AGILE SUPPLY CHAIN FOR CONTAINER TERMINAL

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Abstract: Growth and survival of an organisation are depended on the systematic planning and execution. A model is needed as it is a description of a system. This paper provides a container terminal for understanding the Supply chain process within terminal compound. Container terminal systems and functions are similar with manufacturing and material handling. The skeleton of the process in mapping using IDEF0 function as a powerful business process reengineering tool to model the operational process of container terminal. This model emphasise on the supply chain agility of container terminal from IDEF technique. It is a foresight idea in designing a supply chain of container terminal model based on processes from practical and theoretical feedback to ensure the practicability.

***Keywords**:* Agility, Container terminal, IDEF0, Supply chain

INTRODUCTION

Seaport is an interface between land and sea in transporting goods and people from point of origin to point of destination. Seaport has been established since early civilisation and evolves gradually from time to time. The emerging of container in 1950's has changed the trade of handling cargo from using net, pallet and break bulk to a uniform of box. The container terminals developments are in line with series of container vessels, handling equipments and technologies. This has created state-of-the-art container terminal in catering demand from users. The complexities of container terminals are being mentioned by previous researcher in this area and more complex with generation of container vessels in the market. Most of modern container terminals are integrated with supply chain process. Container terminals itself are having transportations, material handlings, warehousing, order processing, inventories and information technologies components. The complexities of container terminals are necessary to have an integrated system and a systematic monitoring process in dealing with discharge and loading containers.

THEORETICAL PERSPECTIVE

Supply Chain Management

In the early days, movement of goods and people are called as physical distribution. During that era, the movement process was not as complicated as today. The demand and supply is on the necessity rather than needs. However, the industrialisation revolution has changed the world after war world II, when people needs are more complicated and demand tremendously increased. The distribution also changed dramatically, customers are demand on the efficient and effective delivery system. The Council of Logistics Management (1986) define logistics as the process of planning, implementing, and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods, and related information flow from point-of-origin to point-of-consumption for the purpose of conforming to customer requirements. This definition is based on the current distribution channel from the point of origin to the users. However, the distribution evolution is still developing and operators have to fulfil all the demand from customers.

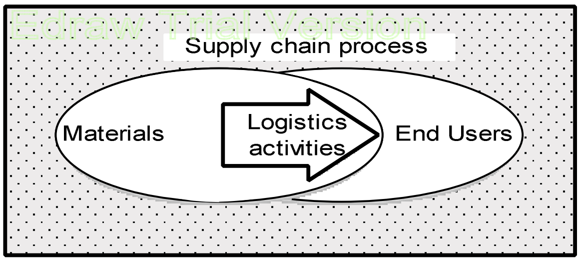

Figure 1: Relationship between Supply Chain and Logistics

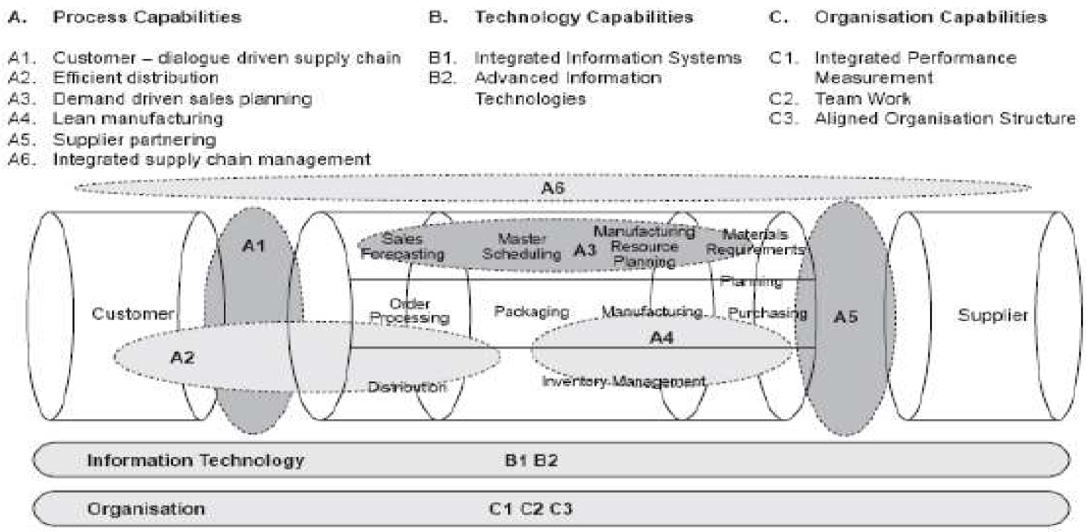

Figure 2: Supply chain operations framework model [21]

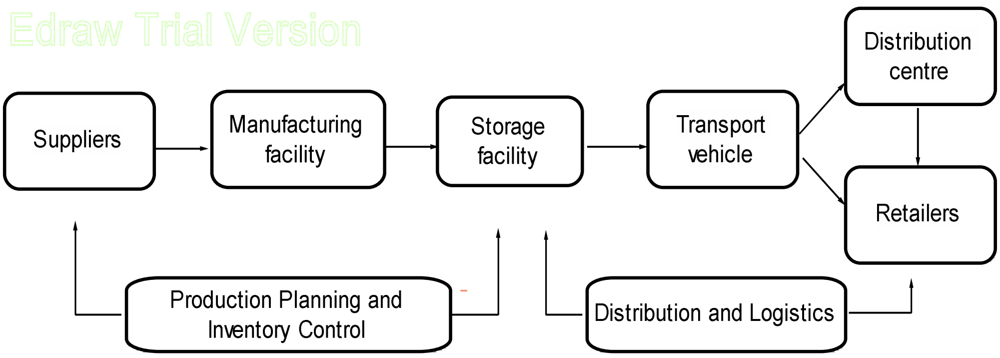

Figure 3: The Basic Supply Chain Process [6]

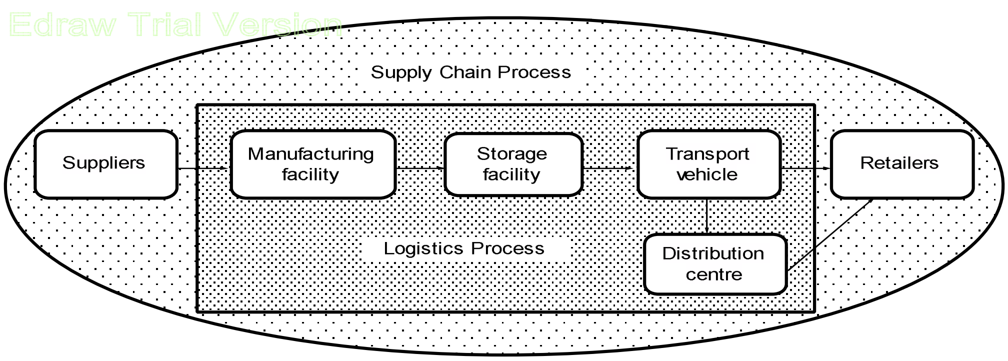

Figure 4: logistics inside Supply chain Process

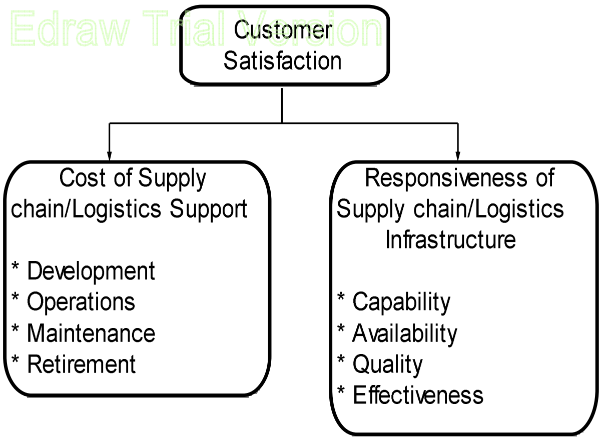

Figure 5: Supply chain and logistics goals

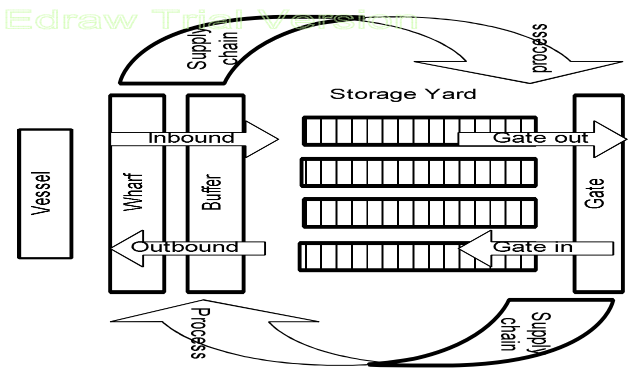

Figure 6: Typical container terminal layout with supply chain process

When the distribution process becomes complicated, another systematic distribution process is called as supply chain management (SCM) has been introduced. It was introduced by consultants in early 1980s and subsequently gained tremendous attention and it has been widely used especially in 1990s. This situation has made CLM revised their definition in 1998 to become logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements. The definition is covered the flow of goods, services, and information in both manufacturing and service sectors.

Figure 1 shows the relationship between supply chain and logistics, where logistics part of supply chain process in distributing goods to users. The distribution roles become greater as users demand increase gradually.

A systematic framework model for supply chain operations in an organisation was developed to understand the theoretical concept of an organisation [21]. The framework model consists of 3 components that are process capabilities, technology capabilities and organisation capabilities. Figure 2 shows the general framework for supply chain operations in an organisation. This process involve from the point of origin to point of customer. In general, there are 5 components of the process; customer, order processing/distribution, manufacturing/packaging/inventory-management, planning/purchasing and supplier. Hence, the complete process is called as integrated supply chain management. As a result, an efficient process of supply chain is able to increase organisation productivity and performance. In challenging scenario of modern economy, this process is crucial in maximising organisation profit and reduces unnecessary cost. An organisation must have all process, technology and organisation capabilities in order to compete with rivals.

Supply chain is an integrated manufacturing process wherein raw material converted into final products, then delivered to customer [6]. Basically, it comprises 2 basic integrated processes: the production planning and inventory control process and the Distribution and Logistic process.

Figure3 shows the basic process of supply chain which consist 2 elements; production planning and inventory control process and distribution and logistics. These 2 elements have covered all aspects of chain process i.e., manufacturing and storage sub-processes, and their interface(s). In detail, it is cover production planning and inventory process i.e., raw material, manufacturing process and material handling. Distribution and logistics covered all aspects of management inventory retrieval, transportation and final product delivery. Storage facility is the integral part of both elements.

Supply chain and logistics are two concept concerning the performance of business performance and highly interrelated [9]. However, these two are significantly different in terms of the thinking approach. Technically, supply chain is consisting of firms collaborating to leverage strategic positioning and to improve operating efficiency, whereby logistics is the work required to move and position inventory throughout a supply chain. Therefore, logistics is subset of supply chain within the broader framework of supply chain itself.

As been show by figure 3 and figure 4, there is nothing different between supply chain and logistic. However, most of researchers, practitioners, consultants academicians followed revised definition by CLM in 1998 as logistics is part of supply chain to complete the process. The elements of logistics are the key component in coordinate and integrate the process of supply chain to become successful. Figure 5 shows the supply chain and logistic goals in supplying products and services to customer. The objectives of supply chain and logistics are right product, right location, right time, right service, right information and right value are the component in coordinating and integrating all the resources for the supply chain.

By understanding basic supply chain process, it can be understood that container terminal plays a pivotal role as interface of sorting goods via land and sea. As a matter of fact, terminal itself plays it role as storage facility and central transport vehicle for inbound and outbound of goods.

Figure 6 shows basic container terminal layout and the process of supply chain implemented. Container terminal has four main components; gate, storage yard (container be placed for import and export or transhipment), Buffer (area for prime mover, fork lift etc moving around between storage yard and wharf) and wharf (place for vessel berth). The processes continuously happen for container inbound and outbound. The end process for container inbound is gate out for delivery to client, and for outbound end by loading onto vessel. Transhipment is an inbound process and the container be placed at storage yard while waiting for connecting vessel.

There are number of supply chain research topics and methodologies that have been identified and studied since the emergence of supply chain concept [56]. In optimization criteria in supply chain models have included cost [10], on the inventory levels [1], profit [16], fill rate [35], stockout probability [25], product demand variance [49], and system capacity [60] to name as an example. The previous researches look at deterministic and stochastic models deal with isolated parts of the supply chain system such as supply-production, production-distribution, or inventory-distribution systems. Some models are concerned with strategic issues for supply chains such as the most cost-effective location of plants and warehouses, flow of goods, etc., while others are concerned with operational issues such as order size, fill rate, inventory levels, etc.

However, until recently, measuring supply chain performance has not been considered an important source of competitive information. Even within corporations such as Sears and General Motors, which historically have had large company-owned supply chain systems, performance and measurement systems, in terms of their distribution networks, were not in existence [52]. This is partially due to the fact that the tradeoffs/relationships between the measures/decision variables that characterize specific supply chain components are often not completely known. For example, stockout levels and inventory turns are two mutually dependent variables with performance tradeoffs. Technological and process innovations can shift the cost trade off curves by reducing the cost of achieving lower inventories at a particular stockout level, or the cost of achieving lower stockouts at a particular inventory level. Information on changes in tradeoffs may not be readily available. Another reason for the absence of performance measurement tools is that the effective management of the supply chain requires knowing the performance of the overall chain rather than simply the performance of the individual supply chain members. Each supply chain member has its own strategy to achieve efficiency. However, what is best for one member may not work in favour of another member. Sometimes, because of the possible conflicts between supply chain members, one member's inefficiency may be caused by another's efficient operations. For example, the supplier may increase its raw material price to enhance its revenue and to achieve an efficient performance. This increased revenue means increased cost to the manufacturer. Consequently, the manufacturer may become inefficient unless it adjusts its current operating policy. Measuring supply chain performance becomes a difficult and challenging task because of the need to deal with the multiple performance measures related to the supply chain members, and to integrate and coordinate the performance of those members.

Integrated Definition Function

An effective and efficient management of supply chains has proven in offering prompt and reliable delivery of high-quality products and services for an organisation. Therefore, performance evaluation of the entire supply chain is extremely important to make sure the objectives are achieved. Hence, it is crucial by combining highly efficient resources of the supply chain elements in providing competitive and cost-effective products and services. Lack of appropriate performance measurement is the major obstacle to an effective of management of supply chain [34]. An alternative yet powerful technique, Integrated Definition Function (IDEF) has been introduced to map container terminal function as it is represented a set of standardized methods and family of graphical language for informational modelling in field of Software Engineering (SE), business processes and objects, and improvement of business process. The framework project called Integrated Computer Aided Manufacturing (ICAM) which was developed late 1970s as IDEF by United States Air Forces (USAF). IDEF aim is using Information Technology and modelling as a tool for production productivity in manufacturing. One of the methods, IDEF0 (Function Modelling) is a designed method to model the decisions, actions, and activities of an organization or system. The method is based on the Structured Analysis and Design Technique (SADT) of The United State Air Force that develop the model for communicating and analysing the functional perspective of the system. ICAM program developed a series of techniques like IDEF0 as to produce an information model as its represents structure and semantics of information for the subject area. IDEF1 function is to produce information model for the subjected area and IDEF2 as dynamics model as time-varying behavioural characteristics of subjected area. The generations of IDEF varies from IDEF0 to IDEF14 and play different functions (discuss under IDEF method). Practically, an effective IDEF0 models are able to organise and analyse of a system in an organisation. Hence, this can promote good communication between the analyst and the customer.

Taking into consideration supply chain as a medium of delivering products and services, IDEF0 is useful for a functional analysis in mapping the process. As a mapping process, IDEF0 is good in term of communication tool when involve with decision making. The goal of newly developed IDEF techniques is to enable experts to comprehend problems from different views and levels of abstraction. In this regard, integrated IDEF methods present basic tools of some modern strategies and methodologies of business process improvement, for example: Business Process Reengineering (BPR), Continuous Process Improvement (CPI), Integrated Product Development (IPD), Just-in- Time (JIT), Production Planning and Control (PPC), Quality Function Deployment (QFD), Total Quality Management (TQM), Total Productive Maintenance (TPM) [2,3,11,15,19,23,28,38, 51,54 and 55]. The application of integrated IDEF methods can solve narrow class problems, as well as can eliminate deficiencies of these problems proposing general methods.

The integrated concept of modelling has been accepted by the USA government, Pentagon and NATO and neither document cannot be defined until it is described using this methodology. A task which achieves this methodology must involve problems characterized by client/ server architecture, that is, to connect multiple computers. This approach enables connection of future IS and demands systems of quality defined by the ISO 9000 standard [26].

RESEARCH APPROACH

The IDEF Method

Strong software support there exists, which integrates IDEF methods, and enables connection of IDEF methods with other tools, such as software for simulation of business processes, software for activity based management of costs etc. Some integrated IDEF methods are: IDEF0 for function modelling, IDEF1 for information modelling, IDEF1X for data modelling, IDEF2 for modelling simulations, IDEF3 for modelling processes, IDEF4 for object-oriented projecting, IDEF14 for modelling networks (Table 1) [39]. Some types of IDEF methods are described in the works such as research on the IDEF0 [3,13,18,29,30,36,41,50,53 and 57], on the IDEF1 [58], IDEF1X [33, 36,37,42 and 43], IDEF2 [59], IDEF 3 [27,31,44 and 47], IDEF4 [45], IDEF5 [48], IDEF6 [46], as mentioned some to name those have conducted research on the IDEF methods.

All of the aforementioned IDEF versions are used for different purposes, as techniques for informational (semantic) modelling of data and as formal graphical language; also for needs of relation modelling of data and forming relation database (RDB). Initially the IDEF0 language for functional modelling was created in the frame of Structured Analysis and Design Technique (SADT) technique, and one subset of these methods (IDEF1X method, which was the first published in 1993 with Natural Language Information Analysis Method formerly known as Nijssen′s or An Information Analysis Method (NIAM) method presents the precursor of EXPRESS software tools for development of Standard for the Exchange of Product Model Data (STEP) applications. Complementary use of IDEF and UML to name [18 and 32].

The evolution of Integrated Definition Function (IDEF) [39] and it has different function for each type of IDEF. Table 1 depicts the attribute of each IDEF with its function. IDEF1 is used for information modelling, which captures conceptual views of the enterprise's information. It is an analysis method to capture, communicate, analyze, and understand the information needs of the enterprise. The models simply identify the enterprise's concepts of information such as department and employee and the concept that there is a relationship between the two, such as employee works in a department. IDEF1 is not a method for designing the database, but is a tool for the enterprise to understand the information it deals with, so information resource management can be supported. IDEF1X is used for data modelling, which captures the logical view of the enterprise's data and is based on an entity relationship model. It is a design method for logical database design once the information system requirements are known. The focus is on the actual data elements of the information system to be developed. IDEF2 Simulation Model Design method is used to represent time varying behaviour of resources in a manufacturing system. It has been replaced by various commercial products and notations. The IDEF3 Process Description Capture method is used to capture behavioural aspects of a system [44]. From domain experts, descriptions are captured in which the precedence and causality relationships between activities and events of the process are shown. Thus, IDEF3 is a structured method used to express how a system or an organization works and show different user views of the system. IDEF3 consists of two modelling modes: the Process Flow Description (PFD), which describes how things actually work in the organization, and the Object State Transition Description (OSTD), which summarizes an object's allowable transitions in a particular process. The PFD provides a process- centric view, and the OSTD view provides, among other elements, entry and exit criteria. These two complementary views more than adequately describe a process. The IDEF4 object-oriented design method was developed to support the object-oriented paradigm. IDEF4 supports the object-oriented design method. It currently supports design to implement C language applications. IDEF 5 through IDEF14 has not been pursued in depth at this time. Some academic work has been done in several areas, and the future of these methods is uncertain. IDEF 5 through 14 exists today in various stages and is intended to provide the capability to describe additional views listed in Table 1.

Table 1: List of IDEF Family Methods [39]

Type	Description
IDEF0	Function Modelling
IDEF1	Information Modelling
IDEF1X	Data Modelling
IDEF2	Simulation Modelling
IDEF3	Process Description Capture
IDEF4	Object-Oriented Design
IDEF5	Ontology Description Capture
IDEF6	Design Rationale Capture
IDEF8	User Interface Modelling
IDEF9	Scenario-Driven IS Design
IDEF10	Implementaion Architecture Modelling
IDEF11	Information Artifact Modelling
IDEF12	Organisation Modelling
IDEF13	Three Schema Mapping Design
IDEF14	Network Design

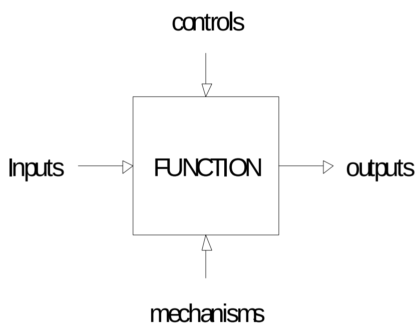

Figure 7: ICOM concept in IDEF modelling [22]

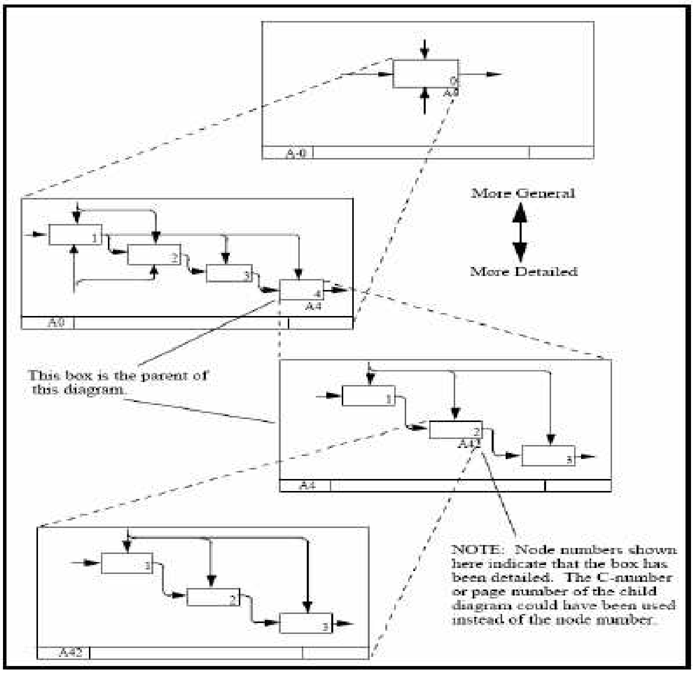

Figure 8: Decomposition Strucutre in IDEF0

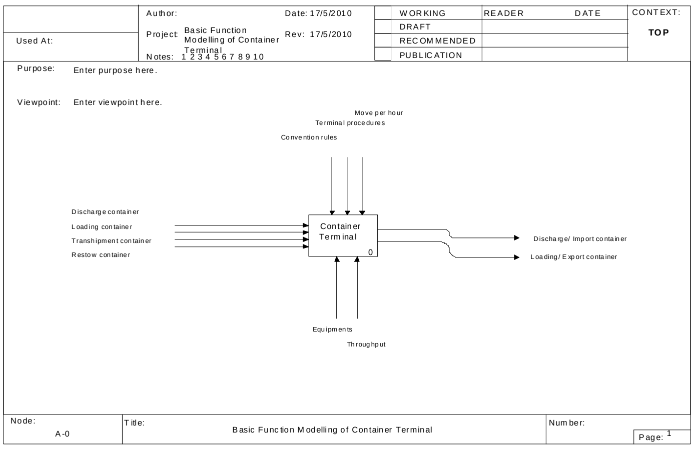

Figure 9: Basic function IDEF0 modelling in container terminal

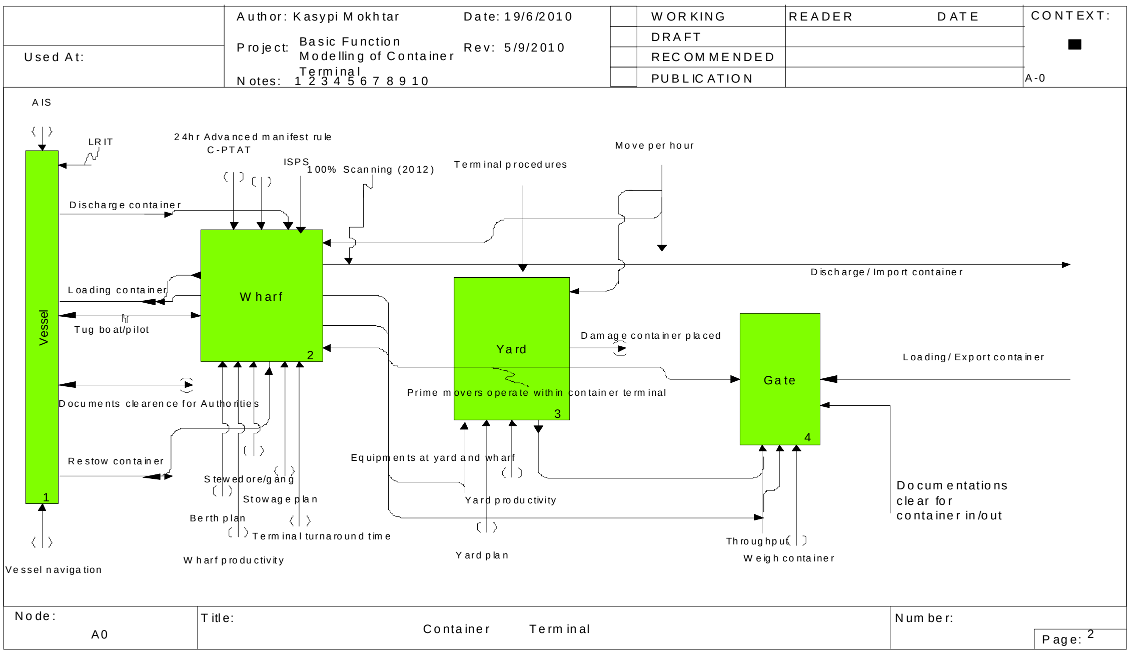

Figure 10: IDEF0 model for container terminal

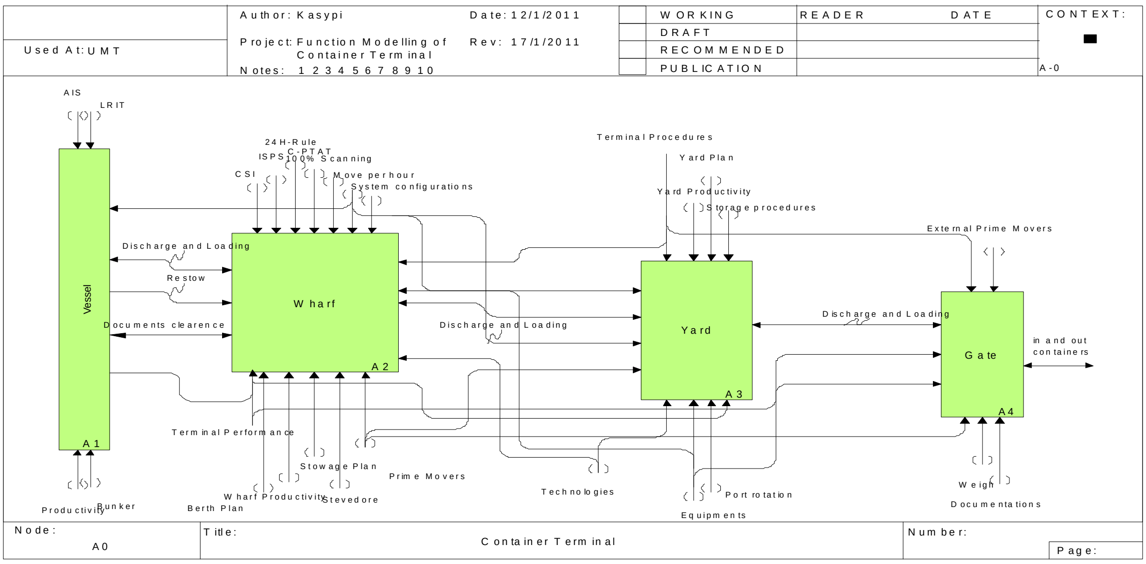

Figure 11: Validated IDEF0 Model

The IDEF method is used to indicate from the simple to complex function models in an organisation. There are many levels of IDEF which translate into different meaning of function. IDEF0 is one of the levels which signify the descriptive models that show the high level activities of a process. Figure 1 shows the function model indicates major activities and the input, control, output, and mechanisms associated with each major activity. IDEF0 models let the modeller portray a view of the process, the inputs (I) – trigger the activity by the arrow from the box left side, controls (C) – guide or regulate the activity by the arrow from the top and describe function 'why' and 'how', outputs (O) – results of performing the activity by the arrow coming out the box, and the mechanisms (M) – system, people, equipments used to performed the activity by the arrow from the bottom represents resources. It is also called ICOMs, in further; the process can be further disintegrated to show lower-level activities and ICOMs. In addition, these ICOMs needs some point as another notation to portray all points as branch control. Figure 7 shows the basic syntax of ICOM concept in IDEF0 modelling technique.

Figure 8 depicts decomposition structure in IDEF0. The top down mapping technique from gerenal to specific processes are expanded from ICOM basic and apply into detail diagram to the whole processes. The top level diagram can be decomposed into subsections of the system precisely with more arrows and names. Next level again decompose into subsection is called parent to child. All the decomposition process must follow strictly the syntax and sementic rules in ensuring the model able to describe precisely.

RESULT AND DISCUSSION

IDEF0 Supply Chain for Container Terminal

This paper is refer to the function modelling (IDEF0) at the container teminal. In general, function of a container terminal is similar where its discharge and loading container from and to vessel that berth at the wharf. However, the complexities of the terminal are depends on the types of vessels berth as the facilities for generation of vessels are slightly different. Taking into consideration of container terminal in Malaysia, the IDEF0 is able to portay level of functions for container terminal can be visualised as a system integrated. In addition, the function of IDEFs are different according to the needs of the system itself. In handling Malaysian container terminal supply chain, IDEF0 is use as a technique to model the activities involve within container terminal compound. Taking Klang Port as area of study to develop the model, some basic idea of ICOM has been generalised. The IDEF0 idea of modelling container terminal is made to ensure the operational process of the container is well structured.

Figure 9 depicts basic modelling of IDEF0 at container terminal in Peninsular Malaysia. Normal activities for inputs are discharge, loading transhipment and restow of container. The inputs are based on the container operation when vessels are berth at the quay side. The outputs of container terminal are import and export containers where these containers are being place for shipment at the container terminal either from or to vessel. The mechanisms of the process are deal with productivity, equipments, throughput of container at the container terminal. The controls of the process are convention, procedures and move per hours. At this point, control will monitor all the processes in dealing with every element of rules and regulations.

IDEF0 Model at Klang Container Terminal

Figure 10 shows the initial IDEF0 model that has been developed. The development of IDEF0 initial model derived from literatures, discussion and researcher experience in the logistics, warehousing, shipping and container terminal industry. There are 4 segment of activities i.e., vessel, wharf, yard and gate. Commonly the mentioned activities are happen within the container terminal. Each of the activities normally interrelated to each other. The main activity happens is discharge and loading container. It happens throughout yard, wharf and vessel. The model comprises area of operational, policies, documentations, planning and execution. By having mentioned segment, it is easier to map the model. The model has been validated through the various meetings

held with the relevant entities of the company. The utility of this proposal has been perceived by the company as an application object in order to model and to improve the production and transport planning process. It is important to clarify that the company's decision-makers accept and understand the model from a user's point of view, but that they can also extend it or modify it. The validation of the proposed model has generated some improvement proposals which are described in the next section.

Validation Model for IDEF0 at Klang Container Terminal

The final suggested model was built after creating the initial conceptual IDEF0 model. The interview for the model validation from the practitioner point of view is needed to ensure the validity of the model. To make sure validation is conducted properly, there are 2 sets of model (figure 10 and 11). Figure 10 shows the initial model before it has been validated with the expert from the industry. The range of experts varies from container terminal operator to shipping company. Discussion has been made with these expert and they are from the middle management and above (assistant manager and above). The discussion covers every aspect of the model to ensure the validity of model. Both experts either from container terminal or shipping company have agreed on the importance of the model. It is also practical to use, however, some terminology need to be refined since practitioner prefer to use their own terminology and sometimes it is different between container terminal and shipping company.

CONCLUSION

Container becomes an important medium of handling cargo globally. Container terminal is an interface between land and sea for cargo transaction. It is a key element in handling cargo either at port of loading or port of discharge. The complexities of container terminal needs proper mapping systems as this will increase container terminal performance as a whole. By using IDEF0, the container terminal operator enables to manage the process flow on the operation, management, planning and execution process as a whole. The mapping process is able to determine critical point of container terminal process and foresee the problem in advance.

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