CONSIDERING NEW TECHNOLOGIES FOR INVENTORY PHYSICAL COUNT AT THE AIRBUS WAREHOUSE

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ABSTRACT

Airbus Supply Chain Management and Logistics is trying to find the new technology concepts to optimize the warehouse management in terms of the inventory control. Inventory physical count (IPC) is a method to verify that the actual inventory amount at the physical locations. Three technologies including drone, image processing, and Weightlog are studied to analyse the pros and cons for the application of the inventory physical count at the Airbus warehouse. The data of the warehouse management is collected at the subcontracted warehouse operated by Kuehne Nagel in Toulouse, France to understand the concept of the warehouse management and key activities. Regarding the data from the on-site observation, there are four classification of SKUs in the storage area including large-sized, standard-sized, small-sized, and non-standard SKUs. These various classifications determine the selection of the new technology for IPC. Drone and image processing potentially work together in large-sized, standard-sized, and non-standard SKU storage area, but the Weightlog is suitable for the small-sized SKU storage area. However, the Airbus warehouse management team need to improve the activities in each storage area to enhance the performance of these new technologies.

KEY WORDS: Airbus/ Warehouse/ Inventory/ Count/ Technology

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CHAPTER I
INTRODUCTION

1.1 Background

In accordance with the company consulting project between IAE Toulouse École de Management of Université Toulouse 1 Capitole and Airbus Supply Chain Management and Logistic Department (Airbus SCM&L), the team of researchers were assigned to study and contribute the innovative technology concepts towards warehouse management.

Currently, there are voluminous warehouses operated by Airbus SCM&L and subcontracted warehouses to fulfill the demand of production lines and service parts. Due to the large number of warehouses, Airbus SCM&L is trying to find the innovative technology concepts and strategic plans for the inventory control in order to reduce cost and enhance the stock accuracy. Besides, fully-automated and semi-automated technologies are highlighted by the department since the company is inclined to depend on innovative devices and robotic machines to cope with changes in the future.

Inventory Physical Count (IPC) is one of general methods to verify that the inventory amount in the system are corresponding to the actual amount. Typically, it requires a particular scale of labor forces depending on the volume of stock on hand, the number of stock keeping units (SKUs) and the size of the warehouse. Therefore, the cost of labor forces and time consumption are taken into account for the warehouse management.

Thanks to the collaborative support from Airbus SCM&L, the team of the researchers were allowed to observe Kuehne + Nagel, one of Airbus subcontracted warehouses in Toulouse, France, to understand the overall procedure in the warehouse and refer the study to this warehouse only.

Nowadays, various technologies such as autonomous robots and drones are introduced in the warehouse operation in order to work efficiently and reduce the workload for labor. For instance, Amazon warehouse had implemented the autonomous robots

to carry the entire shelf to the staffs for pick-pack goods per the received orders. Therefore, Airbus SCM&L is searching for the possibility to adapt such a technology concept to IPC with the purpose of optimization and cost-saving.

1.2 Problem Statement

In respect of the inventory physical count (IPC), Airbus SCM&L is trying to find innovative technologies for the warehouse management to perform the physical count and reduce the needs of labor force and time consumption. To be on the right track, the understanding of the warehouse management and the analysis of the technology concepts existing in the warehouse management business would help the researchers weigh the pros and cons of each technology concept.

1.3 Research Objectives

Corresponding to the project of new technologies for Airbus warehouse management, the researchers were required to study the concept of the warehouse management and contribute the findings by following these objectives consecutively.

1. To understand the concept of the warehouse management and key activities including the flow of SKUs movement from inbound, storage, and outbound, particularly based on Airbus subcontracted warehouse that the researchers already observed.
2. To analyze the value chain of Airbus warehouse management and identify the issues regarding the inventory physical count for the prospect development of innovative technologies.
3. To contribute the analysis of pros and cons of the findings together with the limitation of the innovative technologies for IPC.

1.4 The Scope of Research

This study only focuses on the subcontracted warehouse operated by Kuehne + Nagel in Toulouse, France. The types of materials stored in this warehouse are categorized into three groups according to the packaging: (1) standard packaging goods, which means materials are packed into the standard carton labelled with barcode identification, (2) non-standard packaging goods, which means the large-sized and special-shaped materials such as turbofan engine, cabin, S-shaped pipe and so on, and (3) repackaging goods, which means the small-sized materials such as bolt, screw, and other mechanic fasteners, removed from the standard packaging and filled in the moveable drawer cabinets. This study, thereby, highlights on the inventory in the storage area particularly. The transit inventory in the inbound area, quarantine zone, and outbound area are not included in the study because the SKUs would be moved in or out from the warehouse eventually.

CHAPTER II
LITERATURE REVIEW

2.1 Warehouse Management

Warehouses nowadays are not only designed to store things, but also set to receive, break down, repackage, and distribute work-in-process (WIP) goods to a manufacturing location or finished goods to customers (Wisner, Leong, and Tan, 2015).

Warehouse management is a part of the supply chain management since warehouses are built to store and supply products to customers or users who triggers the demand in the supply chain (Emmett, 2005). Also, the warehouse management is explained further that the planning of all the warehouse activities from receiving goods to dispatching of orders by customers or users should be taken into consideration in order to boost the effectiveness and efficiency of the warehouses. The warehouse management involves with both systematic operational procedures and strategic management in business aspects.

2.2 Key Activities in the Warehouse Management

To understand the key operational activities in the warehouse management, Mohan (2012) concluded the functions of warehousing by the following process:

1. Receiving: Incoming goods are unloaded from the carrier at the inbound dock. The delivery documents, receipt and transportation information are recorded. Eventually, the goods are moved to the inspection.

2. Inspection: This process includes quality and quantity check to ensure before confirming goods receipts record.

3. Repackaging: In case of non-standard packaging, some warehouse has the process to pre-pack in unit load or pallet load to fit in the storage.

4. Put away: This process is to bin and store goods in their respective areas including temporary area from the inbound dock.

5. Storage: Goods will be binned on the assigned area depending on the calculation from warehouse management system (WMS) or configuration from the process owner

6. Order picking or selection: Orders are sent by customers or users to identify the required quantities of each goods. This process has a significant impact on cost effectiveness and inventory level because the warehouse management needs to satisfy customers and user whereas it needs to consider the regulations of order picking such as first-in first-out (FIFO), first-expire first-out (FEFO), bulk-breaking strategy, fully-loaded pallet order, and so on.

7. Sortation: This process allows the warehouses to group the area of storage such as grouping by customer, turnover rate, dangerous goods, and so on. Accordingly, the goods can be moved directly to the assigned destination.

8. Picking and Shipping: The picked goods are loaded and packed on pallets, and they are moved to the shipping area to be delivered to customers or users.

9. Cross-docking: This process allows goods to be moved directly from reception area to the shipping dock so that the goods are not stored in the warehouse.

10. Replenishing: The stock must be maintained at the specific level of inventory to ensure that the order picking location is filled by the assigned goods.

2.3 Inventory and Inventory Management

Inventory is defined as materials or products that are stored for sales, service, production or other purposes related to particular business (Sangchot, 2015). Inventory can be classified into four major groups:

1. Raw material (RM): materials or parts which are for the production line

2. Work-in-process material (WIP): materials which are in the process of next production line or assembly line. Otherwise, the materials are not completely produced as the finished goods.

3. Maintenance, repair, and operation supplies (MRO): machine spare parts or materials which are for replacement and maintenance of machines

4. Finished goods (FG): products which are completely produced to send to customers or users

Inventory should be carefully controlled by recording in system and physically counting because it represents the capability of generating income and revenue to business, on financial point of view (Emmett, 2015). To elaborate more about the relationship between inventory and revenue, the number of remaining inventory (unsold goods), incoming inventory (in-transit goods), and closing inventory (sold-out goods) reflects the cost of sales (Abdullah, Chandren, and Nadarajan, 2015). Cost of sales is the summation of the remaining and the incoming, subtracted by the closing. The gross profit will be correspondingly reduced by the cost of sales (Gross profit = sales – cost of sales). As a consequence, it is crucial that inventory should be recorded and reported at the correct quantity and unit price to confirm the accurate inventory amount, with the purpose of exact calculation of the gross profit.

Inventory management is a method to ensure that the number of the remaining inventory is sufficient to support present and future demands from users or customers (Sangchot, 2015). The method of inventory management starts from recording the number of inbound and outbound goods, balancing the number of inventory to be in line with the consumption rate, and handling the cost of inventory control which are involved with economic order quantity, safety stock, and reorder point. As the matter of fact, it is difficult to support production lines or customers timely in case the inventory record is not accurate (Bragg, 2004). A company must ensure that the quantity, the location of a material, the units of measurement, and the part number are correct in order to reduce a risk of inventory inaccuracy. Therefore, one of the most essential material handling measurements is inventory accuracy.

2.4 Inventory Physical Count (IPC)

Inventory physical count (IPC) is a procedure to count inventory quantity at the physical location, performed by staff members under the control of management (Abdullah, Chandren, & Nadarajan, 2015). With this procedure, the existence, accuracy, and condition of inventory are verified. The firms are in charge of setting the frequency of the inventory physical count. The frequent inventory physical count boosts the quality inventory management in terms of accuracy and condition of inventories; for instance, slow-moving, damaged and obsolete. It is recommended that the firms should have the

inventory physical count done once at least once a year before the closing financial at the year-end because the level of inventories determines the firm performance and position for the whole year. The IPC process cycles relate to the participation between managerial and operational level to create a plan, organize a timeline, control a performance, and perform a count. It begins with the starting point which takes place one or two months prior to IPC day with the purpose of the preparation for instructional manual, plan, implementation and communication between managerial and operational parties.

After the counting process, the count sheets are verified and reported to the managerial level in order to approve the variance and the adjustment in the inventory system. Furthermore, the final discrepancy reports the variance between the inventory book balance and the physical balance in order to identify the underlying reasons for the discrepancies.

2.5 New Technologies and the Application in the Warehouse Management

In this part, the new technologies including drone, image processing, and weight measurement are reviewed to analyze the possible application in the warehouse management.

2.5.1 Drone

At the beginning of the unmanned aerial vehicle (UAV) development in 1961, drone was introduced as the military weapon by an American engineer named Elmer Sperry, in order to carry a torpedo (Békési & Koronváry, 2017). The flying torpedo became the prototype of further military weapons nowadays including modern missiles, non-pilot airplane, and Stealth Drone. Even though UAV was originated with the image of potentially dangerous and harmful weapons for military purpose, the flying drone was applied and developed for non-military uses such as commercial purpose and personal entertainment gadget, which can basically record visual data and send back to users. Furthermore, in August, 2016, Federal Aviation Administration (FAA) relaxed the restriction of drone uses in the commercial purposes (Appelbaum & Nehmer, 2017). For example, the outdoor drone use is generally not allowed to fly higher than 400 feet above the ground regardless of the permission by FAA. Therefore, drones are widely

used by civilians in many businesses such as surveyor service, supply chain management, media, and news.

In terms of commercial purposes, drones are efficiently customized and utilized to facilitate the operational process in various industries. For instance, surveyors were implementing the outdoor drone use to gather aerial maps and stitch topographic maps with the less time consumption than before (Campbell & Katz, 2016). Flying in a standard pattern and clear airspace, the survey drones captured a large number of photos even above of the inaccessible areas. In the media and news industry, many news footages in risky areas were recorded by the flying drones; for example, the protest movement in Poland and Moscow (Békési & Koronváry, 2017).

To relate with the industry of the supply chain management, drones were firstly brought to support the logistic operation. In 2013, Amazon CEO Jeff Bezos launched Prime Air, a service using small drones to deliver packages up to five pounds to customers within thirty minutes (Wunderlin, 2017). The concept of using drones in the logistic operations, accordingly, ignited many researchers to focus on innovative technology throughout the supply chain. Subsequently, the possible roles of drones in the warehouse were further highlighted to seek for the key activities in warehouse management which drones can work with, cooperatively.

Regarding the inventory count and control, the innovation of drone uses was suitable to use in the process of information gathering in order to verify inventory and assets because the drones can support to count inventory at the upper of rack and repeatedly work on same predictable tasks, by flying in the warehouse, scanning barcodes of each SKUs with the attached barcode scanner, and sending the data back to users (Appelbaum & Nehmer, 2017). Furthermore, the drones could perform smoother inventory cycle counts than requiring 10 to 15 people to find lost pallets and slots which are supposed to be filled with goods (Wunderlin, 2017). For example, PINC Solutions proposed the technology concept that allowed the drones to perform the full cycle count when there was no one working in the warehouse (Banker, 2016).

Nevertheless, there were some arguments towards the limit of the drone use in the inventory count. In terms of visual data performance, drones would not provide accurate results if there were amount of ground cover such as the piling up objects, leading to the miscounting (Campbell & Katz, 2016). Likewise, the inventory stacking behind

another in a slot was a concerns of cycle count by drones since they may not access to count that inventory and possibly miscalculate. This limitation had not been minimized because smaller drones are being experimented (Banker, 2016). The complete autonomous system was additionally challenging to companies in terms of the cost-driven factor because the specialists were required to maintain the drone system and provide trainings to other related workers (Wunderlin, 2017).

2.5.2 Image Processing

Apart from the barcode scanner attached on the drones, a camera is a tool to record visual data including images and videos, which can be used for particular purposes. Image processing is the technology that contributes digital signal processing of two- or higher-dimensional signals and arranges the imagery data from an individual photo to more complicate imagery data and pattern by specific designed set of algorithms (Tango, 2016). In general, the image processing transforms measures density levels on a sensor into numeric data in computer memory and generates digital images by referring to overall image size, the number and kind of fine details, and structural complexity. Due to the growth of image processing software and the advancement in the camera devices, the number of businesses has applied this technology to support many operational activities (Birajdar & Mankar, 2013).

In the medical care industry, the image processing was introduced to assist the operation in terms of the digital tool. For example, the image-processing algorithm was developed to provide the image of Pressure Injuries (PI), damage to the integrity of the skin and/or underlying tissue (Tibes, Cherman et al., 2016). Nurses or users tested application on mobile devices by taking a picture of the injury and uploading them to allow the image-processing algorithm to identify the stage of PI and support the decision on treatment methods. The accuracy of the result was 100% referring tested images only; however, the study still needed a greater number of PI cases to store the database for the image-processing algorithm and increase the accuracy. Furthermore, the standardization of the area on human body to be photographed, the proper procedure of healthcare professionals, and training of how to use the device were the limitation towards the implementation.

Another application of the image processing is BakeryScan, a point-of-sales system using a camera to scan unpackaged breads and the image processing calculates the total amount. Under the development by BRAIN Co., Ltd., the image processing together with a sophisticated algorithm distinguishes the similarity of each bread type and accommodate daily variation. The result of the implement reached to 97% accuracy rate, which the company believed that this device reduced the time consumption and improve sales productivity.

Figure 2.1 BakeryScan by BRAIN Co., Ltd.

However, the same concerned point of this technology, as the implementation in the PI detection device, was that the capability of learning of the image-processing algorithm became more accurate, the more photos and footages the device took.

2.5.3 Weight Measurement

The small size materials such as bolt, screw, and other mechanical fasteners are a part of all SKUs in the Airbus warehouse that need to be monitored. The small and identical figure of each material possibly cause human errors in inventory physical counting. According to the technology reviews, one of the research team suggested the weight measurement technology named Weight Log by SFS Unimarket AG.

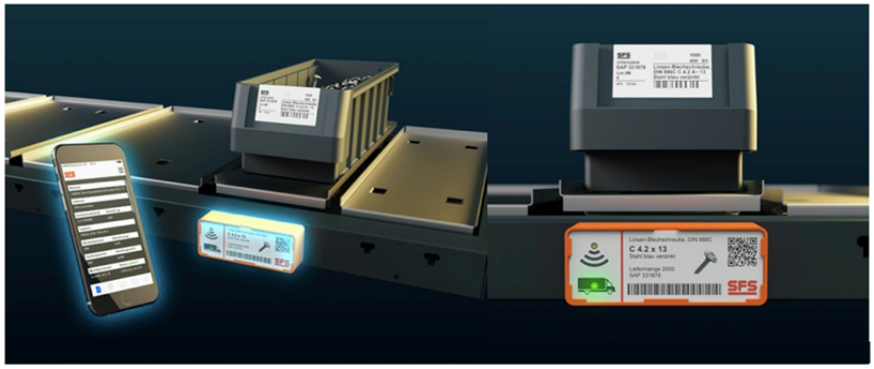

Figure 2.2 Weightlog by SFS Unimarket AG

Regarding the functionality of the Weightlog, every tank in the warehouse was equipped with a weighing cell and driven by captors that defined the weight and alerted the receiver when the minimum stock was achieved. The small-sized products were assigned in particular box above the weighing cell. Every bin was registered with the minimum stock of each SKUs that needed to be maintained. Once the weight reached to the minimum stock, the captor automatically sent an alert to a receiver to see the remaining stock and need to replenish. The Weightlog was a movable and wireless instrument that the company can adjust the location and installment in line with the change of layout of the warehouse. However, the specification such as identification code, dimension, and weight must be carefully registered to the main system SKU by SKU in order to prevent the miscalculation and wrong stock replenishment.

CHAPTER III
RESEARCH METHODOLOGY

In relation to the milestone assigned by Airbus SCM&L, the research methodology is composed of two sections: the conceptual framework and the data collection.

3.1 Conceptual Framework

In the section of conceptual framework, Value Chain Model (Porter, 1985) is used as a tool to guide the key activities to observe the warehouse management and analyze the prospect problems in each area that impact the inventory physical count. SWOT analysis is subsequently brought into the analysis and evaluation of the pros and cons of the new technology implementation in the existing warehouse. The conclusion and recommendation, accordingly, base on the analysis of the new technologies to suggest necessary improvements in the warehouse management.

3.1.1 Value Chain

In 1985, the concept of Value Chain by was introduced by Michael Porter to observe a sequence of activities, which are operated by a firm to provide a product or service (Hanot, 2016). The activities are categorized into two groups. First, primary activities, which directly add value to the products, include inbound logistics, operation, outbound logistics, marketing, sales and service. Second, support activities including procurement, finance and accounting, research and development, human resources, and firm infrastructure, indirectly yield value to the firm or not add any value to the product, but they are essential for sustaining a business.

Figure 2.1 Value Chain Model by Porter (1985)

In this company project, the researchers focus on the primary activities in order to observe the key activities in the Airbus warehouse. The key activities, accordingly, are listed to understand the flow of SKU movement in the warehouse, which is the first objective of the company project. Furthermore, the knowledge of the key activities in the warehouse allows the researchers to understand the current condition and concerns towards the inventory physical count as well as the warehouse management.

3.1.2 SWOT Analysis

SWOT chart is consisted of four elements: strengths, weaknesses, opportunities, and threats. This conceptual framework helps evaluating organization, project, or business as well as defining if the strategy should be refined or adapted to the dynamic of external factors (Hanot, 2016). The outcome of SWOT analysis can be useful to present the finding and to craft future strategic plans.

In this company project, the researchers compare the strengths to the weaknesses of each new technology for the inventory physical count. For opportunities and threats, the researchers mainly focus on the external factors regarding the aerospace industry that possibly impact the implementation of the new technologies for the inventory physical count at the warehouse. As a result, SWOT analysis helps the researchers to find pros and cons of the new technologies for the inventory physical count together with the limitation that can be suggested for further studies.

3.2 Data Collection Method

In the section of data collection method, the on-site observation at Kuehne + Nagel warehouse, one of the third-party warehouses of Airbus, is allowed to gather visual data and unstructured interviews. For the knowledge of new technologies in the warehouse management, the data are retrieved from the related articles on the journals and articles on the Internet as the secondary information for the analysis. Beside, the information about the Weightlog is retrieved by one of the team members because the interview is in French, and it needs to be summarized in English.

CHAPTER IV
FINDING AND DATA ANALYSIS

Corresponding to the findings, the researchers report the key activities from the site observation and relates to the framework of Value Chain to illustrate the entire procedures in the warehouse. The classification of SKUs is reported, as well, to acknowledge how to store each type of SKUs. Afterwards, the information from key activities in the actual warehouses and data collected from the journal reviews are analyzed under SWOT framework.

4.1 Key Activities in Value Chain of the Warehouse Management

With reference to the observation in the Kuehne + Nagel warehouse, the whole primary activities can be determined in three groups based on the framework of the Value Chain: (1) inbound logistics, (2) storage, and (3) outbound logistics.

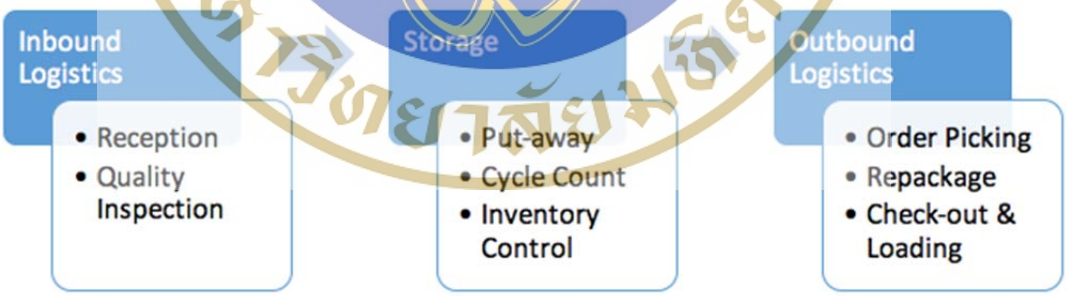

Figure 4.1 Primary Groups of Key Activities in Kuehne + Nagel Warehouse

To understand the crystal-clear concept, the sub-level activities of each primary group are explained in the context of Airbus warehouse management by the followings.

4.1.1 Inbound Logistics

There are two major activities in the inbound logistics including *reception* and *quality inspection*.

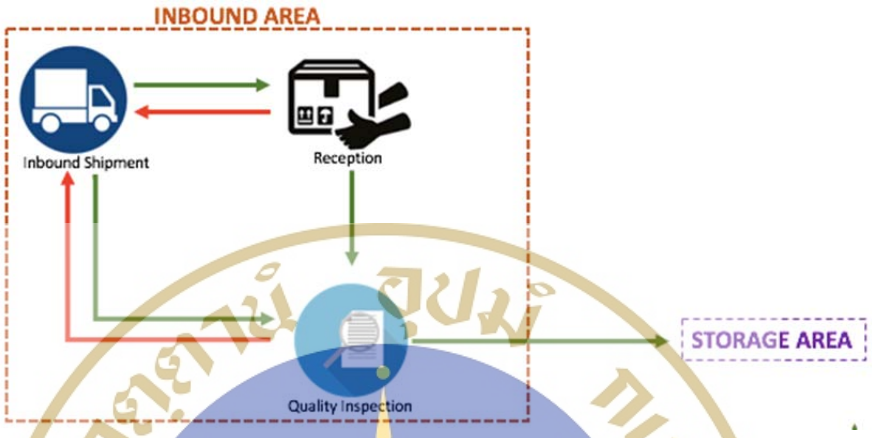

Figure 4.2 The Workflow of the Inbound Area

Firstly, once a carrier with the goods arrives at the inbound dock, they are unloaded, and the shipping documents are completely processed at the reception area to check the batch of goods, certificates of analysis, and other necessary documents such as custom clarification form. In case of successful reception, the goods are received in the system; then, the barcode label is printed to identify all details of the goods. Eventually, the goods are moved to the quality inspection area (also called quarantine zone). However, in case of wrong parts and document discrepancy, the goods are not received and rejected back to the suppliers immediately.

Second, the received goods are in the quality inspection process. According to the site observation, Airbus warehouse activities contain both visual inspection and document inspection. Regardless of quality issues, the goods are prepared in the temporary area for put-away process. In case of any quality issues, the defected goods are moved to the quality inspection area in order to rework some minor defects, or to replace with the qualified one from suppliers. Accordingly, the defected goods are not allowed to move into the storage area.

4.1.2 Storage

After the goods are completely verified and received, the software in the warehouse management system calculates the available space to fill goods in the free rack. The dimension of packaging, the type of goods, the turnover rate and the space availability are taken into account to suggest the suitable area. This function can be configured according to the warehouse management strategy. Eventually, the goods are put away in the storage area.

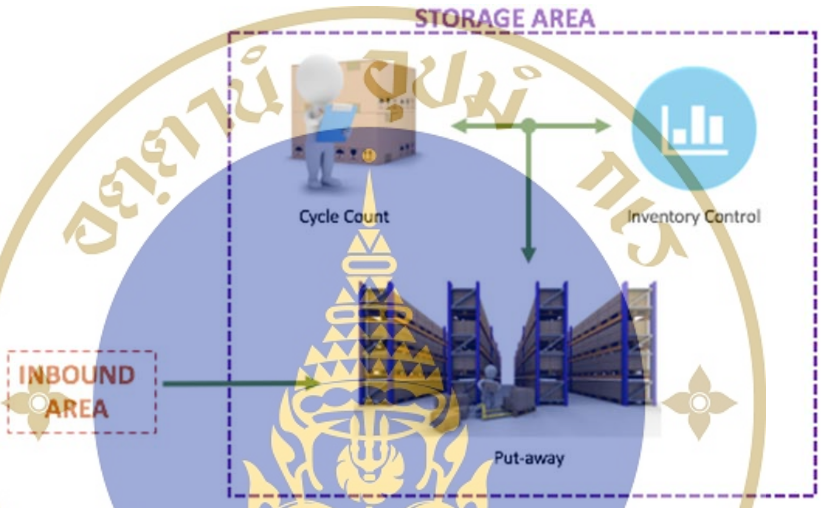

Figure 4.3 The Workflow of the Storage Area

In terms of the inventory control, the supply planning team are in charge of monitoring the current stock, the incoming stock, the shelf-life and the consumption rates in order to plan for re-ordering and reduce the number of overstock and obsolescent parts.

In terms of the cycle count or inventory physical count, the logistics team physically and visually check the goods in the stock to find out the variance between the number recorded in the system and the physical stock when there is no stock movement, also called the shut-down period. This key activity is relevant to the storage area and the classification of each SKUs because the ways to handle are different in particular section of the storage area, which is explained in another topic.

4.1.3 Outbound Logistics

The production line or the market place confirms the orders so that the logistic team issue the picking list to refer the location of goods, the batch, and the quantity of goods. As a result, the goods are prepared in the temporary zone.

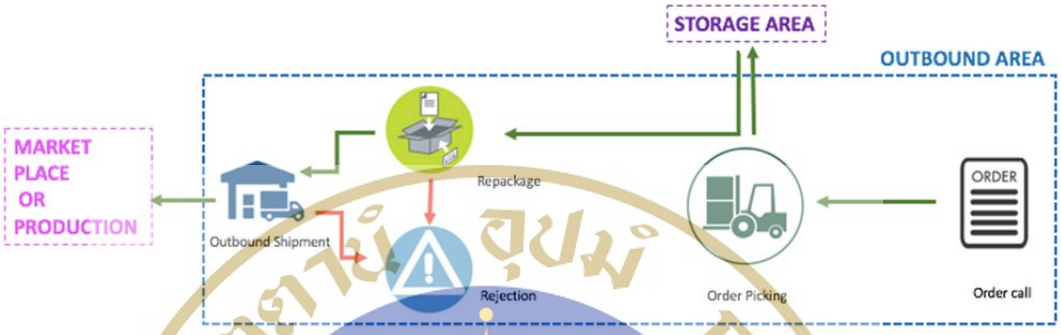

Figure 4.4 The Workflow of the Outbound Area

After that, the goods are moved to the repackage zone in order to put in the standard packaging. For example, the bolts are filled in the standard returnable box. A label of goods is printed and placed on the box to indicate the information of the delivery. Other large-sized goods are also repackaged in the specific packaging designed for particular production lines.

When the goods are completely repackaged, they are loaded on the carrier. All of the delivery documents including a certificate of analysis, a delivery notes, an invoice, and so on are prepared together with the goods. Finally, the carrier checks out from the warehouse, and it delivers the goods to the production line or the market place.

In accordance with three primary groups of the activities in the warehouse management, the workflow is created by connecting every moves of the goods from inbound to outbound.

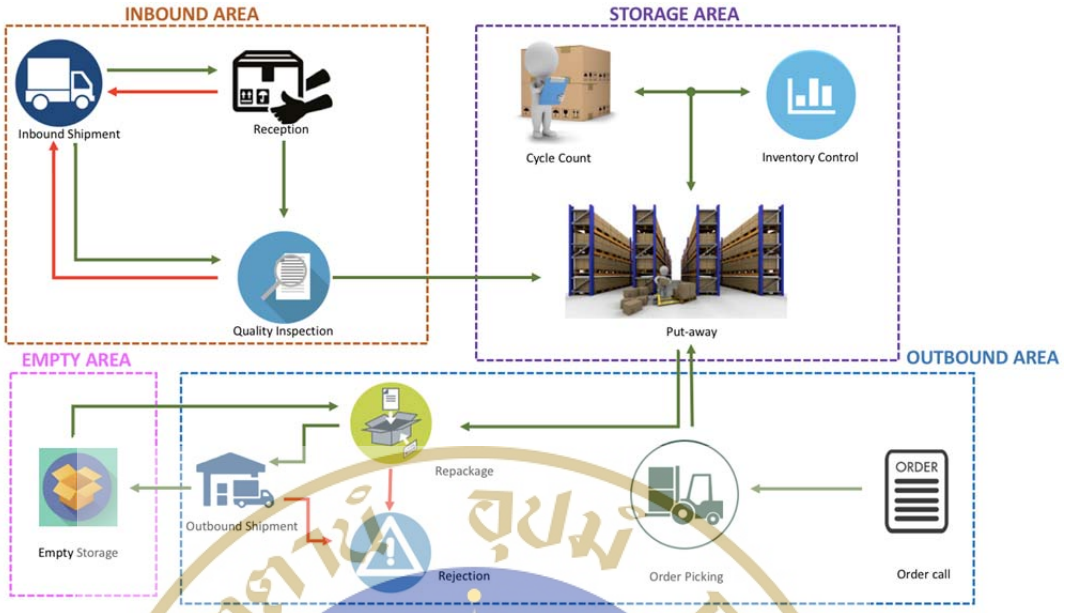

Figure 4.5 The Overall Workflow of the Warehouse Management in Kuehne + Nagel Warehouse

Walking through all area in the warehouse, the researchers would map the key activities and the actual layout of the warehouse in order to understand the flow of the goods movement.

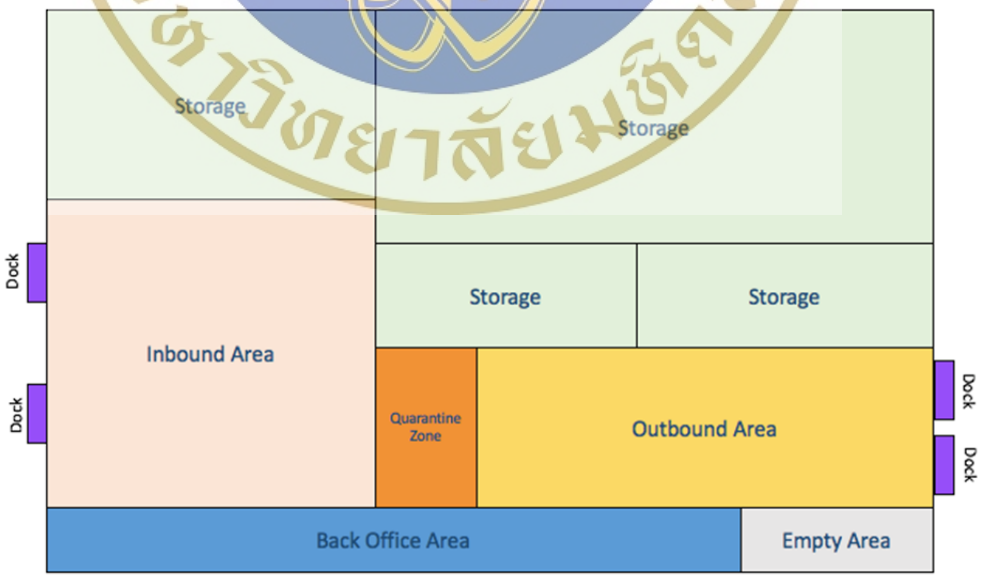

Figure 4.6 The Layout of Kuehne + Nagel Warehouse from the Observation

From the layout, the storage area consumes approximately more than 50% of all area. The storage zone is also divided into four sub-section according to the type of the SKUs, which are stored in the different condition. This topic is explained more subsequently to help understand the unique characteristics of each storage zone.

4.2 The Classification of Storage Keeping Units (SKUs) in the Warehouse

Apropos the inventory physical count, the classification of SKUs in the warehouse should be observed in order to understand the different handling procedure. In Kuehne + Nagel warehouse, there are four major types of SKUs classified by size and shape. The different classification also determines the particular section of the storage area.

Figure 4.7 Sub-sections of the Storage Area

The first section of the storage area is the large-sized SKUs; for instance, the external component parts of the airplane including turbo fan engines, spoilers, flaps, and other engines. Furthermore, other finished goods such as galley carts and airplane compartments are stored in this area. Because of the vulnerability concerns, these large-sized SKUs are placed on-ground storage, and piling up the SKUs are not allowed.

This section, accordingly, consumes large area while the number of SKUs was not plenty. The barcode labels are attached on the SKUs.

The second section of the storage area is the standard-sized SKUs, which means the goods are packed in the standard carton. On the pallet, the cartons can be piled up in the particular number of levels, depending on the packaging registration of each SKUs. These cartons are put away on the racks. The barcode labels are attached on each carton to identify the details of the SKUs.

The third section of the storage area is the small-sized SKUs including bolts, screws, and other mechanical fasteners. These SKUs are transferred from the second section after a carton of particular SKU is unpacked and filled in the rack with many drawers. This special type of racks allows a staff to pick up goods conveniently when he/she receives orders that particularly identifies the codes of each small SKUs. Also, it prevents the discrepancy of picking-up process due to the small size of goods which are visually identical, but not the same products. There is not a label on the products since they have been unpacked and fill in the bins. There is only a product code for each SKU on the bin.

The last section of the storage area is the non-standard SKUs including S-shaped pipes and other specific shapes. The size of products is not as large as the products in the first section; accordingly, some SKUs can be piled up in proper ways. However, most of the SKUs are hanged on the the hooks attached on the railings.

4.3 Problem Analysis in each Sub-section of Storage Area

In the part of the problem analysis, the issues result from the observation in each sub-section of the storage area and the checklist of the key activities in the warehouse management from the literature reviews. There are three key activities including repackaging, put-away, and storage that the problematic issues are found.

The first problematic issue relates to the key activity of repackaging. From the observation, the small-sized SKUs are from the cartons of standard-sized SKUs that are unpacked and filled in the rack with many drawers. There is not repackaging before put-away for other areas.

The second problematic issue relates to the key activity of put-away. After the repackaging, the small-sized SKUs are put in the drawers, and there is not a barcode label on the materials. Only barcode label with identification number, batch, and quantity is placed on each drawer to indicate the SKU code. A barcode label is attached with the carton or physical product of large-sized and standard-sized SKUs. For the non-standard SKUs, some SKUs are attached with standard label codes, but some SKUs are imprinted by the laser from the suppliers.

Table 4.1 Summary of Problem Analysis in each Sub-section of Storage Area

Problematic Issues	Repackaging	Put-Away	Storage		
	Repackaging Before Put-away	Barcode Label	Piling-up	Patterned Storage	Limited Accessible Space
Large-sized SKUs	N	Y	N	Y	N
Standard-sized SKUs	N	Y	Y	Y	N
Small-sized SKUs	Y	N*	Y	N	Y
Non-standard SKUs	N	Y	Y	N	Y

Definition: 'Y' = The area relates to the problematic issue

'N' = The area does not relate to the problematic issue

'*' = The specific condition in particular areas has a potential impact on the problematic issue

The third problematic issue relates to the key activity of storage which can be classified into three dimensions.

In terms of pilling up, all types of SKUs, except large-sized SKUs, are stacked up at the certain level depending on the registration of each SKUs. The reason is the vulnerability of the products that might not handle the weight pressure and lead to the damage eventually.

In terms of the patterned storage condition, both large-sized and standard-sized SKUs are arranged on the pallet in the patterned layout that the SKUs have been registered. However, the small-sized SKUs are filled in the drawers in the non-patterned layout since the size is too small to arrange in the bin. Furthermore, the non-standard SKUs are piled up and hanged on the railings in the non-patterned ways because some specific shapes, for example the hexagonal joints of the S-shape pipe, does not support to pile up in the patterned ways compared with the carton shape of standard-sized SKUs.

In terms of limited accessible space, the space between each pallet and rack is narrow to allow staffs and devices move openly, especially in the small-sized and non-standard SKU storage area. In other areas, the space between each location of SKU is conveniently enough to allow the devices move without the spatial constraint.

4.4 Strength and Weakness Analysis of the New Technologies for Inventory Physical Count at the Warehouse

To consider the potential of the new technologies for IPC at the warehouse, the researchers focus on the strengths and weaknesses as the internal factors that impacts on the evaluation of pros and cons of the implementation including drone, image processing, and weight measurement. Table 2 shows the comparison of each new technology against the problematic conditions in each sub-section of the storage area from the previous section to understand the tendency of the application for IP at the warehouse. The green color means ‘applicable’. The yellow color means ‘potentially applicable but need the improvement from warehouse’. The red color means ‘inapplicable due to the technology limitation’. Last, the black color means ‘irrelevant to the problematic conditions’ which the technology specification does not relate to the area and issues.

Table 4.2 Comparison of New Technology and Tentative Application in each Sub-Section Storage

Storage Area	Problematic Conditions	New Technologies		
		Drone	Image Processing	Weight Log
Large-sized SKUs	NO repackaging before put-away			
	Barcode label			
	NO piling up			
	Patterned Storage			
	NO limited accessible space			
Standard-sized SKUs	NO repackaging before put-away			
	Barcode label			
	Piling up			
	Patterned Storage			
	NO limited accessible space			
Small-sized SKUs	Repackaging before put-away			
	NO barcode label			
	Piling up			
	NO Patterned Storage			
	Limited accessible space			
Non-standard SKUs	NO repackaging before put-away			
	Barcode label			
	Piling up			
	NO Patterned Storage			
	Limited accessible space			

Definition: GREEN = Applicable

YELLOW = Potentially applicable but need the improvement from warehouse

RED = Inapplicable due to the technology limitation

BLACK = Irrelevant to the problematic conditions which the technology specification does not relate to the area and issues

4.4.1 Strength and Weakness of Drone

On the dimension of the strengths of the uses of drones for IPC at the warehouse, this technology concept can potentially reduce the dependence of human work force since it was the semi-automated concept. Many journals agreed on the same way that the drones were proper to work on the routine and predictable tasks, identical to the IPC. Related to the key activities in the warehouse, the IPC takes place during the no stock period, which allows a project developer to configure and design the route of drones in order to perform IPC, so that the drones can be set to fly and scan barcode on particular schedule.

However, the major weakness of the uses of drones for IPC at the warehouse is that the drones possibly fail to access the limited space. Due to the observation in the warehouse, the storage area for the small-sized SKUs is not possible to access by drones because the space between each rack is narrow as well as the space between each row. Moreover, another limit is that drones cannot provide accurate results if the target is covered with a number of layers. In the case of the warehouse, both small-sized and non-standard storage areas are seen as the multi-layer coverages because the SKUs are piling up and arranged in non-patterned way.

4.4.2 Strength and Weakness of Image Processing

The strength of the image processing is complement to the drone technology. In addition to the barcode scanner, the images from flying drone can be processed to suggest the number of actual SKUs to physically count. In case the areas including small-sized and non-standard SKU storage area that the drone cannot access, the staffs can get inside these areas and take photos. The system can analyze these visual data and suggest the physical number back.

On the contrary, the weakness of the image processing is that the algorithms of this technology requires sample pictures as much as the capability of the system to learn. The system developer should configure the algorithms to support the whole SKUs in terms of arrangement pattern in the storage area. In the non-standard SKU area, it is necessary the warehouse staffs arrange and stack the material in the patterned ways the system can recognize and generate accurate counts. However, it would not be possible to arrange the small pieces of whole bolts in the small-sized SKU area to support the

device. Accordingly, this technology may not minimize the gap of drone uses for IPC in this area.

4.4.3 Strength and Weakness of Weight Log

The strength of Weight Log is that the device can measure the total weight of the entire amount of SKU in the bin, suitable for the replacement of the existing cabinets in the warehouse regardless of spatial constraint. In case of IPC at the warehouse, the staffs can cross-check with the actual weight divided by the weight per piece in order to see the actual amount at the actual location; accordingly, it reduces the human workforce despite piling-up materials in the bin.

However, the weakness of this technology is that the master data including identification code, dimension, and weight must be carefully recorded in the system. Also, the staffs must carefully replenish the stock to prevent the product discrepancy in each bin and the wrong calculation because the device detects only the weight. No labels attached on products; as a consequence, the appearance of the products is the only way to categorize, which might cause an error due to very identical shape in some SKU. Plus, this technology is not applicable for other areas including large-sized, standard-sized, and non-standard SKUs because of the device specification designed for small pieces of products, especially.

4.4 Opportunity and Threat Analysis of the Aerospace Industry for the New Technology Implementation for Inventory Physical Count at the Warehouse

For opportunities and threats, the analysis bases on the external factors resulting from the aerospace industry that can either encourage or impede the necessity of the drone, image processing, and Weightlog for IPC at the warehouse.

As regards the opportunities in the aerospace industry, the Global Market Forecast 2017 – 2036 by Airbus SAS reported that the market of air transport had been growing 60% since 2006. Also, they forecasted that the global market would demand for 34,900 new air crafts by 2036. To relate with the warehouse management, the prospect

higher demands in future increase the frequency of production shifts, which result in the high turnover rate of SKUs in warehouse. Accordingly, it is considered as the opportunity for the drone and image processing for IPC that the cycle count would be assigned more often in order to reduce the stock discrepancy in the warehouse. Moreover, Weight Log would be suitable to cover present and future demands because its functions boost the inventory accuracy and punctual replenishment rate.

Nevertheless, the threats of the aerospace industry have an impact on the drone and image processing for IPC at the warehouse. In case the forecast of global market by Airbus is far away from the reality, the demand for aircrafts might not result as high as the expectation. For example, the jet oil price or the insecurity of the air transportation could have a short-term effect on the demand of end-user of passenger aircrafts. Even though the upstream industry, like the warehouse industry, would not directly be affected by the fluctuation from the market, the implementation of these two technologies is tentatively considered as the optional tools that can be replaced by the human force. Additionally, the aircraft seems to be the slow-moving products due to a few number of buyers in the market compared to automotive and consumer goods. The purchase orders of the finished aircraft must be proposed in advance for years so that the sourcing and procurement of raw materials and WIP parts from suppliers are determined in advance. The increase of demand, therefore, in future would not have dramatic impacts on the inventory turnover because the production capacity is still limited by Airbus.

CHAPTER V
CONCLUSION AND DISCUSSION

On the ground of findings and analysis, the study contributes the conclusion, discussion, and limitation of the study. Furthermore, the suggestion for future study is also provided.

5.1 Conclusion

The study and observation reveal that the various classification of the SKUs is the primary factor that determines the new technology selection. The combination of drone and image processing can potentially perform the IPC at there sub-section of the storage area including large-sized, standard-sized, and non-standard SKU area. However, the warehouse management needs to improve the ways to arrange the products in the non-standard SKU area to facilitate the performance of the image detection and reduce the risk of miscalculation by the system. For the small-sized SKU area, the Weight Log technology is the potential companion to other technology because it can measure the total weight and total quantity at the physical location. It potentially reduces the time consumption. Additionally, this technology practically implements in the warehouse of SFSIntec Screw in France; therefore, Airbus can directly contact with the supplier to see the possible application in Airbus warehouse. To boost the accuracy rate of the Weight Log, the master data preparation of the small-sized SKUs must be correct at the first place to prevent the quantity discrepancy, and the replenishment must be ensured that the right SKU as well as quantity and batch is filled in the right location.

Considering the external impacts on the new technology implementation, the characteristic of the aerospace industry is the secondary factor that indirectly lessened the needs of the drone and image processing in IPC. Based on the SWOT analysis, the purchase rate of aircrafts is not as fast as automobile and consumer goods because of product core functions, price, and maintenance costs. The initial demand is triggered by

a few end-customers in advance because the lead-time manufacturing process and testing consume a year approximately. Accordingly, the planned production of each year is constant so that the material consumption and replenishment are prone to proceed consecutively steady. At the end, the turnover rate of SKUs could be roughly determined by the quota of production and the forecasted orders, which assign the bills of materials in each component of the aircraft. Resulting from the predictable turnover rate, the warehouse management team can control the frequency of IPC which may not require many cycles. The uses of drones and image processing would be postponed to the optional choice instead since the inventory control does not require a number of counts per year.

5.2 Discussion

Based on the literature reviews, Banker (2016), Applebaum and Nehmer (2017), Wunderlin (2017) agreed on the same way that the drones were possibly used in the inventory count because of the innovative functions to fly from place to place, and to scan barcodes of each label. However, the on-site observation points out the limit that the current technology of drones cannot perform suitably; for example, in the storage area where goods are piled up or stacked behind another.

To work with drone and image processing for IPC more effectively, the feature of the storage should contain the large-sized or standard-sized products. Therefore, these technology concepts are recommended to run a trial in a warehouse that stores the identical and standardized packaging, widely found in consumer goods, in order to study in-depth towards the performance in action. Moreover, the application of the image processing with the drone could generate extended result in terms of the visual data and the count prediction based on the image recognition in the system.

5.3 Limitation of the Study

The conceptual framework of SWOT analysis would create the false perceptions of the new technologies because it portrays the broad images towards the past research and environment. For this study, the aim of SWOT analysis is to raise an awareness towards the practical functions of the technology concepts. A trial-run

should be provided in the Kuehne + Nagel warehouse in order to record the real result from the implementation.

Additionally, drone and image processing are new to the warehouse management business. There were few papers to reflect the result of the drone uses in IPC. Stated in the journal by Banker (2016), the drone uses in IPC had been being developed and studied whether the smaller size of drones can work well in this field or not. As a result, there are plenty rooms of improvement for these new technology implementation in the warehouse management business to discover.

5.4 Suggestion for Future Study

Speaking of the key activities in warehouse management, the picking process is another dimension to study the possibility of the drone uses. Because Amazon was a successful case of using flying drone to deliver goods to consumers, it is possible that drones pick goods from the shelf and deliver them to the outbound area. Drones can be applied for the security monitoring in the warehouse as well. Accordingly, the suggestion for future study is to focus on other key activities in the warehouse management to seek for more adaptably suitable rooms for the drone uses.

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