สำนักหอสมุดกลาง พระจอมเกล้าลาดกระบัง

A REFERENCE MODEL OF THE DISTRIBUTION CENTER IN HOSPITAL SUPPLY CHAIN

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THESIS TITLE	A REFERENCE MODEL OF THE DISTRIBUTION CENTER IN HOSPITAL SUPPLY CHAIN
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ABSTRACT

The eminent increase in demand for quality healthcare services in Thailand over the last decade has prompted the need to improve healthcare services systems. The supply chain and logistics management plays an important role in increased effectiveness and efficiency of healthcare services operations in public hospitals, the largest medical service providers in Thailand. To improve the efficiency of services would start from the beginning how the medical products distributed and stored before used to the patients. A reference model for hospital supply chain will assist management in developing a seamless supply chain processes integrating vendors, manufacturers, hospitals and internal operational departments. This will result in a well-designed operational framework which improves performance in various areas, such as response times, process transparency, and quality of care, costs, risks and time.

This research adopts the Supply-Chain Operations Reference model (SCOR) designed by the Supply-Chain Council and Business Process Model and Notation (BPMN), which are widely used in designing universally applicable and reusable organization structure frameworks with descriptions of business and supply chain processes, performance metrics, best practices, and technologies. The study focuses on identifying the current generic supply chain processes within the distribution centers of three-large-size hospitals in Thailand, and developing a standardized model with a common language of distribution processes for hospital supply chain based on SCOR model and BPMN method. The standardized model derived is characterized as activities-based with top-down management decision making criteria for further implementation as a result.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Supply chain and logistics management has been continuously developed to improve business performance in organizations over the last three decades. It is undeniably the one of the most critical mechanisms for any industry since the efficient management of supply chain and logistics is the key to success of any suppliers, manufacturers and retailers, for example. Hospital industry, in particular, has been growing with the ever increasing demands for healthcare services. Hospitals serve customers and patients whose demands are varied dramatically; therefore, the supply chain and logistics has been at the heart of hospital management.

However, hospital's supply chain and logistics development is still at the early age as opposed to that of other industries. A typical hospital supply chain is a complex network consisting of the linkage role between vendors, manufacturers, distributors, hospital and internal departments. The co-ordination of material flow and information flow within the chains are subject to individual hospital's strategy and policy. The efficient supply chain management contributes greatly to competitive advantage of any business; hence, the inefficient one may cause the opposite. As a result, hospitals have to align their objective and strategy to maximize patient care while minimizing variable costs and wastes (Everard, 2001: DeScioli, 2005).

1.2 Background and Problem Statement

In Thailand, most hospitals are owned and managed by government with; the traditional hospital management. The lack of standardized processes of such management cause poor operations and co-ordinations between relevant units in supply chain and may lead to unsatisfied service provided to customers. It is apparent that amidst the increased demands for healthcare services, the number of state health personnel and facilities system could not support them (Ministry of Public Health, 2008-

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2010). Kritchanchai (2012) highlighted that the top concerns and problems raised by focused parties in healthcare industry in Thailand are inefficient business process, data inconsistency and fragmented supply chain system. This has prompted the need for a proposed framework for Thailand healthcare supply chain which is based on the confirmed problems and intervention improvement; standardization, information sharing and business process re-engineering. The problems of management and operational system at Ramathibodi hospital, a large sized public teaching hospital with approximately 1,000 with continuous increased in number of patients, caused high inventory level, high average storage time, and poor storage conditions in each distribution center due to limited space and facilities support system (Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

Several supply chain management and development studies suggested that distribution center is one of the most significant parts in supply chain because it represents a large amount of costs of material storage and control (e.g. temperature-controlled, distribution process etc.). In effect, supply chain and logistics management is crucial for inventory distribution and control in distribution center to achieve optimal accuracy, timeliness, traceability to attain hospital's performance (Hutujuta and Punnakittikasem, 2001; Toba et al., 2008). To maximize the long term hospitals' competitiveness in patient's safety, business process re-engineering, standardization and information sharing through efficient and effective supply chain and logistics management, the development and implementation of reference model of the distribution center in hospital supply chain is required (Brown et al., 2011). The full-scale model in distribution processes derived from the reference model will connect the role and responsibility of data interfaces and activities in hospital supply chain. The well-designed structure and standardized processes will improve performance, response times and quality of care for decision making as a result. Therefore, the present study focuses on a full-scaled reference process model of the distribution center in hospital supply chain.

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1.3 Objective of the Study

The purposes of the study is to develop a generic business process models with a set of performance parameters for distribution center that support decision makings and act as a reference model for use in top-down structured organizations.

The research question of this study is:

How can reference process models be designed for the distribution center for large-size-hospital supply chain in Thailand?

The qualitative research approach applied in the study includes in-depth interviews, additional desk research and observation of the existing distribution process at two public and one private large-scale hospital. The data was collected and analyzed to obtain the As-Is pharmaceutical distribution process as a basis for the development of the standardized generic model.

1.4 Scope of the Study

The present research studied the existing business process model of distribution center of three large-size-hospitals in Thailand to identify the best practice and development of generic reference process models in the hospitals' supply chains.

1.5 Methodology

This research followed the qualitative research method of in-depth interviews, additional desk research and observation to the existing distribution processes at Hospital A, Hospital B and Hospital C, in order to collect the data to analyze and redesign the As-Is process into the standardized generic model.

The Supply-Chain Operations Reference model (SCOR) designed by the Supply-Chain Council and Business Process Model and Notation (BPMN), which are widely used in designing universally applicable and reusable organization structure frameworks with descriptions of business and supply chain processes, performance metrics, best practices, and technologies. The research adopted SCOR model principle and performance metrics to identify and measure the current generic supply chain processes

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within the distribution centers of three-large-size hospitals in Thailand, and develop a standardized model with a common language of distribution processes for hospital supply chain using BPMN method.

1.6Thesis Outline

The structure of research will be organized in four steps; (i) literature review, (ii) case observation and analysis, (iii) reference process design and (iv) model review and validation. The remainder of this paper is organized as follows and shown in outline activities in Table 1.1. In chapter 2, the related literatures are reviewed and analyzed with the selected research methodology and methods. It explained the basic knowledge on distribution center and specific structure for healthcare industry, Reference models (RM) SCOR model and metrics, including Business Process Modeling Notation (BPMN). Then it is argued the existing studies and presented how reference process models can be designed for the distribution center for large-size-hospital supply chain to reach its objective.

Subsequently, chapter 3 is described the case studies observation and AS-IS distribution process in hospitals, preparing for the reference process modeling in chapter 4. The structure-interview-questionnaire are designed and conducted at selected hospitals, with additional desk information collected in this step. Conceptual supply chain model is analyzed based on AS-IS processes and sequences to identify the specific characteristics of business process and constrains. The generic processes will be determined into SCOR process categories (plan, source, make, deliver and return).

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Table 1.1Thesis outline activities

1. Introduction		
2. Literature review		
	2.1	Hospital Supply chain
	2.2	Distribution center for Hospital
	2.3	Reference Process Model
	2.4	SCOR-Model
	2.5	Evaluating tools e.g. Structured-interview process with designed-oriented methodology
	2.6	Previous studies on related topics
3. Case observation and analysis		
	3.1	Select large-size-hospitals to interview
	3.2	Design and conduct structured-interview questionnaire and additional desk information research
	3.3	Data analysis on As-Is processes and sequences
	3.4	Conceptual Supply chain model
	3.5	Identify the specific characteristics of business process and constrains
	3.6	Identify the main factors that determines the differences among Supply chain configuration within Hospital industry (Comparing between public and private hospitals)
	3.7	Defines the process, plan, source, make, deliver and return
	3.8	Addresses different process categories per level 1 process
	3.9	Defines detailed activities per process category and performance metrics
4. Design specific reference process model in hospital DC using BPMN		
	4.1	SCOR Model
	4.2	Business Process Diagram using BPMN Notation
5. Verify and validate the reference model		
	5.1	The reference model will be reviewed by in-depth interviews with experts of hospitals
	5.2	Research conclusion and Recommendation for the reference model implementation

SCOR model and BPMN will be used to design the reference process model in chapter 4 which is based on generic process-performance mapping for each activity within distribution center of hospital supply chain. SCOR model is presented at level 1 to level 3, in order to explain the correlation of performance metrics and role and

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responsibility at each process. In additional SCOR level 3.5 will be extended for the further implementation roadmap. Next, the research results are verified and validated for further implementation suggestion. In the last chapter, once the reference model have been designed based on SCOR process and performance metrics frameworks, we will discuss and summarize how the reference process model can be used for the distribution center for other hospitals in Thailand and future research.

1.7 Research Constrains

- Limited contribution in public hospitals because of laws and government processes that would affect the designed reference model in term of decision making criteria and processes
- Implementation of reference process model depends on the management point-of-view, policies and existing system accessibility and facilities
- The designed reference process model from this paper will base on an extensive case study in 3 hospitals (2 publics and 1 private), and be reviewed in-depth by hospital experts. As result, the research could provide solid evidence that the designed model in hospital DC meet the specific requirements to reference process model. Nevertheless, there may have some important opportunities for future development and research

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CHAPTER 2

LITERATURE REVIEW

2.1 Hospital Industry and Its Supply Chain

Hospital industry is quite similar to the other industries, instead of producing the products to deliver, hospital provide the healthcare services to the customers or patients. The variety of product and service enterprises, the readiness of medicals and medical supplies, pharmaceutical staffs and the availability of beds or operating rooms are the most important factors in this industry. Supply chain and logistics management has become a key to success of hospital management, which to consider the significant factors that affect to patient's safety and operations costs.

A typical hospital supply chain is a complex network within its independent processes, operations and organizations; consisting of different parties between vendors, manufacturers, distributors, hospital and internal departments (see Figure 2.1). Hospital's strategy and policy management has limited criteria for each hospital's including hospitals' size, geographic location, diversification, and various specializations. According to Richard et al (2002) and Kritchanchai (2012) described the four main types of players in typical hospital supply chain which are Vendors or Manufacturers, Distributors as 'External chain', and Hospitals (or healthcare providers), Payers (or patients or governments) as 'Internal chain'. Manufacturers may also have many vendors or suppliers who involve the creation of active ingredients contained within the medications. Once the active ingredients are produced into useable drug dosage and ready to deliver, the finished products are distributed to hospital by distributors. For Internal chain, the hospital has also storage location for finished products that require to be kept as inventory and distribute to the points of care units or dispensing point further.

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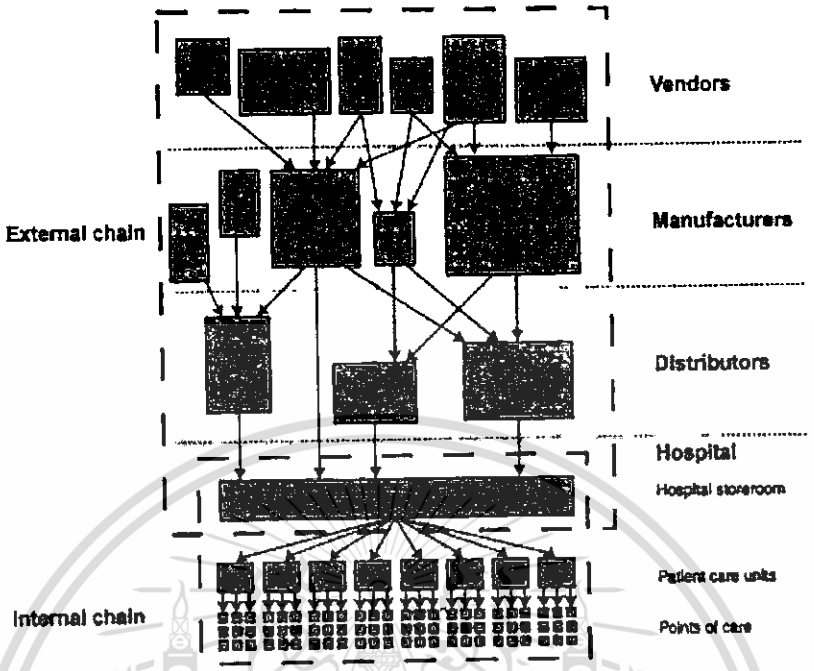

Figure 2.1 Typical Hospital Supply Chain (resource: Rivard Royer et al, 2002)

Supply chain and logistics management concept has just been introduced to hospital industry at an early stage. The continuous improvement of supply chain performance has become one of a critical issue for any suppliers, manufacturers, and the related retailers to gain and sustain their competitiveness, as well as in the hospital industry in order to maximize patient care with optimal cost and wastes. Samuel, et al. (2008) provides the overview of the current issues in hospital supply chain that is very fragmented and the coordination between players are yet possible. They identified several factors in the case study in US as contributing to the problems faced by hospitals in managing their supply chain, which actually impact bottom line profitability of any operations. The outdated IT systems and infrastructure, poor inventory and distribution management, ad-hoc procurement systems, lack of executive involvement, no process improvement culture and fragmented supply chain are main factors in nowadays issues in hospital supply chain. (Samuel, et al. 2008; Moon, 2004; Burns, et al., 2002)

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It has been proved from the survey results, conducted by Center for Innovation in Healthcare Logistics; in US (2008) that show about 42 percent of respondents see the lack of data standards as a challenge to achieving Supply chain Excellence.

In Thailand, the traditional stated-own hospital management and limited facilities systems still could not fully support the number of patient visits increased per year at each healthcare service (Ministry of Public Health, 2008-2010). Kritchanchai (2012) mentioned that which cause inefficient business process, data inconsistency and fragmented supply chain system as the top three concerns and problems in the focus area. Operations and co-ordinations across parties in hospital supply chain are lack of standardization in processes, which has prompted the need for a proposed framework for Thailand healthcare supply chain in the large scale of improvement.

Table 2.1 External and internal factors that affect the hospital's performance and service level

External Factors	Internal Factors
Number of patients increased	Management policy at all levels (Strategic, Tactical, Operational)
Coordination between chains	Purchasing process has long lead-time
International standard of good storage practice and good distribution practice	Inventory and distribution management are inefficient
Information Technology	Limitation of storage space
Laws and expectation related to quality of services	Limitation of facilities and IT systems

Table 2.1 presents the external and internal factors that affect the hospital's performance and service level. Most importantly, the effectiveness and efficiency of data and material management flows along the chain can improve supply chain performance and service level, to serve customers better. It is apparent that the

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healthcare supply chain lacks identification standards for the pharmaceutical products and information flow within the processes, especially for the inventory management or distribution system that will be discussed further in the next session. (Angelica, et al., 2011; Hutujuta and Punnakittikasem, 2001; Toba et al., 2008; Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

In sum, therefore, the lack of standardized processes of such management, poor operations and co-ordinations between relevant units in supply chain and unsatisfied service provided to customers are presented in current healthcare supply chain situations.

2.2Distribution Center in Hospital Supply Chain

As the results of uncontrolled storage conditions and distribution processes with the inefficient data flows along the chain at Ramathibodhi hospital in previous case study, visible the impact of materials' quality and availability which inadvertently linked to the chance of patient's survival and recovery process. Therefore distribution management is one of the most significant parts in hospital supply chain. The problem of management policy and operational system in such distribution processes caused high inventory level, high average storage time, stock data Inaccuracy, long cycle time on process, high logistics cost, high products return costs, product out of date, poor quality of products, lost track of products, poor service level and poor storage conditions in each distribution center due to limited space and facilities support system. (Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

2.2.1 Distribution Center

Distribution Center is one type of warehouse where products are kept and transferred in from suppliers and out to customers with quicker response to serve customers' fluctuated demands that would better their competitiveness in customer service levels and logistics costs. It is becoming more and more critical player in supply chain and the implementation of a warehouse management information system (WMS)

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in any businesses. With the high performance of warehousing operations and controls, it helps company to reduce transportation cost and achieve the market competition. (Faber et al., 2002)

A distribution center is a means to an end – satisfying customers' requirements through distribution processes. As a consequence, it is not necessary that it holds inventory, although it may hold some for short periods of time (e.g. cross-docking). The primary distribution process can be described in four-main-sequence of receiving (inbound), storage (put-away), order-picking and shipping (outbound). Similar to the most cases for other industries, distribution center in hospital supply chain is to keep the products with good standard to ensure the quality and readiness of products that reach the patients with no shortage. (Bartholdi and Hackman, 2008; Gu et al, 2006)

With the complexity and variety of products required for hospital business and the criticality of need to the patients' safety, availability of the products at high quality is mostly important. Nynke Faber et al. presented in their study about warehouse complexity to warehouse planning and control structure to the use of warehouse management information systems that would help organization link or exchange its warehouse data along with reporting, in order to effectively track and trace the products within warehouse and between the delivery processes.

According to some literature reviewed and research results, Derek T. (2005) proposed that a hospital should develop its supply chain strategy and inventory policy for a specific product based on that product's unit cost, demand, variability, physical size, and criticality. The research analyzes demand data from two hospitals and demonstrates that resulting in reducing cost and ensuring product availability which help minimizing storage space to maximizing patient care space, along with reducing material handling time and costs for all medical staff (nurses, pharmacists, doctors) and minimizing non-liquid assets (inventory), which help better improved its efficiency up to 50 percent comparing to previous system.

As same as Lina Al-Qatawneh (2011), who studied the hospital logistics system case using dynamics model for evaluating different inventory classification method in cost,

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and usage value of items, which based on the criticality of need, service level assignments and consumption rates to provides useful guidelines for the optimized cost within its overall material and information supply chain flow between hospital and distributors (see Figure 2.2). Thus information supply chain flow is also the key power that drives the efficient supply chain. (John J. Bartholdi et al, 2008; Peter Baker, 2007; Nynke Faber et al)

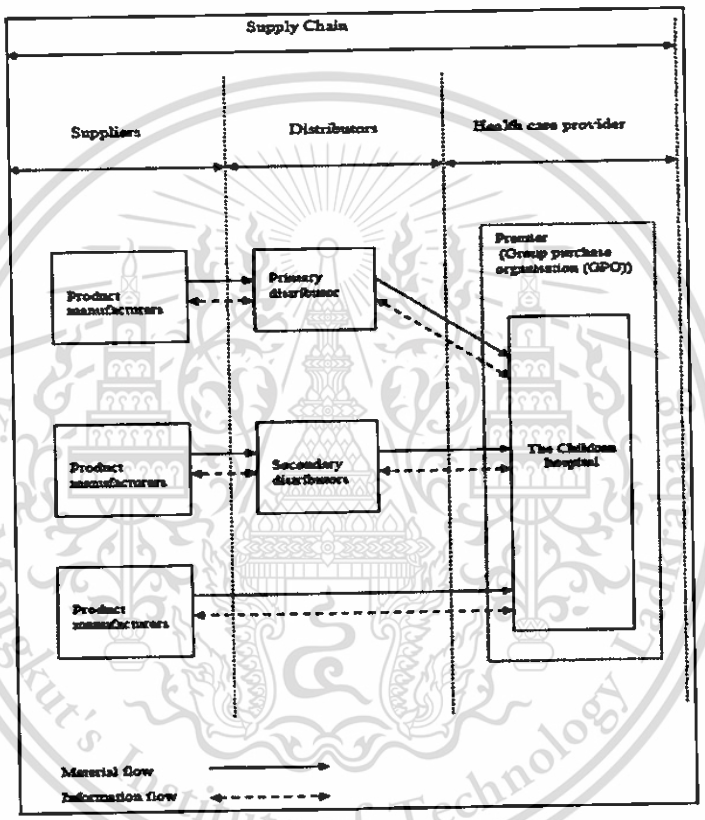

Figure 2.2 Sample of material and information supply chain flow between hospital and distributors

2.2.2 DC Design Structure

A DC design structure can be classified into three design levels; which are strategic level, tactical level and operational level; within processes, resources and organization's perspective. The strategic distribution decisions mapping is initiating consider capability requirements, network design issues and facility considerations according to Figure 2.3. (Rouwenhorst et al., 1999; Coyle, 2003)

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- Strategic level considers decisions that have a long term impact, mostly concern high investments.
- Tactical level considers a medium term decisions based on the outcomes of the strategic decisions discussed in the proceeding subsection. It has a lower impact than the strategic decisions, but still requires some investments that typically concern the dimensions of resources.
- Operational level, each process is to be carried out within the constraints set by the strategic and tactical decisions. It is a short term policies decision that implies to have less interaction.

As mentioned so far, you will see that the Distribution center process and design structure are relate to the decision-making from the top level strategic planning to tactical and operational activities. Figure 2.4 describes the relation of decision planning at each level and information flows along the distribution systems that are the keys to success of any distribution centers.

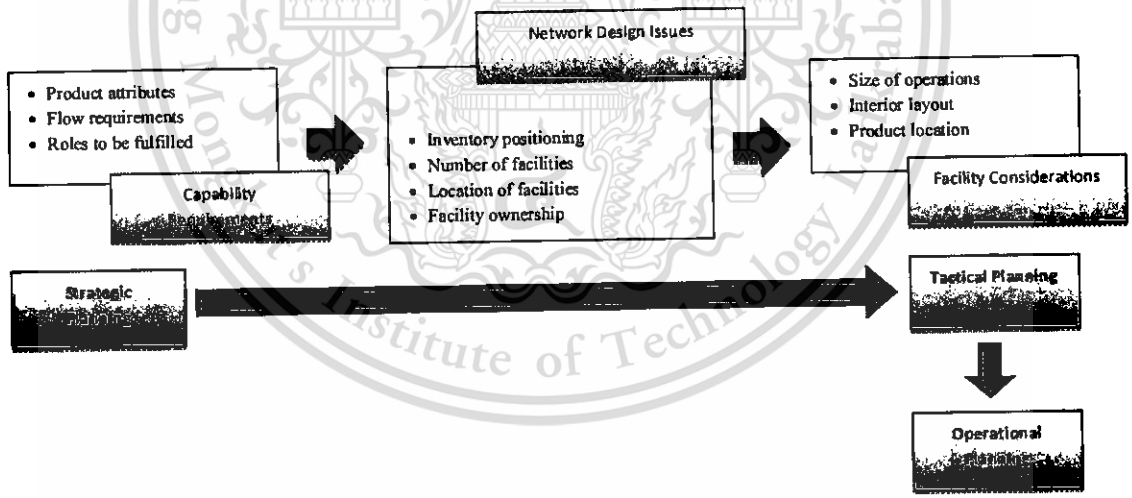

Figure 2.3 Strategic Distribution Decisions

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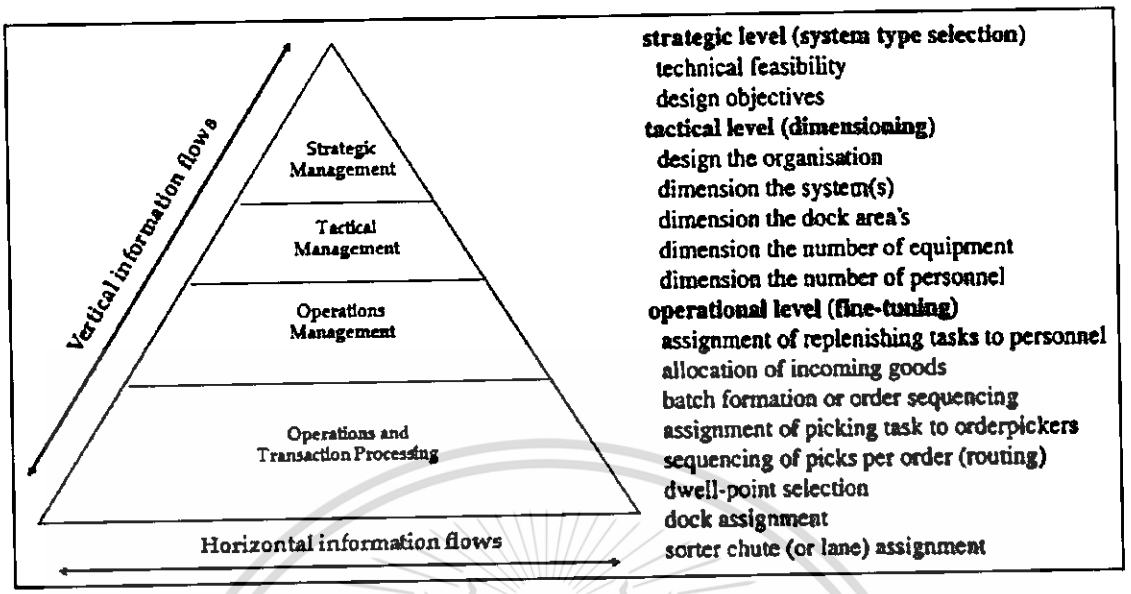

Figure 2.4 Distribution Decision levels and information flows

Apart from the proper the design of information flows in warehouse system, inventory management policy should be certain concerned, especially for hospital supply chain that continuously growing its number of patients significantly impact to the healthcare systems in Thailand and in other developing countries. While the personnel and facilities systems are not expanded enough to fully support, main issue was pointed out at the inventory management policy in the individual hospital, namely for pharmaceutical products.

Most researchers commented that studied hospital cases were lack of proper inventory policies for each specific type of products that have different demand characteristics, which have large impact on storage amount and conditions that finally leads to patients' safety. Some items were not available when needed (stock-out), and some items were kept in the inventory for too long causing inventory costs increased. Other issue also concluded to the limited of storage space within the hospital and could not expand and some hospitals have problem with information systems which could not track and trace the inventory level that affected to the purchasing processes accordingly. (Paul, C. Brown et al, 2011; Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

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It is mentioned in Engineering Today article (2553) that Bangkok hospital, the famous private hospital, is the first hospital who implemented the supply chain and logistics systems in healthcare business in Thailand; using National Healthcare Systems or NHS to provide the healthcare services and distribution center to serve their 17-chain-hospitals around the country. The project has been successful in cost reduction of inventory; improve service time and accuracy of medical products, including documents and specimen delivery with mobile transporter system to manage the orders and less human errors in the processes. (Hutujuta and Punnakittikasem, 2001; Healthcare Supply Chain Excellence Centre (LogHealth), 2012)

Moreover, Kumar et al. (2008) has proposed the business process re-engineering for the central distribution center at Hospitals in Singapore. As a result of the re-designed distribution center structure help improve about 50 percent of utilization in more than half of the activities. One of the most efficient and effective way is by using Reference modeling tools, which will be explained in the next session.

2.2.3 Distribution Center Processes in Healthcare

Distribution center process can be commonly illustrated as in Figure 2.5 as a primary processes, starting from receiving the products from suppliers then put-away product to storage locations, and order picking process is done when the order placed in the system until shipping to the customers. Replenishment process is occurred when re-supply at picking location required. (Mohsen H., 2002; Jinxiang G. et al, 2007; Lina A., 2011)

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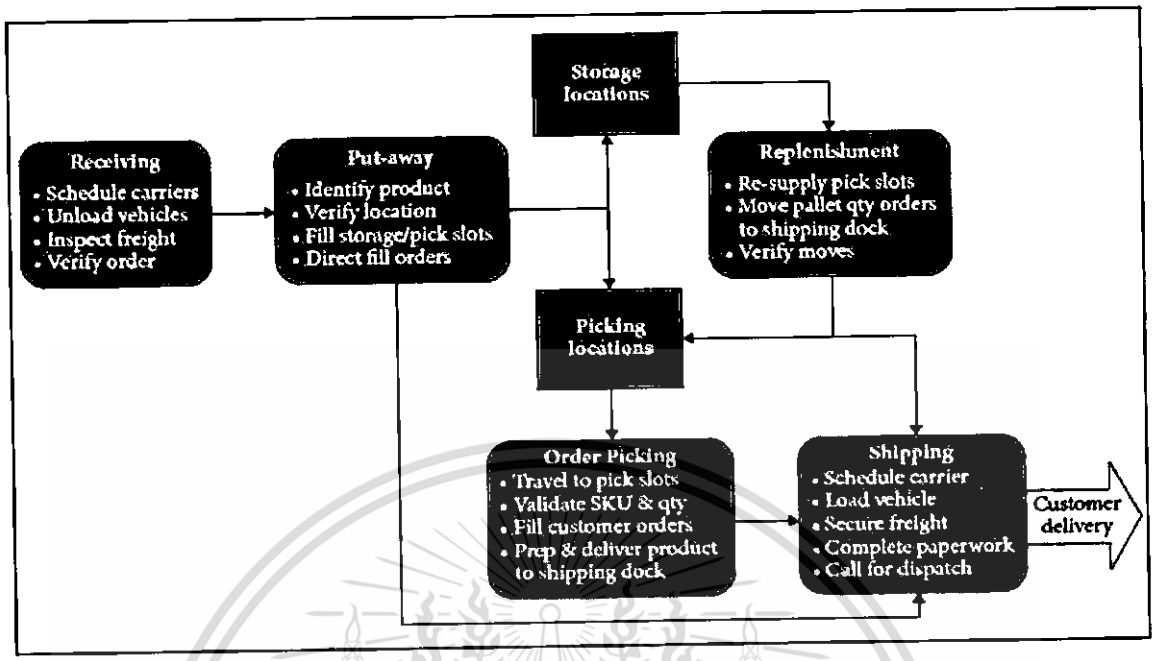

Figure 2.5 Primary DC processes

1) **Receiving** is the beginning process in warehouse after planed-order placed to suppliers, the ordered receipt of all materials or products are delivered and received into the warehouse. This step may include verify the order and inspect products quality.

2) **Put-away** is the next activity of placing identical products in storage, when products are received in bulk from a supplier and subsequently packaged singly. Including material handling, location verification, and products placement/fulfillment.

3) **Storage** is physical containment of products as the main role of warehouse while it is awaiting an order to be placed. Storage method depends on the lot size and quantity of the items in inventory and the material handling characteristics of the product or its container, considering also the storage location and move-path within the warehouse in order to reduce material handling cost and improve space utilization.

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4) **Replenishment** is to move and fulfill the products from storage location to the picking location for further order picking process.

5) **Order picking** is the process of removing items from picking location to fill up customers' order and prepare for loading at shipping docks. There are different Order picking method considering batching, routing and sequencing, and sorting steps, e.g. Single-order picking, batching and sort-while-pick, batching and sort-after-pick, single-order picking with zoning, and batching with zoning for example.

6) **Packaging or Sortation** may require re-packing the batch picks in merchandisable quantities into individual orders for shipping to customers.

7) **Shipping** is to check the orders for completeness such as packaging of products in appropriate shipping containers, preparing shipping documents, including packing lists, address labels and bills of lading, also weighing shipments to determine shipping charges, and then accumulating orders by outbound carrier for loading trucks.

Primary DC processes as described above are at the warehouse operation level, which all activities consequence has to be planned along with the layout design and considered the products physical characteristic for material handling and movement.

From the literature review on warehouse operations, JinxiangG. et al (2007) concluded that the past research studied focusing more on storage and order-picking functions which caused the largest impact on the overall warehouse operational performance including storage capacity, space utilization, and order picking efficiency. As the result of the case study by Rene K. (2007) shown the typical estimated cost of Order-picking cost was about 55 percent of the total warehouse operating cost because it is the most labor-intensive and costly activity.

The structured decision making level is the well-connected structure and have impact to each alternative made at each level, especially for the logistic network decision making mainly in three level as mentioned in session 2.2.2.

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Typically, in the warehouse process flow design will be considered based on the business characteristic and demand market. In healthcare specific will be more concerns about the products storage condition and transport of time and temperature sensitive requirements (especially for pharmaceutical products). The standard guidance was conducted by WHO (2011) International standard for good storage practice and good distribution practice.

World Health Organization or WHO set up the model guidance for the storage and transport of time- and temperature-sensitive pharmaceutical product (TTSPP) (2011) that any pharmaceutical good or product which, when not stored or transported within predefined environmental conditions and/or within predefined time limits, is degraded to the extent that it no longer performs as originally intended. Therefore storage conditions should be defined and described on the label of the product by the manufacturers.

All drugs should be stored according to the conditions described on the label. When specified on the label, controls for humidity, light, etc., should be in place. Storage areas should be designed or adapted to ensure good storage conditions. In particular, they should be clean, dry, have adequate circulation and maintained within acceptable temperature limits.

To reduce human error, general storage areas are well lit. Storage conditions for medical products can be defined into three main groups by following:-

1) Room temperature storage condition

Ambient temperature offerings keep pharmaceutical products at room temperature: between 15°C and 25°C (59°–77°F) or up to 30°C with normal storage conditions; which means storage in a dry, clean, well-ventilated area depending on climatic conditions.

2) Cold storage condition

Refrigerators may be suitable for cold storage of small volumes of some products, for example eye drops, which require cold storage but are less susceptible to

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being out of the recommended temperature range applies to low-risk products as well as high-risk products such as vaccines, insulin and blood products, which normally require storage between2°C and 8°C (35°–46°F).

3) Freezer storage condition

A small but increasing number of products must be stored frozen (e.g. some blood products and products of biotechnology). These will be labeled store below -5°C (freeze) or below -15°C (deep freeze) or they may show a range (e.g. -15°C to -20°C). Storage units must be capable of maintaining the required temperature in all parts of the load, and temperatures should be monitored within the load and recorded daily.

In term of warehouse design consideration, medical products must be transported, handled and controlled stored in a manner that mitigates the risk of exposure to temperatures outside labeled storage conditions; which potentially impacting the safety, quality and effectiveness of the products, at every point in the chain, precautions should be taken to minimize the effect of external conditions on the quality and stability of the product. (Health Canada, 2011; ABB Limited, 2009).

2.3 Reference Models (RMs)

Reference Models (RMs) are generic conceptual models and framework which represent the business's best practice universally applied in company specific processes or projects. RMs delivers best-practice information that can replicate for several times. There are different types of RMs available for company reference which represent a combination of two or more model types in many cases as visualized in Figure 2.6.(Kirchmer, 2011; Miers, 2008).

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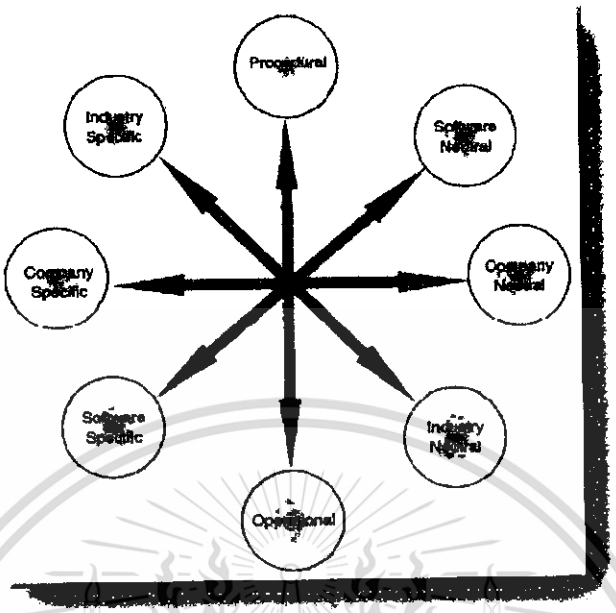

Figure 2.6 Types of business process reference models

The development of process design and continuous sustainably improvement for the company or cross-industry could reuse the RMs in combination or individually, to reduce the development cost and time to company's specific process models (Kalpic and Bernus, 2002; Pajk et al, 2012). Verdouw et al. (2010) brought about an example of Reference Model usage designed for fruit industry in Europe. They analyzed fruit-specific knowledge and generic knowledge in cross-industry standards and proposed the business process that could provide fruit companies with personalized configuration in supply chain design and information system implementation.

Similar to hospital supply chain, the reference process model designed using generic process could be applied to hospitals at all scales. The benefits will not be limited to the hospitals themselves but extended to the related players in hospital supply chain and, ultimately, to the patients. The reference processes in the model explain the roadmap for each role and responsibility with step-by-step activities. Besides the operational steps, the reference processes provide control points and key performance of each activity. The outline activities and performance metrics support the

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management team in decision making and can be adapted to company's needs. In sum, the reference process model engineers the management plan at strategic, tactical and operational levels.

Kirchmer, M. (2011) discussed reference models benefits and its excellence, focusing on process design of the management of process excellence (MPE) as shown in Figure 2.7. MPE connects process strategy, information technology and people together in the enterprise as part of an effective inter-enterprise collaboration for the long term success. He claimed that MPE knowledge can enable high-performance business for large to small size organizations. The benefits of implementing Reference Models to business include:

- Cost reduction
- Time reduction
- Quality improvement
- Risk reduction
- Transparency
- Common language
- Basis for benchmarking

The management of process excellence (MPE) begins with the business process strategy of an organization, which underlines role of enabler for innovation and agility within every phase. The reference models (RMs) and process design are one of the strategic guidance outcome where the business processes are specified in details. The implementation can be done based on information technology (IT) support the inter-enterprise processes, following through people.

While process design is a key success of management of process excellence, Business process management (BPM) as a result, is a conceptual process-centric approach for improving performance that includes information technology with process and governance methodologies. The process templates are generally called "business process reference models". The use of process templates that are adapted to company

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specific requirements or specific environments provided can help company to improve the efficiency and effectiveness of that process design and implementation.

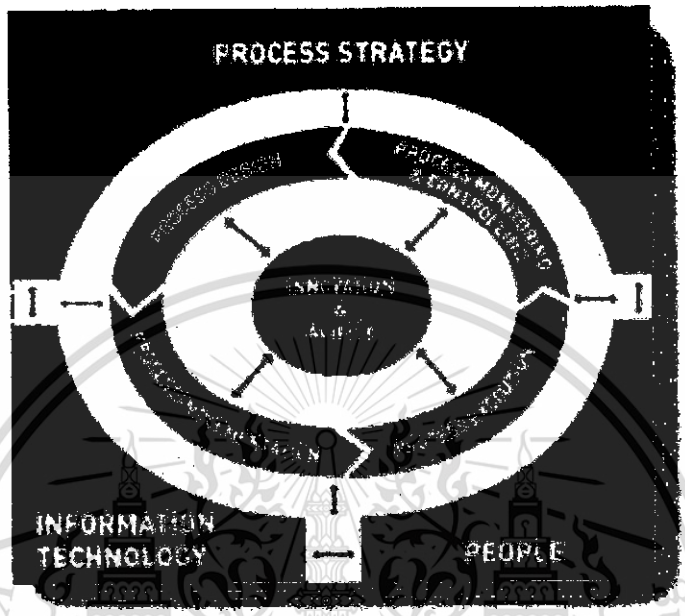

Figure 2.7 Focus on process design of the management of process excellence (MPE)

The great sample of business process reference model that has been continuously developed using industry organization knowledge and is used all over the world, are known as SCOR model. SCOR model contains all interactions and activities along the supply chain, covered from supplier's supplier to a customer's customer with provided framework and performance measurement. We will describe more on what are SCOR model and its contributions in the next session.

2.4SCOR Model

The Supply Chain Operations Reference model (SCOR), designed by the Supply Chain Council (2012), is the most widely used business process reference models in various industries. It is one of Supply Chain management tools used to address the overall processes and activities from supplier's supplier to a customer's customers. The SCOR model has five basic processes: Plan (P), Source (S), Make (M), Deliver (D) and

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Return (R), and provides a standard process model which describes the organization best practice framework of management processes. The model contains a linkage between business objectives to supply chain operations, with standard metrics to measure process performance or KPI at each level of hierarchy.

The SCOR model provides a unique framework that links business process, metrics, best practices and technology into a friendly structure to support communication among organization and supply chain partners. It helps company to improve the effectiveness of supply chain management and related improvement activities from order entry through paid invoice, also physical material transaction including equipment, supplies, spare parts, bulk product, software, etc. The model itself draws a level of supply chain process using building blocks, which successfully describe and provide a basis of supply chain improvement for any global projects. The SCOR model consists of four major components:

- Performance: Standard attribute and metrics to measure process performance at each level that align with company strategic objective
- Processes: Standard or unique activity that define and describe management processes and role and responsibility relationships, to meet company objective
- Practices: Classification and management of unique practices and process sequence that help improve process performance
- People: Standard definitions and framework for managing skills, experience, aptitude, training and competency required in the supply chain

SCOR model has four levels of hierarchy: top, configuration, process element and implementation. The top level (Level 1) is the design of process types (Plan, Source, Make, Deliver, and Return). The second level (Level 2) involves configuration of the supply chain that is the detailed descriptions of the process types' sub categories, such as 'Make to stock', 'Make to order', and 'Engineer to order' or 'Production execution'. The third level (Level 3) is the decomposition of processes to the process element

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level, in line with its strategies and performance metrics. The fourth level (Level 4) is for company implementation of their supply chain and best practice solution. This level is not included in SCOR framework but can be applied as a sub-process in specific business conditions. (SCOR, 2011)

Regarding hospital's supply chain, Martinelly et al. (2009) has proposed a conceptual model for the hospital supply chain using PORTER-SCOR level 1-3 and logical diagrams at level 4. They proposed the optimal process flows with the benchmarks for simulating logical diagram of hospital supply chain. The researchers applied SCOR framework Level 1 to Level 3 to design the reference process model of distribution center in hospital supply chain.

As SCOR is a reference model, the purpose of a process reference model or business process framework, is to describe company process standard architecture consisting of four major sections; performance, processes, practices, and people. In this paper, we aim to study the distribution processes within three-large-size hospital in Thailand and analyze the generic process as a SCOR framework. Since the SCOR level four requires specific details from each hospital environment for the implementation stage, the proposed reference process model in this study was upgraded to SCOR level 3.5 adopting generic processes. The SCOR level 3.5 takes into account the tactical and operational levels that support management team in making decision as shown in Figure 2.8.

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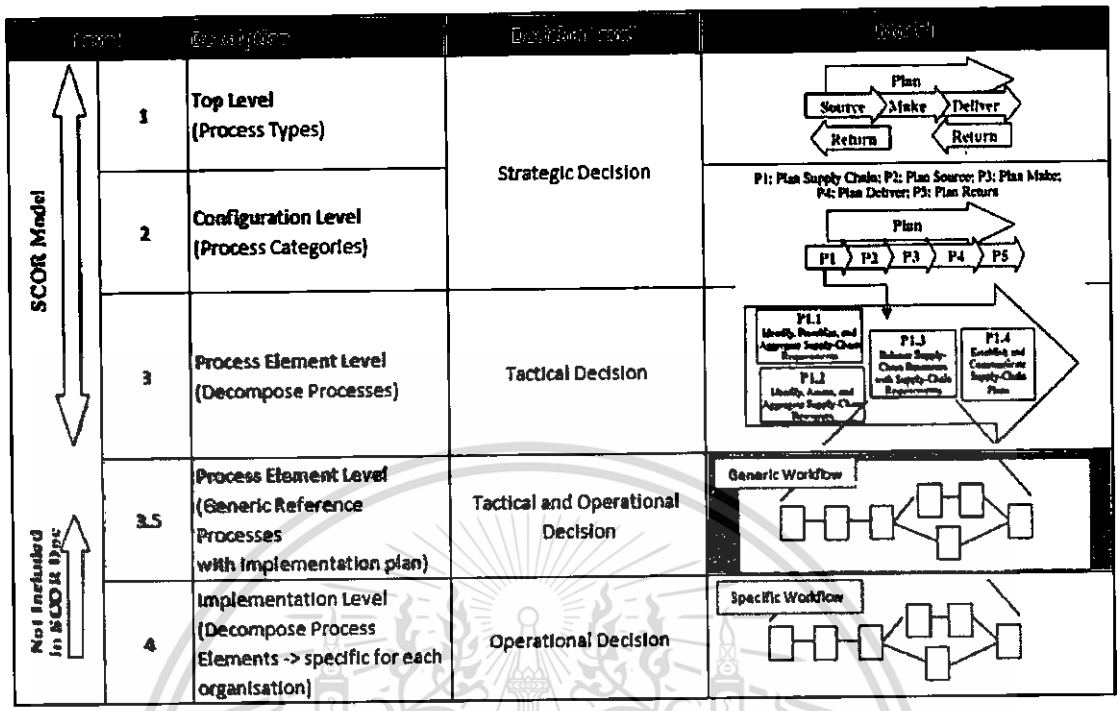

Figure 2.8Levels of SCOR Model

Georgise F. et al (2012) wrote the conclusion on their literature review of adapting the SCOR model to suit the different scenarios. The improvements of industries' efficiency and effectiveness have been proven by SCOR implementation. The future directions for research highlighted to focus on the area of developing a business process, performance metrics, and the appropriated best practices applications, especially in developing countries.

Therefore the revised SCOR model has adapted to the generic processes, to explain each activity of business process by specified role and responsibility at level 3.5. This resulted in distribution process reference model for hospital distribution center that can help management of hospital foresee the process flows within the designed distribution network, capacity requirement and facility considerations. SCOR model level 3.5 will lead to tactical and operational decision planning to implement future development plans. However, the implementation steps will be considered under individual hospital policy and vision.

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2.5 SCOR Performance Attributes and Metrics

Supply Chain Performance measurement system can be developed based on SCOR metrics and Practices. The correlations between metrics and processes of the system enable management to comprehend the relationships across the system and accomplish organization's goal and overall performance. Ineffective and inefficient performance measurement system affect the entire supply chain management system as managers could not monitor and gather all necessary information for decision-making. In addition, the performance measurement system could make process improvement possible as Harington (1991) said that "If you cannot measure it, you cannot control it. If you cannot manage it, you cannot improve it."

Performance measurement and metrics have a significant role in Supply Chain Management in determination of company's objectives and future courses of action plans, and in evaluation of performance (Gunasekaran et al., 2004). Kocaoglu et al. (2011) studied a supply chain performance metrics in a hierarchical way, using AHP and TOPSIS methods to weight metrics importance. They found that performance metrics priorities support to the organization's strategic direction. There are various methods used in supply chain performance systems designed to measure operational performance, evaluate effectiveness and efficiency and continuously improving overall supply chain performance to achieve company's competitive advantages. How and what elements to measure are the key questions required clarification while developing performance measurement system depends on which aspects of the key objectives. (Cai et al., 2009)

Healthcare Performance Measurement, in particular, involves performance of several stakeholders and functions such as, suppliers, delivery, customer-service, and inventory management in a supply chain. The target outcomes of healthcare supply chain are, for example, the recovery of patient's health, responsiveness to support during care, quality of services, and productivity of the resources within the healthcare systems. Performance of each stakeholders and functions are complicated to measure

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and, as a result, are unable to be evaluated by any single performance method (Smith et al., 2010).

The SCOR Model describes supply chain activities for business at each level, and defines a set of performance metrics used to evaluate the processes. There are five dimensions to performance measurement: Supply Chain Reliability, Supply Chain Responsiveness, Supply Chain Agility (Customer-Focused attributes), and Supply Chain Costs, Supply Chain Asset Management Efficiency (Internal-Focused attributes). Table 2.2 explained the SCOR performance attributes, which an attribute itself cannot be measured without a set of metrics. Performance attributes are used to set high level of strategic direction, therefore the sum of metrics calculations are the key performance of supply chain to achieve these strategic attributes.

The SCOR Metrics is a standard measurement guidance for Supply Chain Performance linking metrics to support decision-making process. A good performance measurement system provides key measurement method which incorporates process alignment that aims to achieve strategic goals of organization. (SCOR, 2011)

The SCOR metrics are organized in a hierarchical structure as well as SCOR Model process framework, it describes in level-1, level-2 and level-3 metrics. The relationships between these levels are diagnostic. At Level 1 has ten strategic metrics primary which are the key performance indicators (KPI) for company strategic measurement as shown in Figure 2.9. It is used as a framework for multiple SCOR processes in supply chain. Level-2 metrics indicate the root-cause of performance gap for level-1 metrics, and level-3 metrics are linked to the operational processes.

At SCOR level 1, the performance attribute is defined as strategic metrics which covered both customer-facing attributes and internal-facing attributes. For instants, the Reliability attribute has level 1 metric as RL.1.1 Perfect Order Fulfillment. Level 1 metric consists of four metrics in level 2. RL.2.1 % of Orders Delivered in Full, RL.2.2 Delivery Performance to Customer Commit Date, RL.2.3 Documentation Accuracy, and RL.2.4 Perfect Condition. The level 2 metrics RL.2.1 % of Orders Delivered in Full is measured

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in level 3 sum up with RL.3.33 Delivery Item Accuracy and RL.3.35 Delivery Quantity Accuracy.

Table 2.2 The SCOR Performance Attributes (SCOR, 2011)

Performance Attribute	Definition
Reliability	The ability to perform tasks as expected. Reliability focuses on the predictability of the outcome of a process. Typical metrics for the reliability attribute include: On-time, the right quantity, the right quality.
Responsiveness	The speed at which tasks are performed. The speed at which a supply chain provides products to the customer. Examples include cycle-time metrics.
Agility	The ability to respond to external influences, the ability to respond to marketplace changes to gain or maintain competitive advantage. SCOR Agility metrics include Flexibility and Adaptability
Costs	The cost of operating the supply chain processes. This includes labor costs, material costs, management and transportation costs. A typical cost metric is Cost of Goods Sold.
Asset Management Efficiency (Assets)	The ability to efficiently utilize assets. Asset management strategies in a supply chain include inventory reduction and in-sourcing vs. outsourcing. Metrics include: Inventory days of supply and capacity utilization.

Performance Attribute	Performance Attribute Definition	Level 1 Strategic Metric
Supply Chain Reliability	The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Perfect Order Fulfillment (RL.1.1)
Supply Chain Responsiveness	The speed at which a supply chain provides products to the customer.	Order Fulfillment Cycle Time (RS.1.1)
Supply Chain Agility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Upside Supply Chain Flexibility (AG.1.1)
		Upside Supply Chain Adaptability (AG.1.2)
		Downside Supply Chain Adaptability (AG.1.3)
Supply Chain Costs	The costs associated with operating the supply chain.	Supply Chain Management Cost (CO.1.1)
		Cost of Goods Sold (CO.1.2)
Supply Chain Asset Management	The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-Cash Cycle Time (AM.1.1)
		Return on Supply Chain Fixed Assets (AM.1.2)
		Return on Working Capital (AM.1.3)

Figure 2.9 SCOR Performances Attribute at Level-1

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2.5.1 Supply Chain Reliability

The Reliability attribute addresses the ability to perform tasks as required delivery process. The Perfect orders fullfilment metric (RL.1.1) considers the percentage of orders meeting delivery performance with complete and accurate documentation and no delivery damange.Reliability focuses on the predictability of the outcome of a process. Typical metrics for the reliability atribute include: On-time, the right quantity, the right quality. The sum of the scores calculation based on the performance at each level 2 and level 3 components of that order line (e.g. product and quantity, date & time and customer, documentation and condition). See table 2.3 for Supply Chain Reliability at level 1 to 3. Perfect order fulfillment is considered "perfect" if the order has been delivered to customer as per original commitment through the supply chain:-

- Delivered all items completely with the correct quantities
- Delivered on time to customer within committed date
- Documentation supporting the order is complete and accurate; including packing slips, bills of lading, invoices, quality certifications, etc.
- Faultlessty installed and correct configuration (if applicable), no damage and meet customer's satisfaction

Table 2.3 Supply Chain Reliability at level 1- 3

Supply Chain Reliability	
RL.1.1	Perfect Order Fulfillment
RL.2.1	% of Orders Delivered in Full
RL.3.33	Delivery Item Accuracy
RL.3.35	Delivery Quantity Accuracy
RL.2.2	Delivery Performance to Customer Commit Date
RL.3.32	Customer Commit Date Achievement Time Customer Receiving
RL.3.34	Delivery Location Accuracy
RL.2.3	Documentation Quality Accuracy
RL.3.31	Compliance Documentation Accuracy

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Table 2.3 Supply Chain Reliability at level 1- 3 (Cont.)

Supply Chain Reliability	
RL.3.43	Other Required Documentation Accuracy
RL.3.45	Payment Documentation Accuracy
RL.3.50	Shipping Documentation Accuracy
RL.3.4	Perfect Condition
RL.3.12	% Of Faultless Installations
RL.3.24	% Orders/Lines Received Damage Free
RL.3.41	Orders Delivered Damage Free Conformance
RL.3.42	Orders Delivered Defect Free Conformance
RL.3.55	Warranty and Returns

2.5.2 Supply Chain Responsiveness

The Responsiveness attribute describes the speed of repeated performance at each activity. Responsiveness as a customer focused attribute, addresses on speed to serve customer measuring cycle time metrics. The actual cycle time starts from the order receipt and ends with customer acceptance of the order, to achieve order fulfillment to customer.

Order Fulfillment Cycle Time (RS.1.1) is captured when customer places the order until the order is fulfilled, and considered to be a 'gross' cycle time. Both value-add and non-value-add or dwell time are measured within the two events or activities. The responsiveness performance of the organization is determined by the cumulative cycle time of all activities that occurs when fulfill the order (see Table 2.4).

Table 2.4 Supply Chain Responsiveness at level 1- 3

Supply Chain Responsiveness	
RS.3.1	Order Fulfillment Cycle Time
RS.3.4	Source Cycle Time
RS.3.8	Authorize Supplier Payment Cycle Time
RS.3.35	Identify Sources of Supply Cycle Time

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Table 2.4 Supply Chain Responsiveness at level 1- 3 (Cont.)

Supply Chain Responsiveness	
RS.3.107	Receive Product Cycle Time
RS.3.122	Schedule Product Deliveries Cycle Time
RS.3.125	Select Supplier and Negotiate Cycle Time
RS.3.139	Transfer Product Cycle Time
RS.3.140	Verify Product Cycle Time
RS.2.2	Make Cycle Time
RS.3.33	Finalize Production Engineering Cycle Time
RS.3.49	Issue Material Cycle Time
RS.3.101	Produce and Test Cycle Time
RS.3.114	Release Finished Product to Deliver Cycle Time
RS.3.123	Schedule Production Activities Cycle Time
RS.3.128	Stage Finished Product Cycle Time
RS.3.142	Package Cycle Time
RS.2.3	Deliver Cycle Time
RS.3.16	Build Loads Cycle Time
RS.3.18	Consolidate Orders Cycle Time
RS.3.46	Install Product Cycle Time
RS.3.51	Load Product & Generate Shipping Documentation Cycle Time
RS.3.95	Pack Product Cycle Time
RS.3.96	Pick Product Cycle Time
RS.3.102	Receive & Verify Product by Customer Cycle Time
RS.3.110	Receive Product from Source or Make Cycle Time
RS.3.111	Receive, Configure, Enter, & Validate Order Cycle Time
RS.3.116	Reserve Resources and Determine Delivery Date Cycle Time
RS.3.117	Route Shipments Cycle Time
RS.3.120	Schedule Installation Cycle Time
RS.3.124	Select Carriers & Rate Shipments Cycle Time

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Table 2.4 Supply Chain Responsiveness at level 1- 3 (Cont.)

Supply Chain Responsiveness	
RS.3.126	Ship Product Cycle Time
RS.3.4	Delivery Retail Cycle Time
RS.3.17	Checkout Cycle Time
RS.3.32	Fill Shopping Cart Cycle Time
RS.3.34	Generate Stocking Schedule Cycle Time
RS.3.97	Pick Product from Backroom Cycle Time
RS.3.109	Receive Product at Store Cycle Time
RS.3.129	Stock Shelf Cycle Time

2.5.3 Supply Chain Agility

The Agility attribute describes the ability to respond to unexpected external influences; the flexibility to and speed of change. External influences include: unpredictable increases or decreases in customer demand, suppliers or partners going out of business, natural disasters, acts of (cyber) terrorism, availability of financial resources (the economy), labor issues. Supply Chain Flexibility is one of the SCOR key performance indicators including; Adaptability, and Value-at-Risk as a customer focused attribute.

The calculation of Upside Supply Chain Flexibility shown in Table 2.5is the minimum time required to complete the unplanned sustainable increase which considers Source, Make, and Deliver components. The number of days required to achieve and unplanned sustainable 20 percent increase in quantities delivered.

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Table 2.5 Supply Chain Agility at level 1- 3

Supply Chain Agility	
AG.1.1	Upside Supply Chain Flexibility
AG.2.1	Upside Flexibility (Source)
AG.2.2	Upside Flexibility (Make)
AG.2.3	Upside Flexibility (Deliver)
AG.2.4	Upside Return Flexibility (Source)
AG.2.5	Upside Return Flexibility (Deliver)
AG.1.2	Upside Supply Chain Adaptability
AG.2.6	Upside Adaptability (Source)
AG.2.7	Upside Adaptability (Make)
AG.2.8	Upside Adaptability (Deliver)
AG.2.9	Upside Return Adaptability (Source)
AG.2.10	Upside Return Adaptability (Deliver)
AG.1.3	Downside Supply Chain Adaptability
AG.2.11	Downside Adaptability (Source)
AG.2.12	Downside Adaptability (Make)
AG.2.13	Downside Adaptability (Deliver)
AG.1.4	Overall Value at Risk/VAR
AG.2.14	Supplier's/Customer's/Product's Risk Rating
AG.2.15	Value at Risk (Plan)
AG.2.16	Value at Risk (Source)
AG.2.17	Value at Risk (Make)
AG.2.18	Value at Risk (Deliver)
AG.2.19	Value at Risk (Return)

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2.5.4 Supply Chain Costs

Supply Chain Costs are the total cost that occurs when operating the process to deliver products and services to customers. Typical costs include labor cost, material cost, automation, transportation cost and overhead associated with supply chain processes. The Supply Chain Costs is internal focused attribute. Table 2.6 shows level of the SCOR key performance indicators for cost. Total cost to Serve (CO.1.001) is level 1 metric, which determines from the sum of:-

- CO.2.001 Planning Cost
- CO.2.002 Sourcing Cost
- CO.2.003 Material Landed Cost
- CO.2.004 Production Cost
- CO.2.005 Order Management Cost
- CO.2.006 Fulfillment Cost
- CO.2.007 Returns Cost

Total Cost to Serve comprises of two types of cost: Direct cost and Indirect cost, where generally requires activity based costing capabilities for direct cost and a system to allocate indirect cost.

- Direct cost is the directly attributed to fulfilling customer orders, applying to the cost of materials used and/or delivered, all direct supply chain labor for instant.
- Indirect cost is required to operate the supply chain processes, such as, lease and maintain equipment, inventory depreciation, damage and returns costs, etc.

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Table 2.6 Supply Chain Costs at level 1- 3

Supply Chain Costs	
CO.1.001	Total Cost to Serve
CO.2.001	Plan Cost
CO.3.001	Planning Labor Cost
CO.3.002	Planning Automation Cost
CO.3.003	Planning Property, Plant and Equipment Cost
CO.3.004	Planning GRC and Overhead Cost
CO.2.002	Source Cost
CO.3.005	Sourcing labor Cost
CO.3.006	Sourcing Automation Cost
CO.3.007	Sourcing Property, Plant and Equipment Cost
CO.3.008	Sourcing GRC and Overhead Cost
CO.2.003	Material Landed Cost
CO.3.009	Purchased Materials Cost
CO.3.010	Material Transportation Cost
CO.3.011	Material Customs, Duties, Taxes and Tariffs Cost
CO.3.012	Material Risk and Compliance Cost
CO.2.004	Production Cost
CO.3.014	Production (Direct) Labor Cost
CO.3.015	Production Automation Cost
CO.3.016	Production Property, Plant and Equipment Cost
CO.3.017	Production GRC and Overhead Cost
CO.2.005	Order Management Cost
CO.3.018	Order Management Labor Cost
CO.3.019	Order Management Automation Cost
CO.3.020	Order Management Property, Plant and Equipment Cost
CO.3.021	Order Management GRC and Overhead Cost

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Table 2.6 Supply Chain Costs at level 1- 3 (Cont.)

Supply Chain Costs	
CO.2.006	Fulfillment Cost
CO.3.022	Transportation Cost
CO.3.023	Fulfillment Custom, Duties, Taxes and Tariffs Cost
CO.3.024	Fulfillment Labor Cost
CO.3.025	Fulfillment Automation Cost
CO.3.026	Fulfillment Property, Plant and Equipment Cost
CO.3.027	Fulfillment GRC, Inventory and Overhead Cost
CO.2.007	Return Cost
CO.3.028	Discounts and Refunds Cost
CO.3.029	Disposition Cost
CO.3.030	Return GRC, Inventory and Overhead Cost
CO.2.008	Cost of Goods Sold

2.5.5 Supply Chain Asset Management Efficiency

The Asset Management Efficiency attribute is used to illustrate the ability of company to efficiently utilize and manage its assets. Asset management strategies in supply chain include inventory reduction and in-source vs. outsource. Example metrics include: Inventory days of supply, capacity utilization. The SCOR key performance indicators include: Cash-to-Cash Cycle Time (AM.1.1)is a value metric, which measured by converting into days the supply of inventory in stock and the number of days outstanding for accounts receivable and accounts payable as shown in Table 2.7 Asset Management Efficiency is an internal focused attribute, where represents the time from the point where a company pays for the resources consumed in the performance of a service to the time that the company received payment form the customer for those services.

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Table 2.7 Supply Chain Asset Management Efifciency at level 1- 3

Supply Chain Asset Management Efficiency	
AM.1.1	Cash-to-Cash Cycle Time
AM.2.1	Days Sales Outstanding
AM.2.2	Inventory Days of Supply
AM.3.16	Inventory Days of Supply (Raw Material)
AM.3.17	Inventory Days of Supply (WIP)
AM.3.23	Recycle Days of Supply
AM.3.28	Percentage Defective Inventory
AM.3.37	Percentage Excess Inventory
AM.3.44	Percentage Unserviceable MRO Inventory
AM.3.45	Inventory Days of Supply (Finished Goods)
AM.2.3	Days Payable Outstanding
AM.2.4	Return on Supply Chain Fixed Assets
AM.2.5	Supply Chain Fixed Assets
AM.2.4	Supply Chain Revenue
AM.3.11	Deliver Fixed Asset Value
AM.3.18	Make Fixed Asset Value
AM.3.20	Plan Fixed Asset Value
AM.3.24	Return Fixed Asset Value
AM.3.27	Source Fixed Asset Value
AM.2.6	Return on Working Capital
AM.2.6	Accounts Payable (Payables Outstanding)
AM.2.7	Accounts Receivable (Sales Outstanding)
AM.2.8	Inventory

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According to SCOR Performance Attributes and Metrics, a company can measure its performance on how successful it is in achieving its desired positioning within the competitive market space. However, the efficient and effective based on process design which should consider the correlation of process and performance metrics at sub-levels (level 3), referring from the SCOR-based alignment framework and Best Practices. The processes in SCOR are a unique activity performed to meet pre-defined outcomes that aims to fulfill customer orders. We will go through more details of SCOR process in the next sessions.

2.6 SCOR Process

The SCOR process provides a set of pre-defined descriptions for activities most companies perform to effectively execute their supply chains. SCOR identifies two more levels of process that indicates the span of the process. A level-1 process has multiple level-3 processes and Level-2 process categories determine the capabilities within the level-1 processes. The key level-2 processes are Make-to-Stock vs. Make-to-Order vs. Engineer-to-Order for Source, Make and Deliver processes and Defective vs. MRO vs. Excess for the Return process.

Level-3 processes are workflow process steps that are performed in a certain sequence in order to plan supply chain activities, source materials, make products, deliver goods and services and handle product returns. Level-4 processes are generally industry, product, location and/or technology specific, which company may develop standard process descriptions of activities within the level-3 processes.

Fredrik P., et al. (2012) applied SCOR model in Level 3 processes to their simulation template as the useful tool for speed up the modeling of supply chains. The study was focusing on the relevant sub-processes in Source, Make and Deliver in Level 3 where more details can be visible to schedul and manage the process of delivering products to customer. Similar to Mehdi S. et al. project, that mapped the SCOR processes and best-practices to Steel industry that could lead to supply chain

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performance improvement.The six macro-level SCOR processes Plan, Source, Make, Deliver, Return and Enable are well-known and widely adopted in various industries.

1)Plan: The Plan processes optimize the activities to identify, aggregate, prioritize and gather all requirements and information sources, in order to achieve supply chain objectives.

2) Source: The Source processes represent the activities to conversion of materials or creation of the content for services, to meet planned or actual demand.

3) Make: The Make processes give the framework of production or manufacturing activities for all types of material conversions to meet planned or actual demand, including Assembly, Chemical processing, Maintenance, Repair, Overhaul, Recycling, Refurbishment, and Re-manufacturing.

4) Deliver: The Deliver processes describe the activities related to the creation, maintenance and fulfillment of customer orders to meet planned or actual demand, including the receipt, validation and creation of customer orders, scheduling order delivery, pick, pack and shipment and invoicing the customer.

5)Return: The Return processes visible the activities associated with the reverse flow of goods, identify the need to return, the disposition decision making, the scheduling of the return and the shipment and receipt of the returned goods, to support post-delivery to customer.

6) Enable: The Enable processes associated with the management of the supply chain including business rules, performance, data, resource, facilities, contract, supply chain network management, and to compliance with risk management.

The contribution from the unique SCOR processes is the standard framework which provide standard blocking-structure of management processes and activitiesthat can easily to communicate to the users and other functions in organization. As a comprehensive tool for supply chain management, SCOR model provide the clear framework and definitions for evaluating, positioning, and designing the supply chain processes, to meet company objectives and improvement.

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In order to visualize the model in practical way, there are various of software tools to enhance the SCOR-based model frombusiness process modeling to implementation. Dong J.; et al. (2006) have implemented the SCOR-based transformantion plateform though simultion and optimization techniques using IBM SmartSCOR, which has been successfully visible transformation in two levels, from supply chain strategy design or redisign to supply chain process improvement. As well as e-SCOR and applications of e-SCOR that use for modeling and simulation environment based on SCOR, to analyze the supply chain. Barnett M. and Miller C. (2000) have combined the e-SCOR simulation applications to SCOR model that enable the improved design, with real-time monitoring and control, optimization and decision support and management.

However, this study is at idea stage to design and describe or normative the generic business process as a reference model, by applying the SCOR model framework in distribution processes of hospital supply chain. The simulation and analysis tool is not in our scope and require in-depth information to proceed e.g. time in process and operations cost for example. Thus we aimed to adapt our proposed model with the Business process modeling notation or BPMN as a descriptive and normative tool and technique, which will discuss further in next session.

2.7Business Process Modeling Notation (BPMN)

BPMN Version 2.0 was introduced by the OMG (Object Management Group) (2011) as one of the standardized tool visualizing diagrams used to model and interpret the business process diagram. The purpose is to facilitate communication of an end-to-end process to all cross-functional organization units by means of information structure in both professional management and technical IT terms. In this regard, BPMN standardizes blocked-structured process execution languages, between the business process design and process implementation (Cornu et al., 2013). BPMN provides a symbolic diagram notation of each role in a company, divided by lane and pool for individual activity in a process. Figure 2.10 shows three core elements, which are Event, Activity, and Gateway, that form the structure of and describe the process diagram. (Minoli, 2008)

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BPMN is popular in both business and IT communities because its symbolic visuals can provide a simple way to communicate process information to other business users, process implementers, customers and suppliers. Based on a global survey of BPMN process modelers conducted by Recker (2008), approximately 51 percent of the respondents use BPMN for business purposes (process documentation, improvement, business analysis, stakeholder communication); whereas, 49 percent of the respondents use the notation for technical purposes (process simulation, service analysis and workflow engineering). From the survey, Microsoft Visio was the tool used by 18.2 percent of the respondents; therefore, it was applied as the tool for the present study as described in the later session.

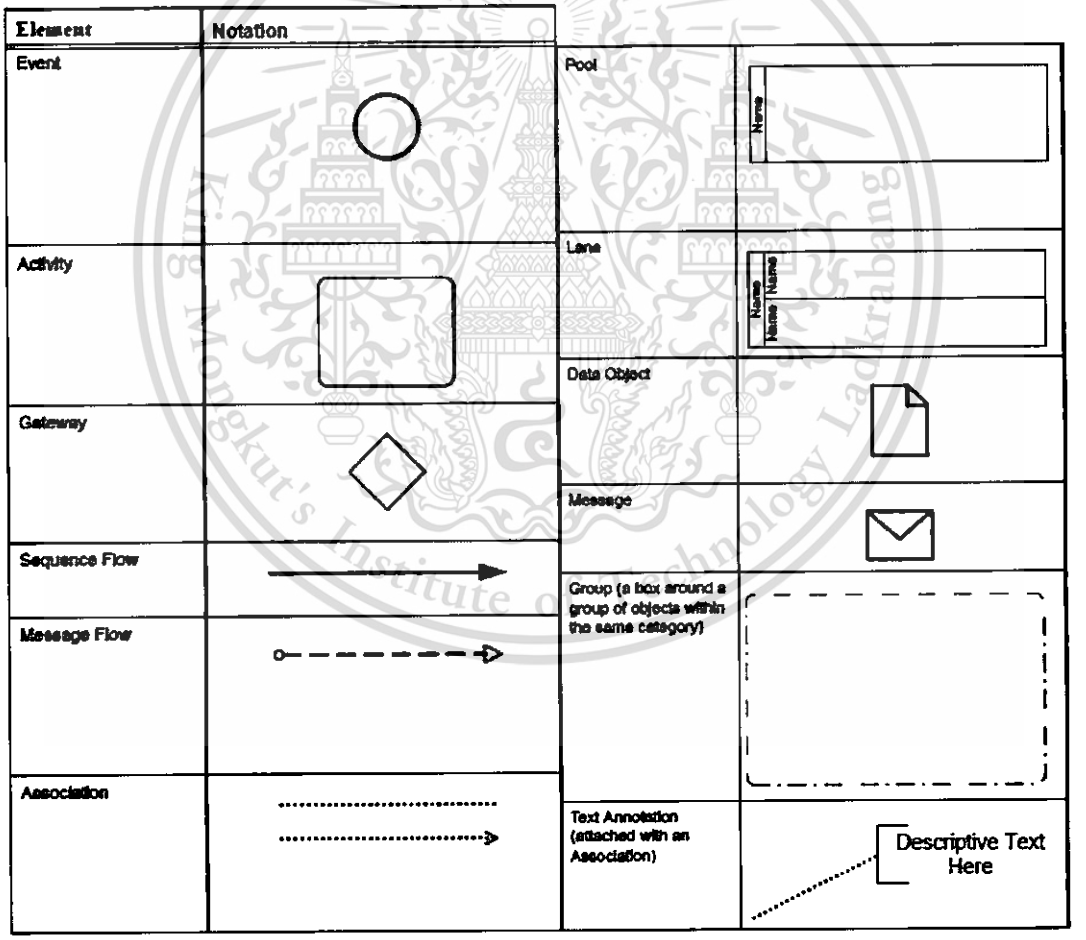

Figure 2.10 Basic BPMN Modeling Elements

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Thus BPMN is one of the standardized tool visualizing diagrams which used to model and describe the business process diagram in order to illustrate how the system is designed and processed. The informative and systematic structure could help reduce representational complexity of the end-to-end process to all cross-functional organization. In addition, those technical symbolic diagrams can be used to enhance the IT application design and development further including the message passing of web services. (Volzer, 2010)

As the business process model design, we draw the diagram using BPMN symbolic workflows starting from Event to the subsequence activities, within specific Pool and Lane. A pool is used to represent a relevant role while Lane provides the department or functions within organization. We can divide pool into Lanes to identify role and responsibility for each activities flow. Business decisions and/ or parallel process flow is modeled using gateways, and we can put annotation text to describe each block to easy understanding. There are four main categories of elements in a business process diagram or BPMN which are :-(Owen, et al, 2003; Minoli, 2008; White, 2007; Mendling et al., 2010)

- **Flow Objects** (Events, Activities, and Gateways) provide the graphical interrelationships of the process flows and behavior.
- **Connecting Objects** (Sequence flow, Message flow, Association) help connect the Flow objects in a diagram according to their sequence.
- **Swimlanes** (Pools, Lanes) are used to organize group of the participants in a process for separated functional capabilities or responsibilities.
- **Artifacts** (Data object, Group, Annotation) are allowing modelers to put some additional context to a specific process.

As mentioned earlier in this session that BPMN is widely used in many industries Khabbazi M.R., et al (2013) has also applied BPMN 2.0 with the generic framework of inbound logistics model and behavior of the system within SME environment. They have mapped out the functionality and behavior of logistics system requirements as a guideline and framework to assist the related players and for future applications and

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development.Khalifa H. I., et all (2011) adopted BPMN to transportation process of containers because of its user-friendly interface for the analysis and the decision making.

Another example for applying BPMN in healthcare environment, Muller R., and Rogge-Solti A. have identified several role-related process modeling requirements of the healthcare domain. They designed the BPMN process model to address the complex problem of healthcare, where they separated those specific roles and activities with color for some shared tasks. BPMN help them to flexibly identify and visualize processes and roles more clearly, also to synchronize actions and knowledge from all departments. Barros, et al. (2012) present an integrated and lightweight design approach for Enterprise Architectures implementing BPMN-based system in hospitals, which could demonstrate its feasibility and usability, reducing complexity and time for modeling.

General uses of BPMN are designed basically in two types of models, which are for Collaborative (public) B2B processes and Internal (private) Business processes. To apply BPMN into business process modeling, the generic framework and process are required to identify. In the next sessions, we used BPMN internal business processes platform to represent the SCOR framework with gathered processes flows and other information to analyze the As-Is and To-Be processes.

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CHAPTER 3

CASE STUDY AND ANALYSIS

3.1 Case Study Overview

As mentioned in Chapter 2 that our research has studied the current generic supply chain processes within the distribution centers of three-large-size hospitals as case study environments, and modeled based on the information from the in-depth structure interview conducted with the hospital head officers in related work area and site observation.

According to the Healthcare Cost and Utilization Project (updated for 1988-2004), U.S. Department of Health and Human Services (HCUP, 2006), using inpatient sample to estimate trends to define the definition of teaching hospital, non-teaching hospital bed size categories in rural and urban area of the U.S. region as shown in Table 3.1.

Table 3.1 Bed Size Categories in the 1998 – 2004 Sample Design

Region	Location/Teaching	Small	Medium	Large
Northeast	Rural	1 – 49	50 – 99	100+
	Urban Non-teaching	1 – 124	125 – 199	200+
	Urban Teaching	1 – 249	250 – 424	425+
Midwest	Rural	1 – 29	30 – 49	50+
	Urban Non-teaching	1 – 74	75 – 174	175+
	Urban Teaching	1 – 249	250 - 374	375+
South	Rural	1 – 39	40 – 74	75+
	Urban Non-teaching	1 – 99	100 – 199	200+
	Urban Teaching	1 – 249	250 – 449	450+
West	Rural	1 – 24	25 – 44	45+
	Urban Non-teaching	1 – 99	100 – 174	175+
	Urban Teaching	1 – 199	200 – 324	325+

Oxford dictionary (2014) has defined word *"Generic"* as "Characteristic of or relating to a class or group of things which not specific". Thus ***Generic Process*** is the group of processes with related characteristic and not subjected to one environment. Therefore the selected hospitals are to represent the valid as-is hospital distribution processes, as they are one of the most famous and largest hospitals in Thailand.

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This research followed the qualitative research method of in-depth interviews, additional desk research and observation to the existing distribution process at Hospital A, B and C shown in Table 3.2, in order to collect the data to analyze and redesign the As-is process into the standardize generic model. The structure of research will be organized in four steps; (i) literature review, (ii) case observation and analysis, (iii) reference process design and (iv) model discussion for implementation.

Table 3.2 Basic information of Hospital A, B and C for cases analysis

No.	Hospital(s)	Capacity	No. of visits	Type of hospital
1	Hospital A One of the largest medical schools in South East Asia	More than 2,000 beds	More than one million outpatient visits per year	Public hospital
2	Hospital B It won the best Thailand's Most Admired Company in 2013 by the Company Magazine	More than 1,000 beds	More than 5,000 outpatients served per day	Public hospital
3	Hospital C The first and the largest private-hospitals in Thailand. It has grown its branches network to 13 locations around the country and the broader Asian region.	about 300 beds with 13 network locations throughout Thailand	More than 800,000 outpatients served per year	Private-hospitals

In summary, the case study environments for public hospitals consist of a large-size hospital, which one of those is the oldest and largest hospital in Thailand. Hospital A is one of the largest medical schools in South East Asia. It has a capacity of more than 2,000 beds and more than one million outpatient visits per year. Hospital B has about 1,000 beds capacity with more than 5,000 outpatients served

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per day. It won the best Thailand's Most Admired Company in 2013 by the Company Magazine, with average score 7.04 in overall for the image of brands owned and lead in innovation in Hospital business in Thailand.

Another location for our case study is the first and the largest private-hospitals in Thailand. Hospital C has grown its branches network to 13 locations around the country and the broader Asian region, offering the most advance and specialized medical treatment technology, under logistics center and lab specialties distribution for all the branches.

3.2 Relevant Roles and Responsibilities in Distribution Center Process

Further on case observation and analysis, we found that the distribution center processes run through four major roles and responsibilities in Hospital supply chain. There are two ways of interactions; inbound logistics and outbound logistic flows as shown in Figure 3.1.

Figure 3.1 inbound logistics and outbound logistic flows

- **Inbound logistic processes** considers as external distribution or stock-in process. It consists of all activities between supplier, purchasing department and distribution center. Purchasing plans for the order by re-order point and submit purchasing orders to suppliers for delivery to distribution center within agreed timeline in contracts.

- **Outbound logistic processes** considers as internal distribution or stock-out process. It consists of all activities between distribution center and dispensing

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points within hospital. The dispensing points once update their stock on hand and then plan to reserve the drug request to distribution center, then internal distribution (outbound) or stock-out occurs on schedule.

Next session will describe the case studies observation and as-is distribution process in hospitals, preparing for the reference process modeling in Chapter 4. The structure-interview-questionnaire are designed and conducted at selected hospitals, with additional desk information collected in this step.

3.3 As-Is Distribution Processes

The as-is distribution processes of these three hospitals, can be divided into two main parts, which are internal distribution (outbound) processes and external distribution (inbound) process. As described in Chapter 2, there are 7 primary distribution processes, starting with receiving products from suppliers and put-away to storage location and move to storage for replenishment until order triggered for delivery. Once order placed from dispensing points then products will be picked up and may require for packing or sortation before ship/deliver to customer (dispensing points). See below Figure 3.2for primary distribution processes.

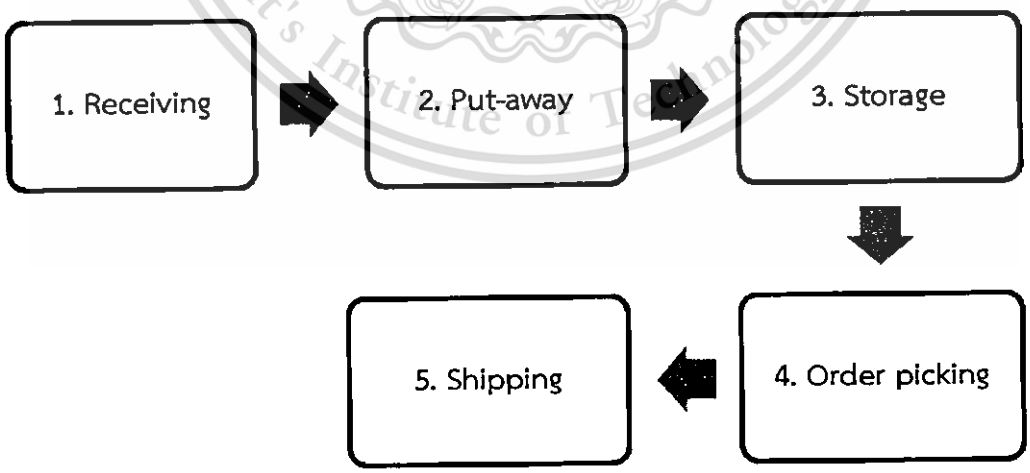

Figure 3.2 Primary distribution processes

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1) **Receiving** process based on our case environments, there are mainly one pharmacist and two staffs who check items, sign on approval documents and key goods received per order into ERP system.
2) **Put-away** is process to recheck products and verify location after received from a supplier, then move products into storage for further products placement/fulfillment.
3) **Storage** is physical location of products containment while it is awaiting an order picking process.
4) **Order picking** is the process of picking items from picking location to fill up customers' order and prepare document for loading at shipping docks. This process may include re-packing some batch picks quantities per customers' orders
5) **Shipping** is to check the orders completeness such as packaging of products in appropriate shipping containers, preparing shipping documents, including packing lists, address labels, to be ready for deliver.

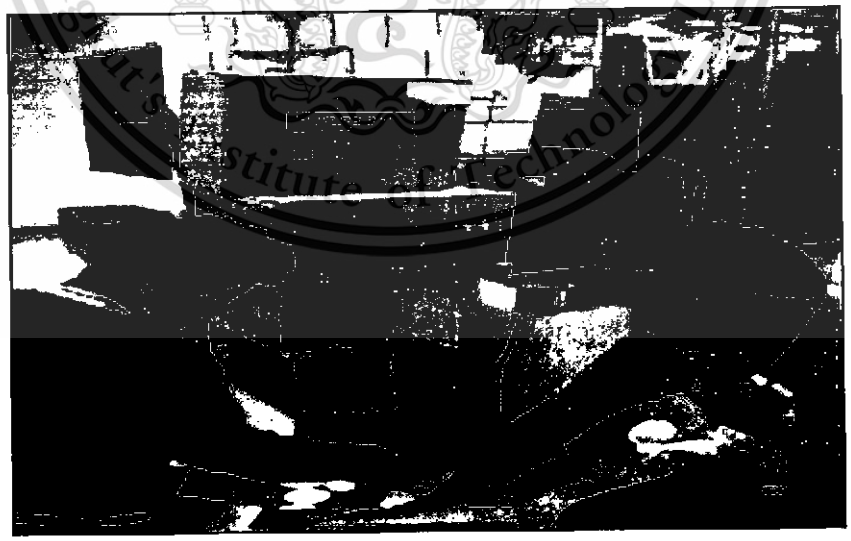

Figure 3.3 Receiving processes

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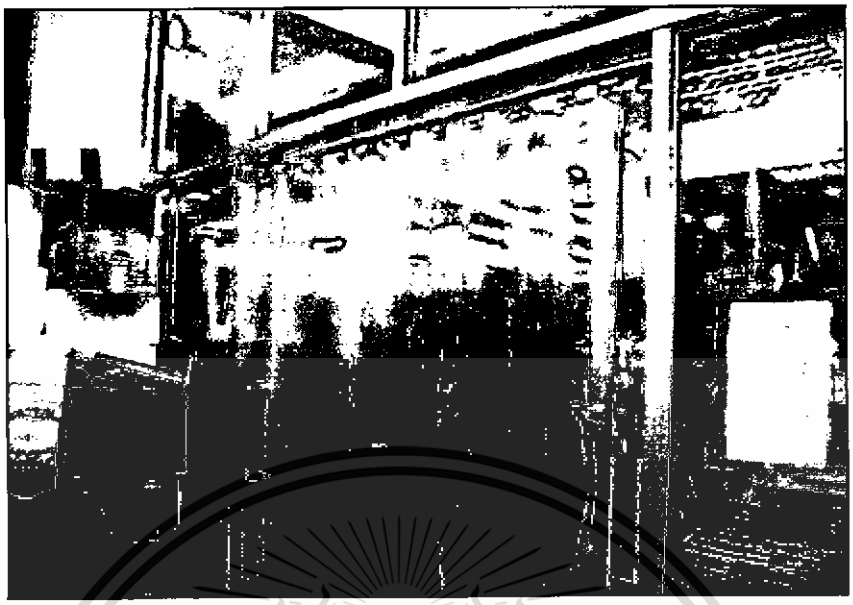

Figure 3.4 Put-away process

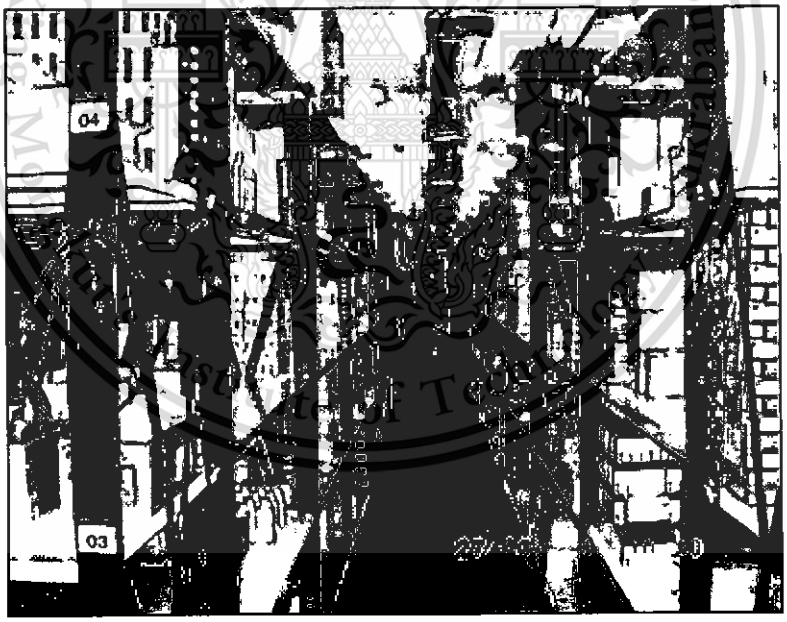

Figure 3.5 Storage process

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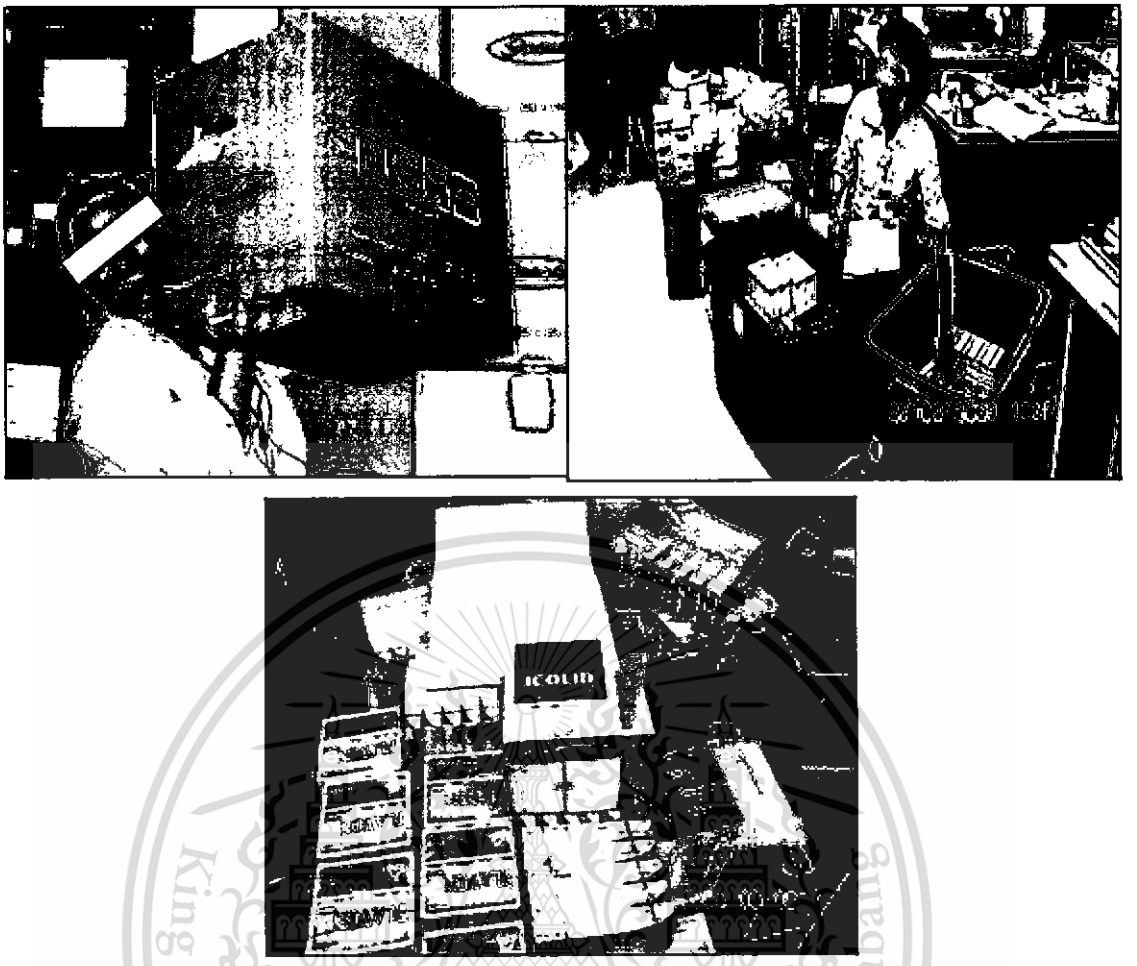

Figure 3.6 Order picking and Packing

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Figure 3.7 Special handling box for temperature-controlled products

The first staff will pick-up the products at the storage location with required quantities where products may keep in bulk amounts as shown in Figure 3.7. Then the second staff will re-check and write down the amounts for each order to be delivered. The products will be re-packed for each dispensing points to be ready to deliver at this stage. For the cold-storage pharmaceutical products that required temperature control, staff will have to separate those into special handling cooler box. The temperature log-tag thermometer will be set in the box for quality control

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at the origin location and kept in the box. Once dispensing point received the products, they will check temperature of log-tag again and will return the whole lot if the temperature is not qualified.

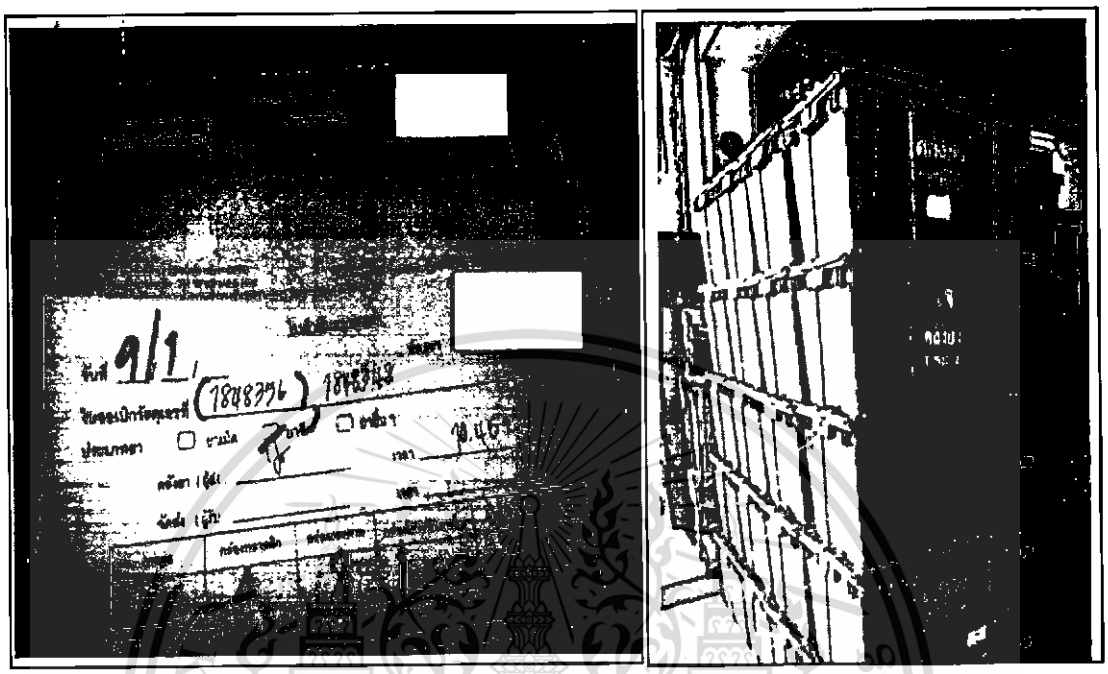

Figure 3.8 Shipping document

3.3.1 External Distribution (Inbound) or Stock-In Processes

The external distribution (Inbound) or Stock-in process, it will begin at purchasing department running through the stock on hand and placing orders to suppliers, then within agreed lead-time the distribution center will receive the goods and proceeds on with the distribution center processes. See figure 3.9 for inbound logistics flow.

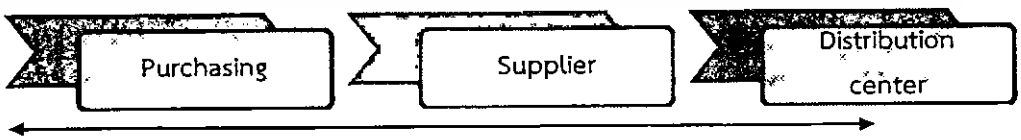

Figure 3.9 Inbound logistics flow

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From the gathered information on distribution process at three hospitals, the activities at purchasing department are very similar. The distribution process starts when purchasing staff analyses the stock on hand against the reorder point by using material replenishment planning program. If the stock on hand is less than reorder point, purchasing staff will create the purchasing order and get approver sign on, then send it via fax to suppliers to place orders. Suppliers once receives the purchasing order, they will check their available stocks and plan for order picking and delivering to the distribution center at hospital within two weeks.

For the distribution center, the receiving process requires to verify the orders correctness by three committees (one pharmacist, and two staffs). At this step, committees will check the physical product quality and randomly check inside the package. Suppliers are required to attach the quality certificate document, or temperature check equipment (for cold-storage), rather than checking goods physical appearance only. If the quality of the order is acceptable, committees will sign on the receiving documents and log book, then update stock balance on stock card for Hospital A and B. Also update good received quantity and lot details into ERP system for further record and tracking. Then products will move to the specified location in storage. On the other hand, if the quality of the order delivered is not satisfactory, the distribution center will return goods for the whole batch as per contracts agreement.

In sum, you can see in Figure 3.10-3.12 that the as-is inbound distribution process from these three hospitals, are with slightly different within roles and responsibilities and system. Hospital A, B and C are starting the processes at purchasing department, to monitor the stock on hand and place orders to suppliers. Within the lead time of 2 weeks, supplier will deliver goods to distribution center. Focusing at all activities within distribution center, are also in the same direction with high standard and control points. This is very significant to pharmaceutical products where the certified quality is a must for patients' safety.

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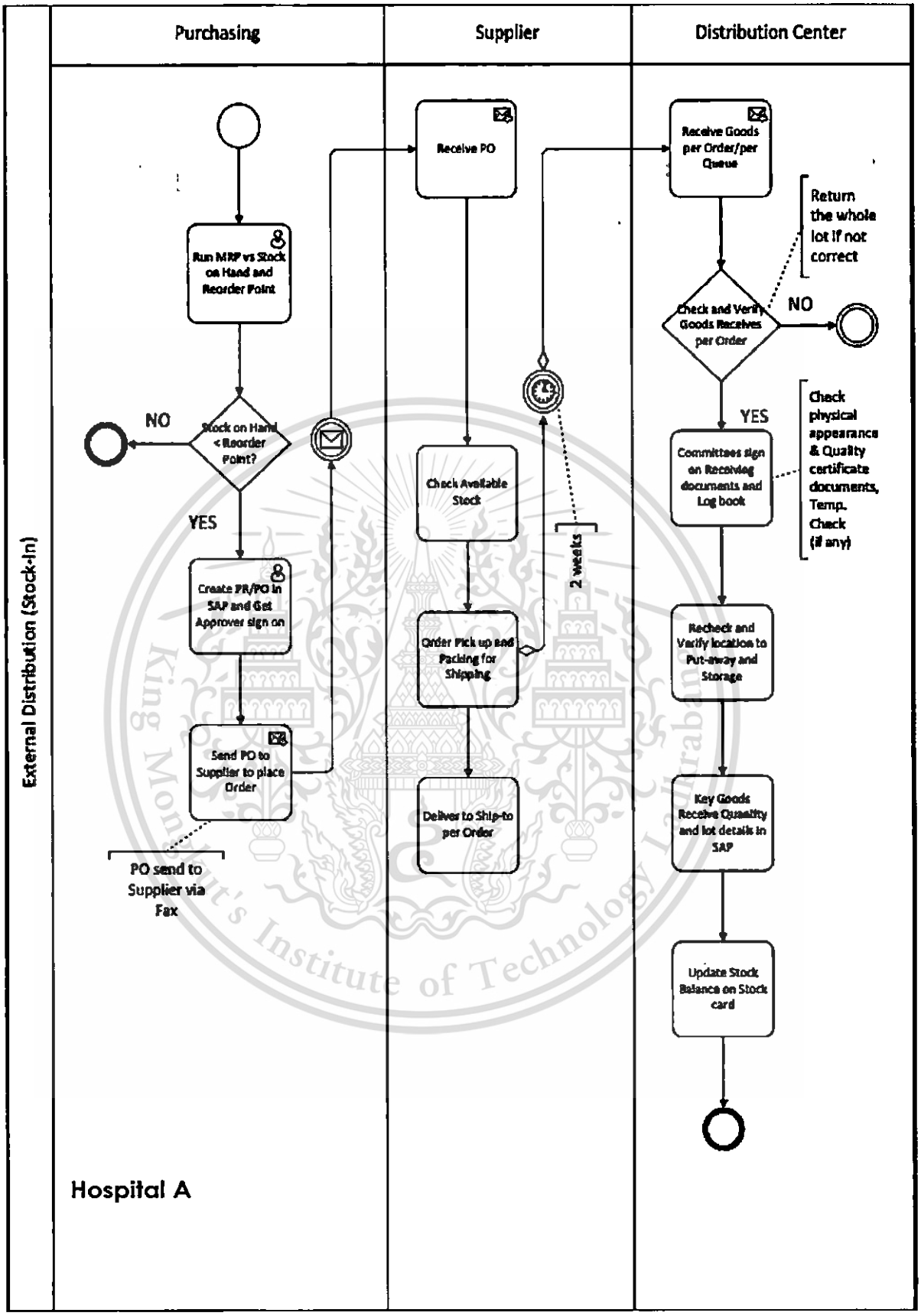

Figure 3.10As-is inbound distribution process from Hospital A

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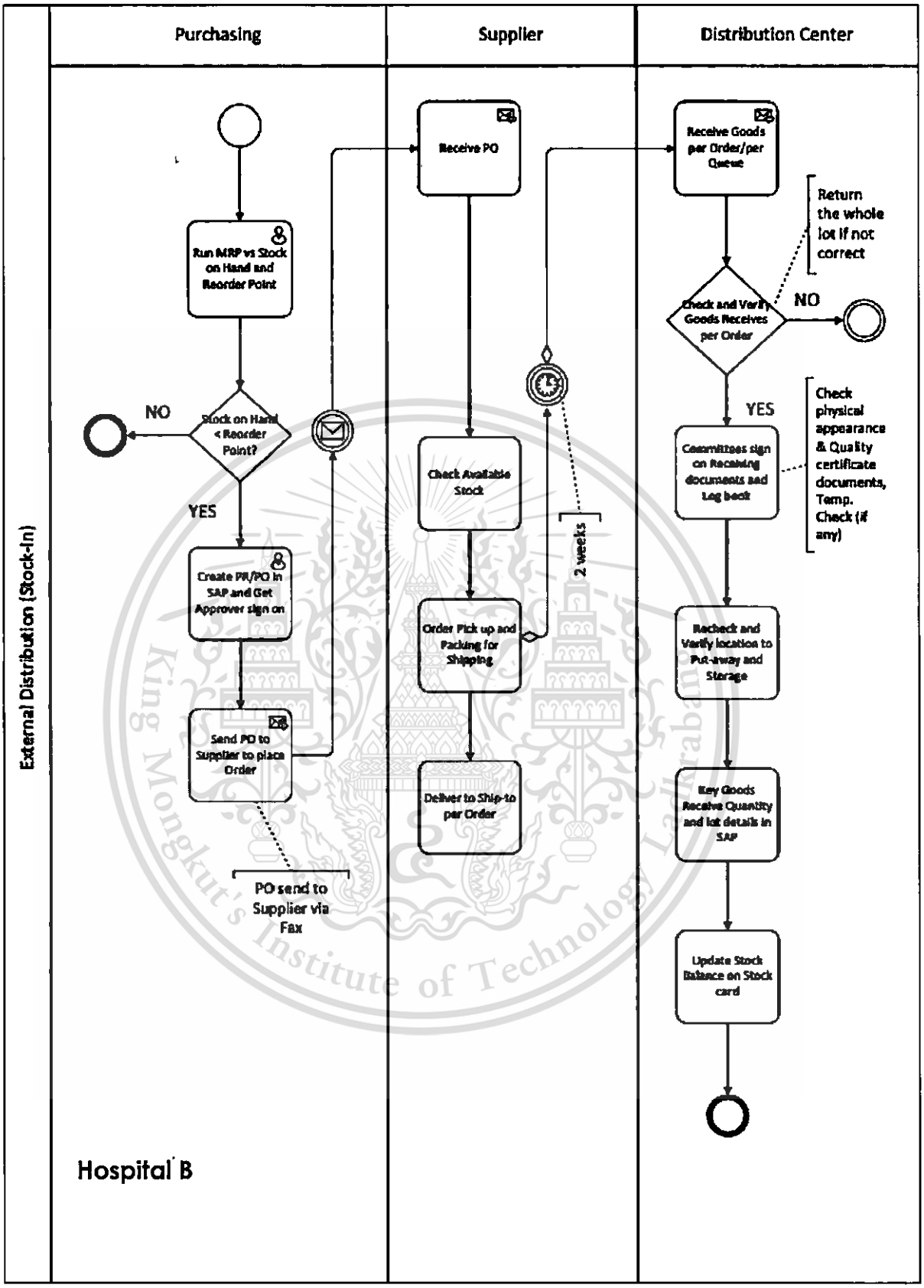

Figure 3.11As-is inbound distribution process from Hospital B

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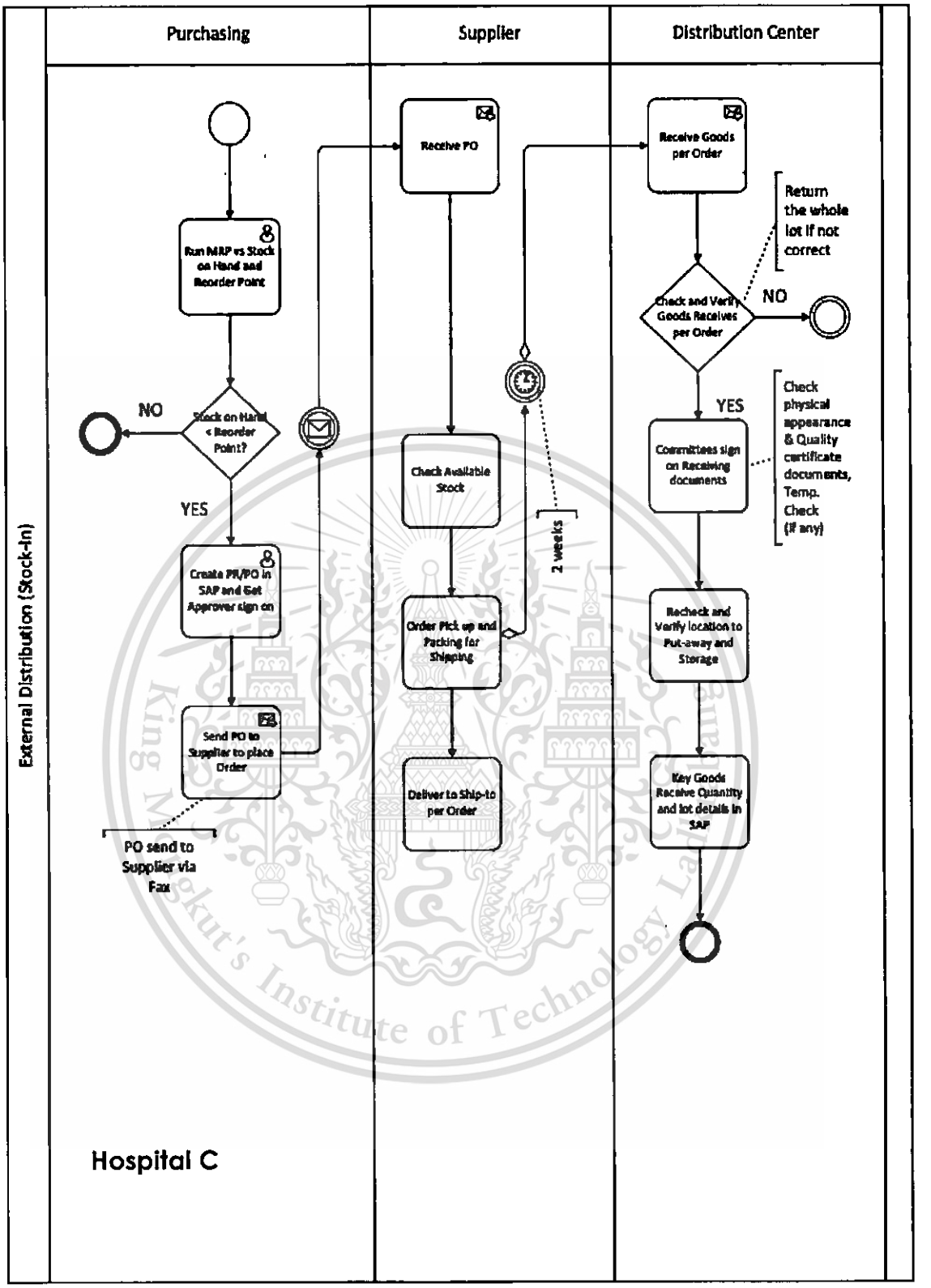

Figure 3.12 As-is inbound distribution process from Hospital C

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3.3.2 Internal Distribution (Outbound) or Stock-Out Processes

The Internal distribution (outbound) or Stock-out in Figure 3.13. occurs on schedule weekly plan, starting from the dispensing points update their stock on hand and plan to reserve the drug request to distribution center. The relevant activities are including Order picking, Packaging or Sortation and Shipping.

Figure 3.13 Outbound logistic flows

From Figure 3.14-3.16 Dispensing points at each location will start running material replenishment planning program to see the remaining stock on hand, and staff will enter drug request if replenishment needed for Hospital A and B. While Hospital C run the auto reservation created in SAP and plan for order-pick up and deliver by distribution center without redundant start up. The approval is required before sending the request to distribution center for further fulfillment by schedule day and time.

Distribution center, after received drug request lists from dispensing points will pick-up products and packing for shipping to each location per request. The pick-up orders will be written down the quantity and recheck before shipping and update goods issue into ERP system for tracking records and stock count calculation. Apart from recording good issue into system, Hospital A and B also calculate stock balance on stock card. On planned date and time, distribution center will deliver requested order to the dispensing points, where order will be checked and put-away to storage to serve patients.

However, in this study we will focus only the activities occurred within distribution center to fine tune the generic processes for reference process model design.

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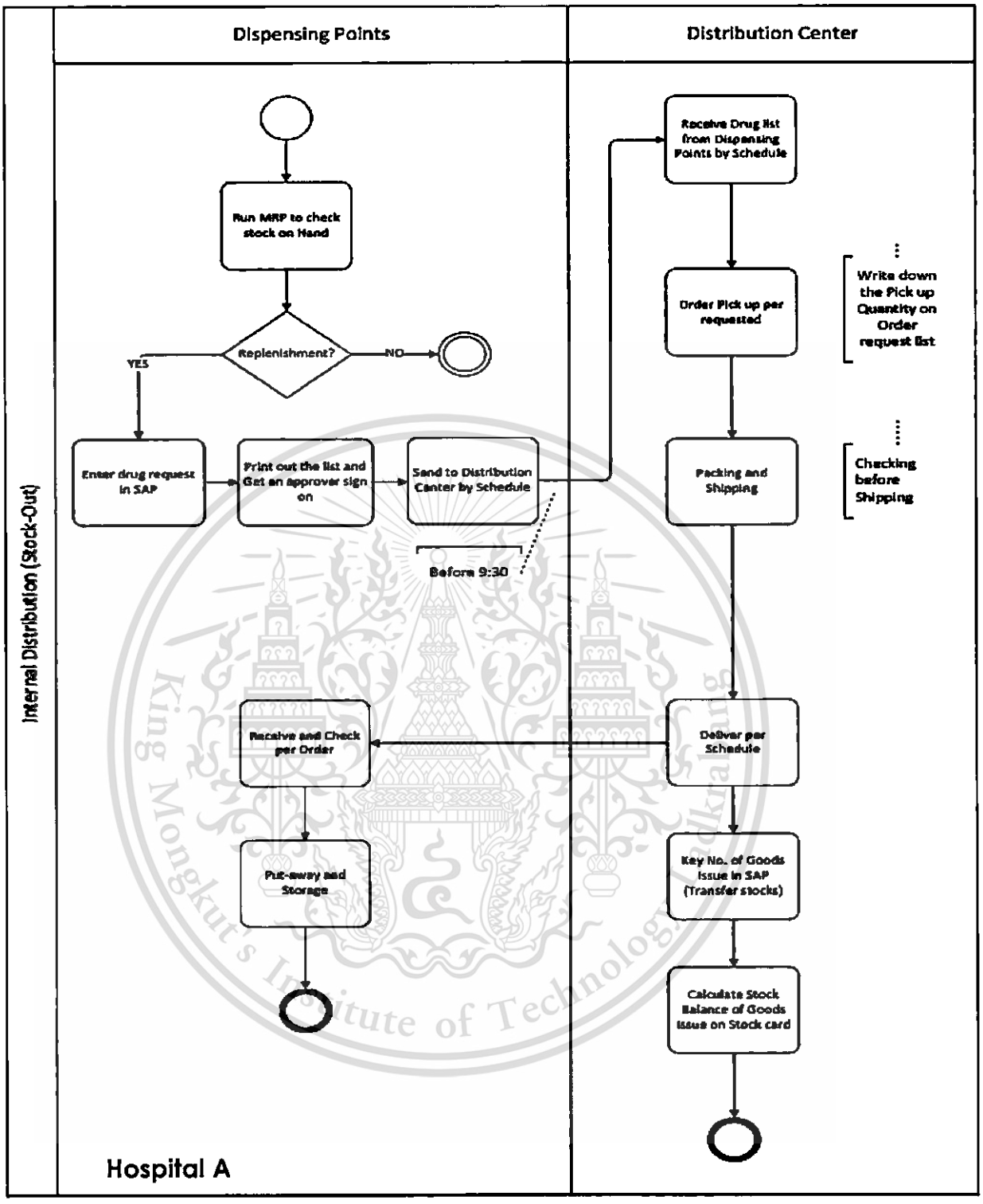

Figure 3.14 As-is outbound distribution process from Hospital A

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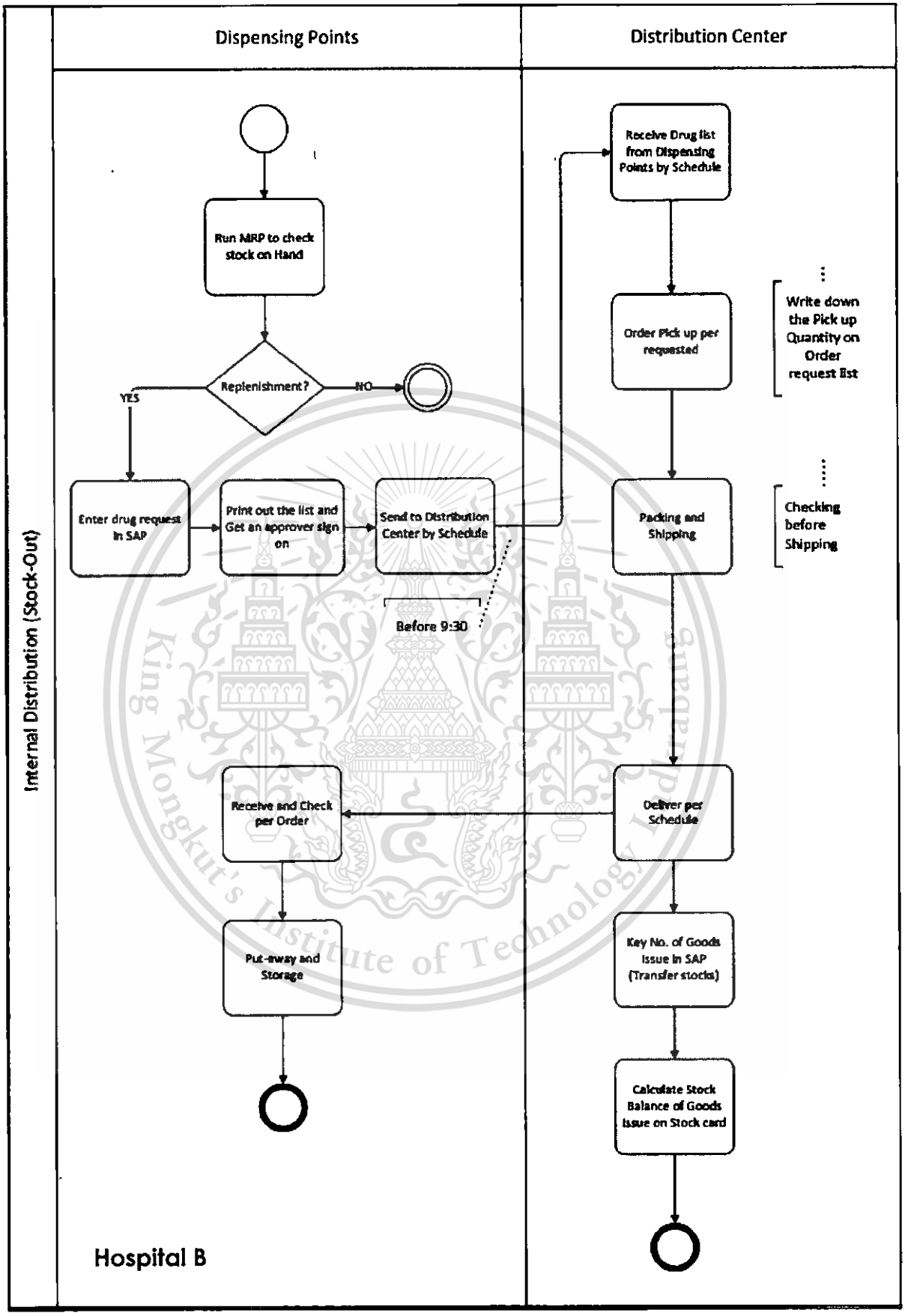

Figure 3.15 As-is outbound distribution process from Hospital B

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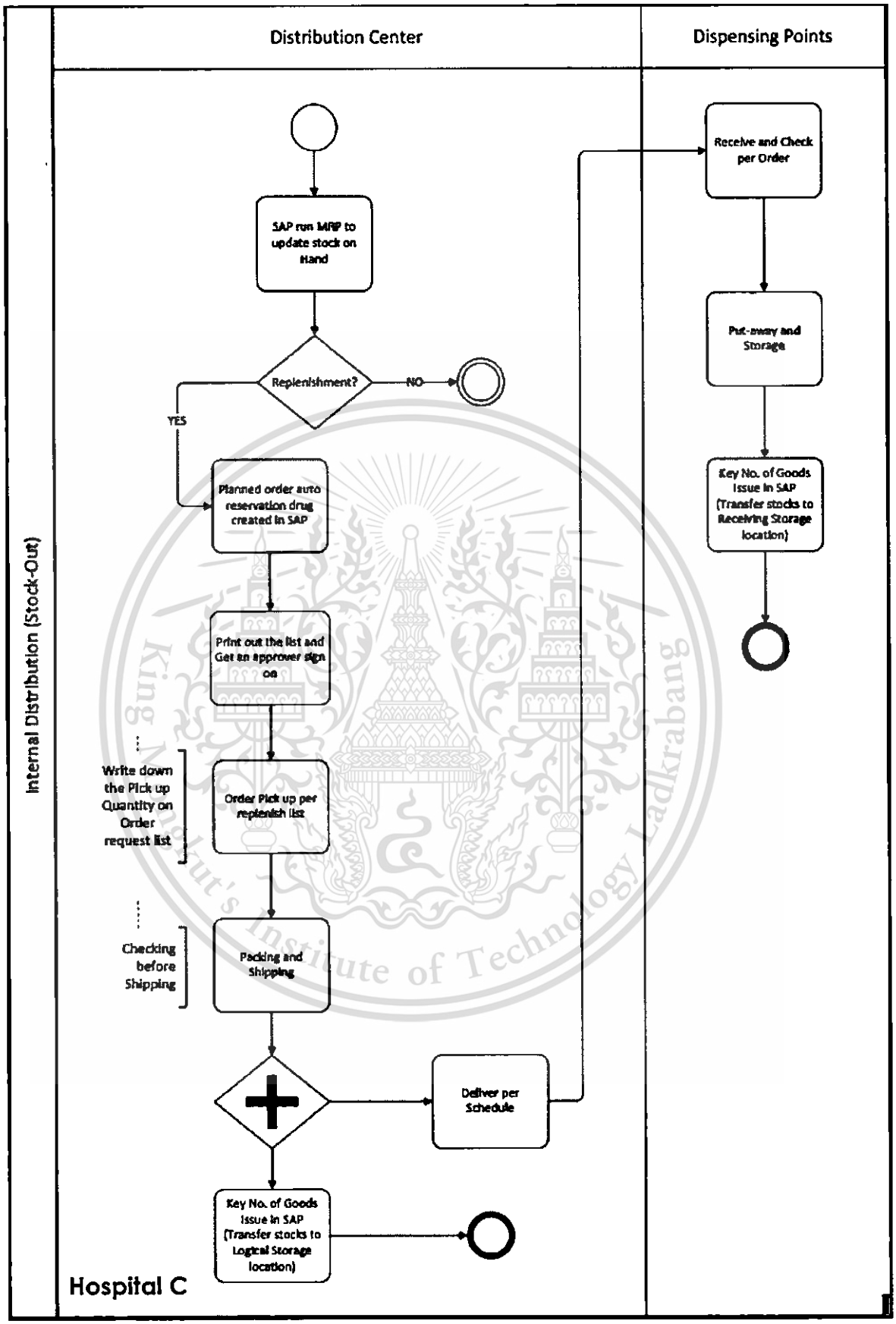

Figure 3.16 As-is outbound distribution process from Hospital C

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From the case observations and in-depth interview with high-level officers at three hospitals, we found that the distribution processes at each distribution centers are similar. There are similar patterns and processes are observed in the distribution centers for these three hospitals, with different technology, system and management policy. Therefore the generic processes are classified into five main processes as Receive, Put-away, Storage, Order Picking and Shipping (see Figure 3.17). The similarity of processes in three hospitals can be potentially applied and extended to the reference model of same direction of control parameters and standard.

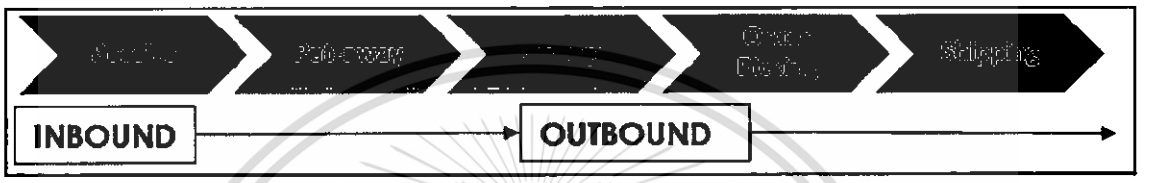

Figure 3.17 Generic Distribution Center Processes

In addition, as-is process concerns are determined in this step as following:-

1. Process more manual in some activities
2. Unspecified roles and responsibilities
3. No standard work instruction process
4. No measurable KPI for each process

Conceptual supply chain model is analyzed based on as-is processes and sequences to identify the specific characteristics of business process and constrains. The generic processes will be determined into SCOR process categories (plan, source, make, deliver and return) in the next chapter.

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CHAPTER 4

CASE STUDY AND RESULTS

4.1 Reference Process Design

In previous chapter, we have studied the as-is processes of three-large-size hospital in Thailand to identify the reference model of distribution center in hospital supply chain based on following proposed methods:-

1. SCOR Model and Metrics
2. BPMN notation for IT implementation purpose

Product movement types are to identify the products' demand characteristics especially for hospitals that implements stockless supply chain policies. The demands have to be analyzed and modeled on a daily or monthly basis and it can be defined from the frequency of usage and Sales forecast. It can be classified into three levels as Slow-moving, Moderate-moving and Fast-moving, which affects the re-ordering point at the inbound process in order to manage inventory cost to balance with fluctuated demand.

From the generic processes in the distribution center of general hospital, the pattern of product movement shows that most of medicines are usually kept stock for daily demand usage and some that are for vital usage are required to be stored in hospital even with no demand. Therefore the 'Reference Process Model' will be designed based on Make-to-Stock model structure using five major processes within distribution center (see Figure 4.1).

Figure 4.1 Generic distribution center processes

After we classified what are the generic processes are being done within the distribution center of the hospital, and the particular roles, we will organize them into the SCOR model at each level. At the top-level (level-1) will used to describe the scope of process type of distribution center as high level. Level-2 will differentiate the strategies of the level-1 processes, containing 26 processes as sub-

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categories. Level-3 processes will then describe the sequence steps taken to perform and execute the element to align with its strategies and performance metrics.

The fourth level (Level 4) is described the industry specific activities and detailed implementation of processes that required to perform level-3 processes. At this level-4 is not included in SCOR model framework, therefore, we decided to enhance our reference model to the SCOR level 3.5 to determine some specific activities and concerns of hospital supply chain. The SCOR model level 3.5 enables the decision-making from the top level strategic planning to tactical and operational activities as a work related guideline processes and control.

As a results, the well-designed reference process model helps support management team in decision-making planning and to communicate to other functions across the organizations. Introducing SCOR model framework and a set of performance metrics, the standard measurement system are identified to distribution center of hospital supply chain. Also by applying this model using BPMN notation platform, it can easily further implementation in IT for process/performance improvement and development purpose.

4.1.1 SCOR Level 1

We adopted the SCOR Model framework to describe the pharmaceutical products flow and information flow within and throughout distribution center. The six macro-level processes Plan, Source, Make, Deliver, Return and Enable are processes from supplier's supplier to customer's customer. The activities that are used to determine on typical hospital supply chain process types applied as in Figure 4.2.

Manufacturers are classified into primary and secondary manufacturers. The primary manufacturers are manufacturers who do the creation of active ingredient contained within the medication and supply to the secondary manufacturers for further usable drug transforming process.

Focusing within the distribution center processes, where the products or finished goods transferred from suppliers to distribution center at hospitals, and distribution center to dispensing points. Some distribution centers are tended to responsible by

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third party companies, drug manufacturers or wholesalers. It is found in some cases that they are available to bring the product at the front of dispensing points in a very short lead-time.

Unlike the other industries, healthcare supply chain is required some specific handling controlled-system and inventory management. The professional healthcare providers are tended to become more important parts of its supply chain. The products are delivered on their availability to minimize inventory cost, with the standard quality control. Therefore, the professional distribution processes are considered at this high level to set the basis-of-competition performance targets.

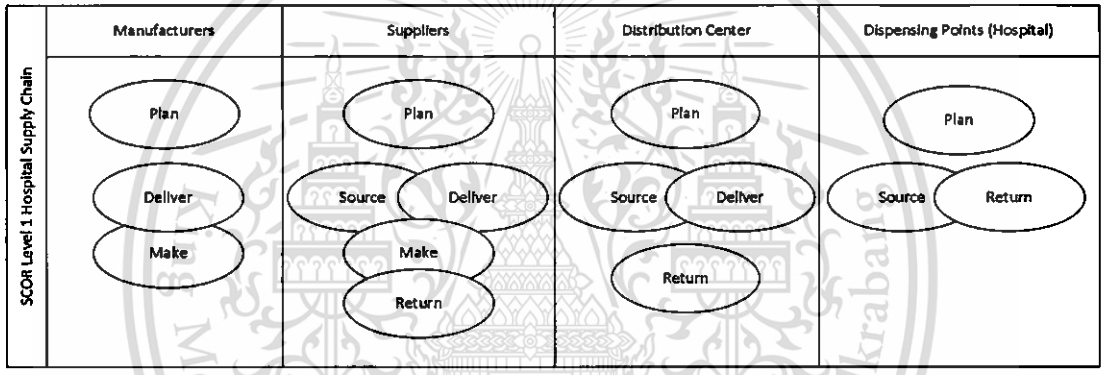

Figure 4.2 SCOR Level 1 Healthcare Supply Chain

4.1.2 SCOR Level 2

For process categories, as mentioned earlier that we focused on distribution center processes and some parts on 'Purchasing' will also be considered. The SCOR Level 2 in Figure 4.3 is modeled based on Make-to-Stock products. We renamed the process categories to align with distribution processes and hospital supply chain per following:-

- **Plan (PL)** : the process to determine requirements and corrective action to achieve supply chain objective for Inbound and Outbound logistics
- **Receive (RE)** : the process of ordering and receiving products, including replenishment inventory and return for defective product

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- **Put-away (PU) :** the process of transferring verified products to storage location
- **Order-Picking (OR) :** the process of receiving the orders and pick up products to be ready for shipping
- **Shipping (SH) :** the process of order management and order fulfillment activities to serve customer satisfaction
- **Return (RT):** the process of moving defective products back through the supply chain or supplier

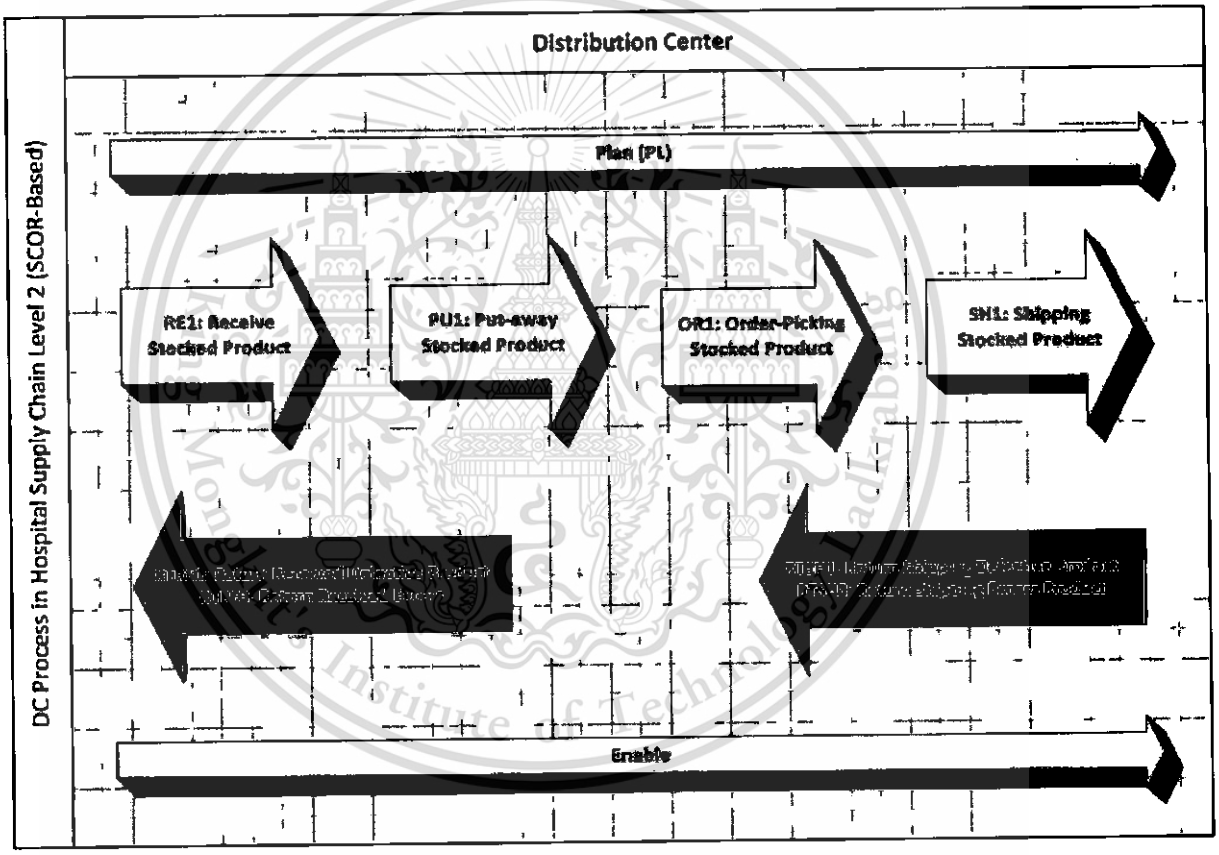

Figure 4.3Distribution Process in Hospital Supply Chain Level 2 (SCOR-Based)

Normally, the typical distribution process in hospital supply chain can be described using Make-to-stock standard framework. Starting from purchasing staff will plan the orders by calculating the stock on hand against the re-order point and sending information to suppliers for further steps. Once suppliers deliver the products at distribution center, the Receiving (RE), Put-away (PU) processes will be actioned as inbound logistics. Then when there are any orders from dispensing points

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placed to distribution center, Order-picking (OR) and Shipping (SH) will be processed for outbound logistics accordingly. The Return (RE) process will be done only when there is defective products found and need to be returned to the origin sources. While Enable processes are support the other processes along the supply chain.

4.1.3 SCOR Level 3 to Level 3.5

In previous session, SCOR level 1and Level 2 described how the processes are defined in the high level of distribution center in hospital supply chain. SCOR Level 3 will break down processes into a tactical decision level while additional model Level 3.5 will consider the operational decision level of the distribution center using the generic Inbound and outbound logistics throughout the processes (see in Figure 4.4).

As mentioned in section 3.4 that we have put in extra effort to upgrade SCOR model Level 3 to Level 3.5, in order to show users the roadmap on how the reference model can be implemented in such environments. Figure 4.4 reference model for distribution center process in hospital supply chain (SCOR-Based Level 3.5) shows us the interface between purchasing – distribution center (inbound) – distribution center (outbound) – dispensing points.

It is written in BPMN platforms to represent the start and end processes of information flow and product flow for the whole processes. This is important for the IT part; to design on how each of the information will be link together, and using that to select the proper IT supports to achieve the most efficiency performance. The reference model can also be used to support the capability requirement, network design, facilities considerations, and scope down to operational planning as mentioned in session 3.2.

Determined the case studies scenarios into reference model based on SCOR best-practice, we classified the process categories according to processes within distribution center as; Plan (PL), Receive (RE), Put-away (PU), Order-Picking (OR), Shipping (SH) and Return (RT). With this classification, the management of hospital can see the operation scale and manage in which position is required for each activity, and design for the organization workforce at each process for the required

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role to be fulfilled. Therefore, the purchasing, distribution center and Dispensing points are separated by lanes, where inbound and outbound distribution center can be seen clearly in group of activities.

At the beginning, each role will be triggered by receiving information to start the process. For example, purchasing will start Process PL1.1 from Inventory level, then establish and communicate supply chain plan, PL1.2 (Ordering plans) submit to suppliers with RE1.1 (Product Schedule) to deliver to distribution center (inbound). The workflow process will continue to the next role and activities respectively, as well as, product and information movement where necessary along the roles and responsibilities.

However, some processes are the same activities and are defined as same Process ID, such as, RE 1.2, RE 1.3 and PU 1.1 process. These are separated and specified more particularly by roles and responsibilities. Also the performance metrics using at each process, each roles are different by the measuring methods, which will be described in the next section.

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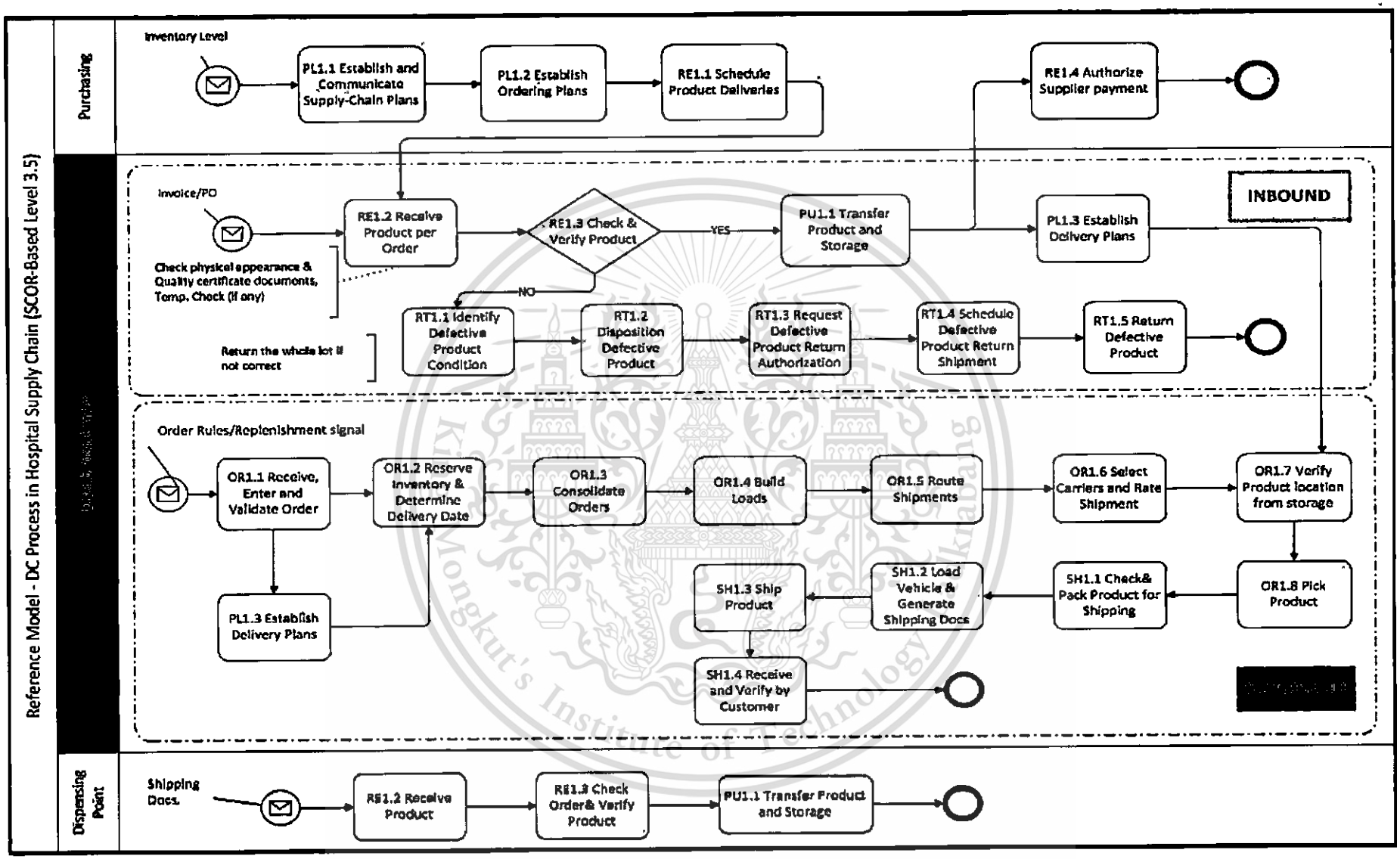

Figure 4.4 Reference Model of Distribution Process in Hospital Supply Chain (SCOR-Based Level 3.5)

4.2 Performance Analysis and Control

As mentioned in Chapter 1 in the overview of problem background that hospital supply chain still require a proper improvement and control of inventory with quality of goods storage and distribution practices conditions, those system affect directly to the patient safety and hospital's performance and service level. In this section you will see the performance outcome of Metric ID at each activity based on SCOR Level 3 that impacts the top-down process and decision in terms of time, cost and efficiency.

Hence the Metric is a standard for measurement of the process performance in supply chain, and SCOR Metrics are demonstrated in three-level of pre-defines metrics. For example in Table 4.1, Performance Attribute – Reliability at Level-1 Metric is RL.1.1 (Perfect Order Fulfillment) as its strategic metric and key performance indicators (KPI). It has four main 'Level-2' metrics and various 'Level-3' metrics identified with the processes. It shows that Process SH1.2 (Load Vehicle & Generate Shipping Docs) at distribution center (Outbound) directly affects the performance 'Level-2' Metric RL2.3 (Documentation Accuracy), and those are part of the KPI at Level-1 metric RL1.1 (Perfect Order Fulfillment). Therefore the analysis of performance of metrics ID from Level-1 through 3 can help manager to find the root cause of overall performance.

Table 4.1 Level-1 through 3 of Performance Attribute – Reliability and Processes linked

[illegible]	[illegible]	[illegible]	[illegible]		
Reliability [Total Perfect Orders] / [Total Number of Orders] x 100%	**RL.1.1** **Perfect Order Fulfillment**	**RL.2.1** **% of Orders Delivered in Full**	RL.3.33 Delivery Item Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
			RL.3.35 Delivery Quantity Accuracy		
		RL.2.2 **Delivery Performance to Customer Commit Date**	RL.3.32 Customer Commit Date Achievement Time Customer Receiving	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.34 Delivery Location Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
		RL.2.3 **Documentation Accuracy**	RL.3.31 Compliance Documentation Accuracy	SH1.2 Load Vehicle & Generate Shipping Docs	Distribution Center (Outbound)
			RL.3.43 Other Required Documentation Accuracy		
			RL.3.45 Payment Documentation Accuracy		
			RL.3.50 Shipping Documentation Accuracy		
		RL.2.4 **Perfect Condition**	RL.3.12 % Of Faultless Installations	N/A	N/A
			RL.3.24 % Orders/lines received damage free	RE1.3 Check Order& Verify Product	Distribution Center (Inbound)/ Dispensing Point
			RL.3.41 Orders Delivered Damage Free Conformance	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.42 Orders Delivered Defect Free Conformance		

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In our research, the designed Reference Model of distribution center in hospital supply chain is considered at Process / Metrics Alignment level based on SCOR Best Practices. The Performance-Process mapping diagrams show that outbound distribution, starting from order receipt to deliver to customers, is the key function in distribution center and it has the most impact on overall Performance. Reliability and Responsiveness are the major Performance attributes of the outbound distribution with covering process activities about 40.74 and 44.45 percent respectively; as they are addressed to customer-facing attributes, whereas Agility, Cost and Asset Management Efficiency have a small impact for about 15 percent from total 27 processes in Distribution center.

Further in this session, from SCOR Model Level 3 we have mapped the processes and performance metric IDs for each role and responsibility within the distribution center process of hospital supply chain, in order to show the implementation roadmap how the interaction of the process and how the key performance are interaction. Performance-Process mapping diagram can enable the performance monitoring system at each role, where individual process can be visible and measured.

Level-3 performance metrics are related to SCOR level-3 processes as shown in Figure 4.5 to 4.8 at each role and responsibility. The performance attributes represent performance metrics at each aspect of individual activity. For example, in Figure 4.5the performance-process mapping for Purchasing, at PL1.1 Establish and communicate supply-chain plans process are computing by Inventory days of supply (A.M.2.2) and Establish supply chain plans cycle time (R.S.3.30). While the performance of Receive product per order (RE1.1) process at distribution center (inbound) are considered in more complex aspects of metrics, such as, %of orders/lines processed complete (R.L.3.18), % of orders/lines received on-time to demand requirements (R.L.3.20), etc.

The selection of performance metrics is specified to the process according to SCOR framework guideline, where level-1 metrics is calculated and collected from the total sum up items in all levels. Hence the hierarchy of process steps and performance metrics are identified by roles, SCOR and BPMN help enable communication among supply chain partners. Moreover the staffs can work smoothly and more measurable follow the guideline. Suppliers and related parties can flawlessly deliver and receive the products within a short lead-time when Purchasing place the orders.

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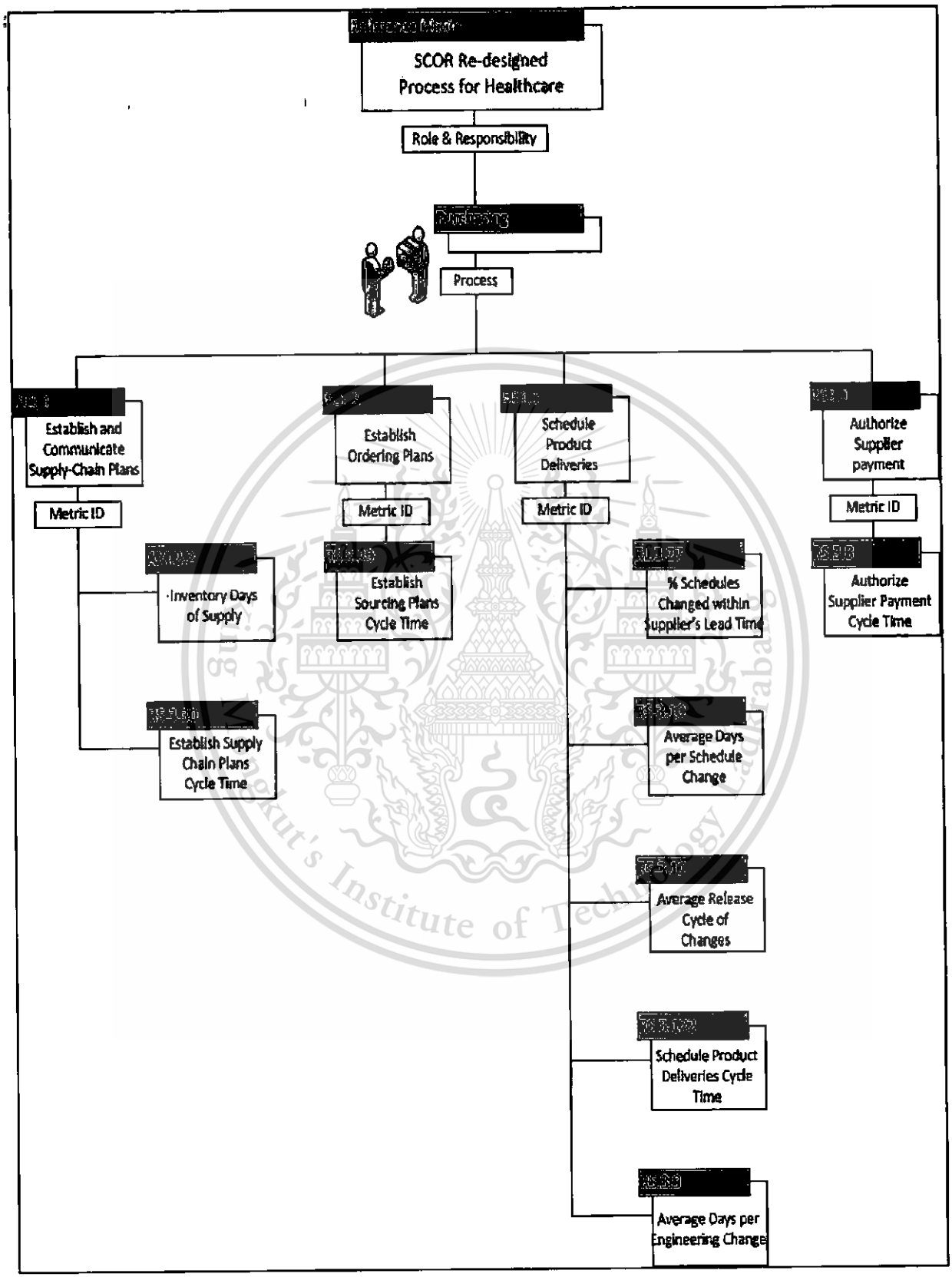

Figure 4.5 Performance-Process Mapping at Purchasing

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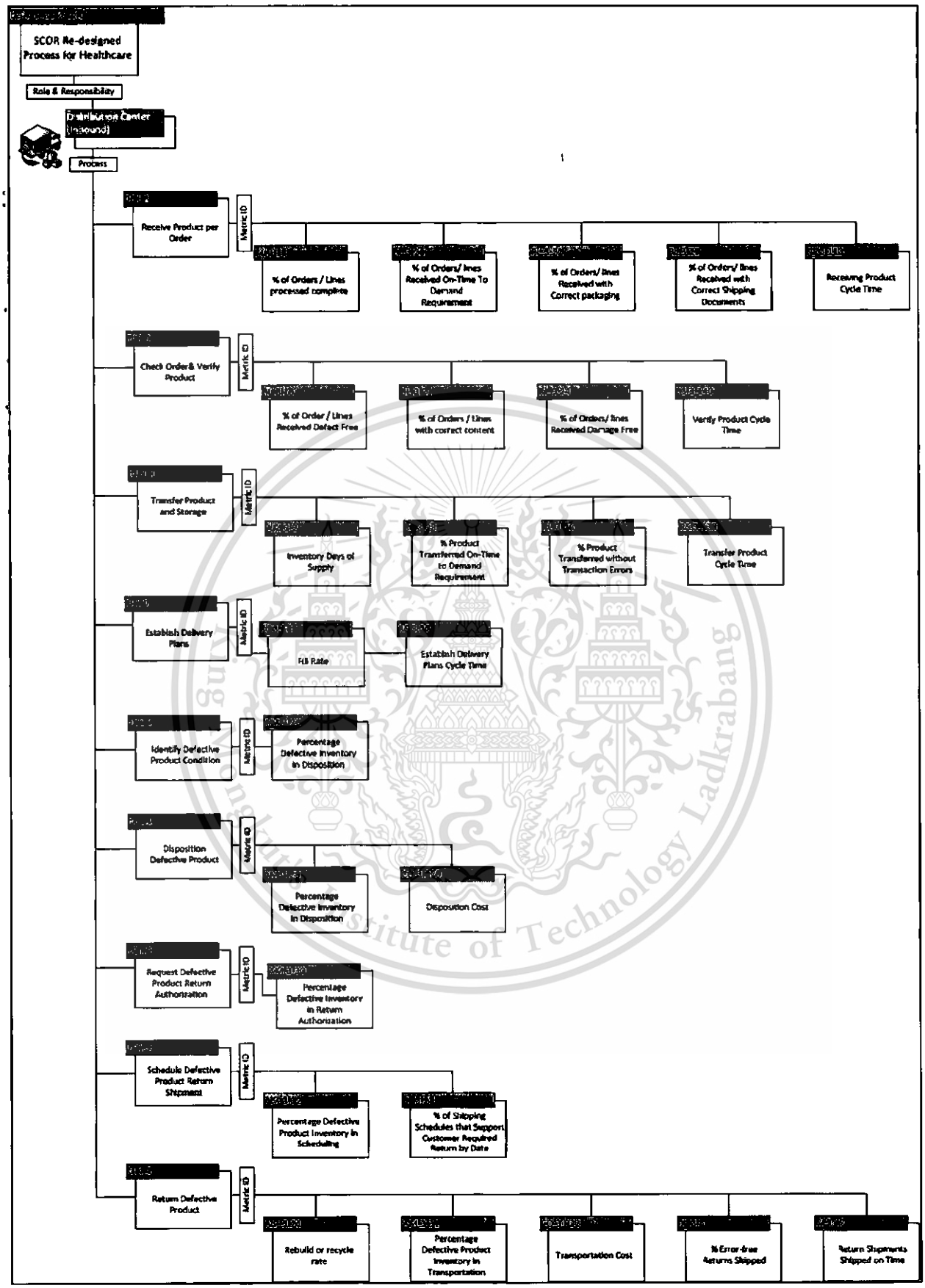

Figure 4.6 Performance-Process Mapping at Distribution Center (Inbound)

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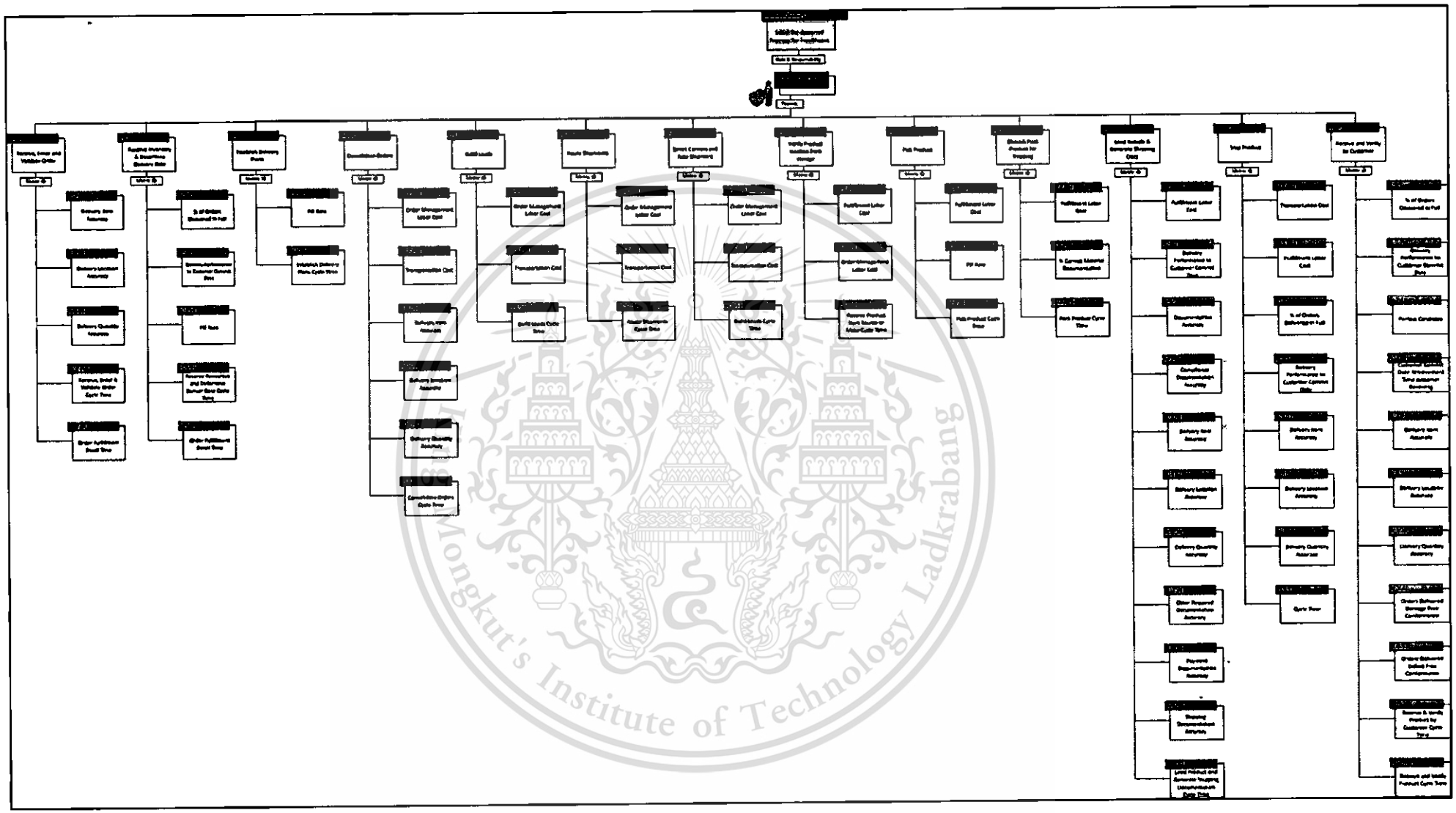

Figure 4.7 Performance-Process Mapping at Distribution Center (Outbound)

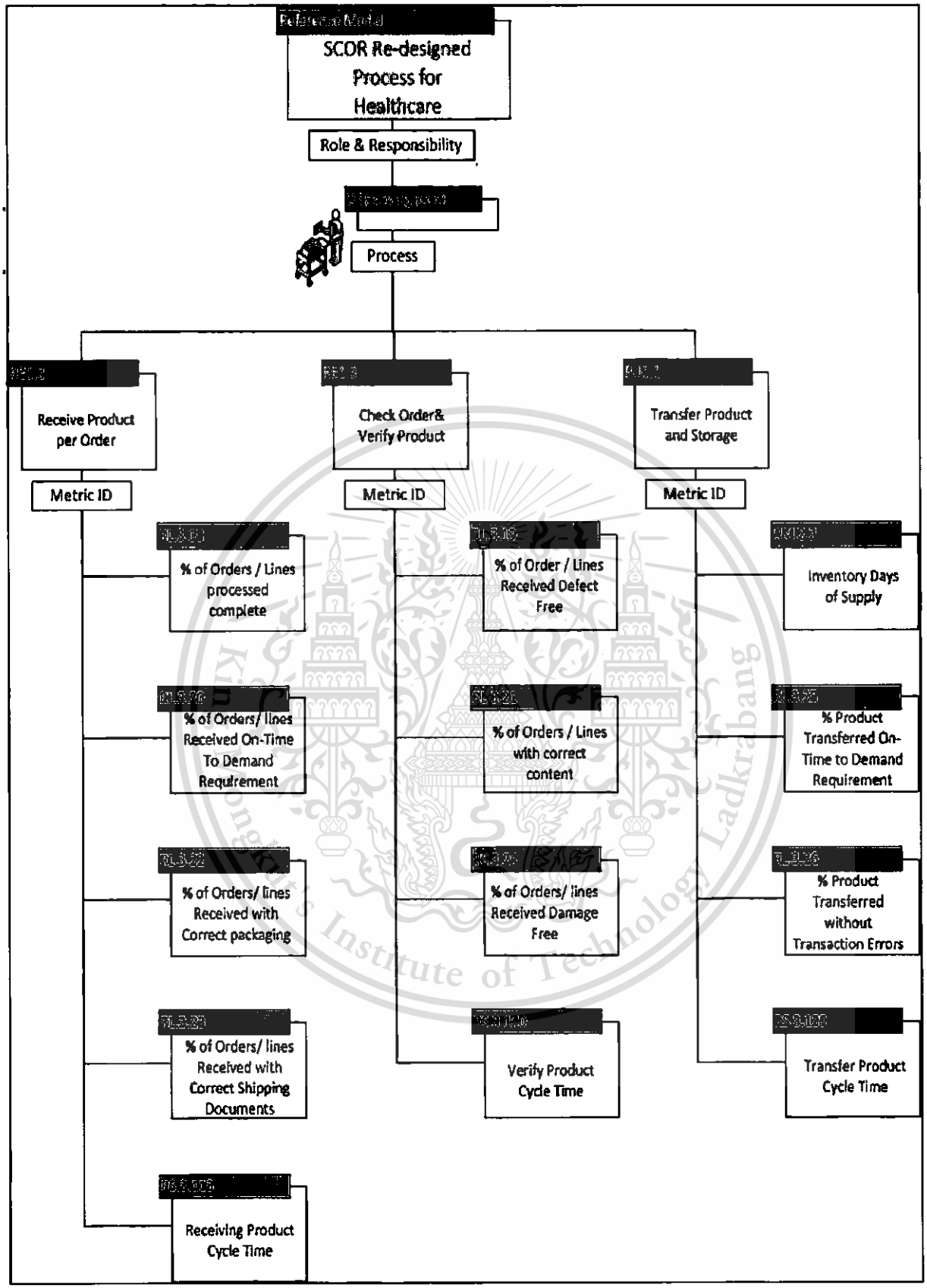

Figure 4.8 Performance-Process Mapping at Dispensing Point

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CHAPTER 5

CONCLUSION AND FURTHER STUDY

5.1 Conclusion and Discussion

The lack of the standardization for the end to end process throughout hospital supply chain, and the absence of alignment of the performance measurement system with the company objectives are continued prevalent issues in hospital supply chain management nowadays. From the case study and literature review on reference model and hospital supply chain, the as-is process in distribution center of all three-large-size hospital still handle distributionprocesses by using ERP system and manually update stock balance on stock card without specific roles and responsibilities, work instructions and measurable KPIs. These unsolid work processes and control gapsin current process cause inefficiency and fragmented supply chain. Thus, point to the need for the application of reference model using SCOR model and its performance metrics can improve the standardization processes across organizations in hospital supply chain, increase effectiveness and efficiency, higher quality of pharmaceutical products throughout distribution processes, which lead to an overall performance of hospital to patients' safety as highest priority as cost reduction and ultimately increased stakeholder's value.

Therefore, the current study aimed to identify the reference model of distribution center ofthree-large-size hospitals in Thailand by using SCOR model as framework and its metrics for performance measurement, with BPMN notation for Information Technology(IT)function implementation purpose. The reference model assisted the researcher to compare the difference hospital's supply chain management approaches to one another and yield several benefits which include:

- Maximizing the long term hospitals' competitiveness in patient's safety
- Enabling flexibility for process implementation for IT, and support for management decision making
- Standardizing major processes in distribution center
- Standardizing interactions and data interface by Roles and Responsibilities

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- Developing a full-scaled of key performance indicators at each process and roles

In addition, the model can assist the manager on setting standard guidelines for implementation and/or process improvement within distribution center and for the hospital supply chain as a whole. A well-structured reference model provides key performance indicators for each process and roles. As a result, it can help management analyze the problem's root causes for further improvement.

In our research,we has studied the current generic supply chain processes within the distribution centers of three-large-size hospitals as case study environments, and modeled the supply chain process based on the information from the in-depth structure interview conducted with the hospital head officers in related work area and site observation. We found that the distribution center process run through four major roles and responsibilities in Hospital supply chain. In these two ways of interactions; inbound logistics and outbound logisticsflows include purchasing, suppliers, distribution center and dispensing points (hospitals).The as-is distribution processes of these three hospitalstart with receiving products from suppliers and put-away to storage locations and move to storage for replenishment until orders triggered for delivery.Once order placed from dispensing points then products will be picked up and may require for packing or sortation before ship/deliver to customers (dispensing points).

From the gathered information on distribution process at three hospitals, the activities are very similar, but slightly different within roles and responsibilities, facility system, and hospital's management policies.Therefore the generic processes are classified into five main processes as Receive, Put-away, Storage, Order Picking and Shipping. The similarity of processes in three hospitals can be potentially applied and extended to the reference model of same direction of control parameters and standards.Thus,reference model is analyzed based on as-is processes and sequence workflowsusing five major processes within distribution centerto identify the specific characteristics of business process and constraints of distribution processes in hospital supply chain. The generic processes were determined into SCOR process

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framework(plan, source, make, deliver and return) and metricsbased on Make-to-Stock model structure.

After we classified what are the generic processes which are being done within the distribution center of the hospital and the particular roles, we will organize them into the SCOR model at each level 1-3.As level-4 is not included in SCOR model framework, therefore, we decided to enhance our reference model to the SCOR level 3.5 to determine some specific activities and concerns of hospital supply chain. The SCOR model level 3.5 enables the decision-making from the top level strategic planning to tactical and operational activities as a work related guideline processes and control. Then at SCOR Level 3.5 describes the sequence steps taken to perform and execute the elements to align with its strategies and performance metrics.

Further from SCOR Model Level 3.5, we have mapped the processes and SCOR performance metric IDs for each role and responsibility within the distribution center process of hospital supply chain, in order to show the implementation roadmap how the interaction of the processes and how the key performances are interaction. Performance-Process mapping diagram can enable the performance monitoring system at each role, where individual process can be visible and measured. This resulted in helping management team to define the root-cause of operations issue in processes.

As a result, the well-structured reference model can be reused to support decision making for distribution center management of hospitals in any scale, and/or implement to standardize business process, to improve supply chain performance measurement system, data consistency, quality of service level and response time for as-is processes improvement. Moreover, the designed models that have been reviewed with hospital expert to align with existing distribution processes, can be used to communicate to cross-functional departments, and to implement further with Information Technology (IT) departmentand people management; depending on hospitals' management policies.

In conclusion, this research has reached its objective and shown how thereference process model can be designed for the distribution center for large-size-hospital supply chain in Thailand, where in the specific areas of reference model and performance measurement were determined. The SCOR framework apply to

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main activities in distribution center; Plan, Receive, Put-away, Order-Picking, Shipping and Return, where specific roles and responsibilities are defined at each process. Detailed process guidelines will be very helpful for managing its operations and performance progress tracking to promote supply chain integration and future development.

5.2 Further Study

In this research has applied the reference process model based on the management point-of-view, policies and existing system accessibility and facilities at the selected hospitals environment, therefore the designed model from this paper will depend on an extensive case study in three hospitals (two public and one private), and the reviewed in-depth by hospital experts. As a result, the research could provide solid evidence that the designed model in hospital distribution center meet the specific requirements to reference process model for further implementation.

Nevertheless, there may have some important opportunities for future development and research due to limited contribution in public hospitals because of laws and government processes that would affect the designed reference model in term of decision making criteria and processes. Additional research and practice in BPMN notation and programs for implementation may be useful for example BPMN web-based, in specific environment, to adjust the real-time data collection at each process and see how process cycle time and other factors are impact the key performance indicators at high strategic level, tactical level and operational level.

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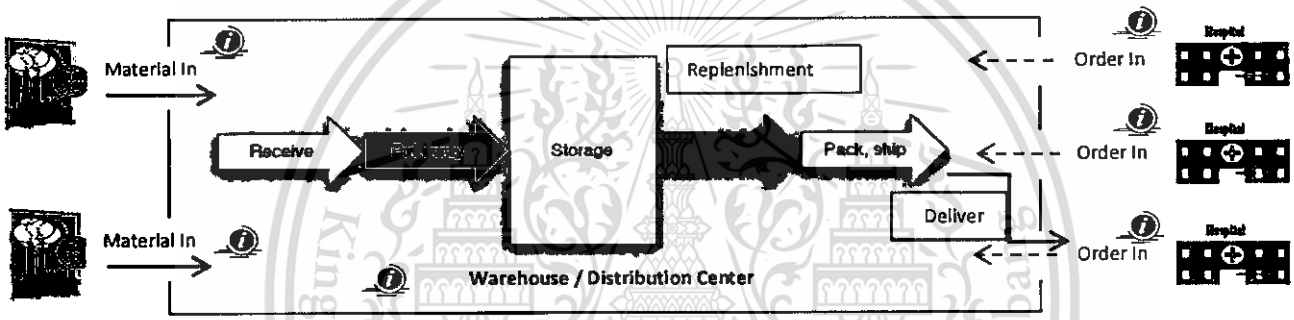
APPENDICE A: Operation Self-AssessmentForm

Operation Self-assessment can be divided into 2 main parts, which are drugs and medical supplies inventory process procedure and drugs and medical supplies inventory process policy.

Part 1 Drugs and Medical Supplies Distribution Process Procedure

Process procedure in the distribution center is included process of Receive, Put-Away, Storage, Picking, Replenishment, Packing and Shipping, and Delivery.



Please fill in the form and provide the explanation in the blank by the true statement according to the practical in your organization, if you have any evidence please attach as your consider for endorsing this research. This questionnaire will be categorized into 20 aspects of discussion and 45 aspects of objective as the following.

1. Please describe the inventory management in current practice. How have the drugs and medical supplies been categorized and stored?

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   .....

2. How many drug store, working place and time, in the present (please indicate the average minute per time for each process below)?

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Receive	.....minute/time
Put-Away	.....minute/time
Storage	.....minute/time
Picking	.....minute/time
Replenishment	.....minute/time
Packing and Shipping	.....minute/time
Deliver	.....minute/time
Other (if any)	.....minute/time

3. Please provide the organization structure for inventory process. How have they been arranged their job responsibility in each process?

.....

.....

.....

4. Please prioritize the important of working process and their relationship with human resource in the organization arranged in order from the least to greatest (1-5).

The important of working process (1-5)	
.....Receive	Responsible position.....
.....Put-Away	Responsible position.....
.....Storage	Responsible position.....
.....Picking	Responsible position.....
.....Replenishment	Responsible position.....
.....Packing and Shipping	Responsible position.....

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.....Deliver Responsible position.....

.....Other (if any)..... Responsible position.....

The important of information (1-5)

.....Receive Responsible position.....

.....Put-Away Responsible position.....

.....Storage Responsible position.....

.....Picking Responsible position.....

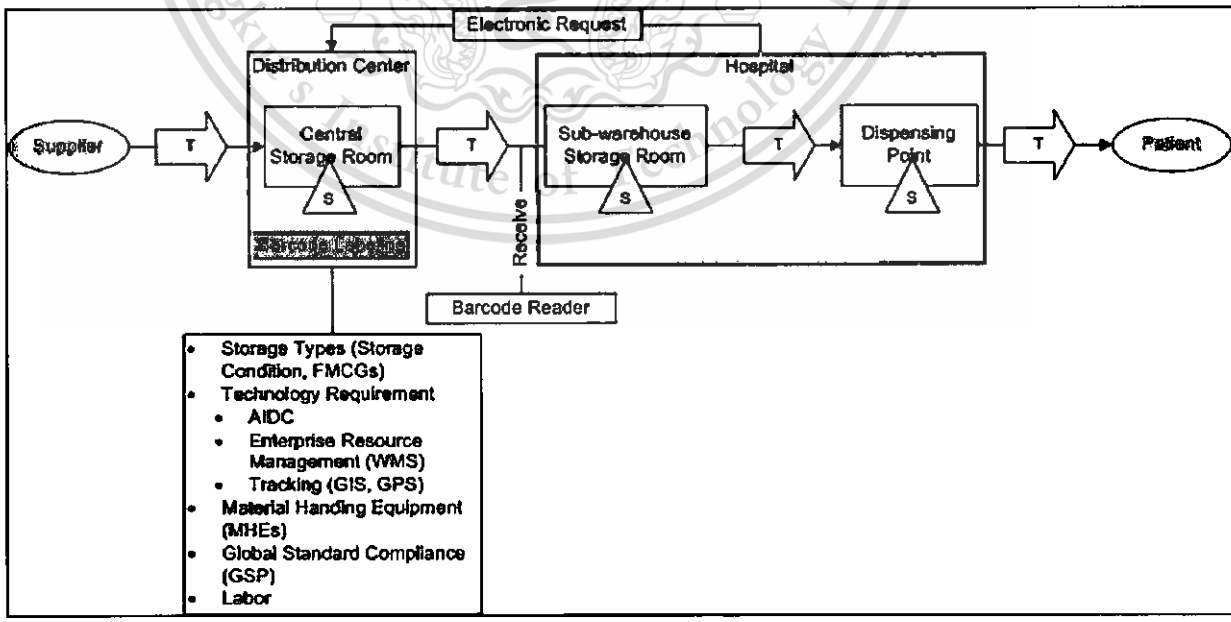
.....Replenishment Responsible position.....

.....Packing and Shipping Responsible position.....

.....Deliver Responsible position.....

.....Other (if any)..... Responsible position.....

5. Please describe the distribution procedure for each process.



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6. Please describe the inspection procedure and time of receiving process from distributor or manufacture. How do they inspect before storage and their current tool such as barcode application for read and record in the system?

.....

.....

.....

7. How are store schedule and product collection due to order? Is there any technology to indicate work division and product position? (Direct, Directed or Batch/ Sequence Put-Away)

.....

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.....

8. Please describe the procedure and time of stock checking in distribution center.

.....

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9. How are internal and external transportation systems including category and schedule per day?

.....

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10.How have internal and external information of drugs and medical supplies been transferred and exchanged?

.....

.....

.....

11.Please give the example of the important document? How has it been stored, for an example medicine stock inspection document from other department?

.....

.....

.....

12.Please provide time and procedure of product collecting and packing due to demand order. Is there any replenishment time indication for main medicine inventory such as time of product waiting to delivery from temporary stock to collecting rack (Single Order Picking, Batch Picking, or Zone Picking)?

.....

.....

.....

13.How has product category in the system been divided for order and purchase system from hospital customer, customer from hospital, or internalcustomer (subordinate medicine inventory)? Please also provide the informationof drugs and medical supplies name collecting (Coding: Database).

.....

.....

.....

14.Is there any pre stock inspection before order? If yes, please indicate system that applied for determination and planning.

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15.Please indicate time and Procedure for purchasing order approval and price quote from distributor. Who is the responsible person?

.....

.....

.....

16.Please indicate the average time and work instruction for purchasing and delivery including purchase order approval from the upper to the distributor.

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17.Please indicate time and work instruction for bill and customer receipt issue, including the supplier payment.

.....

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18.What are the document for product return and what is the actual plan for each case?

.....

.....

.....

19.Is there any standard for product damage case from transportation or non-conformity since suppliers. Please provide the example.

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20.How many main suppliers and please explain their delivery contract?

.....

.....

.....

21. Which technology and software systems do you apply to manage internal data (purchasing-distribution center) and distributors?

.....ERP (please indicate ....WMS (please indicate .....)

.....Microsoft Office (please indicate .....) .....Other (please indicate .....)

22. Which supporting equipment and facility do you use?

.....Forklift .....Barcode Reader .....RFID tag .....Other (please indicate.....)

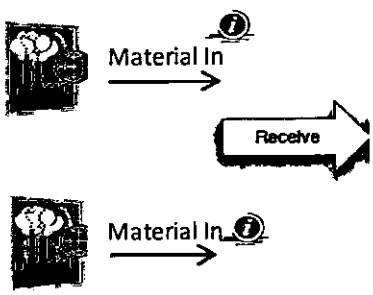
23. How were storage and safety system being used?

.....Temperature control .....Environment .....Other (please indicate.....)

24. Is there any working license such as medicine purchasing license and drugs and medicine supplies storage license?

.....Yes ....No

<u>Receive</u>



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25. Is there any product arrival notification system or Advances Shipping Notices (ASNs)?

.....Yes .....No

26. Is there any barcode provided product code, product name, supplier code, number of Goods Release Note Reference, date, volume, and other detail for support product arrival?

.....Yes .....No

27. Is there any product quality inspection procedure?

.....Yes .....No

28. Is there any support for product expiration date and number of production reference as a capability to track and trace product data from the arrival to customer delivery?

.....Yes .....No

29. Is there any product life record on shelf?

.....Yes .....No

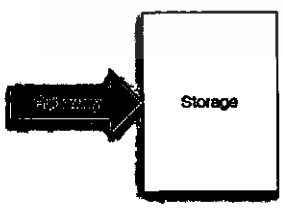
30. Is there any support for Cross-docking system?

.....Yes .....No

31. Is there any support for product status tracing from the arrival to temporary storage or on hold until finishing?

.....Yes .....No

Put-Away and Storage



Warehouse / Distribution Center

32. Is there any in advance specific storage position at the arrival?

.....Yes .....No

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33. Is there Warehouse Management System software (WMS) to support product storage procedure?

.....Yes .....No

34. Is there any indication procedure to specify storage position for each product category?

.....Yes .....No

35. Is there any Warehouse Management System software (WMS) to indicate position stock list for the large batch?

.....Yes .....No

36. Is there any temperature or environmental control for storage from the arrival area to inventory?

.....Yes .....No

37. Has the position of goods storage category been indicated to be fixed or random position?

.....Fixed position .....Random position

38. What kind of moving storage for the majority of goods?

.....Fast moving .....Slow moving

39. Is there any procedure or work standard?

.....Yes .....No

40. Is there any important document or detail in product package for goods indication?

.....Yes .....No

41. Is there any Safety stock for each categories of drug and medical supplies and how many average volumes?

.....Yes .....No If yes the average volumes is.....days/month

42. Is there any drug demand evaluation for Safety stock and how (for examples, forecasting technique or statistic method)?

.....Yes .....No If yes please indicate.....

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43. Is there any Service Level standard for drug inventory? If yes how was your Service Level in practical and is there any statistical data involvement?

.....Yes . .....No If yes please indicate.....

Picking and Replenishment

Warehouse / Distribution Center

44. Is there any checking for inventory status before receiving the order from hospital or customer from hospital or internal customer (subordinated drug inventory)?

.....Yes .....No

45. Is there any Warehouse Management System software (WMS) to support automatic replenishment and indicate picking position to deliver from the main inventory to picking storage

.....Yes .....No

46. Which system is your practical replenishment?

.....FIFO (First-in, First-out) .....FEFO (First-expire, First-out)

.....Other(Please indicate.....)

47. Is there any inspection procedure for replenishment in the inventory (for example, product name verification, product code, product volume, expiration date and moving position)?

.....Yes .....No

48. Is there any standard of working procedure for product moving from Bulk location to picking location?

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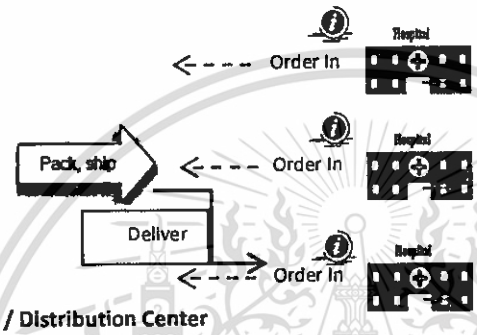
.....Yes .....No

49. Is there any standard of working procedure to manage failure such as wrong replenishment position due to software system?

.....Yes .....No

<u>Ordering, Packing and Shipping, and Delivery</u>



50. Is there any Warehouse Management System software (WMS) that linked to customer ordering/purchasing system?

.....Yes .....No

51. What does the ordering system align to?

.....Old volume ordering .....Demand ordering

.....Other(Please indicate.....)

52. Is there any system or procedure for ordering status tracking?

.....Yes .....No

53. Which ordering software system or method do you use?

.....WMS .....EDI .....E-mail .....Fax .....Phone

.....Other(Please indicate.....)

54. Is there any ordering management for urgent case and how long does it take for receiving or cancel order?

.....Yes .....No If yes please indicate time.....days

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55. What is the average frequency of monthly ordering? Is there any drug demand evaluation in the practical and how (for example, forecasting technique or statistic method)?

.....Yes .....No If yes please indicate.....

56. Is there any plan for time schedule, location and direction for ordering delivery?

.....Yes .....No

57. Is there any transportation service from the external?

.....Yes .....No

58. Is there any system to manage Back-Order?

.....Yes .....No

59. Is there any system to support picking schedule by position indicating?

.....Yes .....No

60. Is there any product list or information cover in the picking and packing process?

.....Yes .....No

61. Is there any system or tool to support picking and delivery in the adequate volume?

.....Yes .....No

62. Is there any goods reservation in advance for regular customer?

.....Yes .....No

63. Is there any checking procedure for customer receiving and product quality sampling compared with the ordering document and how? If yes please also indicate the quality sampling support system.

.....Yes .....No If yes please indicate.....

64. Is there any product return schedule with suppliers, in case of damage or expiration (for example, the return allowance of drug with suppliers before expiration in 6 months)?

.....Yes .....No

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65. Is there any calculation or concerning of maximum efficiency for drug inventory and utility?

.....Yes .....No

Part 2 Drug and medical supplies inventory process policy

There will be discussed in 4 questionnaires as the following.

1. How is the involved policy of drug and medical supplies inventory in the present practice? How does the policy tend to be in long terms?

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2. How did the trend of drug inventory management capital including transportation in the past years and the plan of management in the future?

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3. Please describe the standard of work evaluation and statistical data record in practical, and also give the advice in the aspect of the important to total management

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to improve the standard in the future (for example, the accuracy of drug receiving and ordering, sufficient medical supplement, on-time delivery).

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4. Please indicate frequently problem and difficulty from working process.

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Suggestion and additional discussion (as reasonable)

- Please suggest the requisite improvement that involved in internal working system for drug inventory in the present.

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- Is there any disaster plan to manage in the emergency case? If yes please describe.

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- Other suggestion

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APPENDICE B: Performance Self-Assessment Evaluation Form

Please mark X at the relevant topics of performance and process measurement system for your organization

	ความน่าเชื่อถือของห่วงโซ่อุปทาน	Supply Chain Reliability	YES	NO
RL.1.1	การจัดหาสินค้าให้กับลูกค้าอย่างครบถ้วน	Perfect Order Fulfillment		
RL.2.1	อัตราร้อยละคำสั่งซื้อส่งได้เต็มจำนวน	% of Orders Delivered In Full		
RL.3.33	ความถูกต้องของสินค้าที่จัดส่ง	Delivery Item Accuracy		
RL.3.35	ความถูกต้องของจำนวนสินค้าที่จัดส่ง	Delivery Quantity Accuracy		
RL.2.2	ประสิทธิภาพการจัดส่งตามวันที่ตกลงกับลูกค้า	Delivery Performance to Customer Commit Date		
RL.3.32	คำสั่งซื้อที่ได้รับตรงเวลาตามวันที่ตกลงกับลูกค้า	Customer Commit Date Achievement Time Customer Receiving		
RL.3.34	ความถูกต้องของสถานที่จัดส่ง	Delivery Location Accuracy		
RL.2.3	ความถูกต้องของเอกสาร	Documentation Accuracy		
RL.3.31	ความถูกต้องของเอกสารบังคับใช้ตามกฎหมาย	Compliance Documentation Accuracy		
RL.3.43	ความถูกต้องของเอกสารอื่นที่จำเป็น	Other Required Documentation Accuracy		
RL.3.45	ความถูกต้องของเอกสารจ่ายเงิน	Payment Documentation Accuracy		
RL.3.50	ความถูกต้องของเอกสารขนส่ง	Shipping Documentation Accuracy		
RL.2.4	สภาพความสมบูรณ์	Perfect Condition		
RL.3.12	อัตราร้อยละการติดตั้งที่ไม่ผิดพลาด	% Of Faultless Installations		
RL.3.24	อัตราร้อยละของคำสั่งซื้อที่ไม่	% Orders/Lines Received Damage		

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	เสียหาย	Free		
RL.3.41	คำสั่งซื้อที่จัดส่งตามมาตรฐานการจัดส่งสินค้าโดยไม่เกิดความเสียหาย	Orders Delivered Damage Free Conformance		
RL.3.42	คำสั่งซื้อที่จัดส่งตามมาตรฐานการจัดส่งสินค้าที่ไม่มีตำหนิ	Orders Delivered Defect Free Conformance		
RL.3.55	การรับประกันและการคืนสินค้า	Warranty and Returns		
	การตอบสนองห่วงโซ่อุปทาน	**Supply Chain Responsiveness**	**YES**	**NO**
RS.1.1	รอบเวลาการจัดหาสินค้าให้กับลูกค้า	Order Fulfillment Cycle Time		
RS.2.1	รอบเวลาการจัดหาสินค้า	Source Cycle Time		
RS.3.8	รอบเวลาการอนุมัติจ่ายเงินแก่ผู้ขายสินค้า	Authorize Supplier Payment Cycle Time		
RS.3.35	รอบเวลาการระบุตำแหน่งของสินค้า	Identify Sources of Supply Cycle Time		
RS.3.107	รอบเวลาการรับสินค้า	Receive Product Cycle Time		
RS.3.122	รอบเวลาการจัดตารางจัดส่งสินค้า	Schedule Product Deliveries Cycle Time		
RS.3.125	รอบเวลาการเลือกและต่อรองกับผู้จัดจำหน่าย	Select Supplier and Negotiate Cycle Time		
RS.3.139	รอบเวลาการเคลื่อนย้ายสินค้า	Transfer Product Cycle Time		
RS.3.140	รอบเวลาการตรวจสอบสินค้า	Verify Product Cycle Time		
RS.2.2	รอบเวลาการผลิต	Make Cycle Time		
RS.3.33	รอบเวลาการสรุปการจัดวางรูปแบบผลิต	Finalize Production Engineering Cycle Time		
RS.3.49	รอบเวลาการการจัดส่งวัตถุดิบ	Issue Material Cycle Time		
RS.3.101	รอบเวลาการผลิตและทดสอบ	Produce and Test Cycle Time		
RS.3.114	รอบเวลาการส่งสินค้าเพื่อจัดส่ง	Release Finished Product to Deliver Cycle Time		
RS.3.123	รอบเวลาการจัดตารางกิจกรรมการผลิต	Schedule Production Activities Cycle Time		

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RS.3.128	รอบเวลาการเตรียมสินค้าที่บรรจุหีบห่อก่อนการเคลื่อนย้ายสู่แหล่งจัดเก็บสินค้า	Stage Finished Product Cycle Time		
RS.3.142	รอบเวลาการบรรจุหีบห่อ	Package Cycle Time		
RS.2.3	**รอบเวลาการจัดส่ง**	**Deliver Cycle Time**		
RS.3.16	รอบเวลากาจัดบรรทุกสินค้าเพื่อการขนส่ง	Build Loads Cycle Time		
RS.3.18	รอบเวลาการรวบรวมคำสั่งซื้อ	Consolidate Orders Cycle Time		
RS.3.46	รอบเวลาการจัดวางสินค้า	Install Product Cycle Time		
RS.3.51	รอบเวลาการบรรทุกสินค้าและการจัดทำเอกสารจัดส่ง	Load Product & Generate Shipping Documentation Cycle Time		
RS.3.95	รอบเวลาการบรรจุหีบห่อสินค้า	Pack Product Cycle Time		
RS.3.96	รอบเวลาการรับสินค้า	Pick Product Cycle Time		
RS.3.102	รอบเวลาการรับและตรวจสอบสินค้าโดยลูกค้า	Receive & Verify Product by Customer Cycle Time		
RS.3.110	รอบเวลาการรับสินค้าจากแหล่งทรัพยากรหรือฝ่ายผลิต	Receive Product from Source or Make Cycle Time		
RS.3.111	รอบเวลาการรับ, ตั้งค่า, บันทึกและตรวจสอบยืนยันความถูกต้องของคำสั่งซื้อ	Receive, Configure, Enter, & Validate Order Cycle Time		
RS.3.116	รอบเวลาการสำรองทรัพยากรและการกำหนดวันที่การจัดส่ง	Reserve Resources and Determine Delivery Date Cycle Time		
RS.3.117	รอบเวลาการวางเส้นทางจัดส่งสินค้า	Route Shipments Cycle Time		
RS.3.120	รอบเวลาการจัดตารางการติดตั้ง	Schedule Installation Cycle Time		
RS.3.124	รอบเวลาการเลือกผู้ขนส่งและตีราคาจัดส่ง	Select Carriers & Rate Shipments Cycle Time		
RS.3.126	รอบเวลาการส่งสินค้า	Ship Product Cycle Time		
RS.2.4	**รอบเวลาการจัดส่งสินค้าปลีก**	**Delivery Retail Cycle Time**		

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RS.3.17	รอบเวลาการจ่ายเงิน	Checkout Cycle Time		
RS.3.32	รอบเวลาการเติมเต็มตระกร้าสินค้า	Fill Shopping Cart Cycle Time		
RS.3.34	รอบเวลาการสร้างตารางสินค้าคงคลัง	Generate Stocking Schedule Cycle Time		
RS.3.97	รอบเวลาการเลือกสินค้าจากห้องเก็บสินค้า	Pick Product from Backroom Cycle Time		
RS.3.109	รอบเวลาการรับสินค้าจากห้องเก็บสินค้า	Receive Product at Store Cycle Time		
RS.3.129	รอบเวลาการบรรจุสินค้าบนชั้นวาง	Stock Shelf Cycle Time		
	ความยืดหยุ่นห่วงโซ่อุปทาน	**Supply Chain Agility**	**YES**	**NO**
AG.1.1	**การยืดหยุ่นในการเพิ่มขึ้นของห่วงโซ่อุปทาน**	**Upside Supply Chain Flexibility**		
AG.2.1	การยืดหยุ่นในการเพิ่มขึ้น (จัดหา)	Upside Flexibility (Source)		
AG.2.2	การยืดหยุ่นในการเพิ่มขึ้น (จัดทำ)	Upside Flexibility (Make)		
AG.2.3	การยืดหยุ่นในการเพิ่มขึ้น (จัดส่ง)	Upside Flexibility (Deliver)		
AG.2.4	การยืดหยุ่นในการเพิ่มขึ้นของการส่งคืน (จัดหา)	Upside Return Flexibility (Source)		
AG.2.5	การยืดหยุ่นในการเพิ่มขึ้นของการส่งคืน (จัดส่ง)	Upside Return Flexibility (Deliver)		
AG.1.2	**การยืดหยุ่นในการเพิ่มขึ้นของการปรับตัวของห่วงโซ่อุปทาน**	**Upside Supply Chain Adaptability**		
AG.2.6	การยืดหยุ่นในการเพิ่มขึ้นของการปรับตัว (จัดหา)	Upside Adaptability (Source)		
AG.2.7	การยืดหยุ่นในการเพิ่มขึ้นของการปรับตัว (จัดทำ)	Upside Adaptability (Make)		
AG.2.8	การยืดหยุ่นในการเพิ่มขึ้นของการปรับตัว (จัดส่ง)	Upside Adaptability (Deliver)		
AG.2.9	การยืดหยุ่นในการเพิ่มขึ้นของการปรับตัวกับการส่งคืน (จัดหา)	Upside Return Adaptability (Source)		

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AG.2.10	การยืดหยุ่นในการเพิ่มขึ้นของการปรับตัวกับการส่งคืน (จัดส่ง)	Upside Return Adaptability (Deliver)		
AG.1.3	การยืดหยุ่นในการลดลงของห่วงโซ่อุปทาน	Downside Supply Chain Adaptability		
AG.2.11	การยืดหยุ่นในการลดลง (จัดหา)	Downside Adaptability (Source)		
AG.2.12	การยืดหยุ่นในการลดลง (จัดทำ)	Downside Adaptability (Make)		
AG.2.13	การยืดหยุ่นในการลดลง (จัดส่ง)	Downside Adaptability (Deliver)		
AG.1.4	มูลค่าความเสี่ยงโดยรวม	Overall Value at Risk (VAR)		
AG.2.14	ระดับความเสี่ยงของผู้จัดจำหน่าย, ลูกค้าและตัวสินค้า	Supplier's/Customer's/Product's Risk Rating		
AG.2.15	มูลค่าความเสี่ยง (วางแผน)	Value at Risk (Plan)		
AG.2.16	มูลค่าความเสี่ยง (จัดหา)	Value at Risk (Source)		
AG.2.17	มูลค่าความเสี่ยง (จัดทำ)	Value at Risk (Make)		
AG.2.18	มูลค่าความเสี่ยง (จัดส่ง)	Value at Risk (Deliver)		
AG.2.19	มูลค่าความเสี่ยง (ส่งคืน)	Value at Risk (Return)		
	ต้นทุนห่วงโซ่อุปทาน	Supply Chain Costs	YES	NO
CO.1.001	ต้นทุนการบริหารจัดการโดยรวม	Total Cost to Serve		
CO.2.001	ต้นทุนการวางแผน	Planning Cost		
CO.3.001	ต้นทุนการวางแผนแรงงาน	Planning Labor Cost		
CO.3.002	ต้นทุนการวางแผนระบบอัตโนมัติ	Planning Automation Cost		
CO.3.003	ต้นทุนการวางแผนสินทรัพย์โรงงานและเครื่องมือต่างๆ	Planning Property, Plant and Equipment Cost		
CO.3.004	ต้นทุนการวางแผนค่าแรงงาน	Planning GRC and Overhead Cost		
CO.2.002	ต้นทุนการจัดหา	Sourcing Cost		
CO.3.005	ต้นทุนการจัดหาแรงงาน	Sourcing labor Cost		
CO.3.006	ต้นทุนกาจัดหาระบบอัตโนมัติ	Sourcing Automation Cost		
CO.3.007	ต้นทุนการจัดหาสินทรัพย์โรงงานและเครื่องมือต่างๆ	Sourcing Property, Plant and Equipment Cost		
CO.3.008	ต้นทุนการจัดหาค่าแรงงาน	Sourcing GRC and Overhead Cost		

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CO.2.003	ต้นทุนวัสดุในการผลิต	Material Landed Cost		
CO.3.009	ต้นทุนในการจัดซื้อวัสดุ	Purchased Materials Cost		
CO.3.010	ต้นทุนในการจัดส่งวัสดุ	Material Transportation Cost		
CO.3.011	ต้นทุนในการสั่งซื้อและภาษีต่างๆ	Material Customs, Duties, Taxes and Tariffs Cost		
CO.3.012	ต้นทุนในการจัดการความเสี่ยงของวัสดุ	Material Risk and Compliance Cost		
CO.2.004	ต้นทุนการผลิต	Production Cost		
CO.3.014	ต้นทุนแรงงานการผลิต	Production (Direct) Labor Cost		
CO.3.015	ต้นทุนการผลิตด้วยระบบอัตโนมัติ	Production Automation Cost		
CO.3.016	ต้นทุนการผลิตสินทรัพย์โรงงาน และเครื่องมือต่างๆ	Production Property, Plant and Equipment Cost		
CO.3.017	ต้นทุนการผลิตค่าแรงงาน	Production GRC and Overhead Cost		
CO.2.005	ต้นทุนการจัดการสินค้าตามคำสั่งซื้อ	Order Management Cost		
CO.3.018	ต้นทุนแรงงานในการจัดการสินค้า	Order Management Labor Cost		
CO.3.019	ต้นทุนการจัดการคำสั่งซื้อด้วยระบบอัตโนมัติ	Order Management Automation Cost		
CO.3.020	ต้นทุนการจัดการคำสั่งซื้อสินทรัพย์โรงงาน และเครื่องมือต่างๆ	Order Management Property, Plant and Equipment Cost		
CO.3.021	ต้นทุนต้นทุนค่าแรงงานการจัดการคำสั่งซื้อ	Order Management GRC and Overhead Cost		
CO.2.006	ต้นทุนการเติมเต็มสินค้า	Fulfillment Cost		
CO.3.022	ต้นทุนการจัดส่งสินค้า	Transportation Cost		
CO.3.023	ต้นทุนในการเติมเต็มสินค้าและภาษีต่างๆ	Fulfillment Custom, Duties, Taxes and Tariffs Cost		
CO.3.024	ต้นทุนแรงงานในการเติมเต็มสินค้า	Fulfilment Labor Cost		
CO.3.025	ต้นทุนแรงงานในการเติมเต็มสินค้าด้วยระบบอัตโนมัติ	Fulfillment Automation Cost		

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CO.3.026	ต้นทุนการเติมเต็มสินทรัพย์โรงงานและเครื่องมือต่างๆ	Fulfiillment Property, Plant and Equipment Cost		
CO.3.027	ต้นทุนต้นทุนค่าแรงงานการเติมเต็มสินค้าและคลังสินค้า	Fulfillment GRC, Inventory and Overhead Cost		
CO.2.007	ต้นทุนการส่งคืน	Returns Cost		
CO.3.028	ต้นทุนส่วนลดและคืนสินค้า	Discounts and Refunds Cost		
CO.3.029	ต้นทุนการเคลื่อนย้ายสินค้า	Disposition Cost		
CO.3.030	ต้นทุนการจัดคืนสินค้าและคลังสินค้า	Return GRC, Inventory and Overhead Cost		
CO.2.008	ต้นทุนการขายสินค้า	Cost of Goods Sold		
	การบริหารสินทรัพย์ห่วงโซ่อุปทาน	Supply Chain Asset Management Efficiency	YES	NO
AM.1.1	รอบเวลาหมุนเวียนเงินสด	Cash-to-Cash Cycle Time		
AM.2.1	อัตราการหมุนเวียนของลูกหนี้การค้า	Days Sales Outstanding		
AM.2.2	จำนวนวันของสินค้าคงคลัง	Inventory Days of Supply		
AM.3.16	จำนวนวันของสินค้าคงคลัง (วัตถุดิบ)	Inventory Days of Supply (Raw Material)		
AM.3.17	จำนวนวันของสินค้าคงคลัง (วัตถุดิบที่อยู่ในระหว่างการผลิต)	Inventory Days of Supply (WIP)		
AM.3.23	จำนวนวันของการหมุนเวียนสินค้า	Recycle Days of Supply		
AM.3.28	อัตราร้อยละของสินค้าคงคลังชำรุด	Percentage Defective Inventory		
AM.3.37	อัตราร้อยละของสินค้าคงคลังส่วนเกิน	Percentage Excess Inventory		
AM.3.44	อัตราร้อยละของสินค้าคงคลังที่ต้องนำมาแก้ไขผ่านกระบวนการผลิตใหม่	Percentage Unserviceable MRO Inventory		
AM.3.45	จำนวนวันของสินค้าคงคลัง (สินค้า)	Inventory Days of Supply (Finished Goods)		
AM.2.3	อัตราการหมุนเวียนของเจ้าหนี้การค้า	Days Payable Outstanding		

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AM.1.2	ผลตอบแทนจากสินทรัพย์ห่วงโซ่อุปทาน	Return on Supply Chain Fixed Assets		
AM.2.5	สินทรัพย์ห่วงโซ่อุปทาน	Supply Chain Fixed Assets		
AM.2.4	รายได้ห่วงโซ่อุปทาน	Supply Chain Revenue		
AM.3.11	มูลค่าสินทรัพย์ (จัดส่ง)	Deliver Fixed Asset Value		
AM.3.18	มูลค่าสินทรัพย์ (จัดทำ)	Make Fixed Asset Value		
AM.3.20	มูลค่าสินทรัพย์ (วางแผน)	Plan Fixed Asset Value		
AM.3.24	มูลค่าสินทรัพย์ (ส่งคืน)	Return Fixed Asset Value		
AM.3.27	มูลค่าสินทรัพย์ (จัดหา)	Source Fixed Asset Value		
AM.1.3	ผลตอบแทนจากเงินทุนดำเนินงาน	Return on Working Capital		
AM.2.6	บัญชีเจ้าหนี้การค้า	Accounts Payable (Payables Outstanding)		
AM.2.7	บัญชีลูกหนี้การค้า	Accounts Receivable (Sales Outstanding)		
AM.2.8	สินค้าคงคลัง	Inventory		

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APPENDICE C: International Conference (TLOG 2014)

The Fifth International Conference on Transportations and Logistics, 28 – 30 July 2014 in Bangkok, Thailand

A Reference Model of the Distribution Center in Hospital Supply Chain

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ABSTRACT: The eminent increase in demand for healthcare services over the last decade has prompted the need to improve healthcare services systems. The supply chain management plays an important role in increased effectiveness and efficiency of operations in public hospitals, the largest medical service providers in Thailand. To improve the efficiency would start from how the medical products distributed and stored before used. A reference model will assist management in developing a seamless hospital supply chain processes.This research focuses on identifying the current generic supply chain processes within the distribution center of three-large-size hospitals in Thailand and developing a standardized model with a common language of distribution processes for hospital supply chain based on the Supply-Chain Operations Reference model (SCOR) and Business Process Model and Notation (BPMN). This will result in a well-designed operational framework with activities-based for decision making criteria and implementation that can improve performance in various areas.

Keywords: *SCOR Model, BPMN, Reference Model, Hospital Supply Chain, Distribution Center*

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1. INTRODUCTION

Supply chain and logistics management has been continuously developed to improve business performance in organizations over the last three decades. It is undeniably the one of the most critical mechanisms for any industry since the efficient management of supply chain and logistics is the key to success of any suppliers, manufacturers and retailers, for example. Hospital industry, in particular, has been growing with the ever increasing demands for healthcare services. Hospitals serve customers and patients whose demands are varied dramatically; therefore, the supply chain and logistics has been at the heart of hospital management.

However, hospital's supply chain and logistics development is still at the early age as opposed to that of other industries. A typical hospital supply chain is a complex network consisting of the linkage role between vendors, manufacturers, distributors, hospital and internal departments. The co-ordination of material flow and information flow within the chains are subject to individual hospital's strategy and policy. The efficient supply chain management contributes greatly to competitive advantage of any business; hence, the inefficient one may cause the opposite. As a result, hospitals have to align their objective and strategy to maximize patient care while minimizing variable costs and wastes (Everard, 2001: DeScioli, 2005).

In Thailand, most hospitals are owned and managed by government with; the traditional hospital management. The lack of standardized processes of such management cause poor operations and co-ordinations between relevant units in supply chain and may lead to unsatisfied service provided to customers. It is apparent that amidst the increased demands for healthcare services, the number of state health personnel and facilities system could not support them (Ministry of Public Health, 2008-2010). Kritchanchai (2012) highlighted that the top concerns and problems raised by focused parties in healthcare industry in Thailand are inefficient business process, data inconsistency and fragmented supply chain system. This has prompted the need for a proposed framework for Thailand healthcare supply chain which is based on the confirmed problems and intervention improvement;

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standardization, information sharing and business process re-engineering. The problems of management and operational system at Ramathibodi hospital, a large sized public teaching hospital with approximately 1,000 with continuous increased in number of patients, caused high inventory level, high average storage time, and poor storage conditions in each distribution center due to limited space and facilities support system (Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

Several supply chain management and development studies suggested that distribution center is one of the most significant parts in supply chain because it represents a large amount of costs of material storage and control (e.g. temperature-controlled, distribution process etc.). The uncontrolled storage conditions in distribution center impact materials' quality which inadvertently linked to the chance of patient's survival and recovery. In effect, supply chain and logistics management is crucial for inventory distribution and control in distribution center to achieve optimal accuracy, timeliness, traceability to attain hospital's performance (Hutujuta and Punnakittikasem, 2001; Toba et al., 2008).

To maximize the long term hospitals' competitiveness in patient's safety, business process re-engineering, standardization and information sharing through efficient and effective supply chain and logistics management, the development and implementation of reference model of the distribution center in hospital supply chain is required (Brown et al., 2011). The full-scale model in distribution processes derived from the reference model will connect the role and responsibility of data interfaces and activities in hospital supply chain. The well-designed structure and standardized processes will improve performance, response times and quality of care for decision making as a result. Therefore, the present study focuses on a full-scaled reference process model of the distribution center in hospital supply chain.

The present study is organized as follows: (i) literature review, (ii) purpose of the study, (iii) case observation and analysis, (iv) reference process model design and (v) discussion.

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2. PURPOSE OF THE STUDY

The present research studied the existing business process model of distribution center of three large-size-hospitals in Thailand to identify the best practice and development of generic reference process models in the hospitals' supply chains. The purposes of the study is to develop a generic business process models with a set of performance parameters for distribution center that support decision makings and act as a reference model for use in top-down structured organizations.

The research question of this study is *how can reference process models be designed for the distribution center for large-size-hospital supply chain in Thailand?*

The qualitative research approach applied in the study includes in-depth interviews, additional desk research and observation of the existing distribution process at two public and one private large-scale hospital. The data was collected and analysed to obtain the As-Is pharmaceutical distribution process as a basis for the development of the standardized generic model

3. LITERATURE REVIEW

3.1 Distribution Center

Distribution Center is one type of warehouse where products are kept and transferred in from suppliers and out to customers with quicker response to serve customers'fluctuated demands.It is becoming more and more critical player in supply chain and the implementation of a warehouse management information system (WMS) in any businesses. With the high performance of warehousing operations and controls, it helps company to reduce transportation cost and achieve the market competition. (Faber et al., 2002)

A distribution center is a means to an end – satisfying customers' requirements through distribution processes. As a consequence, it is not necessary that it holds

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inventory, although it may hold some for short periods of time (e.g. cross-docking). The primary distribution process can be described inthe four main sequence of receiving (inbound), storage (put-away), order-picking and shipping (outbound).Similar to the most cases for other industries,distribution center in hospital supply chain is to keep the products with good standard to ensurethe quality and readiness ofproducts that reach the patients with no shortage. (Bartholdi and Hackman, 2008; Gu et al, 2006)

3.2 DC Design Structure

A DC design structure can be classified into three design levels; which are strategic level, tactical level and operational level; within processes, resources and organization's perspective. The strategic distribution decisions mapping is initiating consider capability requirements, network design issues and facility considerations according to Figure 1. (Rouwenhorst et al., 1999; Coyle, 2003)

- Strategic level considers decisions that have a long term impact, mostly concern high investments.
- Tactical level considers a medium term decisions based on the outcomes of the strategic decisions discussed in the proceeding subsection.It has a lower impact than the strategic decisions, but still require some investments that typically concern the dimensions of resources.
- Operational level, each process is to be carried out within the constraints set by the strategic and tactical decisions. Itis short term policies decisions that implies to have less interaction.

As mentioned so far, you will see that the Distribution center process and design structure are relate to the decision-making from the top level strategic planning to tactical and operational activities. Kumar et al. (2008) has proposed the business process re-engineering for the central distribution center at Hospitals in Singapore.As a result of the re-designed distribution center structure helpimprove about 50 percent of utilization in more than half of the activities. Therefore, the design of

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process flow for both physical and information networks are the keys to success of any distribution centers.One of the most efficientand effective way is by using Reference modeling tools, which will be explained in the next session.

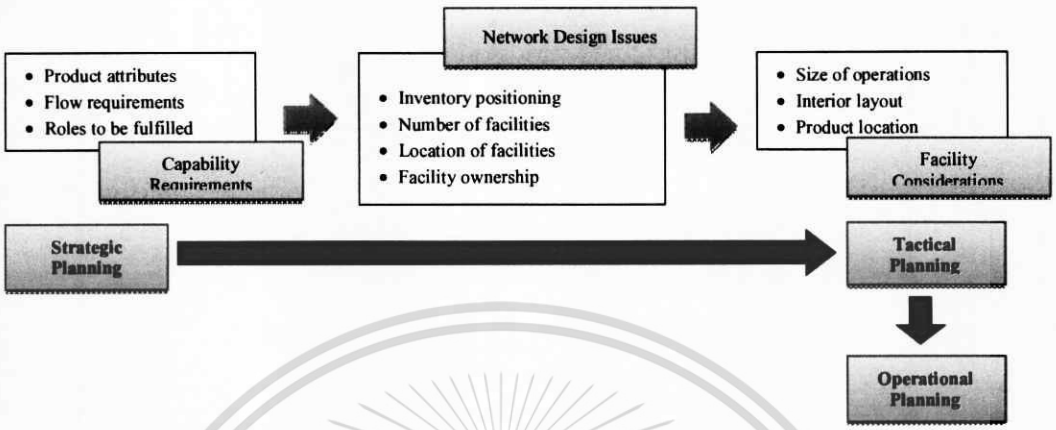

Figure 1 Strategic Distribution Decisions

3.3 Reference Models (RMs)

Reference Models (RMs) are generic conceptual models and framework which represent the business's best practice universally applied in company specific processes or projects. The benefits of implementing Reference Models to business includes cost and time reduction, quality improvement, risk reduction, process transparency, common language and basis for benchmarking (Kirchmer, 2011; Miers, 2008).

The development of process design and continuous sustainably improvement for the company or cross-industry could reuse the RMs in combination or individually, to reduce the development cost and time to company's specific process models (Kalpic and Bernus, 2002; Pajk et al, 2012). Verdouw et al. (2010) brought about an example of Reference Model usage designed for fruit industry in Europe. They analysed fruit-specific knowledge and generic knowledge in cross-industry standards and proposed the business process that could provide fruit companies with personalized configuration in supply chain design and information system implementation.

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Similar to hospital supply chain, the reference process model designed using generic process could be applied to hospitals at all scales. The benefits will not be limited to the hospitals themselves but extended to the related players in hospital supply chain and, ultimately, to the patients. The reference processes in the model explain the roadmap for each role and responsibility with step-by-step activities. Besides the operational steps, the reference processes provide control points and key performance of each activity. The outline activities and performance metrics support the management team in decision making and can be adapted to company's needs. In sum, the reference process model engineers the management plan at strategic, tactical and operational levels.

3.4 SCOR Model

The Supply Chain Operations Reference model (SCOR), designed by the Supply Chain Council (2012), is the most widely used business process reference models in various industries. It is one of Supply Chain management tools used to address the overall processes and activities from supplier's supplier to a customer's customers. The SCOR model has five basic processes: Plan (P), Source (S), Make (M), Deliver (D) and Return (R), and provides a standard process model which describes the organization best practice framework of management processes. The model contains a linkage between business objectives to supply chain operations, with standard metrics to measure process performance or KPI at each level of hierarchy.

SCOR Model has four levels of hierarchy: top, configuration, process element and implementation. The top level (Level 1) is the design of process types (Plan, Source, Make, Deliver, Return). The second level (Level 2) involves configuration of the supply chain that is the detailed descriptions of the process types' sub categories, such as 'Make to stock', 'Make to order', and 'Engineer to order' or 'Production execution'. The third level (Level 3) is the decomposition of processes to the process element level, in line with its strategies and performance metrics. The fourth level (Level 4) is the implementation of the supply chain and best practice solution.

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This level is not included in SCOR framework but can be applied as a sub-process in specific business conditions.

Regarding hospital's supply chain, Martinelly et al. (2009) has proposed a conceptual model for the hospital supply chain using PORTER-SCOR level 1-3 and logical diagrams at level 4. They proposed the optimal process flows with the benchmarks for simulating logical diagram of hospital supply chain. The researchers applied SCOR framework Level 1 to Level 3 to design the reference process model of distribution center in hospital supply chain. Since the SCOR level four requires specific details from each hospital environment for the implementation stage, the proposed reference process model was upgraded to SCOR level 3.5 adopting generic processes. The SCOR level 3.5 takes into account the tactical and operational levels that support management team in making decision as shown in Figure 2.

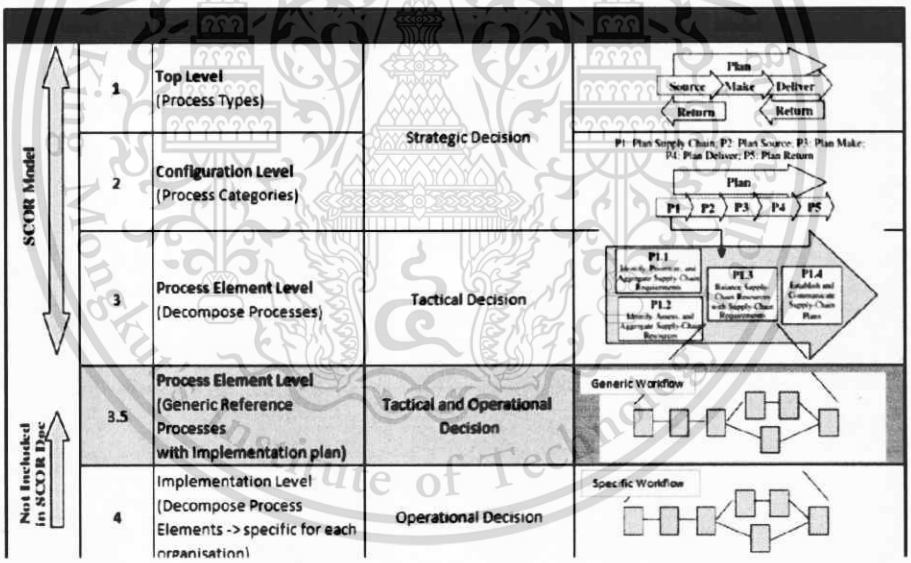

Figure 2Levels of SCOR Model

3.5 SCOR Performance Attributes and Metrics

The SCOR Model describes supply chain activities for business at each level, and defines a set of performance metrics used to evaluate the processes. There are five dimensions to performance measurement: Supply Chain Reliability, Supply Chain Responsiveness, Supply Chain Agility (Customer-Focused attributes), and Supply

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Chain Costs, Supply Chain Asset Management Efficiency (Internal-Focused attributes). The SCOR Metrics is a standard measurement guidance for Supply Chain Performance linking metrics to support decision-making process. A good performance measurement system provides key measurement method which incorporates process alignment that aims to achieve strategic goals of organization. (SCOR, 2011)

The SCOR metrics are organized in a hierarchical structure as well as SCOR Model process framework, it describes in level-1, level-2 and level-3 metrics. The relationships between these levels are diagnostic. At Level 1 has ten strategic metrics primary which are the key performance indicators (KPI) for company strategic measurement. Itis used as a framework for multiple SCOR processes in supply chain. Level-2 metrics indicate the root-cause of performance gap for level-1 metrics, and level-3 metrics are linked to the operational processes. The efficient and effective process design should consider the correlation of process and performance metrics at sub-levels, referring from the SCOR-based alignment framework and Best Practices.

3.6 Performance Measurement System

Supply Chain Performance measurement system can be developed based on SCOR metrics and Best Practices. The correlations between metrics and processes of the system enable management to comprehend the relationships across the system and accomplish organization's goal and overall performance. Ineffective and inefficient performance measurement system affect the entire supply chain management system as managers could not monitor and gather all necessary information for decision-making. In addition, the performance measurement system could make process improvement possible as Harington (1991) said that "If you cannot measure it, you cannot control it. If you cannot manage it, you cannot improve it."

Performance measurement and metrics have a significant role in Supply Chain Management in determination of company's objectives and future courses of action plans, and in evaluation of performance (Gunasekaran et al., 2004). Kocaoglu et al. (2011) studied a supply chain performance metrics in a hierarchical way, using AHP

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and TOPSIS methods to weight metrics importance. They found that performance metrics priorities support to the organization's strategic direction. There are various methods used in supply chain performance systems designed to measure operational performance, evaluate effectiveness and efficiency and continuously improving overall supply chain performance to achieve company's competitive advantages. How and what elements to measure are the key questions required clarification while developing performance measurement system depends on which aspects of the key objectives. (Cai et al., 2009)

Healthcare Performance Measurement, in particular, involves performance of several stakeholders and functions such as, suppliers, delivery, customer-service, and inventory management in a supply chain. The target outcomes of healthcare supply chain are, for example, the recovery of patient's health, responsiveness to support during care, quality of services, and productivity of the resources within the healthcare systems. Performance of each stakeholders and functions are complicated to measure and, as a results, are unable to be evaluated by any single performance method (Smith et al., 2010).

3.7Business Process Modeling Notation (BPMN)

BPMN Version 2.0 was introduced by the OMG (Object Management Group) (2011) as one of the standardized tool visualizing diagrams used to model and interpret the business process diagram. The purpose is to facilitate communication of an end-to-end process to all cross-functional organization units by means of information structure in both professional management and technical IT terms. In this regard, BPMN standardizes blocked-structured process execution languages, between the business process design and process implementation (Cornu et al., 2013). BPMN provides a symbolic diagram notation of each role in a company, divided by lane and pool for individual activity in a process. Figure 3 shows three core elements, which are Event, Activity, and Gateway, that form the structure of and describe the process diagram. (Minoli, 2008).

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BPMN is popular in both business and IT communities because its symbolic visuals can provide a simple way to communicate process information to other business users, process implementers, customers and suppliers. Based on a global survey of BPMN process modelers conducted by Recker (2008), approximately 51 percent of the respondents use BPMN for business purposes (process documentation, improvement, business analysis, stakeholder communication); whereas, 49 percent of the respondents use the notation for technical purposes (process simulation, service analysis and workflow engineering). From the survey, Microsoft Visio was the tool used by 18.2 percent of the respondents; therefore, it was applied as the tool for the present study as described in the later section.

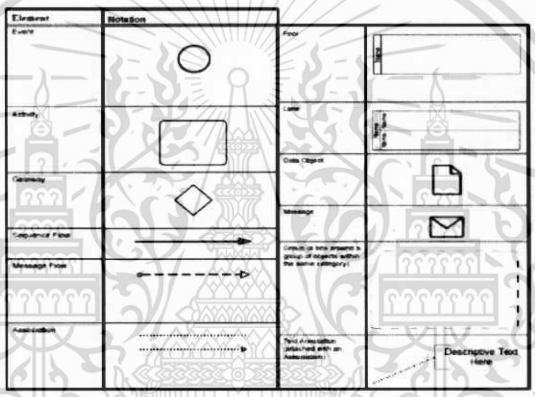

Figure3Basic BPMN Modeling Elements

4. CASE STUDY AND RESULTS

4.1 Case Observation and Analysis

As mentioned in Section 2 that our research has studied the current generic supply chain processes within the distribution centers of three-large-size hospitals as case study environments, and modeled based on the information from the in-depth structure interview conducted with the hospital head officers in related work area and site observation. There are similar patterns and processes are observed in the distribution centers for these three hospitals, with different technology and system or management policy. However, the generic processes are similar and can be

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potentially applied and extended to the reference model of same direction of control parameters.

4.1.1 As-Is Distribution Processes

The case study environments for public hospitals consist of a large-size hospital, which one of those is the oldest and largest hospital in Thailand. Hospital A is one of the largest medical schools in South East Asia. It has a capacity of more than 2,000 beds and more than one million outpatient visits per year. Hospital B has about 1,000 beds capacity with more than 5,000 outpatients served per day. It won the best Thailand's Most Admired Company in 2013 by the Company Magazine, with average score 7.04 in overall for the image of brands owned and lead in innovation in Hospital business in Thailand.

Another location for our case study is the first and the largest private-hospitals in Thailand. Hospital C has grown its branches network to 13 locations around the country and the broader Asian region, offering the most advance and specialized medical treatment technology, under logistics center and lab specialties distribution for all the branches.

The As-Is Distribution processes of these three hospitals, can be divided into two main parts, which are Internal distribution (Outbound) processes and External distribution (Inbound) process. The Internal distribution (Outbound) or Stock-out occurs on schedule weekly plan, starting from the dispensing points update their stock on hand and plan to reserve the drug request to Distribution center.

In Figure 4 shows the As-Is Internal-External Distribution processes of Hospital B, you will see that the 'stock on hand' updates and drug requests are done via ERP system, then the list is passed throughout the Distribution center for further processes. Once orders are picked up, goods is packed and ready to deliver per schedule, dispensing points will check orders when received and Put-away to Storage location. For the External Distribution (Inbound) or Stock-in process, it will begin at

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Purchasing department running through the stock on hand and placing Orders to Suppliers, then within agreed lead-time the Distribution Center will receive the Goods and proceeds on with the distribution center processes.To verify the medical products specially, suppliers are required to attach the Quality certificate document, or Temperature check equipment (for cold-storage), other than checking goods physical appearance only. If the quality of the Order delivered is not satisfactory, the Distribution center will return goods for the whole batch as per contracts agreement.

4.2 Reference Process Design

Product movement types are to identify the products' demand characteristics especially for hospitals that implements stockless supply chain policies. The demands have to be analyzed and modelled on a daily or monthly basis and it can be defined from the frequency of usage and Sales forecast. It can be classified into three levels as Slow-moving, Moderate-moving and Fast-moving, which affects the re-ordering point in order to manage inventory cost to balance with demand.

From the generic processes in the distribution center of general Hospital, the pattern of product movement shows that most of medicines are usually kept stock for daily demand usage and some that are for vital usage are required to be stored in hospital even with no demand. Therefore the 'Reference Process Model' will be designed based on Make-to-Stock model structure using five major processes within distribution center (see Figure 5), which enable suppliers to deliver the products within a short lead-time when Purchasing place the Orders.

4.2.1 SCOR Level 1

When we adopt the SCOR Model to describe the pharmaceutical products flow and information flow within and throughout Distribution center, the activities that are used to determine on process types for SCOR Level 1 as shown in Figure 6.

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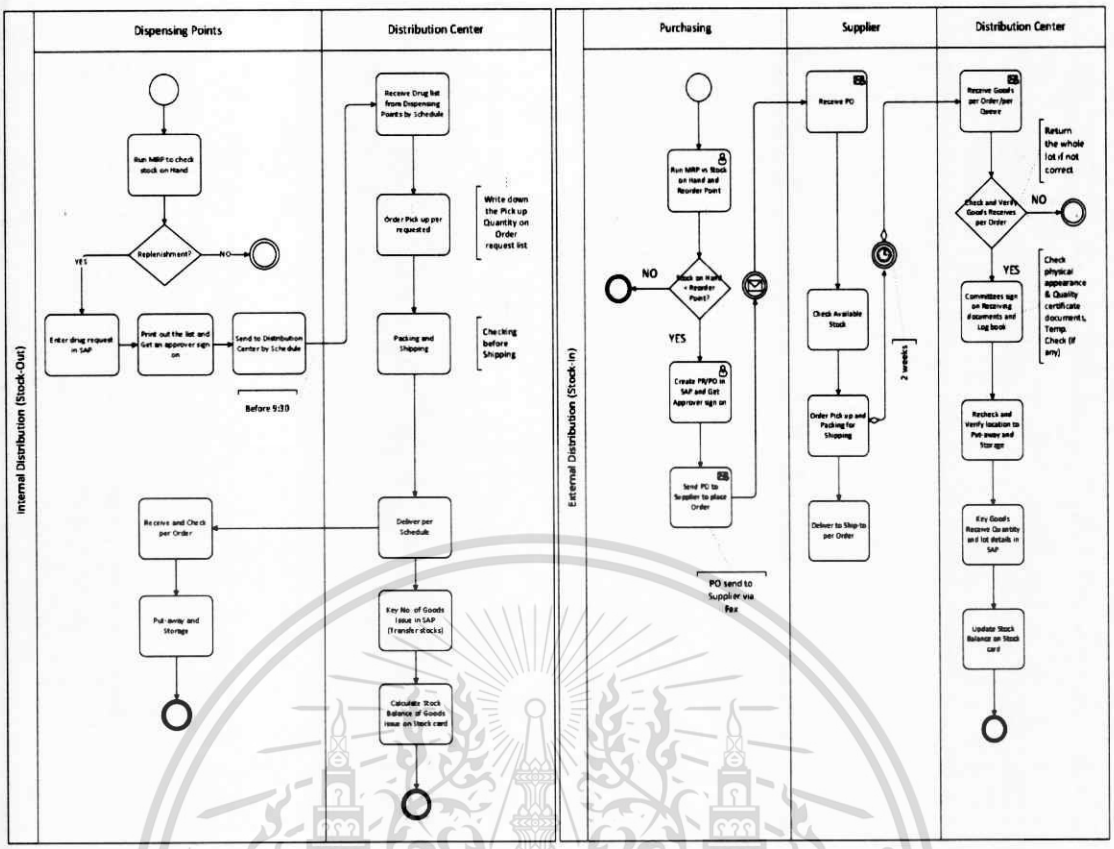

Figure 4Example of Internal- External Distribution Process from Hospital B

Figure5 Generic Distribution Center Processes

4.2.2 SCOR Level 2

For process categories, as mentioned earlier that we focused on Distribution center processes (some parts on 'Purchasing' will also be considered), the SCOR Level 2 in Figure 7is modeled based on Make-to-Stock products, which we rename the process categories to align with distribution processes and hospital supply chain per following:-

- **Plan (PL):** the process to determine requirements and corrective action to achieve supply chain objective for Inbound and Outbound logistics

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- **Receive (RE):** the process of ordering and receiving products, including replenishment inventory and return for defective product
- **Put-away (PU) :** the process of transferring verified products to storage location
- **Order-Picking(OR) :** the process of receiving the orders and pick up products to be ready for shipping
- **Shipping (SH):** the process of order management and order fulfillment activities to serve customer satisfaction
- **Return (RT):** the process of moving defective products back through the supply chain or supplier

4.2.3 SCOR Level 3to Level 3.5

In previous session, SCOR level 1and Level 2 described how the processes are defined in the high level of Distribution center in Hospital supply chain. SCOR Level 3 will break down processes into a tactical decision level while additional model Level 3.5 will consider the operational decision level of the distribution center using the generic Inbound and Outbound logistics throughout the processes (see in Figure 8).

As mentioned in section 3.4 that we have put in extra effort to upgrade SCOR model Level 3 to Level 3.5, in order to show users the roadmap on how the reference model can be implemented in such environments.Figure8 Reference Model for Distribution Center Process in Hospital Supply Chain (SCOR-Based Level 3.5) shows us the interface between Purchasing – Distribution Center (Inbound) – Distribution Center (Outbound) – Dispensing Points. It is written in BPMN platforms to represent the start and end processes of information flow and product flow for the whole processes. This is important for the IT part; to design on how each of the information will be link together, and using that to select the proper IT supports to achieve the most efficiency performance. The Reference Model can also be used to support the Capability Requirement, Network Design, Facilities Considerations, and scope down to Operational Planning as mentioned in session 3.2.

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Determined the case studies scenarios into reference model based on SCOR Best-practice, we classified the Process Categories according to processes within Distribution Centre as; Plan (PL), Receive (RE), Put-away (PU), Order-Picking (OR), Shipping (SH) and Return (RT). With this classification, the management of hospital can see the operation scale and manage in which position is required for each activity, and design for the organization workforce at each process for the required role to be fulfilled.

At the beginning, each role will be triggered by receiving information to start the process. For example, Purchasing will start Process PL1.1 from Inventory level, then establish and communicate supply chain plan, PL1.2 (Ordering plans) submit to suppliers with RE1.1 (Product Schedule) to deliver to Distribution Centre (Inbound). The workflow process will continue to the next role and activities respectively, as well as, product and information movement where necessary along the roles and responsibilities.

However, some processes are the same activities and are defined as same Process ID, such as, RE 1.2, RE 1.3 and PU 1.1 process. These are separated and specified more particularly by roles and responsibilities. Also the performance metrics using at each process, each roles are different by the measuring methods, which will be described in the next section.

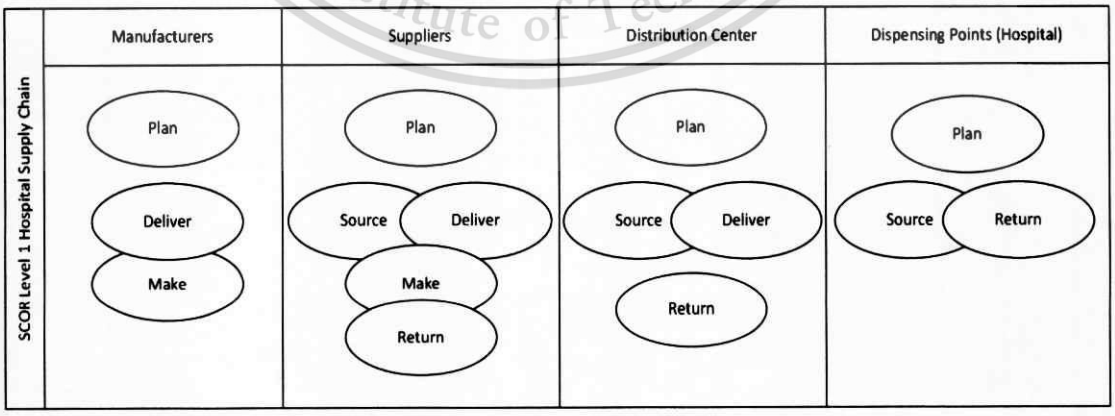

Figure 6 SCOR Level 1 Healthcare Supply Chain

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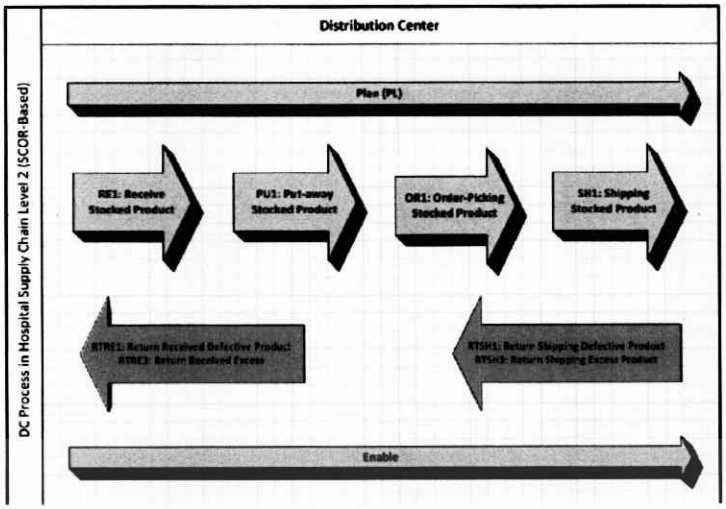

Figure7 Distribution Process in Hospital Supply Chain Level 2 (SCOR-Based)

4.3 Performance analysis and control

As mentioned in Section 1 in the overview of problem background that hospital supply chain still require a proper improvement and control of inventory with quality of goods storage and distribution practices conditions, those system affect directly to the patient safety and hospital's performance and service level. In this section you will see the performance outcome of Metric ID at each activity based on SCOR Level 3 that impacts the top-down process and decision in terms of time, cost and efficiency.

Hence the Metric is a standard for measurement of the process performance in supply chain, and SCOR Metrics are demonstrated in three-level of pre-defines metrics. For example in Table 1, Performance Attribute – Reliability at Level-1 Metric is RL.1.1 (Perfect Order Fulfillment) as its strategic metric and key performance indicators (KPI). It has four main 'Level-2' metrics and various 'Level-3' metrics identified with the processes. It shows that Process SH1.2 (Load Vehicle & Generate Shipping Docs) at Distribution Centre (Outbound) directly affects the performance 'Level-2' Metric RL2.3 (Documentation Accuracy), and those are part of the KPI at Level-1 metric RL1.1 (Perfect Order Fulfilment). Therefore the analysis of performance of metrics ID from Level-1 through 3 can help manager to find the root cause of overall performance.

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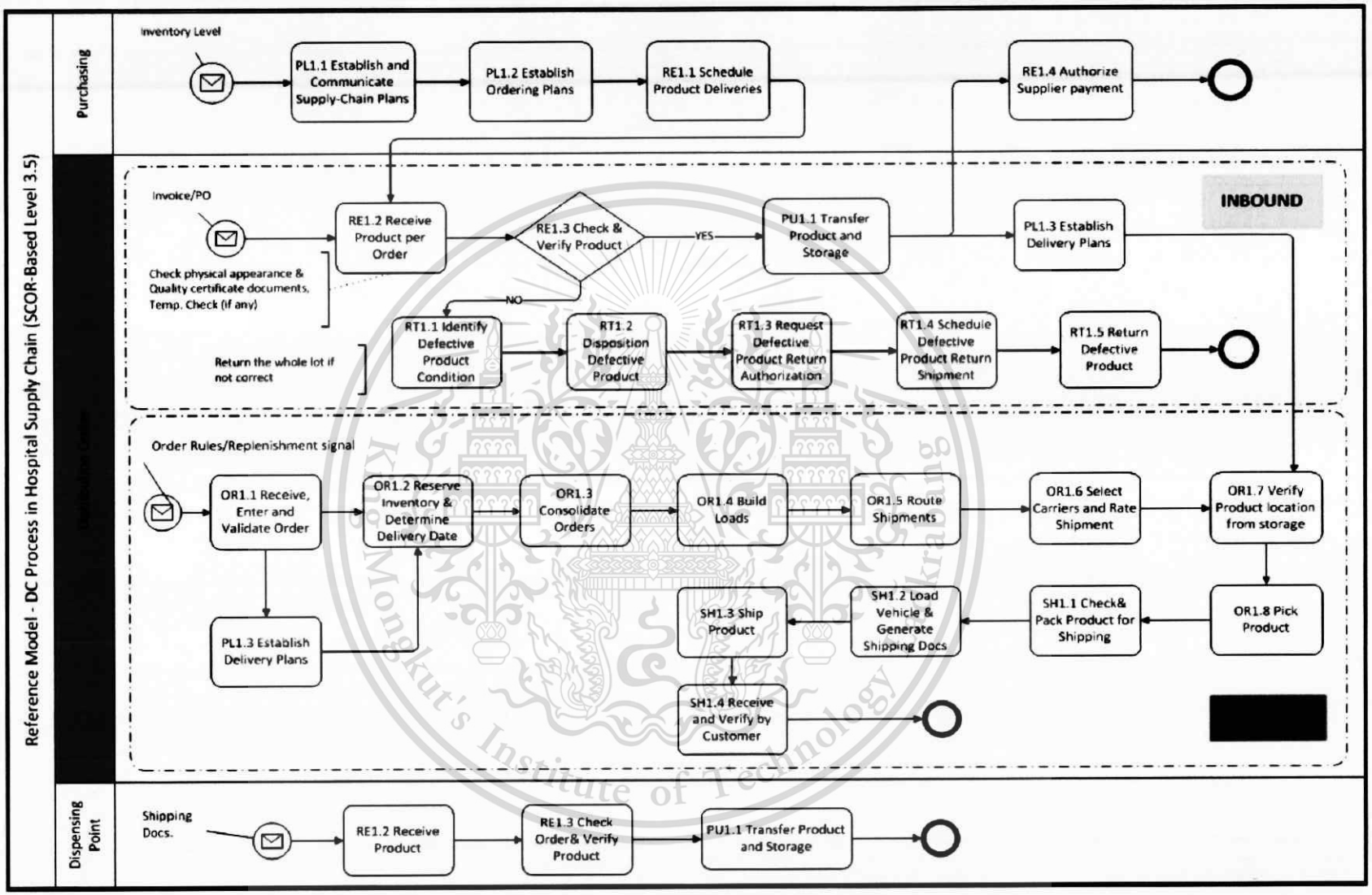

Figure 8 Reference Model of Distribution Process in Hospital Supply Chain (SCOR-Based Level 3.5)

Attribute	Level-1 Metric	Level-2 Metric	Level-3 Metric		
Reliability [Total Perfect Orders] / [Total Number of Orders] x 100%	**RL.1.1** **Perfect Order Fulfillment**	**RL.2.1** **% of Orders Delivered in Full**	RL.3.33 Delivery Item Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
			RL.3.35 Delivery Quantity Accuracy		
		RL.2.2 **Delivery Performance to Customer Commit Date**	RL.3.32 Customer Commit Date Achievement Time Customer Receiving	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.34 Delivery Location Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
		RL.2.3 **Documentation Accuracy**	RL.3.31 Compliance Documentation Accuracy	SH1.2 Load Vehicle & Generate Shipping Docs	Distribution Center (Outbound)
			RL.3.43 Other Required Documentation Accuracy		
			RL.3.45 Payment Documentation Accuracy		
			RL.3.50 Shipping Documentation Accuracy		
		RL.2.4 **Perfect Condition**	RL.3.12 % Of Faultless Installations	N/A	N/A
			RL.3.24 % Orders/lines received damage free	RE1.3 Check Order& Verify Product	Distribution Center (Inbound)/ Dispensing Point
			RL.3.41 Orders Delivered Damage Free Conformance	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.42 Orders Delivered Defect Free Conformance		

Table 1 Level-1 through 3 of Performance Attribute – Reliability and Processes linked

In our research, the designed Reference Model of Distribution center in Hospital Supply Chain is considered at Process / Metrics Alignment level based on SCOR Best Practices. The Performance-Process mapping diagrams show that outbound distribution, starting from order receipt to deliver to customers, is the key function in Distribution center and it has the most impact on overall Performance. Reliability and Responsiveness are the major Performance attributes of the outbound distribution with covering process activities about 40.74 and 44.45 percent respectively; as they are addressed to customer-facing attributes, whereas Agility, Cost and Asset Management Efficiency have a small impact for about 15 percent from total 27 processes in Distribution center (see Figure 9).

Further in this session, from SCOR Model Level 3 we have mapped the processes and Performance Metric IDs for each Role and Responsibility within the Distribution Center Process of Hospital Supply Chain, in order to show the implementation roadmap how the interaction of the process and how the key performance can be measured (see Table A in Appendices).

5. DISCUSSION

From the case study and literature review on Reference Model and Hospital Supply chain, there is still lack of the standardization for the end to end process between

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parties. There are also critical issue on the Performance Measurement system as it is not yet designed for overall performance to reach company objective. In our research, we have studied the generic processes of three-large-size hospital in Thailand to identify the reference model of Distribution center in Hospital Supply Chain based on SCOR Model and Metrics, with BPMN notation for IT implementation purpose. The usage of only modelling language made it easier compared to existing approaches (Barros et al, 2012). With these results, it can be used to assist the manager on setting standard guidelines for implementation and/or process improvement within Distribution center and toward Hospital supply chain. A well-structured reference model demonstrates key performance indicators at each process and roles can help management to analyze the problem root cause for further development.

In conclusion, this research has reached its objective and shown how a process models can be designed for the distribution center for large-size-hospital supply chain in Thailand, where in the specific areas of Reference Model and Performance Measurement were determined. The SCOR framework applies to main activities in Distribution center; Plan, Receive, Put-away, Order-Picking, Shipping and Return, where specific roles and responsibilities are defined at each process. Detailed process guidelines herewith will be very helpful for managing its operations and performance progress tracking to promote the greater supply chain integration and future development.

6. FURTHER STUDY

In this research has applied the reference process model based on the management point-of-view, policies and existing system accessibility and facilities at the selected hospitals environment, therefore the designed model from this paper will depend on an extensive case study in 3 hospitals (2 publics and 1 private), and be reviewed in-depth by hospital experts. As result, the research could provide solid evidence that the designed model in Hospital Distribution center meet the specific requirements to reference process model for further implementation.

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Nevertheless, there may have some important opportunities for future development and research due to limited contribution in public hospitals because of laws and government processes that would affect the designed reference model in term of decision making criteria and processes. Additional research and practice in BPMN notation and programs for implementation may be useful for example BPMN web-based, in specific environment, to adjust the real-time data collection at each process and see how it is impact the key performance indicators at high strategic level.

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APPENDICES

Table A Reference Model designed process mapping based on SCOR Model

Role / Responsibility					
Purchasing	**PL1.1**	sP1.4	**Establish and Communicate Supply-Chain Plans**	RS.3.30	Establish Supply Chain Plans Cycle Time
				AM.2.2	Inventory Days of Supply
	PL1.2	sP2.4	**Establish Ordering Plans**	RS.3.29	Establish Sourcing Plans Cycle Time
	RE1.1	sS1.1	**Schedule Product Deliveries**	RL.3.27	% Schedules Changed within Supplier's Lead Time
				RS.3.9	Average Days per Engineering Change
				RS.3.10	Average Days per Schedule Change
				RS.3.11	Average Release Cycle of Changes
				RS.3.122	Schedule Product Deliveries Cycle Time
	RE1.4	sS1.5	**Authorize Supplier payment**	RS.3.8	Authorize Supplier Payment Cycle Time
Distribution Center (Inbound)	**PL1.3**	sP4.4	**Establish Delivery Plans**	RL.3.36	Fill Rate
				RS.3.27	Establish Delivery Plans Cycle Time
	PU1.1	sS1.4	**Transfer Product and Storage**	RL.3.25	% Product Transferred On-Time to Demand Requirement
				RL.3.26	% Product Transferred without Transaction Errors
				RS.3.139	Transfer Product Cycle Time
				AM.2.2	Inventory Days of Supply
	RE1.2	sS1.2	**Receive Product per Order**	RL.3.18	% of Orders / Lines processed complete
				RL.3.20	% of Orders/ lines Received On-Time To Demand Requirement
				RL.3.22	% of Orders/ lines Received with Correct packaging
				RL.3.23	% of Orders/ lines Received with Correct Shipping Documents

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				RS.3.113	Receiving Product Cycle Time
	RE1.3	sS1.3	**Check Order& Verify Product**	RL.3.19	% of Order / Lines Received Defect Free
				RL.3.21	% of Orders / Lines with correct content
				RL.3.24	% of Orders/ lines Received Damage Free
				RS.3.140	Verify Product Cycle Time
	RT1.1	sSR1.1	**Identify Defective Product Condition**	AM.3.29	Percentage Defective Inventory in Disposition
	RT1.2	sSR1.2	**Disposition Defective Product**	CO.3.029	Disposition Cost
				AM.3.29	Percentage Defective Inventory in Disposition
	RT1.3	sSR1.3	**Request Defective Product Return Authorization**	AM.3.30	Percentage Defective Inventory in Return Authorization
	RT1.4	sSR1.4	**Schedule Defective Product Return Shipment**	RL.3.28	% of Shipping Schedules that Support Customer Required Return by Date
				AM.3.32	Percentage Defective Product Inventory in Scheduling
	RT1.5	sSR1.5	**Return Defective Product**	RL3.47	Return Shipments Shipped on Time
				RL.3.5	% Error-free Returns Shipped
				CO.3.022	Transportation Cost
				AM.3.21	Rebuild or recycle rate
				AM.3.31	Percentage Defective Product Inventory in Transportation
Distribution Center (Outbound)	OR1.1	sD1.2	**Receive, Enter and Validate Order**	RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RS.3.94	Order Fulfillment Dwell Time
				RS.3.112	Receive, Enter & Validate Order Cycle Time
	OR1.2	sD1.3	**Reserve Inventory & Determine Delivery Date**	RL.3.36	Fill Rate
				RL.2.1	% of Orders Delivered In Full
				RL.2.2	Delivery Performance to Customer Commit Date
				RS.3.94	Order Fulfillment Dwell Time
				RS.3.116	Reserve Resources and Determine Deliver Date Cycle Time
	OR1.3	sD1.4	**Consolidate Orders**	RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				CO.3.022	Transportation Cost
				RS.3.18	Consolidate Orders Cycle Time
				CO.3.018	Order Management Labor Cost
	OR1.4	sD1.5	**Build Loads**	CO.3.022	Transportation Cost
				RS.3.16	Build Loads Cycle Time
				CO.3.018	Order Management Labor Cost
	OR1.5	sD1.6	**Route Shipments**	CO.3.022	Transportation Cost
				RS.3.117	Route Shipments Cycle Time
				CO.3.018	Order Management Labor Cost
	OR1.6	sD1.7	**Select Carriers and Rate Shipment**	RL.3.16	% of Suppliers meeting environmental metrics / criteria
				CO.3.022	Transportation Cost
				CO.3.018	Order Management Labor Cost
	OR1.7	sD1.8	**Verify Product location from storage**	RS.3.108	Receive Product from Make/ Source Cycle Time
				RS.3.110	Receive Product from Source or Make Cycle Time

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				CO.3.024	Fulfillment Labor Cost
	OR1.8	sD1.9	**Pick Product**	RL.3.36	Fill Rate
				RS.3.96	Pick Product Cycle Time
				CO.3.024	Fulfillment Labor Cost
	PL1.3	sP4.4	**Establish Delivery Plans**	RL.3.36	Fill Rate
				RS.3.27	Establish Delivery Plans Cycle Time
	SH1.1	sD1.10	**Check& Pack Product for Shipping**	RL.3.4	% Correct Material Documentation
				RS.3.95	Pack Product Cycle Time
				CO.3.024	Fulfillment Labor Cost
	SH1.2	sD1.11	**Load Vehicle & Generate Shipping Docs**	RL.2.2	Delivery Performance to Customer Commit Date
				RL.2.3	Documentation Accuracy
				RL.3.31	Compliance Documentation Accuracy
				RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RL.3.43	Other Required Documentation Accuracy
				RL.3.45	Payment Documentation Accuracy
				RL.3.50	Shipping Documentation Accuracy
				RS.3.51	Load Product and Generate Shipping Documentation Cycle Time
				CO.3.024	Fulfillment Labor Cost
	SH1.3	sD1.12	**Ship Product**	RL.2.1	% of Orders Delivered In Full
				RL.2.2	Delivery Performance to Customer Commit Date
				RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RS.3.126	Cycle Time
				CO.3.022	Transportation Cost
				CO.3.024	Fulfillment Labor Cost
	SH1.4	sD1.13	**Receive and Verify by Customer**	RL.2.1	% of Orders Delivered In Full
				RL.2.2	Delivery Performance to Customer Commit Date
				RL.2.4	Perfect Condition
				RL.3.32	Customer Commit Date Achievement Time customer Receiving
				RL.3.33	Delivery Item Accuracy
				RL.3.34	Delivery Location Accuracy
				RL.3.35	Delivery Quantity Accuracy
				RL.3.41	Orders Delivered Damage Free Conformance
				RL.3.42	Orders Delivered Defect Free Conformance
				RS.3.102	Receive & Verify Product by Customer Cycle Time
				RS.3.103	Receive and Verify Product Cycle Time
Dispensing point	**PU1.1**	sS1.4	**Transfer Product and Storage**	RL.3.25	% Product Transferred On-Time to Demand Requirement
				RL.3.26	% Product Transferred without Transaction Errors
				RS.3.139	Transfer Product Cycle Time
				AM.2.2	Inventory Days of Supply
	RE1.2	sS1.2	**Receive Product per Order**	RL.3.18	% of Orders / Lines processed complete

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				RL.3.20	% of Orders/ lines Received On-Time To Demand Requirement
				RL.3.22	% of Orders/ lines Received with Correct packaging
				RL.3.23	% of Orders/ lines Received with Correct Shipping Documents
				RS.3.113	Receiving Product Cycle Time
	RE1.3	**sS1.3**	**Check Order& Verify Product**	RL.3.19	% of Order / Lines Received Defect Free
				RL.3.21	% of Orders / Lines with correct content
				RL.3.24	% of Orders/ lines Received Damage Free
				RS.3.140	Verify Product Cycle Time

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APPENDICE D: International Conference (ICLT 2014)

The 6th International Conference on Logistics and Transport 2014, 26 – 29 August 2014 at Kuala Lumpur, Malaysia

A REFERENCE MODEL OF THE DISTRIBUTION CENTER IN HOSPITAL SUPPLY CHAIN

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1. Introduction

Supply chain and logistics management has been continuously developed to improve business performance in organizations over the last three decades. It is undeniably the one of the most critical mechanisms for any industry since the efficient management of supply chain and logistics is the key to success of any suppliers, manufacturers and retailers, for example. Hospital industry, in particular, has been growing with the ever increasing demands for healthcare services. Hospitals serve customers and patients whose demands are varied dramatically; therefore, the supply chain and logistics has been at the heart of hospital management. However, hospital's supply chain and logistics development is still at the early age as opposed to that of other industries. A typical hospital supply chain is a complex network consisting of the linkage role between vendors, manufacturers, distributors, hospital and internal departments. The co-ordination of material flow and information flow within the chains are subject to individual hospital's strategy and policy. The efficient supply chain management contributes greatly to competitive advantage of any business; hence, the inefficient one may cause the opposite. As a result, hospitals have to align their objective and strategy to maximize patient care while minimizing variable costs and wastes (Everagd, 2001: DeScioli, 2005).

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In Thailand, most hospitals are owned and managed by government with; the traditional hospital management. The lack of standardized processes of such management cause poor operations and co-ordinations between relevant units in supply chain and may lead to unsatisfied service provided to customers. It is apparent that amidst the increased demands for healthcare services, the number of state health personnel and facilities system could not support them (Ministry of Public Health, 2008-2010). Kritchanchai (2012) highlighted that the top concerns and problems raised by focused parties in healthcare industry in Thailand are inefficient business process, data inconsistency and fragmented supply chain system. This has prompted the need for a proposed framework for Thailand healthcare supply chain which is based on the confirmed problems and intervention improvement; standardization, information sharing and business process re-engineering. The problems of management and operational system at Ramathibodi hospital, a large sized public teaching hospital with approximately 1,000 with continuous increased in number of patients, caused high inventory level, high average storage time, and poor storage conditions in each distribution center due to limited space and facilities support system (Healthcare Supply Chain Excellence Centre (LogHealth), 2012).

Several supply chain management and development studies suggested that distribution center is one of the most significant parts in supply chain because it represents a large amount of costs of material storage and control (e.g. temperature-controlled, distribution process etc.). The uncontrolled storage conditions in distribution center impact materials' quality which inadvertently linked to the chance of patient's survival and recovery. In effect, supply chain and logistics management is crucial for inventory distribution and control in distribution center to achieve optimal accuracy, timeliness, traceability to attain hospital's performance (Hutujuta and Punnakittikasem, 2001; Toba et al., 2008).

To maximize the long term hospitals' competitiveness in patient's safety, business process re-engineering, standardization and information sharing through efficient and effective supply chain and logistics management, the development and implementation of reference model of the distribution center in hospital supply

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chain is required (Brown et al., 2011).The full-scale model in distribution processes derived from the reference model will connect the role and responsibility of data interfaces and activities in hospital supply chain. The well-designed structure and standardized processes will improve performance, response times and quality of care for decision making as a result. Therefore, the present study focuses on a full-scaled reference process model of the distribution center in hospital supply chain.

The present study is organized as follows: (i) literature review, (ii) purpose of the study, (iii) case observation and analysis, (iv) reference process model design and (v) discussion.

2. Literature review

2.1 Reference Models (RMs)

Reference Models (RMs) are generic conceptual models and framework which represent the business's best practice universally applied in company specific processes or projects. The benefits of implementing Reference Models to business includes cost and time reduction, quality improvement, risk reduction, process transparency, common language and basis for benchmarking (Kirchmer, 2011; Miers, 2008). The development of process design and continuous sustainably improvement for the company or cross-industry could reuse the RMs in combination or individually, to reduce the development cost and time to company's specific process models (Kalpic and Bernus, 2002; Pajk et al, 2012). Verdouw et al. (2010) brought about an example of Reference Model usage designed for fruit industry in Europe. They analysed fruit-specific knowledge and generic knowledge in cross-industry standards and proposed the business process that could provide fruit companies with personalized configuration in supply chain design and information system implementation.

Similar to hospital supply chain, the reference process model designed using generic process could be applied to hospitals at all scales. The benefits will not be limited to the hospitals themselves but extended to the related players in hospital supply chain and, ultimately, to the patients. The reference processes in the model explain the roadmap for each role and responsibility with step-by-step activities. Besides the

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operational steps, the reference processes provide control points and key performance of each activity. The outline activities and performance metrics support the management team in decision making and can be adapted to company's needs. In sum, the reference process model engineers the management plan at strategic, tactical and operational levels.

2.2 SCOR Model

The Supply Chain Operations Reference model (SCOR), designed by the Supply Chain Council (2012), is the most widely used business process reference models in various industries. It is one of Supply Chain management tools used to address the overall processes and activities from supplier's supplier to a customer's customers. The SCOR model has five basic processes: Plan (P), Source (S), Make (M), Deliver (D) and Return (R), and provides a standard process model which describes the organization best practice framework of management processes. The model contains a linkage between business objectives to supply chain operations, with standard metrics to measure process performance or KPI at each level of hierarchy. SCOR Model has four levels of hierarchy: top, configuration, process element and implementation. The top level (Level 1) is the design of process types (Plan, Source, Make, Deliver, Return). The second level (Level 2) involves configuration of the supply chain that is the detailed descriptions of the process types' sub categories, such as 'Make to stock', 'Make to order', and 'Engineer to order' or 'Production execution' The third level (Level 3) is the decomposition of processes to the process element level, in line with its strategies and performance metrics. The fourth level (Level 4) is the implementation of the supply chain and best practice solution. This level is not included in SCOR framework but can be applied as a sub-process in specific business conditions.

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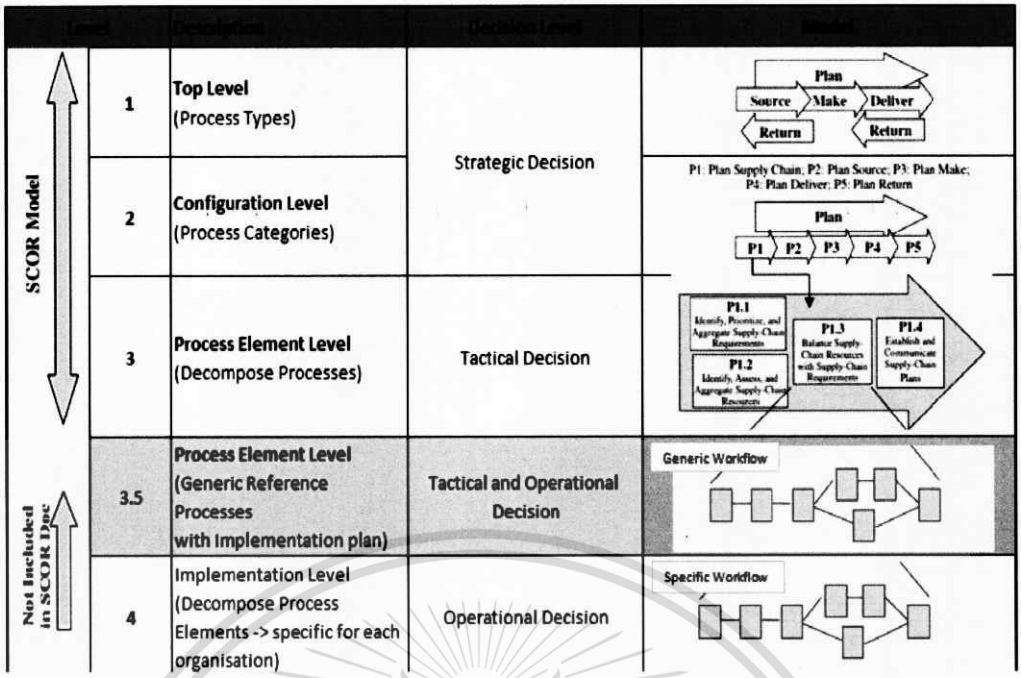

Figure 1: Levels of SCOR Model

Since the SCOR level four requires specific details from each hospital environment for the implementation stage, the proposed reference process model was upgraded to SCOR level 3.5 adopting generic processes. The SCOR level 3.5 takes into account the tactical and operational levels that support management team in making decision as shown in Figure 1.

2.3 SCOR Performance Attributes and Metrics

The SCOR Model describes supply chain activities for business at each level, and defines a set of performance metrics used to evaluate the processes. There are five dimensions to performance measurement: Supply Chain Reliability, Supply Chain Responsiveness, Supply Chain Agility (Customer-Focused attributes), and Supply Chain Costs, Supply Chain Asset Management Efficiency (Internal-Focused attributes). The SCOR Metrics is a standard measurement guidance for Supply Chain Performance linking metrics to support decision-making process. A good performance measurement system provides key measurement method which incorporates process alignment that aims to achieve strategic goals of organization. (SCOR, 2011)

The SCOR metrics are organized in a hierarchical structure as well as SCOR Model process framework, it describes in level-1, level-2 and level-3 metrics. The

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relationships between these levels are diagnostic. At Level 1 Metrics has ten strategic metrics primary as a high level process. The top level metrics are the key performance indicators (KPI) for company strategic measurement and can use as a framework for multiple SCOR processes in supply chain.Level-2 metrics indicate the root-cause of performance gap for level-1 metrics, and level-3 metrics are linked to the operational processes. The efficient and effective process design should consider the correlation of process and performance metrics at sub-levels, referring from the SCOR-based alignment framework and Best Practices.

2.4 Performance Measurement System

Supply Chain Performance measurement system can be developed based on SCOR metrics and Best Practices. The correlations between metrics and processes of the system enable management to comprehend the relationships across the system and accomplish organization's goal and overall performance. Ineffective and inefficient performance measurement system affect the entire supply chain management system as managers could not monitor and gather all necessary information for decision-making. In addition, the performance measurement system could make process improvement possible as Harington (1991) said that "If you cannot measure it, you cannot control it. If you cannot manage it, you cannot improve it."

Performance measurement and metrics have a significant role in Supply Chain Management in determination of company's objectives and future courses of action plans, and in evaluation of performance (Gunasekaran et al., 2004). Kocaoglu et al. (2011) studied a supply chain performance metrics in a hierarchical way, using AHP and TOPSIS methods to weight metrics importance. They found that performance metrics priorities support to the organization's strategic direction. There are various methods used in supply chain performance systems designed to measure operational performance, evaluate effectiveness and efficiency and continuously improving overall supply chain performance to achieve company's competitive advantages. How and what elements to measure are the key questions required clarification while developing performance measurement system depends on which aspects of the key objectives. (Cai et al., 2009)

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Healthcare Performance Measurement, in particular, involves performance of several stakeholders and functions such as, suppliers, delivery, customer-service, and inventory management in a supply chain. The target outcomes of healthcare supply chain are, for example, the recovery of patient's health, responsiveness to support during care, quality of services, and productivity of the resources within the healthcare systems. Performance of each stakeholders and functions are complicated to measure and, as a result, are unable to be evaluated by any single performance method (Smith et al., 2010).

2.5 Business Process Modeling Notation (BPMN)

BPMN Version 2.0 was introduced by the OMG (Object Management Group) (2011) as one of the standardized tool visualizing diagrams used to model and interpret the business process diagram. The purpose is to facilitate communication of an end-to-end process to all cross-functional organization units by means of information structure in both professional management and technical IT terms. In this regard, BPMN standardizes blocked-structured process execution languages, between the business process design and process implementation (Cornu et al., 2013). BPMN provides a symbolic diagram notation of each role in a company, divided by lane and pool for individual activity in a process. There are three core elements that used to form the structure and describe the process diagram, such as, Event, Activity and Gateway (Minoli, 2008).

BPMN is popular in both business and IT communities because its symbolic visuals can provide a simple way to communicate process information to other business users, process implementers, customers and suppliers. Based on a global survey of BPMN process modelers conducted by Recker (2008), approximately 51 percent of the respondents use BPMN for business purposes (process documentation, improvement, business analysis, stakeholder communication); whereas, 49 percent of the respondents use the notation for technical purposes (process simulation, service analysis and workflow engineering). From the survey, Microsoft Visio was the tool used by 18.2 percent of the respondents; therefore, it was applied as the tool for the present study as described in the later section.

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3. Purpose of the Study

The present research studied the existing business process model of distribution center of three large-size-hospitals in Thailand to identify the best practice and development of generic reference process models in the hospitals' supply chains. The purposes of the study is to develop a generic business process models with a set of performance parameters for distribution center that support decision makings and act as a reference model for use in top-down structured organizations. The research question of this study is how can reference process models be designed for the distribution center for large-size-hospital supply chain in Thailand? The qualitative research approach applied in the study includes in-depth interviews, additional desk research and observation of the existing distribution process at two public and one private large-scale hospital. The data was collected and analysed to obtain the As-Is pharmaceutical distribution process as a basis for the development of the standardized generic model

4. Case Study and Results

4.1 Case observation and analysis

As mentioned in Section 2, we will based our research on the current generic supply chain processes within the distribution centres of three-large-size hospitals as case studies environment, and modelled based on the information from the in-depth structure interview conducted with the hospital head officers in related work area and site observation. Similar patterns and processes are observed in the distribution centres of these three hospitals, with different technology and system or management policy. However, the generic processes are similar and can be potentially applied and extended to the reference model of same direction of control parameters.

4.1.1 As-Is Distribution Processes

The case study environments for public hospitals consist of a large-size hospital, which one of those is the oldest and largest hospital in Thailand. Hospital A is one of

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the largest medical schools in South East Asia. It has a capacity of more than 2,000 beds and more than one million outpatient visits per year. Hospital B has about 1,000 beds capacity with more than 5,000 outpatients served per day. It won the best Thailand's Most Admired Company in 2013 by the Company Magazine, with average score 7.04 in overall for the image of brands owned and lead in innovation in Hospital business in Thailand. Another location for our case study is the first and the largest private-hospitals in Thailand. Hospital C has grown its branches network to 13 locations around the country and the broader Asian region, offering the most advance and specialized medical treatment technology, under logistics centre and lab specialties distribution for all the branches.

The As-Is Distribution processes of these three hospitals, can be divided into two main parts, which are the internal distribution (outbound) processes and the external distribution (inbound) process. The internal distribution (outbound) or stock-out occurs on schedule weekly plan, starting from having the dispensing points to update their stock on hand and plan to reserve the drug request to distribution centre. From the As-Is internal distribution processes of Hospital B, it can be seen that the 'stock on hand' updates and drug requests are done via ERP system, then the list is passed throughout the distribution centre for further processes. Once orders are picked up, goods is packed and ready to deliver per schedule, dispensing points will check orders when received and Put-away to Storage location. For the external distribution (inbound) or stock-in process, it will begin with the Purchasing department running through the stock on hand and placing orders to suppliers, then within agreed lead-time the Distribution Centre will receive the goods and proceeds on with the distribution centre processes. To verify the medical products specially, suppliers are required to attach the Quality certificate document, or Temperature check equipment (for cold-storage), other than checking goods physical appearance only. If the quality of the Order delivered is not satisfactory, the Distribution centre will return goods for the whole batch as per contracts agreement.

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4.2 Reference Process Model Design

Product movement types are to identify the products' demand characteristics especially for hospitals that implements stockless supply chain policies. The demands have to be analyzed and modelled on a daily or monthly basis and it can be defined from the frequency of usage and Sales forecast. It can be classified into three levels as Slow-moving, Moderate-moving and Fast-moving, which affects the re-ordering point in order to manage inventory cost to balance with demand. From the generic processes in the distribution centre of general Hospital, the pattern of product movement shows that most of medicines are usually kept stock for daily demand usage and some that are for vital usage are required to be stored in hospital even with no demand. Therefore the 'Reference Process Model' will be designed based on Make-to-Stock model structure using five major processes within distribution centre (see Figure 2), which enable suppliers to deliver the products within a short lead-time when Purchasing place the Orders.

Figure 2: Generic Distribution Center Processes

4.2.1 SCOR Level 1 and level 2

When we adopt the SCOR Model to describe the pharmaceutical products flow and information flow within and throughout the Distribution centre, the activities that are used to determine on process types for SCOR Level 1 is as shown in Figure 3 (left). For process categories, as mentioned earlier that we focused on distribution centre processes (some parts on 'Purchasing' will also be considered), the SCOR Level 2 in Figure 3 (right) is modelled based on Make-to-Stock products, which we rename the process categories to align with distribution processes and hospital supply chain per following:-

- **Plan (PL) :** the process to determine requirements and corrective action to achieve supply chain objective for inbound and outbound logistics

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- **Receive (RE)** : the process of ordering and receiving products, including replenishment inventory and return for defective product
- **Put-away (PU)** : the process of transferring verified products to storage location
- **Order-Picking (OR)** : the process of receiving the orders and pick up products to be ready for shipping
- **Shipping (SH)** : the process of order management and order fulfillment activities to serve customer satisfaction
- **Return (RT):** the process of moving defective products back through the supply chain or supplier

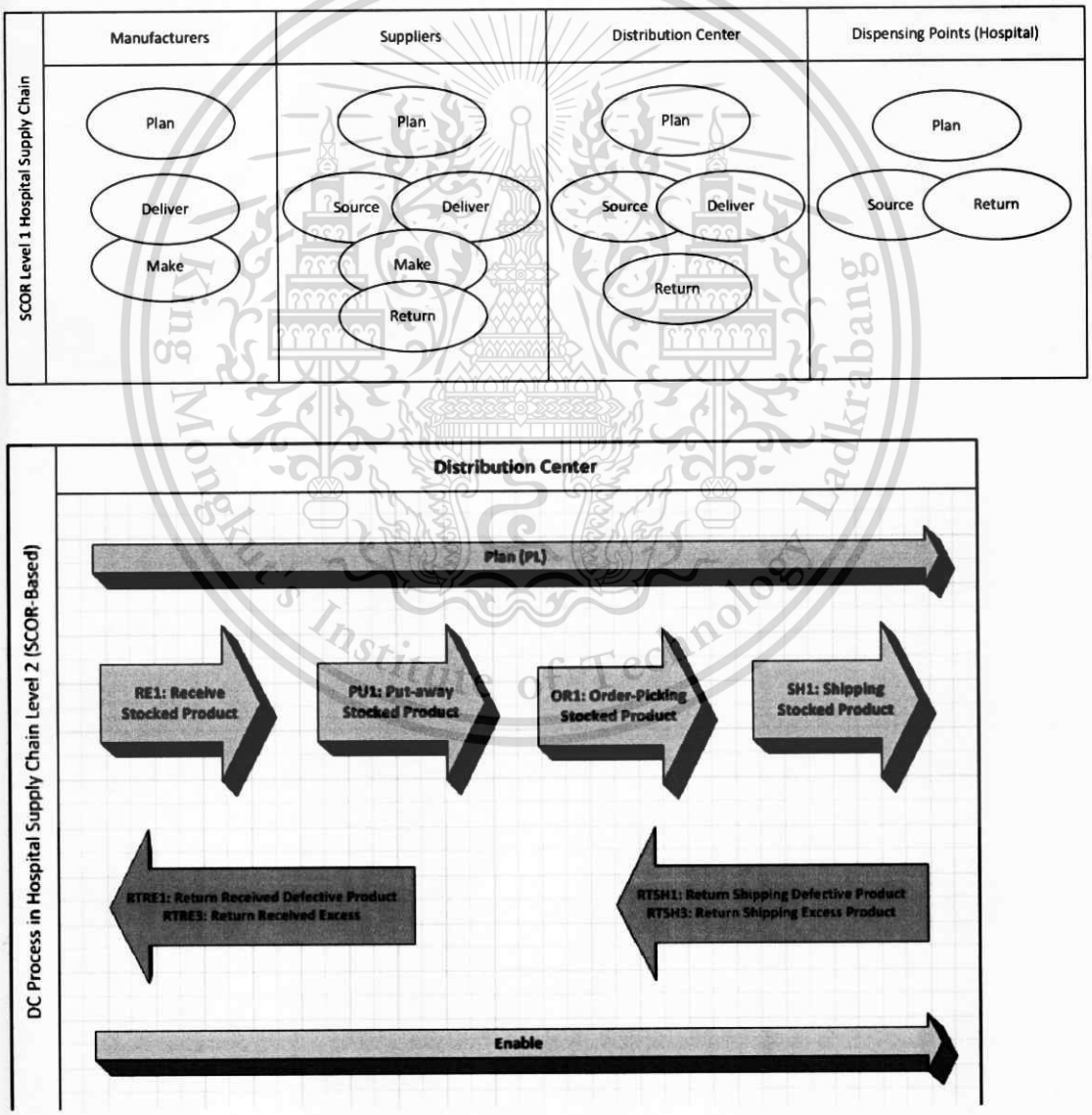

Figure 3: Distribution process in healthcare supply chain (SCOR level 1 and 2)

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4.2.2 SCOR level 3 to level 3.5

In previous section, SCOR level 1and Level 2 described how the processes are defined in the high level of distribution centre in hospital supply chain. SCOR Level 3 will break down processes into a tactical decision level while additional model Level 3.5 will consider the operational decision level of the distribution centre using the generic Inbound and Outbound logistics throughout the processes (see in Figure 4). As mentioned in section 2.2, we have put in extra effort to upgrade SCOR model Level 3 to Level 3.5, in order to show users the roadmap on how the reference model can be implemented in such environments.

Figure 4 Reference Model for Distribution Centre Process in Hospital Supply Chain (SCOR-Based Level 3.5) shows us the interface between Purchasing – Distribution Centre (Inbound) – Distribution Centre (Outbound) – Dispensing Points. It is written in BPMN platforms to represent the start and end processes of information flow and product flow for the whole processes. This is important for the IT part; to design on how each of the information will be link together, and using that to select the proper IT supports to achieve the most efficiency performance. The Reference Model can also be used to support the Capability Requirement, Network Design, Facilities Considerations, and scope down to Operational Planning as mentioned (Rouwenhorst et al., 1999; Coyle, 2003).

Determined the case studies scenarios into reference model based on SCOR Best-practice, we classified the Process Categories according to processes within Distribution Centre as; Plan (PL), Receive (RE), Put-away (PU), Order-Picking (OR), Shipping (SH) and Return (RT). With this classification, the management of hospital can see the operation scale and manage in which position is required for each activity, and design for the organization workforce at each process for the required role to be fulfilled. At the beginning, each role will be triggered by receiving information to start the process. For example, Purchasing will start Process PL1.1 from Inventory level, then establish and communicate supply chain plan, PL1.2 (Ordering plans) submit to suppliers with RE1.1 (Product Schedule) to deliver to Distribution Centre (Inbound). The workflow process will continue to the next role

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and activities respectively, as well as, product and information movement where necessary along the roles and responsibilities. However, some processes are the same activities and are defined as same Process ID, such as, RE 1.2, RE 1.3 and PU 1.1 process. These are separated and specified more particularly by roles and responsibilities. Also the performance metrics using at each process, each roles are different by the measuring methods, which will be described in the next section.

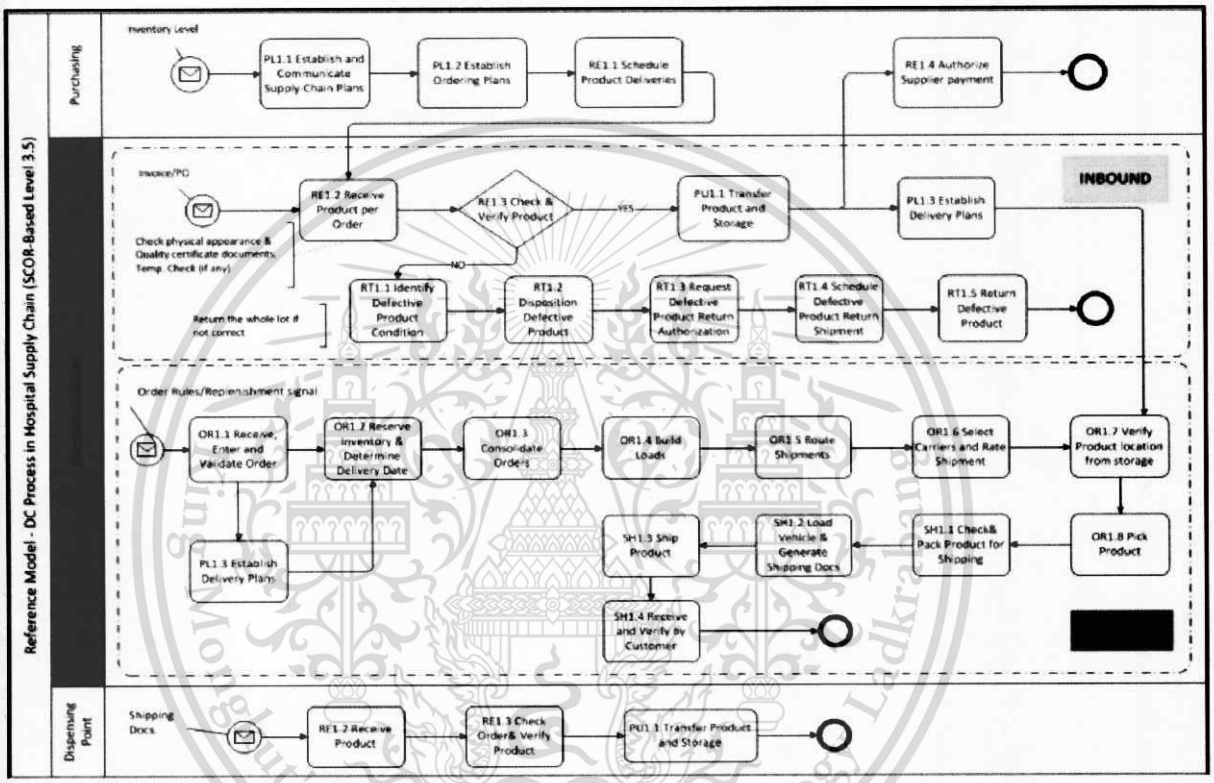

Figure 4: Reference Model of Distribution Process in Hospital Supply Chain (SCOR-Based Level 3.5)

4.3 Performance measurement system design

As mentioned in Section 1 in the overview of problem background that hospital supply chain still require a proper improvement and control of inventory with quality of goods storage and distribution practices conditions, those system affect directly to the patient safety and hospital's performance and service level. In this section you will see the performance outcome of Metric ID at each activity based on SCOR Level 3 that impacts the top-down process and decision in terms of time, cost and efficiency. We have mapped the processes and Performance Metric IDs for each Role

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and Responsibility within the distribution centre process of hospital supply chain, in order to show the implementation roadmap on how the interaction of the process and how the key performance can be measured.

In our research, the designed Reference Model of Distribution centre in Hospital Supply Chain is considered at Process / Metrics Alignment level based on SCOR Best Practices. The Performance-Process mapping diagrams show that outbound distribution, starting from order receipt to deliver to customers, is the key function in Distribution centre and it has the most impact on overall Performance. Reliability and Responsiveness are the major Performance attributes of the outbound distribution with covering process activities about 40.74 and 44.45 percent respectively; as they are addressed to customer-facing attributes, whereas Agility, Cost and Asset Management Efficiency have a small impact for about 15 percent from total 27 processes in Distribution centre.

Hence the Metric is a standard for measurement of the process performance in supply chain, and SCOR Metrics are demonstrated in three-level of pre-defines metrics. From Table 1, Performance Attribute – Reliability at Level-1 Metric is RL.1.1 (Perfect Order Fulfillment) as its strategic metric and key performance indicators (KPI). It has four main 'Level-2' metrics and various 'Level-3' metrics identified with the processes. It shows that Process SH1.2 (Load Vehicle & Generate Shipping Docs) at Distribution Centre (Outbound) directly affects the performance 'Level-2' Metric RL2.3 (Documentation Accuracy), and those are part of the KPI at Level-1 metric RL1.1 (Perfect Order Fulfilment).

The standard process-metrics alignments need to be analyzed to reflect performance aspects at each process. Reliability, Responsiveness, Agility, Cost, and Asset Management Efficiency attributes are demonstrated in three-level of pre-defines metrics. The consequence of the standard performance metric IDs are mapped to SCOR model-level 3, which will serve the performance attributes at the level-2 and level-1 to support the decision making. Therefore the analysis of performance metrics ID from Level-1 through level-3 can help manager to find the

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root cause of overall performance and lead to maximize the long term hospitals' efficiency and cost.

Attribute	Level-1 Metric	Level-2 Metric	Level-3 Metric		
Reliability [Total Perfect Orders] / [Total Number of Orders] x 100%	**RL.1.1** **Perfect Order Fulfillment**	**RL.2.1** **% of Orders Delivered In Full**	RL.3.33 Delivery Item Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
			RL.3.35 Delivery Quantity Accuracy		
		RL.2.2 **Delivery Performance to Customer Commit Date**	RL.3.32 Customer Commit Date Achievement Time Customer Receiving	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.34 Delivery Location Accuracy	OR1.1 Receive, Enter and Validate Order	Distribution Center (Outbound)
		RL.2.3 **Documentation Accuracy**	RL.3.31 Compliance Documentation Accuracy	SH1.2 Load Vehicle & Generate Shipping Docs	Distribution Center (Outbound)
			RL.3.43 Other Required Documentation Accuracy		
			RL.3.45 Payment Documentation Accuracy		
			RL.3.50 Shipping Documentation Accuracy		
		RL.2.4 **Perfect Condition**	RL.3.12 % Of Faultless installations	N/A	N/A
			RL.3.24 % Orders/lines received damage free	RE1.3 Check Order& Verify Product	Distribution Center (Inbound)/ Dispensing Point
			RL.3.41 Orders Delivered Damage Free Conformance	SH1.4 Receive and Verify by Customer	Distribution Center (Outbound)
			RL.3.42 Orders Delivered Defect Free Conformance		

Table 1: Level-1 through 3 of Performance Attribute – Reliability and Processes linked

5. DISCUSSION

In conclusion, this research has reached its objective and the research question. The main purpose of the present study is to develop a standardized business process models with a set of performance parameters for distribution center toward improving the hospital supply chain. The proposed reference process model was designed based on the generic distribution processes at three-large-size hospitals in Thailand. BPMN Notation and SCOR framework were applied to main activities in distribution center; Plan, Receive, Put-away, Order-Picking, Shipping and Return, where specific roles and responsibilities are defined at each process. The efficiency of business process, data consistency and supply chain management system for the end to end process between parties, have been considered for the performance measurement system design. With these results, it can be used to assist the manager on setting standard guidelines for implementation and/or process improvement within Distribution centre and toward Hospital supply chain. A well-structured reference model demonstrates key performance indicators at each process and roles can help management to analyze the problem root cause for further development.

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