousing* (4th Edition ed.). Norwell, MA: Kluwer Academic Publishers
[29] Ackerman, 1997

Other common performance metrics include:

- Orders per hour = $\frac{Orders\ Picked/Packed}{Total\ Orders}$
- Lines per hour $\frac{Lines\ Picked/Packed}{Total\ Warehouse\ Labor\ Hours}$
- Items per hour = $\frac{Items\ Picked/Packed}{Total\ Warehouse\ Labor\ Hours}$
- Cost per order = $\frac{Total\ Warehouse\ Cost}{Total\ Orders}$
- Cost as percentage of sales = $\frac{Total\ Warehouse\ Cost}{Total\ \mathrm{Re}venue}$ [30]

Most of these metrics focus on a group of orders, most commonly distributed over a period of time (weekly or monthly) rather than analyzing each order performance in depth. These are tools used to create benchmarks for overall performance and efficiency as well.

Another approach used to measure efficiency is the Data Envelopment Analysis (DEA). It is a linear programming technique that measures the relative performance of units with multiple inputs and outputs. The efficiency of each unit is measured according to the ratio

[30] Hill, J. M., & McGinnis, D. L. (2003). Warehouse Performance Assessment & Benchmarking. *Georgia Tech*, (pp. 1-7). Atlanta.

of the weighted sum of outputs over the weighted sum of inputs. This allows for multiple factors to be taken into account[31].

With the use of the Internet, the DEA model has been implemented to compare efficiencies not just within, but also between warehouses. The rising DEA-variation model known as iDEAs, Internet-based Data Envelopment Analysis for Warehousing, compares one warehouse to a cohort of "peer" warehouses based on the best performance. The model can also identify the technologies and practices that hold the highest operational efficiency[32].

A last, more general, performance evaluation technique is the assessment of financial and nonfinancial metrics that are consolidated into an objective function with weights assigned by the evaluator. The different performance metrics are presented in Figure 6.

[31] Emrouznejad, A. (2001). *Ali Emzounejad's Data Envelopment Analysis Web Page*. Retrieved from http://www.deazone.com/index.htm

[32] McGinnis, L. F., Chen, W.-C., Griffin, P., Sharp, G., Govindaraj, T., & Bodner, D. (2002). *Benchmarking Warehouse Performance.* Georgia Institute of Technology, School of Industrial & Systems Engineering. Atlanta: GATech.

Level	Performance metrics	Financial	Non-financial
Operational	Cost per operation hour	◆	
	Information carrying cost	◆	◆
	Capacity utilisation		◆
	Total inventory as:	◆	
	– Incoming stock level		
	– Work-in-progress		
	– Scrap level		
	– Finished goods in transit		
	Supplier rejection rate	◆	◆
	Quality of delivery documentation		◆
	Efficiency of purchase order cycle time		◆
	Frequency of delivery		◆
	Driver reliability for performance		◆
	Quality of delivered goods		◆
	Achievement of defect free deliveries		◆

Figure 6: Framework on operational metrics for the performance evaluation of a supply chain[33]

The pallet efficiency model, benchmarking ratios, DEA, iDEAs, supply chain operational framework, and other such models are cost accounting models that focus on direct costs incurred within operations, but do not specifically identify what activities act as bottlenecks, incur wastes, etc. Indirect costs are not measured to a large extent.

Unlike these models, the activity-based costing (ABC) method identifies activities that consume resources and the level of consumption within each. Indirect costs are assigned to direct costs, taking into account more variables and potential drivers of performance within operations. The primary goal of this methodology is to measure the logical and quantifiable relationships between the utilization of resources, the performance of

[33] Gunasekaran, A., Patel, C., & Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain envirnoment. *International Journal of Operations & Production Management , 21* (1/2), 71-87.

activities, and the products or services they provide[34]. Performance models can be created from this ABC methodology.

In order to evaluate the performance of AGUNSA's DCS and identify the origin of rising costs, low value adding activities and wastes must be thoroughly observed. By implementing a model based upon the ABC method, these activities will be taken into account and evaluated to a much deeper extent than the other mentioned models. Nevertheless, certain metrics from the other models will be used to analyze the ABC costing data, mostly relating to capacity and costs statistics.

From May 12th, 2009 to June 21st, 2009, I compiled a general overview of LG operations at the distribution center through information gathered from REPORT warehouse documents, meetings with the various warehouse departments, observational analysis of the processes, and time-data collection.

First, I explored REPORT's Manual of Logistics Procedures, which explained the standard steps to complete the 5 processes, both physical and administrative tasks included. This familiarized me with the expectations of warehouse operations by both REPORT and AGUNSA. I then met with management and the various department heads that informed me of current operations performance, future forecasts, and the overall operations cycle specific to orders from the client LG. I explored the actual performance by entering the

[34] Themido, I., Arantes, A., Fernandes, C., & Guedes, A. (2000). Logistic costs case study - an ABC approach. *Journal of the Operational Research Society , 51* (10), 1148-1157.

warehouse floor and observing each process (reception, storage, order picking, added value services, and dispatch) in detail, analyzing activities involved in completing the goals of each process. With this introduction to warehouse operations at the DCS, I was able to formulate descriptions for the 5 processes.

3.1 Performance data-collection

As a result of these descriptions, I designed a data-collection model unique to the LG Reception process, based on the Activity-based cost (ABC) model, measuring performance in terms of time allocation. . The model I designed is divided into the major activities of the Reception process that added value or cost to the LG operations in terms of time.

3.1.1 Common data-collection procedure

On a daily basis, I received the Reception Schedule from the Planning and Control department that included all expected incoming shipments for the day (See APPENDIX D: SPSS Data Calculations (for all shipments) for example). By identifying all LG orders, I created a data-collection schedule that aimed to cover all of these orders. I arrived 10 minutes prior to the expected time of arrival for the first shipment of the day. I reviewed all Reception documentation for the incoming shipment and shadowed the Reception Supervisor to gather the initial administrative-related data. Times were recorded upon the completion of the various activities and specific observations were recorded for each shipment, such as the number of unloading workers, required reception tools for unloading, assigned reception labels, and number of damaged items. Upon the

completion of the Reception process, the time required for Storage personnel to transport the unloaded shipment to the assigned warehouse location was recorded. Once this process was over, idle time affecting the next shipment was recorded. Figure 7 shows the different activities that were timed for each shipment.

	Description
A	**Request to open door**
	Idle Time:
B	**Take photos of seal**
	Idle Time:
C	**Open seal**
	Idle Time:
D	**Open container**
E	**Take photos of container**
	Idle Time:
F	**Dismount boxes**
	Idle Time:
G	**Take photos of container (End)**
	Idle Time:
	After Close Doors Idle Time:
	After Done Idle Time:
H	**Storage for Reception**
	S.I.T 1:
	S.I.T 2:

Figure 7: Time oriented data-collection model for Reception

3.1.2 Reception time-recorded activities:

A. **Request to open door**: This activity marks the beginning of the Reception process and is triggered by the Reception Supervisor contacting the Security Monitor through professional radio walkie-talkies, requesting to open the incoming shipment's unloading dock gate. The truck is always stationed outside the gate prior to the request. The activity ends once the gate has been opened.

Idle Time: Between activities A and B.

B. **Take photos of seal**: This activity begins once the Reception Supervisor arrives at the gate to take pictures of the container doors and of the seal locking these doors. Once pictures have been taken, the activity is over.

Idle Time: Between activities B and C.

C. **Open seal**: The Reception Supervisor will signal the unloading crew to break the seal once pictures have been taken and container information has been recorded on the Reception forms. The activity ends once the Reception Supervisor signals the driver to open the container.

Idle Time: Between activities C and D.

D. **Open container**: The activity begins once the driver begins to pull out of the gate. He will leave the driver's seat and walk to the back of the truck to open the container doors. He will return to the driver's seat and back the container towards the gate as close as possible. Once the truck is no longer moving, the activity is over

Idle Time: Between activities D and E.

E. **Take photos of container**: The activity begins once the Reception Supervisor arrives at the gate and begins to take photos of the inside of the container in the state in which it arrived. Once pictures are taken, the activity is over.

Idle Time: Between activities E and F.

F. **Dismount boxes**: The activity is triggered the Reception Supervisor's order to begin unloading the shipment. It will end once the last item has been placed in the Reception floor area in front of the gate.

Idle Time: Between activities F and G.

G. **Take photos of container**: The activity begins once the Reception Supervisor arrives at the gate and begins to take photos of the inside of the empty container. Once the pictures are taken, the activity is over.

Idle Time: Between activity G and dock gate door being closed

Idle Time: Between activity of doors being closed and Reception documentation is finalized

Idle Time: Between the finalization of Reception documentation and the beginning of activity H.

H. **Storage for Reception**: This activity begins once Storage personnel begin to pick up the first set of items in the Reception floor area (with manual fork lifts or lift trucks). Items will be transferred to their assigned warehouse location. The activity ends once the last item is placed in the assigned location.

Special Idle Time (S.I.T. 1): Time reception is empty, but unable to receive next shipment.

Special Idle Time (S.I.T. 2): Doors have been closed; however, the truck has not left.

3.2 Comparing and Analyzing Timed Activities

After recording the different steps of the model mentioned above, I statistically analyzed the compilation of data. This statistical data included means, standard variations, frequencies, minimum and maximum values, and percentage contributions plots for each activity. This would analyze the raw data and create key figures for each step. After these descriptive statistics were calculated, the different variables were compared to one another in order to identify what variables demonstrated cause-and-effect relationships. For example, the number of workers or the number of equipment used was plotted against dispatch times in order to understand how the allocation of these resources affected the

activity's cycle times. On the other hand, ratios such as lines per hour and items per hour were also calculated to create benchmarks to compare the different order processing's and to create standards for future operations. These results were driven through quality control analysis as well and led to the evaluation of potential performance, revolving around the decrease in wastes and the increase in capacity. Note that idle times were only used in the statistical analysis if they were greater than 5 minutes.

The objective was to determine areas needing improvement, wastes present, and overall performance of the Reception process for LG shipments. I looked at the different products LG sent to the DCS and variations within each. I also looked at how the varying number of workers and unloading tools affected the efficiency of the activities, as mentioned before..

From this analysis, I determined the key areas creating the least value and requiring the most improvement. Recommendations were made to improve efficiency and reduce wastes within the process.

4 Warehouse Operations at AGUNSA's Distribution Center in Santiago

Like many other warehouses, AGUNSA's DCS is very labor intensive. In module D, REPORT employees perform storage, order picking, added value services, and administrative activities. A third-party company – MTO – performs reception unloading and dispatch loading activities.

The warehouse has implemented 3 mainstream continuous procedures as seen in **Error! Reference source not found.**.

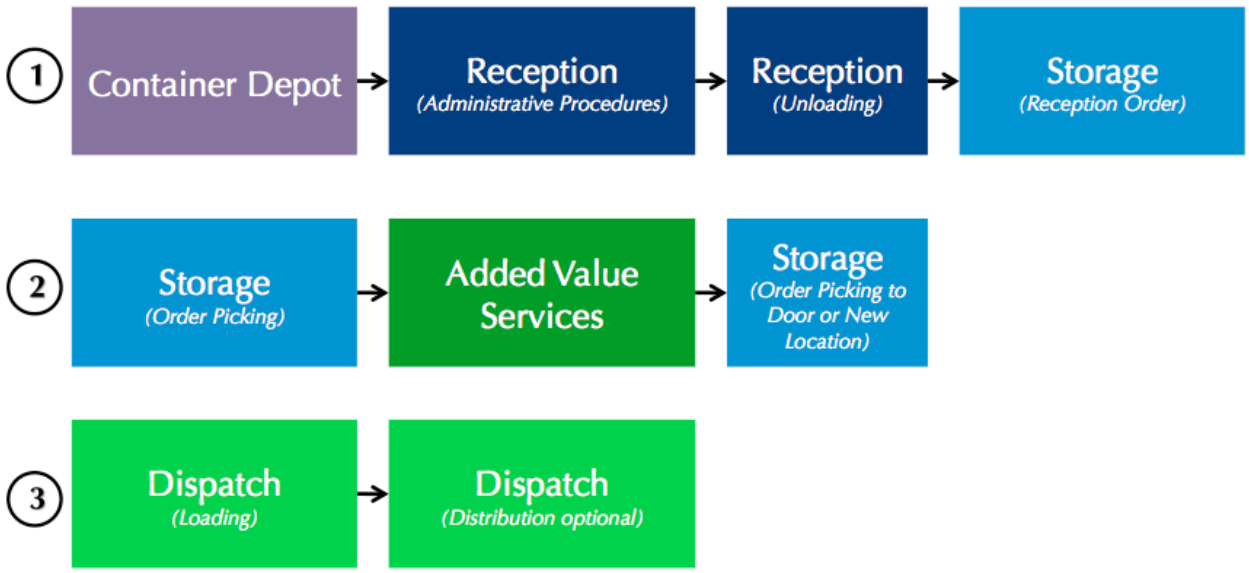


Figure 8: Warehouse Operations' Continuous Procedures

These continuous procedures incorporate the 5 processes of warehouse operations mentioned in Section 2.5 Warehouse OperationsREPORT does differ from other warehouse-

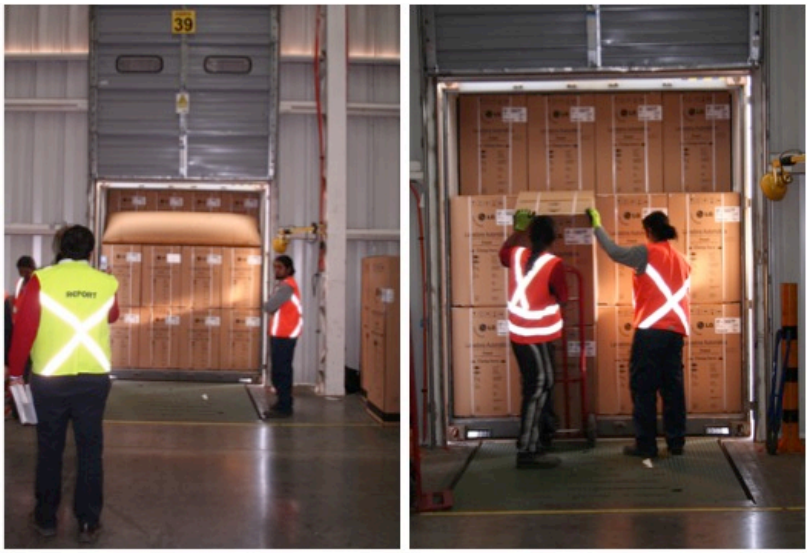
operating companies by combining the Storage and Order Picking processes into the responsibility of one department.

4.1 First Continuous Procedure

The first continuous procedure is basically the Reception process. From the container depot, trucks transport containers to the warehouse. The Reception Office will check transportation documentation from the drivers regarding the shipment, which will be verified with the Planning and Control Schedule. Upon approval, the truck will reposition the container at the assigned unloading dock gate and the Reception Supervisor will fulfill administrative activities – Steps A-E mentioned in Section 3.1.2 Reception time-recorded activities: – that will lead to Step F: Dismount Boxes (See Figure 9).

The first 10% of the SKUs in the shipment will be set aside in the Reception area for REPORT's Technical Inspection to check the inside products for any damages or hazardous conditions. A certain number of these must pass in order to approve the admission of the shipment into the storage locations (specific to each SKU). If this requirement is not met, the Technical Inspection employees will inspect another 10%; if the requirement is not met again, they will inspect all items in the shipment. Items that pass the Technical Inspection will be labeled with the LG warranty label (See Figure 11).

Step B: Photographs of Seal | Step C: Opening Seal | Step D: Opening Container



Step E: Initial Photographs of Container | Step F: Dismount Boxes

Figure 9: Steps B-F of Reception

Manual forklifts are used to unload containers on most occasions; however, certain unique SKUs of greater weight will require a lift truck. MTO employees will place the shipment SKUs into pallets according to specifications on the box and pallet labels and wrap these with stretch wrap to consolidate them (See Figure 14).

The Reception Supervisor will also pass the pallet labels (See Figure 12) and SGS (Societe Generale de Surveillance – provides inspection, verification, testing, and certification services[35]) stickers to MTO employees to be placed on the SKUs (See Figure 9). Any damaged boxes will be set aside and sent to the LG's Damaged Goods area in order to be repackaged according to Technical Inspection instructions (whether the product has been affected by the damaged packaging or not).

Figure 11: LG Technical Service Sticker

Figure 10: SGS Sticker

Figure 12: Pallet Label

[35] SGS. (2009). *Nuestra Organizacion*. Retrieved May 18, 2009, from SGS in Chile Web Site: http://www.cl.sgs.com/es_cl/our_organization_cl

Figure 14: Example of Refrigerator Pallet in Reception Area

Once all items have been unloaded, the Reception Supervisor will take photos of the empty container to capture the state of the container for insurance purposes. The gate will be closed, Reception Order forms will be finalized (reception process will be deemed completion status within the system), and they will be transferred to the Storage team to begin the transportation of pallets to their assigned storage location. White Line products are stored on floor sections designated by location codes, with pallets being positioned one on top of the other (See Figure 14). Electronics are stored in racks both in module D1 and module D (See Figure 15).

Storage: White Line Floor Sections | Storage: 1 Floor Section | Storage: Location Code

Figure 14: White Line Storage Area

Storage: Electronics within Racks | Storage: Pallet of Electronics SKU

Figure 15: Electronics Storage

4.2 Second Continuous Procedure

The second continuous procedure begins with an Order Picking request. The Storage team will retrieve the number of items requested by the order and deliver them to the Added Value Service area or straight to the Dispatch Area according to order instructions. In the Added Value Service, LG's customers' requests will be implemented, such as placing pricing labels on all order items. Once Added Value Service has finished these activities,

they will re-consolidate the pallets. The Storage team will retrieve these and deliver them to the assigned Dispatch gate due to a subsequent Order Picking request.

4.3 Third Continuous Procedure

The last continuous procedure begins in a similar manner to the reception procedure. Truck arrives at assigned loading dock gate, gate opening is requested to security monitor, door is opened and loading begins by MTO employees (initial administrative steps are not required by the Dispatch process). Copies of the transportation and dispatch documents will be given to the truck driver with specific instructions of the delivery time and destination for each order being shipped. These trucks are hired by LG's customers, or by third-party companies within the AGUNSA network. Figure 16 is a flow chart of the operations within the logistics cycle at the DCS.

According to the General Manager and the Planning and Control department, one of the primary issues in warehouse operations for LG, and one of the key sources of overhead costs, has been the lack of performance in the Reception process, the 1st continuous procedure. In fact, the capacity of incoming containers for LG is defined by the time allocated to each activity in the Reception process (resulting in 120 minutes allocated to each incoming shipment by the Planning and Control Schedule). The capacity for LG White Line containers is 20 per day and 5 containers per day for LG Electronics. Unlike the other processes, the inability to fulfill this capacity during regular work hours by the Reception process makes it the bottleneck. Continuous procedures 2 and 3 have met

corporate expectations, and the observation of these procedures deemed them acceptable performance. Since the Reception process acts as the largest source of overhead labor, the model presented in Section 3.1.1 Common data-collection procedure is only specific to this process. As a result, the objective will be to analyze Reception-related activities only.

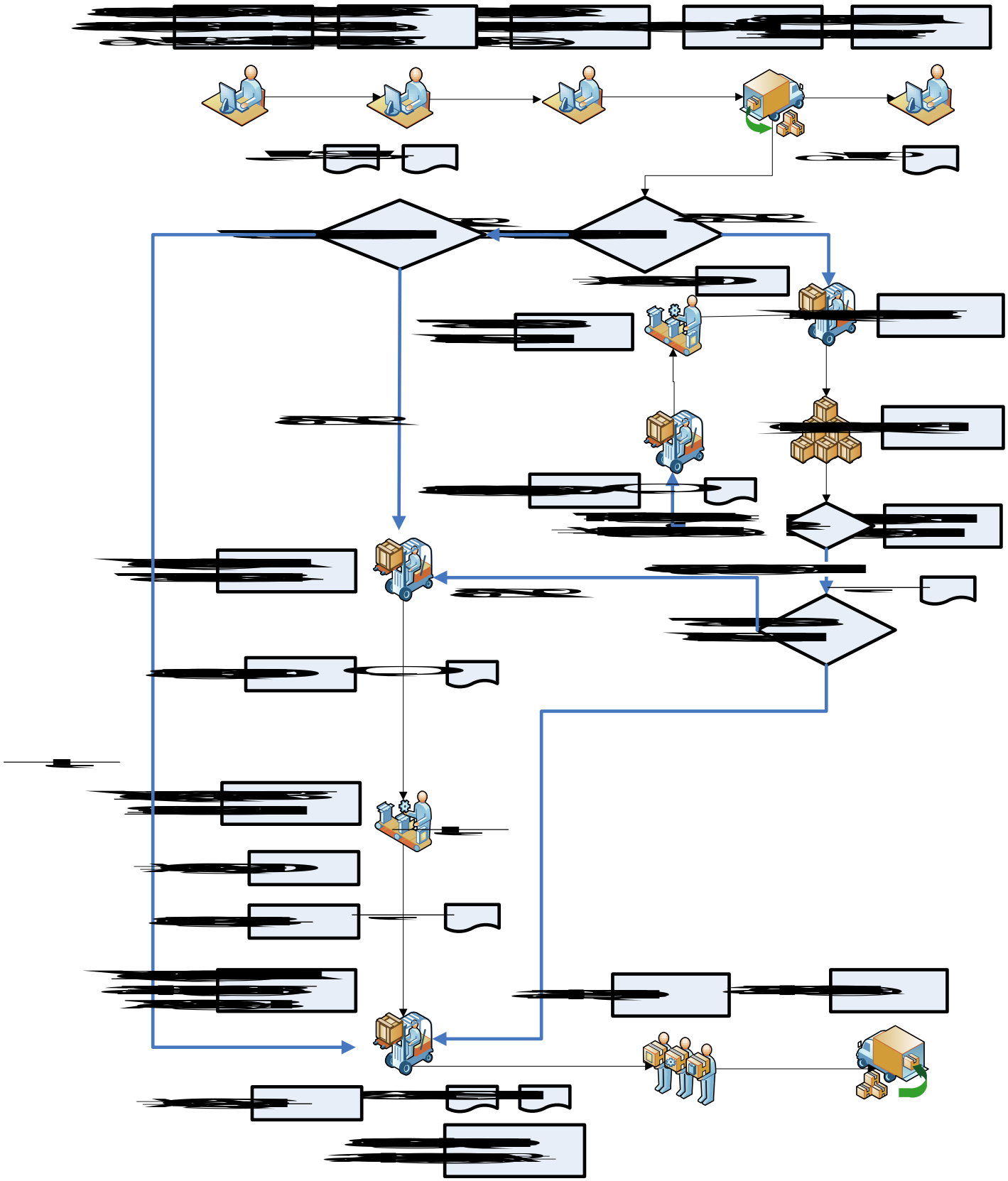


Figure 16: Flowchart of REPORT's Warehouse Operations

5 Results & Discussion

In this section, raw data will be explained, followed by a discussion of the analysis gathered from said data, resulting in recommendations to diminish wastes, i.e. idle times.

5.1 White Line LG SKUs

The White Line at LG ships mostly refrigerators and washing machines to AGUNSA's Distribution Center in Santiago.

5.1.1 Refrigerators

During the time-collection period, 4 different types of refrigerator SKUs were admitted into the warehouse in 13 shipments.

Table 3: Refrigerator Shipments

Product ID	Volume	Weight
GC-B359BLQ	66.0222001	5226.8001
GM-341SC	62.4098002	4810.0002
GM-R439YVQ	65.4959008	4355.0008
GN-V232RL	50.7299002	4590.0002
Total	62.78990813	4528.21513

The recorded times for these shipments resulted in the following statistical results. Refrigerator shipments started an average of 21.01 minutes late during weekday

operations. Although this is a non-value adding aspect of the process, almost all instances amounted to a late start that was within quality control calculations (See Figure 17).

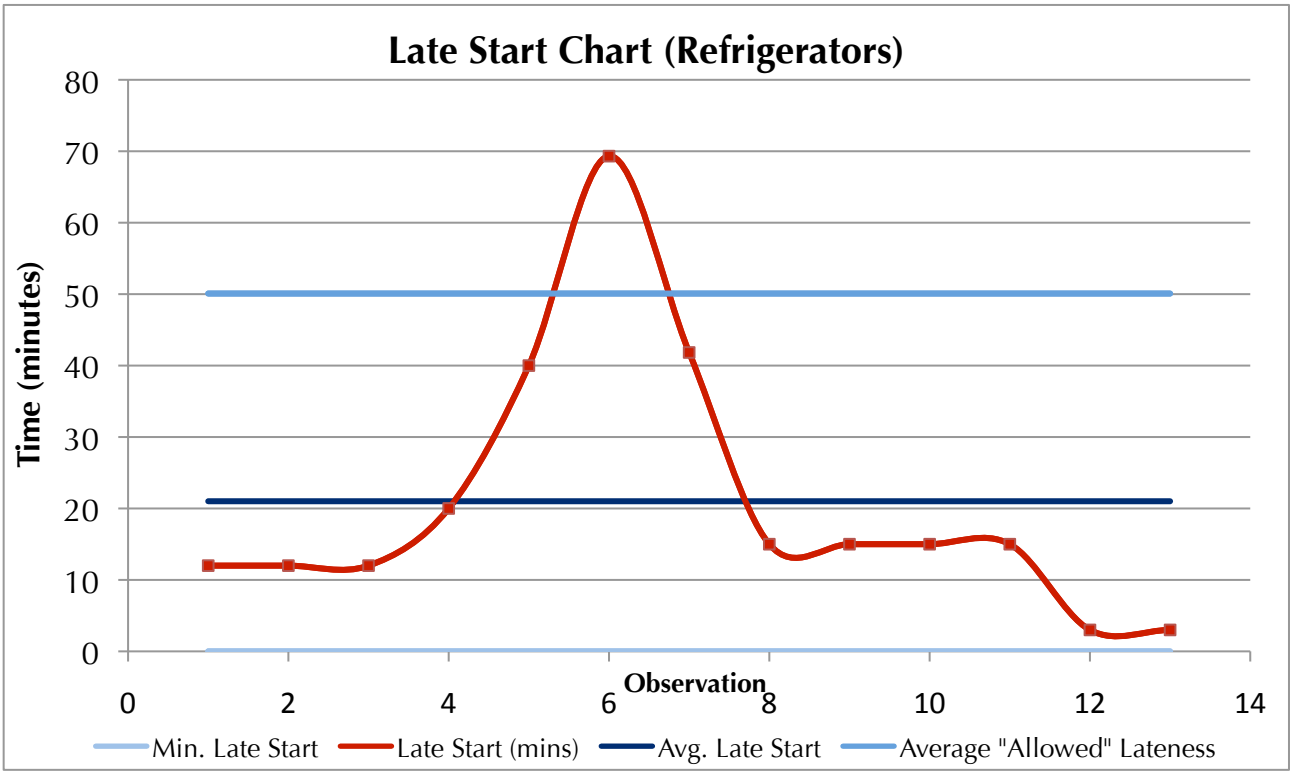


Figure 18: Late Start Refrigerators Quality Control

Active reception time averaged a total of 54.92 minutes. For Step F (Dismount boxes), times correlated with the number of boxes within the shipment. These times met Planning and Control expectations with an average of 19.5 seconds/box for shipments with 67 and 73 boxes, and 20.8 s/box for shipments with 122 boxes (See Table 4). These consistent results were achieved with 3 MTO employees assigned to shipments of 67 and 73/74 boxes, and 4 MTO employees for 122 boxes, with 2 manual forklifts per shipment.

Table 4: Refrigerators Step-F Times

Boxes	N	Mean	St. Dev.
67	8	0:21:47	+/- 1
73/74	3	0:29:21	+/- 5
122	2	0:42:14	+/- 2
Total	13	0:26:12	+/- 8

The average reception idle time was 16.27 minutes for all shipments. An average of 27.8 minutes remained for storage to transport the respective pallets to their storage destination in the warehouse. However, the average idle time of 19 minutes between the end of the Reception process and the beginning of storage, and the average of 15 minutes for Storage personnel to transport the refrigerator pallets to their assigned storage location exceeds the allocated capacity of 120 minutes by around 6 minutes, on average.

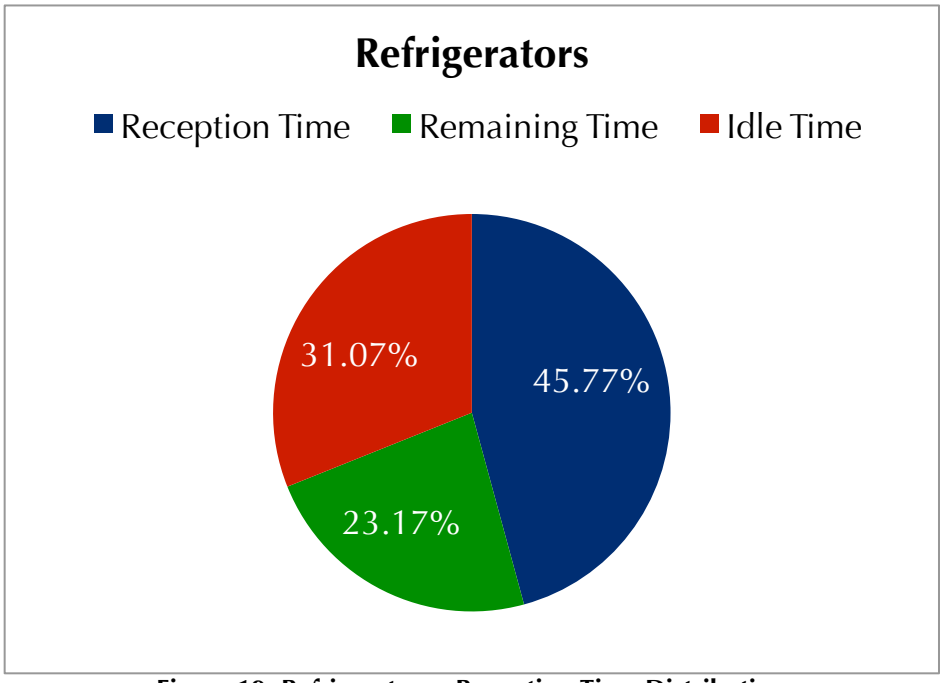


Figure 19: Refrigerators - Reception Time Distribution

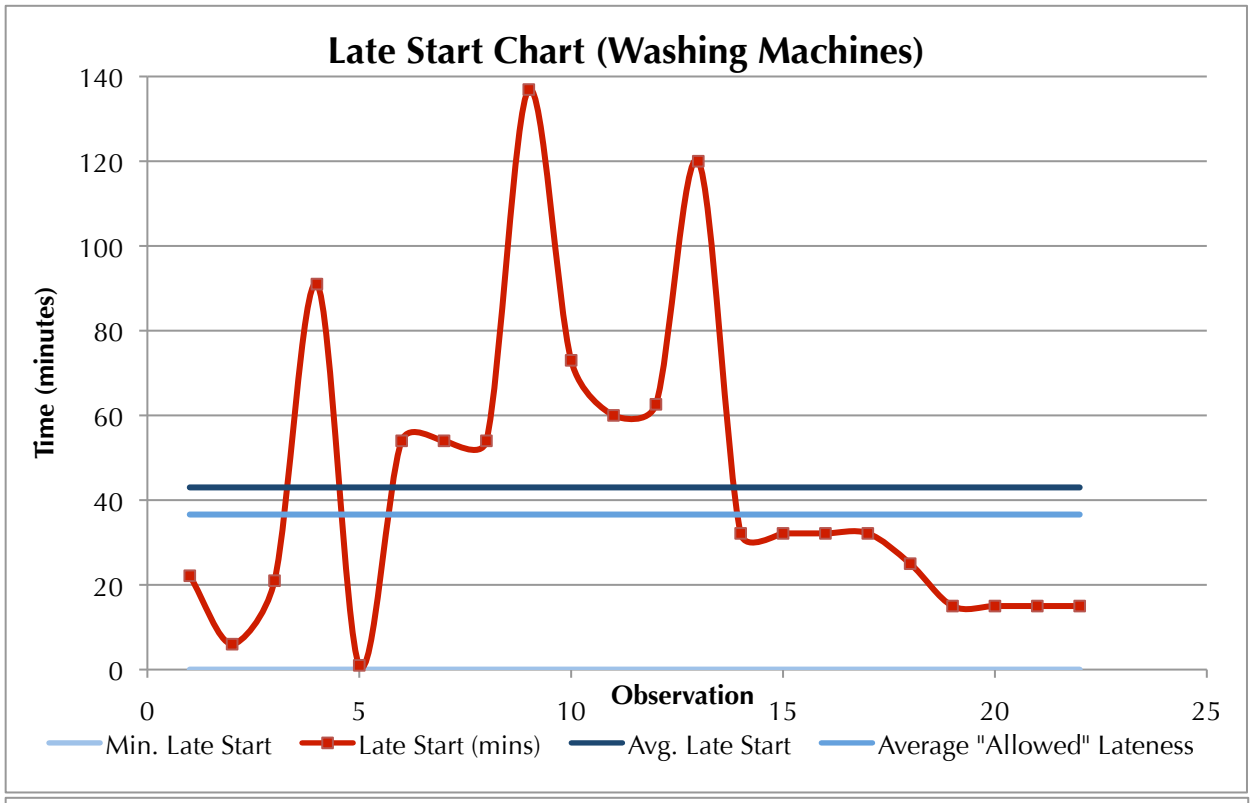
5.1.2 Washing Machines

During the time-collection period, 5 different types of washing machine SKUs were admitted into the warehouse in 26 shipments.

Table 5: Washing Machine Shipments

Product ID	Weight	Volume
F1403FDS	10530.001	59.5980001
WFT1001TEPT	4590.0004	50.7299004
WFT6605TTP	8225.0007	70.7256007
WFT7500TTP	8225.0005	70.7256005
WFT8501TEPT	4887.6679	65.2545449
Total	6599.19226	65.32752726

Washing machine shipments started an average of 43 minutes late. This average was far above the "allowed" late start, the time allocated for variability and delays. In order to achieve adequate operation levels with an acceptable level of late starts, the average number of minutes for late start per container should be at most 20 minutes; however, the ultimate goal is to eliminate any late start times in order to increase the efficiency of operations relating to washing machine orders.



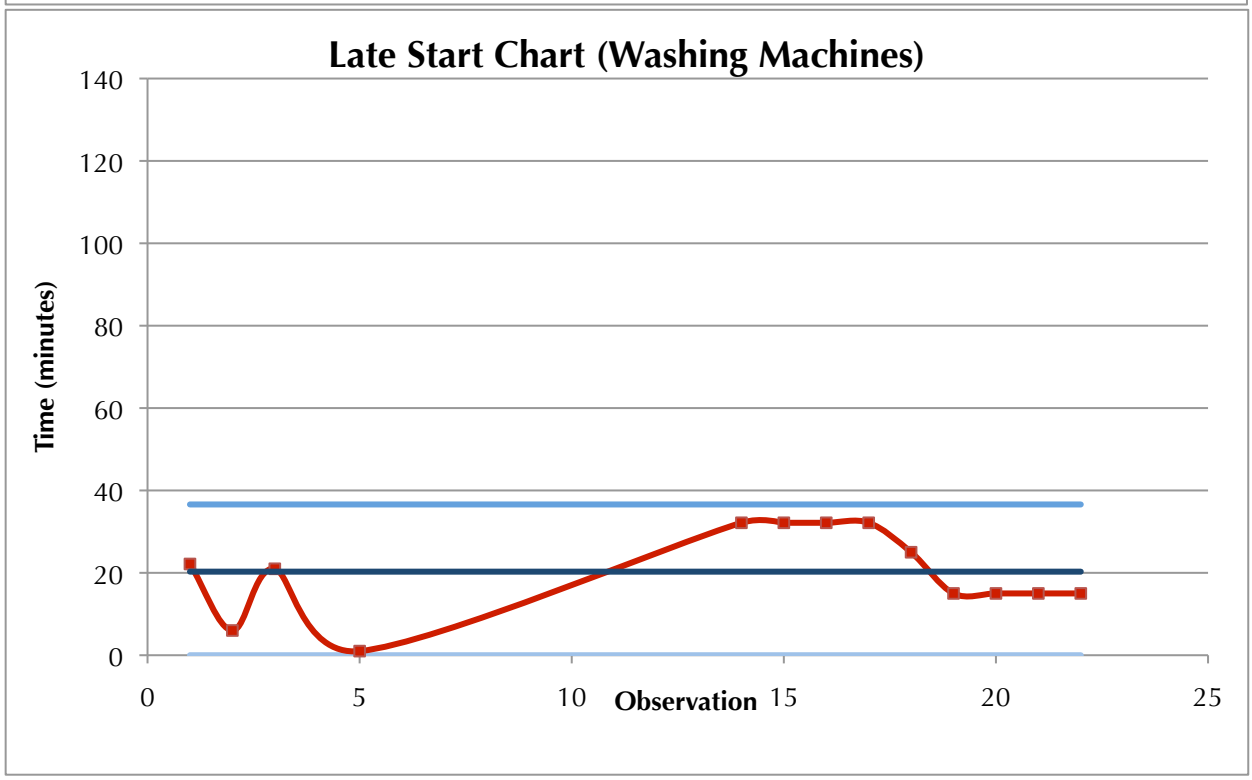


Figure 20: Late Start Washing Machines Quality Control

Active reception time averaged 63.4 minutes. For Step F, times on average varied according to the shipment volumes (See Table 6). Washing machine WFT1001TEPT, of volume 50.7299 mt^3, was unloaded at an average of 9.5s/box. WFT8501TEPT, with volume of 65.4459 mt^3, was unloaded at an average of 11.2 s/box. WFT6605TTP and WFT7500TTP, both with volumes of 70.7256 mt^3, resulted in unloading times of 11.3s/box, with a consistent number of 3 MTO employees using 2 manual forklifts.

Table 6: Washing Machine Step-F Times

Volume	Mean	N	Std. Deviation
50.7299	0:16:09.75	4	0:03:05.496
59.5980	0:29:08.00	1	.
63.7237	0:28:15.00	1	.
65.4459	0:21:12.13	8	0:09:34.711
70.7256	0:44:17.00	12	0:02:28.933
Total	0:31:39.35	26	0:13:25.388

Four MTO employees and 2 manual forklifts unloaded the WFT1001TEPT shipments 75% of the time. For WFT8501TEPT shipments however, there was a distinct difference in unloading times when 3 and 4 MTO employees were present. Allocating 4 employees, regardless of the number of manual forklifts, was 8:19 minutes faster than shipments involving 3 employees (not including 3-employee outlier of 43:15 minutes) (See Table 7).

Table 7: WFT8501TEPT Worker-Dismount time relationship

Ppl	Eqp.	Dismount boxes
3	2	0:43:15
3	2	0:28:15
3	2	0:25:55
3	2	0:23:30
4	2	0:18:07
4	2	0:17:47
4	2	0:17:45
4	3	0:16:35
5	3	0:16:43

As a result of these time-consuming procedures and large quantities of idle time, only 7.63 minutes were available to complete a 20-minute Storage activity that was on average preceded by 19 minutes of idle time. The average washing machine shipment surpassed the 120-minute time allocation by around 31 minutes.

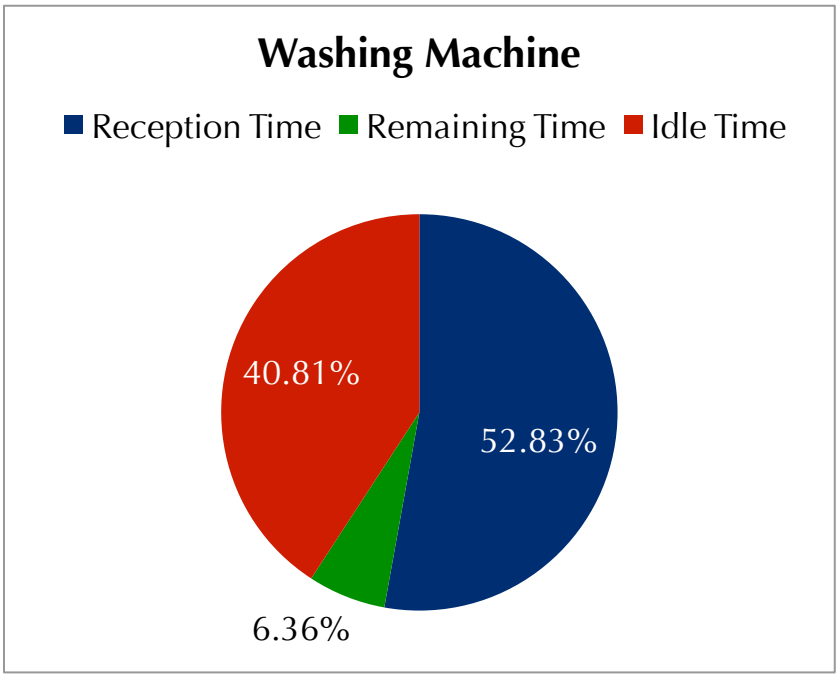


Figure 21: Washing Machine - Reception Time Distribution

Due to overlapping times between Electronics and White Line shipments, and due to the scarce number of Electronics shipments during the time-collection period, only 3 shipments were recorded. For the complete list of times recorded, see APPENDIX B: Timed Data Collection.

5.2 Overall Shipment Performance

Average times for all steps in the model presented in Section 3.1.2 Reception time-recorded activities: are shown in Table 8 and Table 9, for the 42 shipments recorded. The most significant waste for the initial administrative activities is seen in the initial idle time, between the gate opening request and the approach by the Reception Supervisor to the door to capture photos of the seal. This idle time was primarily caused by the allocation of one Reception Supervisor to the 4 gates within sub-module D1 (LG White Line sub-module). Although idle time exist between steps E and F, these are not statistically significant (n=5).

Table 8: Average Times for All Shipments (Part 1)

	N	Minimum	Maximum	Mean	Std. Deviation
Idle Time:	11	0:05:02	0:46:15	0:13:12	0:11:39
Take photos of seal	42	0:00:32.00	0:02:30.00	0:01:17.60	0:00:26.212
Idle Time:	0				
Open seal	42	0:00:15.00	0:04:01.00	0:01:07.26	0:00:46.326
Idle Time:	0				
Open container	42	0:00:19.00	0:14:26.00	0:04:21.60	0:03:45.188
Take photos of container	42	0:00:00.00	0:01:21.00	0:00:08.62	0:00:13.211
Idle Time:	5	0:06:01.00	0:39:56.00	0:24:18.00	0:13:21.717

Once step-F was completed, the biggest source of waste of the entire process presented itself. After MTO employees finish their unloading activities, it takes an average of 13 minutes for the Reception Supervisor to arrive at the gate to take pictures of the container and complete the Reception process. The probably cause is the same as for the previous idle time mentioned – 4 gates to one Reception Supervisor. This time could be effectively used to begin the storage process much sooner, which is another significant source of idle time (See Table 9 *After Done Idle Time*). Once the Reception process has been officially finished and reported to the Reception Office, it takes an average of 21 minutes for Storage to begin their activities.

Table 9: Average Times for All Shipments (Part 2)

	N	Minimum	Maximum	Mean	Std. Deviation
Idle Time:	28	0:05:10.00	0:27:12.00	0:12:53.50	0:06:13.567
Take photos of container.End	42	0:00:00.00	0:01:51.00	0:01:16.36	0:00:20.440
Idle Time:	0				
After Close Doors Idle Time:	4	0:06:06	0:25:46	0:11:30	0:09:31
After Done Idle Time:	11	0:07:17	1:23:30	0:21:30	0:22:24
S.I.T:	4	0:07:35	16:55:13	4:31:53	8:15:58
S.I.T:	8	0:15:10	1:29:29	0:46:20	0:27:13

S.I.T.s 1 and 2 are present in 4 and 8 shipments, respectively, but do not qualify as statistically significant calculations.

Table 11: Substantial Idle Times Summary summarizes some of the idle times calculated in the results mentioned, averaging a total of 16 minutes of idle time in 41 of the 42 shipments.

Table 11: Substantial Idle Times Summary

	N	Minimum	Maximum	Mean	Std. Deviation
Late Start:	38	0:01:00.00	2:46:30.00	0:43:58.87	0:43:09.182
R->S Processing Time:	12	0:00:00	1:23:30	0:19:42	0:22:14
Truck Idle Time:	8	0:15:10	1:29:29	0:46:20	0:27:13
Door Idle Time:	4	0:07:35	17:00:00	4:33:05	8:18:22
Reception Idle Time:	41	0:00:00.00	0:47:52.00	0:16:16.37	0:11:58.128

In addition to these steps, times for technical inspection, stretch film application, pallet sticker application, and SGS sticker application were also recorded for 33 of the 42 shipments (see Table 13: Specific Reception Task Times).

Table 13: Specific Reception Task Times

	N	Minimum	Maximum	Mean	Std. Deviation
Technical Inspection:	33	6.00	31.00	18.9242	6.69319
Stretch Film:	33	3.50	9.50	6.0758	1.24450
Pallet Sticker:	33	1.00	8.50	6.1515	2.25168
SGS Sticker:	33	7.00	25.00	17.0606	5.51243
Valid N (listwise)	33				

For the complete list of SPSS formulated calculations, see APPENDIX D-F.

5.3 Potential Performance

The waste created by the 1st continuous procedure has had a large impact on the capacity and performance of warehouse operations for LG orders. On a daily basis, White Line operations produce an average of 5 ½ hours of reception idle time. This lack of efficiency has not only limited capacity from growing, but has created additional overhead costs (i.e. overtime labor) that should not exist with the current limit of 20 containers/day.

Table 15: Average Daily White Line Reception Times

Product	*Late Start*	*Reception Idle Time*	*Reception Time*	*Remaining Time*	*Programmed Time*
Refrigerators	420.20	325.40	1098.40	556.00	2400.00
Washing Machine	654.00	325.40	1268.00	152.60	2400.00

Table 16: Possible Extra Capacity Calculations

Product	Possible Extra Capacity from Idle Time	Possible Extra Capacity from Late Starts* (am)
Refrigerators	5.9	3.1
Washing Machine	5.1	5.4

Table 16 shows the potential additional capacity that could be reached by eliminating idle time or morning shipment late starts. In other words, at current operations performance, for every 4 containers, 1 entire new shipment could be processed from the wasted time in these procedures. This could result in substantial financial potential gain. A 20% increase in profit could result from improving operations and increasing capacity (See Table 17 and Table 18).

Table 17: Washing Machine Potential New Profits (Chilean Pesos)

Containers Possible	Cost	Revenue	Profit
25	$ 1,152,553.67	$ 1,616,856.29	$ 464,302.63
20	$ 922,042.93	$ 1,293,485.03	$ 371,442.10
			$ 92,860.53

Table 18: Refrigerator Potential New Profits (Chilean Pesos)

Containers Possible	Cost	Revenue	Profit
25	$ 1,125,020.50	$ 1,554,050.22	$ 429,029.72
20	$ 900,016.40	$ 1,243,240.18	$ 343,223.78
			$ 85,805.94

During the month of May alone, the difference between real LG White Line warehouse operations and potential performance differed by 58.3 hours, part of which created an

overhead human resource cost of $129,954 Chilean pesos (See Table 20). Although the overtime labor cost for the month of May 2009 accounts for 2% of Total Operations Cost, this time-based difference critically affects other indirect total costs such as diminishing customer satisfaction and future opportunity benefits.

Table 20: May Reception Financial Analysis

Washing M.		151	
Refrigerator		64	
LGLB		215	
Total M3		13730.10	
Total Cost	**$**	**5,958,861.97**	
Total MTO Cost	**$**	**3,816,250.00**	
Extra HR Cost	***$***	***129,954.40***	
Total Revenue	**$**	**13,592,795.73**	
Total Profit	**$**	**3,817,683.77**	
Real WM Time		250.84	hrs
Real R Time		91.94	hrs
WM Time		*209.89*	hrs
R Time		*74.58*	hrs
Total LB Time		342.77	hrs
LB Time		*284.47*	hrs
Difference		58.30	hrs

6 Conclusion & Recommendations

The goal of this project was to identify the weaknesses of the warehouse operations cycle for the client LG at AGUNSA's Distribution Center in Santiago. In order to complete this objective, I produced a general overview of the warehouse operations relating to LG orders. After generating this overview and observing current operations, it was clear that the Reception process was the bottleneck component of the cycle. Substantial idle times and inappropriate allocation of resources created a large pool of wastes for this procedure. In order to reduce overhead costs, certain actions can be taken to minimize and eventually eliminate these wastes.

6.1 Recommendation #1: Additional Reception Supervisor

The first recommendation is to assign 2 Reception Supervisors to the 4 doors during the 2-hour shipment slots. Through this additional supervisor, idle time between steps A and B and F and G will be reduced. The simple tasks this additional supervisor must perform, totaling an average of 8:09 minutes, can be assigned to an existing REPORT employee without the need to acquire new employees.

6.2 Recommendation #2: MTO Specifications for Planning and Control Schedule

A second recommendation is to incorporate MTO specifications within the Planning and Control Schedule. The difference between 3 and 4 MTO employees involved in certain shipments can critically reduce unloading times, or result in insignificant differences (over-allocating resources to a shipment). The specifications described in Table 21 are recommendations for the products reviewed in this study. REPORT should further research

these requirements for all incoming products in order to ensure the right distribution of MTO employees within the various clients and reduce costs.

Table 21: Recommended Labor & Equipment Specifications for White Line Products in this study

Product ID	MTO Employees	Equipment
GC-B359BLQ	3	2
GM341SC	3	2
GMR439YVQ	3	2
GNV232RL	4	2
WFT1001TEPT	4	2
WFT6605TTP	3	2
WFT7500TTP	3	2
WFT8501TEPT	4	2

6.3 Recommendation #3: Additional Container Truck Driver

A third recommendation is to acquire further truck drivers to transport the containers from deposit to the dock gates. The late arrival of truck drivers at dock gates in the morning had a substantial effect on the rest of the day's performance, generally resulting in overtime required. By eliminating late starts, overtime costs could be drastically decreased. It will be financially more beneficial to hire an additional driver than continue to operate with overtime costs.

6.4 Recommendation #4: Motivational Incentives

Last but not least, a lack of motivation was observed at some points of the warehouse operations cycle. By offering seminars that teach employees of the importance of high performance levels (ex: higher customer satisfaction → greater profits), new attitudes could be instilled into culture of the company. Additional compensation based on performance

levels is also another incentive to increase motivation and reduce the current weaknesses of the processes within warehouse operations.

By implementing these recommendations, wastes in the warehouse operations cycle stemming from the 1st continual procedure will be reduced, along with costs incurred by said wastes. Benefits such as additional capacity, increased customer satisfaction, and greater profits are just a few of the results that these recommendations could generate. Nevertheless, it is extremely important for REPORT to tackle the bottleneck of the warehouse operations cycle in order to grow as a distribution center.

As requested by Gaston Oyarzun, an introductory analysis of automating some activities within the second continuous procedure can be found in APPENDIX A: Second Continuous Procedure Investigation.

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APPENDIX A: Second Continuous Procedure Investigation

REPORT's General Manager at the Distribution Center in Santiago asked for a quick overview investigation concerning the implementation of automated activities within the second continuous procedure (order picking and added value services).

The implementation of an AGVs for the order picking activities results in the following costs:

- Average Vehicle Price = 2862.85 UF (Units of currency used in Chile)
- High Maintenance Costs
- Laser System Installation = 5725.69 UF
- And additional new operational costs

These costs exceed the budget that could be invested in the project according to Mr. Oyarzun.

Automating certain steps within the added value services could potentially decrease labor costs and increase efficiency. One possibility is to install an automated labeling line, the most popular added value service. The automatic labeling line would remove labels from the labeling roll, it would position these according to the client specifications, which would require a rotating labeling machine. The machine must be capable of exceeding current performance velocity, which could potentially result in a relatively high percentage placement error.

Figure 22: Labeling Machine with Printer

Figure 23: Labeling Machine without Printer

Instead of a fully automated system, a partially automated system could be implemented. Sandra Torres from INSAA Ltda (Ingenieria y Control LTDA), an industrial projects consulting firm, suggested 3 options: using automatic labeling machine with manual

controls that prints labels, using automatic labeling machine with manual controls without built-in label printer, and manual labeling with an assembly-line moving strip. The last option, the most attractive, least costly system, would implement a moving strip that would require assembly-line-style activities (See Figure 24). At the end of the line, a pallet-consolidating machine and a stretch wrap machine could be optional additions. The overall process would require less employees and would create a more continuous, faster process – increase in efficiency.

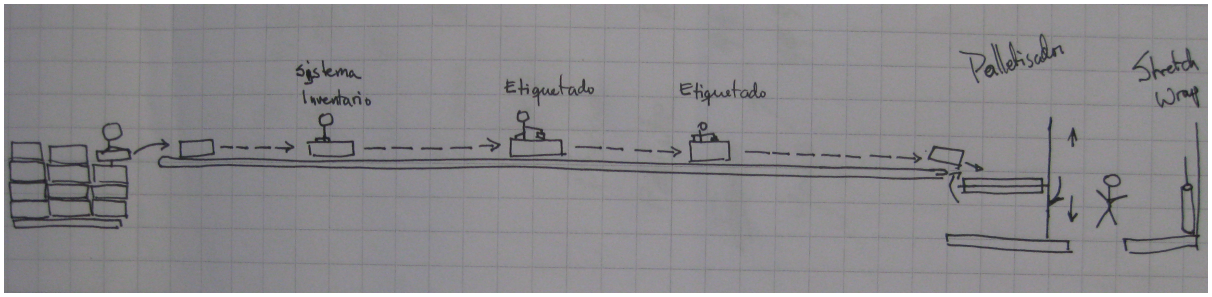

Figure 24: Example of Assembly Line for Added Value Services

APPENDIX B: Timed Data Collection

#	Product Des.	Volume	Weight	Prog Start	Ppl	Eqp.	Request to open door	*Idle Time A:*	Take photos of seal	*Idle Time B:*	Open seal	*Idle Time C:*	Open container
1	Refrigerator	65.4959	4355.0000	8:30:00	3	2	8:42:00		0:01:37		0:01:46		0:02:06
2	Refrigerator	65.4959	4355.0000	8:30:00	3	2	8:42:00	*0:07:00*	0:00:38		0:01:43		0:01:09
3	Refrigerator	62.4098	4810.0000	8:30:00	3	2	8:42:00	*0:10:15*	0:00:40		0:04:01		0:01:51
4	Refrigerator	62.4098	4810.0000	10:30:00	3	2	9:36:45		0:02:28		0:02:25		0:00:55
5	Washing Machine	65.4459	4902.0000	10:30:00	4	2	10:03:45	*0:46:15*	0:01:00		0:00:17		0:04:22
6	Washing Machine	65.4459	4902.0000	10:30:00	3	2	10:52:09		0:02:30		0:00:43		0:01:36
7	Washing Machine	50.7299	4590.0000	14:30:00	4	3	14:36:00		0:01:01		0:00:41		0:11:40
8	Washing Machine	65.4459	4902.0000	14:30:00	5	3	14:50:59		0:01:25		0:01:05		0:00:58
9	Washing Machine	50.7299	4590.0000	14:30:00	4	2	16:01:00		0:01:26		0:00:49		0:10:11
10	Washing Machine	65.4459	4902.0000	16:30:00	4	3	15:33:02		0:01:16		0:00:53		0:04:52
11	Washing Machine	65.4459	4902.0000	16:30:00	4	2	16:31:00		0:01:12		0:01:00		0:02:04
12	Washing Machine	63.7237	4773.0000	16:30:00	3	2	16:07:03		0:00:43		0:00:45		0:00:58
13	Washing Machine	50.7299	4590.0000	14:00:00	3	2	14:54:00		0:00:56		0:01:13		0:03:19
14	Washing Machine	65.4459	4902.0000	14:00:00	3	2	14:54:00		0:00:32		0:00:35		0:02:53
15	Washing Machine	65.4459	4902.0000	14:00:00	4	2	14:54:00	*0:09:02*	0:01:32		0:00:15		0:03:56
16	Washing Machine	65.4459	4902.0000	16:00:00	3	2	15:26:00		0:00:53		0:01:10		0:02:09
17	Washing Machine	50.7299	4590.0000	14:00:00	4	2	16:16:55		0:01:21		0:01:15		0:03:23
18	Refrigerator	50.7299	4590.0000	16:00:00	4	2	16:40:00		0:01:12		0:01:04		0:02:22
19	Refrigerator	50.7299	4590.0000	16:00:00	4	2	17:09:19		0:00:49		0:00:45		0:08:26
20	Washing Machine	59.5980	10530.0000	16:00:00	1		17:13:00		0:01:48		0:00:25		0:07:30
21	Refrigerator	66.0222	5226.8000	17:00:00	3	2	17:41:50		0:00:32		0:01:40		0:02:09
22	Washing Machine	70.7256	8225.0000	8:30:00	3	2	9:30:00		0:01:25		0:00:21		0:14:26
23	Washing Machine	70.7256	8225.0000	8:30:00	3	2	9:32:37		0:01:29		0:00:47		0:01:28
24	Washing Machine	70.7256	8225.0000	8:30:00	3	2	10:30:00		0:01:50		0:00:23		0:11:51
25	Vacuum Cleaner	30.0115	4838.4000	8:30:00	3	1	10:22:22		0:01:02		0:00:19		0:00:34
26	LCD 32" HDTV	65.6451	8292.8000	8:30:00	3	1	11:16:30		0:01:29		0:02:47		0:00:26
27	LCD HDTV	65.0000	8000.0000	8:30:00	3	1	11:00:00		0:01:18		0:01:58		0:00:19
28	Washing Machine	70.7256	8225.0000	8:30:00	3	2	9:02:09		0:01:45		0:00:55		0:08:55
29	Washing Machine	70.7256	8225.0000	8:30:00	3	2	9:02:09		0:01:31		0:00:35		0:05:43
30	Washing Machine	70.7256	8225.0000	8:30:00	3	2	9:02:09	*0:05:02*	0:01:42		0:00:28		0:09:23
31	Washing Machine	70.7256	8225.0000	8:30:00	3	2	9:02:09	*0:09:05*	0:01:25		0:00:48		0:10:00
32	Refrigerator	65.4959	4355.0000	10:30:00	3	2	10:45:00		0:01:30		0:01:44		0:02:00
33	Refrigerator	65.4959	4355.0000	10:30:00	3	2	10:45:00	*0:06:55*	0:01:00		0:01:45		0:01:45
34	Refrigerator	65.4959	4355.0000	10:30:00	3	2	10:45:00	*0:13:55*	0:00:49		0:01:42		0:01:20
35	Refrigerator	65.4959	4355.0000	10:30:00	3	2	10:45:00	*0:19:39*	0:01:01		0:01:47		0:01:37
36	Refrigerator	65.4959	4355.0000	12:30:00	3	2	12:33:00		0:01:15		0:01:43		0:01:33
37	Refrigerator	65.4959	4355.0000	12:30:00	3	2	12:33:00		0:01:22		0:01:46		0:02:55
38	Washing Machine	70.7256	8225.0000	12:30:00	3	2	12:55:00		0:01:24		0:00:40		0:08:01
39	Washing Machine	70.7256	8225.0000	14:30:00	3	2	14:45:00		0:01:30		0:00:23		0:02:55
40	Washing Machine	70.7256	8225.0000	14:30:00	3	2	14:45:00		0:01:34		0:00:45		0:06:22
41	Washing Machine	70.7256	8225.0000	14:30:00	3	2	14:45:00	*0:07:35*	0:01:23		0:00:30		0:03:25
42	Washing Machine	70.7256	8225.0000	14:30:00	3	2	14:45:00	*0:10:33*	0:01:04		0:00:29		0:09:20

#	Take photos of container	Idle Time D:	Dismount boxes	Idle Time E:	Take photos of container.End	Idle Time F:	After Close Doors Idle Time:	After Done Idle Time:
1	0:00:07		0:21:09	0:08:13	0:01:35		0:07:42	
2	0:00:02		0:22:05	0:10:32	0:01:02		0:06:06	0:11:00
3	0:00:04		0:19:33		0:01:10			
4	0:01:21		0:27:09	0:11:16	0:00:47			
5	0:00:00		0:18:07		0:01:36			
6	0:00:43		0:43:15		0:00:00			
7	0:00:05		0:12:54	0:13:53	0:01:20			0:10:00
8	0:00:04		0:16:43	0:15:41	0:01:22			0:20:05
9	0:00:15		0:18:11	0:23:57	0:01:10			
10	0:00:05		0:16:35	0:14:57	0:01:18			
11	0:00:02		0:17:47	0:10:45	0:01:08			
12	0:00:17		0:28:15	0:12:00	0:01:09			
13	0:00:04		0:19:21		0:01:10		0:25:46	1:23:30
14	0:00:03		0:25:55	0:15:25	0:01:30			0:39:29
15	0:00:14		0:17:45	0:16:01	0:01:07		0:06:30	0:10:05
16	0:00:04		0:13:30	0:25:30	0:01:22			
17	0:00:06	0:26:32	0:14:13		0:01:40			0:07:17
18	0:00:07		0:40:30		0:01:32			
19	0:00:05	0:16:26	0:43:58		0:01:10			
20	0:00:06	0:06:01	0:29:08	0:26:58	0:01:51			
21	0:00:05		0:35:17		0:01:05			
22	0:00:06		0:44:20		0:01:28			
23	0:00:05		0:49:01	0:16:53	0:01:22			
24	0:00:04	0:39:56	0:42:13	0:07:56	0:01:35			
25	0:00:02		0:49:07		0:01:16			
26	0:00:09	0:32:35	1:11:00		0:01:32			
27	0:00:09		1:04:57	0:27:12	0:00:11			
28	0:00:06		0:42:09		0:01:04			
29	0:00:07		0:43:06	0:06:22	0:01:20			0:12:00
30	0:00:05		0:45:15	0:08:38	0:01:30			0:18:05
31	0:00:05		0:46:00	0:11:15	0:01:24			
32	0:00:06		0:21:40	0:07:32	0:01:18			
33	0:00:04		0:22:55	0:08:09	0:00:55			
34	0:00:08		0:22:30	0:11:02	0:01:34			
35	0:00:02		0:20:11	0:09:23	0:01:14			
36	0:00:05		0:23:00	0:05:10	0:01:20			
37	0:00:07		0:20:45	0:09:09	0:01:25			
38	0:00:06		0:48:09		0:01:25			
39	0:00:06		0:40:59		0:01:29			0:10:00
40	0:00:04		0:44:22	0:06:46	0:01:11			0:15:00
41	0:00:08		0:43:50	0:09:23	0:01:27			
42	0:00:09		0:42:00	0:11:00	0:01:23			

#	Storage for Reception	S.I.T 1:	S.I.T 2:	Late Start:	Reception Time:	Storage Time:	R->S Processing Time:	Truck Idle Time:	Door Idle Time:	Reception Idle Time:
1	0:11:36	0:11:26	0:30:45	0:12:00	0:49:00	0:11:36		0:30:45	0:11:26	0:15:55
2	1:16:02		1:17:06	0:12:00	0:52:00	1:16:02	0:11:00	1:17:06		0:23:38
3				0:12:00	0:52:00					0:10:15
4				Early	0:50:15					0:11:16
5				0:20:00	0:46:15					0:46:15
6				0:22:09	0:52:51					0:00:00
7	0:22:32		0:30:05	0:06:00	0:46:00	0:22:32	0:10:00	0:30:05		0:13:53
8	0:11:28		0:24:47	0:20:59	0:45:01	0:11:28	0:20:05	0:24:47		0:15:41
9				1:31:00	1:04:00					0:23:57
10				Early	0:47:43					0:14:57
11				0:01:00	0:44:00					0:10:45
12				Early	0:48:21					0:12:00
13		16:55:13	1:29:29	0:54:00	0:57:30	17:00:00	1:23:30	1:29:29	17:00:00	0:25:46
14	0:18:35	0:00:00	0:15:10	0:54:00	0:57:30	0:18:35	0:39:29	0:15:10		0:15:25
15	0:13:40	0:07:35	0:37:50	0:54:00	0:57:30	0:13:40	0:10:05	0:37:50	0:07:35	0:31:33
16	0:10:41	0:53:20	1:05:28	Early	0:54:35	0:10:41		1:05:28	0:53:20	0:25:30
17	0:19:46			2:16:55	0:52:05	0:19:46	0:07:17			0:26:32
18				0:40:00	1:03:58					0:00:00
19				1:09:19	1:20:41					0:16:26
20				1:13:00	1:17:00					0:26:58
21				0:41:50	0:48:10					0:00:00
22				1:00:00	1:12:00					0:00:00
23				1:02:37	1:18:18					0:16:53
24				2:00:00	1:50:15					0:47:52
25				1:52:22	0:58:08					
26				2:46:30	2:25:30					0:32:35
27				2:30:00	1:43:30					0:27:12
28				0:32:09	1:04:54					0:00:00
29	0:28:02			0:32:09	1:08:04	0:28:02	0:12:00			0:06:22
30	0:23:38			0:32:09	1:22:02	0:23:38	0:18:05			0:13:04
31				0:32:09	1:30:02					0:20:20
32				0:15:00	0:45:50					0:07:32
33				0:15:00	0:53:28					0:15:04
34				0:15:00	1:03:00					0:24:57
35				0:15:00	1:04:09					0:29:02
36				0:03:00	0:44:06					0:05:10
37				0:03:00	0:47:26					0:09:09
38				0:25:00	1:09:45					0:00:00
39	0:22:32			0:15:00	0:59:22	0:22:32	0:10:00			0:00:00
40	0:24:28			0:15:00	1:01:04	0:24:28	0:15:00			0:06:46
41	0:21:28			0:15:00	1:07:41	0:21:28	0:00:00			0:16:58
42				0:15:00	1:15:58					0:21:33

#	Technical Inspection:	Stretch Film:	Pallet Sticker:	SGS Sticker:
1				
2				
3				
4				
5				
6				
7	31.0	5.5	8.0	20.0
8	15.0	5.0	5.0	7.5
9	12.5	5.5	4.5	8.5
10	12.0	5.5	5.0	7.0
11	15.0	5.0	5.0	7.5
12	15.0	5.0	5.0	7.5
13	9.5	7.0	2.5	19.5
14	9.5	5.0	3.5	12.5
15	13.5	3.5	1.0	9.0
16	12.5	4.0	2.0	11.5
17	6.0	6.5	3.0	15.5
18	9.0	7.5	5.5	21.5
19	31.0	5.5	8.0	20.0
20	14.5	6.0	4.0	15.5
21	15.0	7.0	2.0	8.0
22	31.0	5.5	8.0	20.0
23	16.5	9.5	8.0	22.0
24	31.0	5.5	8.0	25.0
25				
26				
27				
28	19.0	7.0	8.0	20.0
29	22.0	7.5	8.5	21.0
30	20.0	6.0	7.0	20.0
31	19.0	6.5	8.0	20.0
32	25.0	4.5	8.0	21.0
33	22.0	5.0	8.0	22.0
34	23.0	6.5	8.0	18.5
35	24.0	7.0	7.5	19.0
36	23.5	8.0	6.0	19.0
37	22.0	7.5	7.0	22.5
38	23.0	5.0	8.0	19.5
39	19.5	6.0	8.5	22.0
40	21.5	7.0	8.0	21.0
41	21.0	7.0	7.0	19.5
42	20.5	6.0	7.5	20.0

APPENDIX C: Planning and Control Schedule (Example from May 29, 2009)

Programa de Recepción

REPORT

Planificación, Coordinación y Control de Operaciones

ITEM	Fecha Programada	Código Cliente	Código Bodega	Número OR	Estado	Documento Respaldo	Código Contenedor	Producto(s)
1	5/29/09	LGE	LGE		Preparado	I-0510129	GLDU 701663-2	T1003TEFT1--AFSPECL
2	5/29/09	LGE	LGE		Preparado	I-0510129	CLHU 858837-7	T1003TEFT1--AFSPECL
3	5/29/09	LGE	LGE		Preparado	I-0510129	CMAU 533201-8	T1003TEFT1--AFSPECL
4	5/29/09	LGE	LGE		Preparado	I-0510130	ECMU 960018-0	WFT85B34EF--AFSPECL
5	5/29/09	LGE	LGE		Preparado	I-0510130	ECMU 932882-6	WFT85B34EF--AFSPECL
6	5/29/09	LGE	LGE		Preparado	I-0510132	TTNU 983641-1	GN-V292RLC--APLPECL
7	5/29/09	LGE	LGE		Preparado	I-0510132	CMAU 530010-8	GN-V292RLC--APLPECL
8	5/29/09	LGE	LGE		Preparado	I-0510132	ECMU 907508-1	GN-V292RLC--APLPECL
9	5/29/09	BD	BDVT	184096	Preparado	HH-0	PRSU 410154-9	MX151R (MX151R)
10	5/29/09	BD	BDVT	184081	Preparado	HH-0	CMAU 014086-1	PLANCHA F915 (F915)
11	5/29/09	LGE	LGE		Preparado	508234	SUDU 681553-0	MS2347GR--CSLPECL
12	5/29/09	LGE	LGE		Preparado	507704	MOAU0 78546-3	MH6348AR--CSLPECL
13	5/29/09	LGE	LGE		Preparado	509834	MOFU 051679-0	MH6348AR--CSLPECL; MH3046SP--CSLPECL
14	5/29/09	LGE	LGE		Preparado	509834	MOTU 065468-6	MS2347GR--CSLPECL
15	5/29/09	PHILIPSCE	CSAP	178148	Preparado	DR-181296832	CCLU 399521-4	GC1705/01 ST.IRON HV-AL-FU (889170501110)
16	5/28/09	PIRELLI	CDA		Preparado		CAMION	VARIOS

Programa de Recepción

REPORT

Planificación, Coordinación y Control de Operaciones

Observaciones	Q Pallet Total (Calc)	Q Cajas Total (Calc)	Q Entrada Productos	Q SKU	MT3 (Aprox)	Hora de Programa	Módulo	Anden Solicitado	Anden Recepción	Hora Llegada	Tipo de Arribo
CMA CGM MARINA V.MA4	S/P	102	102	1	65.00	8:30	D1	39			DIRECTO 1
CMA CGM MARINA V.MA4	S/P	102	102	1	65.00	8:30	D1	40			DIRECTO 2
CMA CGM MARINA V.MA4	S/P	102	102	1	65.00	8:30	D1	41			DIRECTO 3
CMA CGM MARINA V.MA4	S/P	114	114	1	65.00	8:30	D1	42			DIRECTO 4
CMA CGM MARINA V.MA4	S/P	114	114	1	65.00	10:30	D1	39			DIRECTO 5
CMA CGM MARINA V.MA4	S/P	93	93	1	65.00	10:30	D1	40			PRIORIDA 1
CMA CGM MARINA V.MA4	S/P	93	93	1	65.00	10:30	D1	41			PRIORIDA 2
CMA CGM MARINA V.MA4	S/P	93	93	1	65.00	10:30	D1	42			PRIORIDA 3
CMA CGMA MARINA	36	3000	12000	1	59.16	8:30	D	23			DIRECTO 1
CMA CGMA MARINA	19	693	3778	3	27.20	8:30	D	22			DIRECTO 2
CAP HARALD	35	653	653	1	65.00	8:30	D	21			PRIORIDAD 1
MOL SERENITY	35	308	308	1	65.00	8:30	D	20			PRIORIDAD 2
MOL SERENITY	35	493	493	2	65.00	8:30	D	19			PRIORIDAD 3
MOL SERENITY	35	662	662	1	65.00	11:30	D	18			PRIORIDAD 4
7009072157	103	288	2304	3	9.54	8:30	E	55			DIRECTO 1
Transrebeca	S/P				110.00	8:30	A3	A3			DIRECTO 1

APPENDIX D: SPSS Data Calculations (for all shipments)

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Idle Time:	11	0:05:02	0:46:15	0:13:12	0:11:39
Take photos of seal	42	0:00:32.00	0:02:30.00	0:01:17.60	0:00:26.212
Idle Time:	0				
Open seal	42	0:00:15.00	0:04:01.00	0:01:07.26	0:00:46.326
Idle Time:	0				
Open container	42	0:00:19.00	0:14:26.00	0:04:21.60	0:03:45.188
Take photos of container	42	0:00:00.00	0:01:21.00	0:00:08.62	0:00:13.211
Idle Time:	5	0:06:01.00	0:39:56.00	0:24:18.00	0:13:21.717
Valid N (listwise)	0				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Idle Time:	28	0:05:10.00	0:27:12.00	0:12:53.50	0:06:13.567
Take photos of container.End	42	0:00:00.00	0:01:51.00	0:01:16.36	0:00:20.440
Idle Time:	0				
After Close Doors Idle Time:	4	0:06:06	0:25:46	0:11:30	0:09:31
After Done Idle Time:	11	0:07:17	1:23:30	0:21:30	0:22:24
S.I.T:	4	0:07:35	16:55:13	4:31:53	8:15:58
S.I.T:	8	0:15:10	1:29:29	0:46:20	0:27:13
Valid N (listwise)	0				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Late Start:	38	0:01:00.00	2:46:30.00	0:43:58.87	0:43:09.182
R->S Processing Time:	12	0:00:00	1:23:30	0:19:42	0:22:14
Truck Idle Time:	8	0:15:10	1:29:29	0:46:20	0:27:13
Door Idle Time:	4	0:07:35	17:00:00	4:33:05	8:18:22
Reception Idle Time:	41	0:00:00.00	0:47:52.00	0:16:16.37	0:11:58.128
Valid N (listwise)	2				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Technical Inspection:	33	6.00	31.00	18.9242	6.69319
Stretch Film:	33	3.50	9.50	6.0758	1.24450
Pallet Sticker:	33	1.00	8.50	6.1515	2.25168
SGS Sticker:	33	7.00	25.00	17.0606	5.51243
Valid N (listwise)	33				

Frequencies

Statistics

		Boxes	Product ID	Ppl	Eqp.
N	Valid	42	43	42	42
	Missing	1	0	1	1

Boxes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	67	8	18.6	19.0	19.0
	73	1	2.3	2.4	21.4
	74	2	4.7	4.8	26.2
	102	4	9.3	9.5	35.7
	111	1	2.3	2.4	38.1
	114	8	18.6	19.0	57.1
	122	2	4.7	4.8	61.9
	150	1	2.3	2.4	64.3
	235	12	27.9	28.6	92.9
	584	1	2.3	2.4	95.2
	664	1	2.3	2.4	97.6
	672	1	2.3	2.4	100.0
	Total	42	97.7	100.0	
Missing	System	1	2.3		
Total		43	100.0		

Product ID

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		1	2.3	2.3	2.3
	3 different codes	1	2.3	2.3	4.7
	32LH20R	1	2.3	2.3	7.0
	F1403FDS	1	2.3	2.3	9.3
	GC-B359BLQ	1	2.3	2.3	11.6
	GM-341SC	2	4.7	4.7	16.3
	GM-R439YVQ	8	18.6	18.6	34.9
	GN-V232RL	2	4.7	4.7	39.5
	VB2718NRTQ	1	2.3	2.3	41.9
	WFT1001TEPT	4	9.3	9.3	51.2
	WFT6605TTP	7	16.3	16.3	67.4
	WFT7500TTP	5	11.6	11.6	79.1
	WFT8501TEPT	9	20.9	20.9	100.0
	Total	43	100.0	100.0	

Ppl

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	2.3	2.4	2.4
	3	31	72.1	73.8	76.2
	4	9	20.9	21.4	97.6
	5	1	2.3	2.4	100.0
	Total	42	97.7	100.0	
Missing	System	1	2.3		
Total		43	100.0		

Eqp.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	9.3	9.5	9.5
	2	35	81.4	83.3	92.9
	3	3	7.0	7.1	100.0
	Total	42	97.7	100.0	
Missing	System	1	2.3		
Total		43	100.0		

Means

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Technical Inspection: * Boxes	33	76.7%	10	23.3%	43	100.0%
Stretch Film: * Boxes	33	76.7%	10	23.3%	43	100.0%
Pallet Sticker: * Boxes	33	76.7%	10	23.3%	43	100.0%
SGS Sticker: * Boxes	33	76.7%	10	23.3%	43	100.0%

Report

Boxes		Technical Inspection:	Stretch Film:	Pallet Sticker:	SGS Sticker:
67	Mean	23.2500	6.4167	7.4167	20.3333
	N	6	6	6	6
	Std. Deviation	1.17260	1.39344	.80104	1.72240
73	Mean	15.0000	7.0000	2.0000	8.0000
	N	1	1	1	1
	Std. Deviation	.	.	.	.
102	Mean	14.7500	6.1250	4.5000	15.8750
	N	4	4	4	4
	Std. Deviation	11.15422	.75000	2.48328	5.31311
111	Mean	15.0000	5.0000	5.0000	7.5000
	N	1	1	1	1
	Std. Deviation	.	.	.	.
114	Mean	12.9167	4.6667	3.5833	9.1667
	N	6	6	6	6
	Std. Deviation	2.08367	.75277	1.74404	2.31661
122	Mean	20.0000	6.5000	6.7500	20.7500
	N	2	2	2	2
	Std. Deviation	15.55635	1.41421	1.76777	1.06066
150	Mean	14.5000	6.0000	4.0000	15.5000
	N	1	1	1	1
	Std. Deviation	.	.	.	.
235	Mean	22.0000	6.5417	7.8750	20.8333
	N	12	12	12	12
	Std. Deviation	4.52267	1.19579	.48265	1.57153
Total	Mean	18.9242	6.0758	6.1515	17.0606
	N	33	33	33	33
	Std. Deviation	6.69319	1.24450	2.25168	5.51243

APPENDIX E: SPSS Data Calculations (for refrigerator shipments)

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Idle Time:	5	0:06:55.00	0:19:39.00	0:11:32.80	0:05:21.814
Take photos of seal	13	0:00:32.00	0:02:28.00	0:01:08.69	0:00:31.351
Idle Time:	0				
Open seal	13	0:00:45.00	0:04:01.00	0:01:50.08	0:00:45.726
Idle Time:	0				
Open container	13	0:00:55.00	0:08:26.00	0:02:19.08	0:01:54.703
Take photos of container	13	0:00:02.00	0:01:21.00	0:00:11.00	0:00:21.115
Idle Time:	1	0:16:26.00	0:16:26.00	0:16:26.00	.
Dismount boxes	13	0:19:33.00	0:43:58.00	0:26:12.46	0:08:13.373
Idle Time:	9	0:05:10.00	0:11:16.00	0:08:56.22	0:01:56.071
Take photos of container.End	13	0:00:47.00	0:01:35.00	0:01:14.38	0:00:14.953
Idle Time:	0				
After Close Doors Idle Time:	2	0:06:06.00	0:07:42.00	0:06:54.00	0:01:07.882
After Done Idle Time:	1	0:11:00.00	0:11:00.00	0:11:00.00	.
Storage for Reception	2	0:11:36.00	1:16:02.00	0:43:49.00	0:45:33.675
S.I.T:	1	0:11:26.00	0:11:26.00	0:11:26.00	.
S.I.T:	2	0:30:45.00	1:17:06.00	0:53:55.50	0:32:46.464
Valid N (listwise)	0				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Late Start:	12	0:03:00	1:09:19	0:21:05	0:19:27
Reception Time:	13	0:44:06.00	1:20:41.00	0:54:55.62	0:10:18.075
Storage Time:	2	0:11:36.00	1:16:02.00	0:43:49.00	0:45:33.675
R->S Processing Time:	1	0:11:00.00	0:11:00.00	0:11:00.00	.
Truck Idle Time:	2	0:30:45.00	1:17:06.00	0:53:55.50	0:32:46.464
Door Idle Time:	1	0:11:26.00	0:11:26.00	0:11:26.00	.
Reception Idle Time:	13	0:00:00.00	0:29:02.00	0:12:57.23	0:09:05.558
Valid N (listwise)	0				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Technical Inspection:	9	9.0	31.0	21.611	6.2639
Stretch Film:	9	4.5	8.0	6.500	1.2247
Pallet Sticker:	9	2.0	8.0	6.667	1.9843
SGS Sticker:	9	8.0	22.5	19.056	4.3835
Valid N (listwise)	9				

Frequencies

Statistics

		Boxes	Product ID	Ppl	Eqp.
N	Valid	13	13	13	13
	Missing	0	0	0	0

Boxes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	67	8	61.5	61.5	61.5
	73	1	7.7	7.7	69.2
	74	2	15.4	15.4	84.6
	122	2	15.4	15.4	100.0
	Total	13	100.0	100.0	

Product ID

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	GC-B359BLQ	1	7.7	7.7	7.7
	GM-341SC	2	15.4	15.4	23.1
	GM-R439YVQ	8	61.5	61.5	84.6
	GN-V232RL	2	15.4	15.4	100.0
	Total	13	100.0	100.0	

Ppl

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	11	84.6	84.6	84.6
	4	2	15.4	15.4	100.0
	Total	13	100.0	100.0	

Eqp.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	13	100.0	100.0	100.0

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Volume	13	50.7299	66.0222	62.789908	5.4787727
Weight	13	4355.0000	5226.8000	4528.215	273.0214944
Valid N (listwise)	13				

Means

Boxes vs. Time

Report

Dismount boxes

Boxes	Mean	N	Std. Deviation
67	0:21:46.88	8	0:01:01.735
73	0:35:17.00	1	.
74	0:23:21.00	2	0:05:22.441
122	0:42:14.00	2	0:02:27.078
Total	0:26:12.46	13	0:08:13.373

Model vs. Time

Report

Dismount boxes

Product ID	Mean	N	Std. Deviation
GC-B359BLQ	0:35:17.00	1	.
GM-341SC	0:23:21.00	2	0:05:22.441
GM-R439YVQ	0:21:46.88	8	0:01:01.735
GN-V232RL	0:42:14.00	2	0:02:27.078
Total	0:26:12.46	13	0:08:13.373

Volume vs. Time

Report

Dismount boxes

Volume	Mean	N	Std. Deviation
50.7299	0:42:14.00	2	0:02:27.078
62.4098	0:23:21.00	2	0:05:22.441
65.4959	0:21:46.88	8	0:01:01.735
66.0222	0:35:17.00	1	.
Total	0:26:12.46	13	0:08:13.373

Weight vs. Time

Report

Dismount boxes

Weight	Mean	N	Std. Deviation
4355.0000	0:21:46.88	8	0:01:01.735
4590.0000	0:42:14.00	2	0:02:27.078
4810.0000	0:23:21.00	2	0:05:22.441
5226.8000	0:35:17.00	1	.
Total	0:26:12.46	13	0:08:13.373

Model Information (weight, Volume)

Report

Product ID		Volume	Weight
GC-B359BLQ	Mean	66.022200	5226.800
	N	1	1
	Std. Deviation	.	.
GM-341SC	Mean	62.409800	4810.000
	N	2	2
	Std. Deviation	.0000000	.0000000
GM-R439YVQ	Mean	65.495900	4355.000
	N	8	8
	Std. Deviation	.0000000	.0000000
GN-V232RL	Mean	50.729900	4590.000
	N	2	2
	Std. Deviation	.0000000	.0000000
Total	Mean	62.789908	4528.215
	N	13	13
	Std. Deviation	5.4787727	273.0215

APPENDIX F: SPSS Data Calculations (for washing machine shipments)

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Request to open door	26	9:02:09.00	17:13:00	13:18:02	2:51:57.772
Idle Time:	6	0:05:02.00	0:46:15.00	0:14:35.33	0:15:37.345
Take photos of seal	26	0:00:32.00	0:02:30.00	0:01:22.19	0:00:24.018
Idle Time:	0				
Open seal	26	0:00:15.00	0:01:15.00	0:00:41.92	0:00:17.348
Idle Time:	0				
Open container	26	0:00:58.00	0:14:26.00	0:05:50.00	0:03:52.957
Take photos of container	26	0:00:00.00	0:00:43.00	0:00:07.65	0:00:08.158
Idle Time:	3	0:06:01.00	0:39:56.00	0:24:09.67	0:17:04.939
Dismount boxes	26	0:12:54.00	0:49:01.00	0:31:39.35	0:13:25.388
Idle Time:	18	0:06:22.00	0:26:58.00	0:14:04.44	0:06:09.882
Take photos of container.End	26	0:00:00.00	0:01:51.00	0:01:19.27	0:00:19.656
Idle Time:	0				
After Close Doors Idle Time:	2	0:06:29.99	0:25:45.99	0:16:07.99	0:13:37.415
After Done Idle Time:	10	0:07:17.00	1:23:30.00	0:22:33.10	0:23:19.925
Storage for Reception	11	0:10:41.00	0:28:02.00	0:19:42.73	0:05:35.974
S.I.T:	3	0:07:35.00	16:55:13	5:58:42.67	9:29:00.629
S.I.T:	6	0:15:10.00	1:29:29.00	0:43:48.17	0:28:08.904
Valid N (listwise)	0				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Late Start:	23	0:01:00	2:16:55	0:43:00	0:35:21
Reception Time:	26	0:44:00.00	1:50:15.00	1:03:24.85	0:15:43.666
Storage Time:	12	0:10:41.00	17:00:00	1:43:04.17	4:48:48.455
R->S Processing Time:	11	0:00:00.00	1:23:30.00	0:20:30.09	0:23:09.336
Truck Idle Time:	6	0:15:10.00	1:29:29.00	0:43:48.17	0:28:08.904
Door Idle Time:	3	0:07:35.00	17:00:00	6:00:18.33	9:31:46.195
Reception Idle Time:	26	0:00:00.00	0:47:52.00	0:16:53.08	0:12:57.652
Valid N (listwise)	2				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Technical Inspection:	24	6.0	31.0	17.917	6.6931
Stretch Film:	24	3.5	9.5	5.917	1.2394
Pallet Sticker:	24	1.0	8.5	5.958	2.3541
SGS Sticker:	24	7.0	25.0	16.313	5.7838
Valid N (listwise)	24				

Statistics

		Boxes	Product ID	Ppl	Eqp.
N	Valid	26	26	26	26
	Missing	0	0	0	0

Frequencies

Boxes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	102	4	15.4	15.4	15.4
	111	1	3.8	3.8	19.2
	114	8	30.8	30.8	50.0
	150	1	3.8	3.8	53.8
	235	12	46.2	46.2	100.0
	Total	26	100.0	100.0	

Product ID

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	F1403FDS	1	3.8	3.8	3.8
	WFT1001TEPT	4	15.4	15.4	19.2
	WFT6605TTP	7	26.9	26.9	46.2
	WFT7500TTP	5	19.2	19.2	65.4
	WFT8501TEPT	9	34.6	34.6	100.0
	Total	26	100.0	100.0	

Ppl

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	3.8	3.8	3.8
	3	17	65.4	65.4	69.2
	4	7	26.9	26.9	96.2
	5	1	3.8	3.8	100.0
	Total	26	100.0	100.0	

Eqp.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	3.8	3.8	3.8
	2	22	84.6	84.6	88.5
	3	3	11.5	11.5	100.0
	Total	26	100.0	100.0	

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Volume	26	50.7299	70.7256	65.327527	7.0357516
Weight	26	4590.0000	10530.00	6599.192	1894.1630768
Valid N (listwise)	26				

Means

Ppl vs. Time

Dismount boxes

Ppl	Mean	N	Std. Deviation
1	0:29:08.00	1	.
3	0:38:55.29	17	0:10:26.383
4	0:16:30.29	7	0:02:06.895
5	0:16:43.00	1	.
Total	0:31:39.35	26	0:13:25.388

Weight vs. Time

Dismount boxes

Weight	Mean	N	Std. Deviation
4590.0000	0:16:09.75	4	0:03:05.496
4773.0000	0:28:15.00	1	.
4902.0000	0:21:12.13	8	0:09:34.711
8225.0000	0:44:17.00	12	0:02:28.933
10530.0000	0:29:08.00	1	.
Total	0:31:39.35	26	0:13:25.388

Volume vs. Time

Dismount boxes

Volume	Mean	N	Std. Deviation
50.7299	0:16:09.75	4	0:03:05.496
59.5980	0:29:08.00	1	.
63.7237	0:28:15.00	1	.
65.4459	0:21:12.13	8	0:09:34.711
70.7256	0:44:17.00	12	0:02:28.933
Total	0:31:39.35	26	0:13:25.388

Boxes vs. Time

Dismount boxes

Boxes	Mean	N	Std. Deviation
102	0:16:09.75	4	0:03:05.496
111	0:28:15.00	1	.
114	0:21:12.13	8	0:09:34.711
150	0:29:08.00	1	.
235	0:44:17.00	12	0:02:28.933
Total	0:31:39.35	26	0:13:25.388

Equip vs. Time

Dismount boxes

Eqp.	Mean	N	Std. Deviation
1	0:29:08.00	1	.
2	0:33:59.23	22	0:13:03.010
3	0:15:24.00	3	0:02:09.965
Total	0:31:39.35	26	0:13:25.388

Model vs. Time

Dismount boxes

Product ID	Mean	N	Std. Deviation
F1403FDS	0:29:08.00	1	.
WFT1001TEPT	0:16:09.75	4	0:03:05.496
WFT6605TTP	0:45:15.71	7	0:02:47.618
WFT7500TTP	0:42:54.80	5	0:01:06.142
WFT8501TEPT	0:21:59.11	9	0:09:15.766
Total	0:31:39.35	26	0:13:25.388

Models Information (Weight & Volume)

Product ID		Weight	Volume
F1403FDS	Mean	10530.00	59.598000
	N	1	1
	Std. Deviation	.	.
WFT1001TEPT	Mean	4590.000	50.729900
	N	4	4
	Std. Deviation	.0000000	.0000000
WFT6605TTP	Mean	8225.000	70.725600
	N	7	7
	Std. Deviation	.0000000	.0000000
WFT7500TTP	Mean	8225.000	70.725600
	N	5	5
	Std. Deviation	.0000000	.0000000
WFT8501TEPT	Mean	4887.667	65.254544
	N	9	9
	Std. Deviation	43.00000	.5740667
Total	Mean	6599.192	65.327527
	N	26	26
	Std. Deviation	1894.163	7.0357516