THE DEVELOPMENT OF INFORMATION TRANSFERRING PROCESSES

For managing the machine's specification and engineering changes

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Bachelor's thesis

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ABSTRACT

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The objective of this thesis is to work out the information transferring processes for managing the information flow concerning the change requests from machine's specification and engineering perspectives. The main target is to develop efficient processes to work with the change management for the NPI projects within inter-company plants of Sandvik.

The understanding of process management for mapping the information flow is derived from supply chain management. Manufacturing planning and control introduces the production environment with the major element, which impacts information delivery. Managing the changes by understanding its causes, and analyzing its crucial and importance provides the basis for information transferring management. Modeling and understanding the current information transferring processes is critical for identifying the existing problems and potential risks in the process. The affection for material handling in the processes has been analyzed. The flowcharts mapped out mainly depend on the collected data from personnel interviews in different locations. The ERP system and PDM system have been studied, since ERP is for managing the BOM and PDM is for managing the changed drawing information within the processes. The development proposal is presented which is from the analysis of the current state processes and the process measurement.

The main focus of the NPI projects is to have the efficient management for transferring the new products' manufacturing and assembly to satisfy the specified market area and customer groups. The information transferring processes for managing the change requests across the three plants need to be defined and developed. Inconsonant and unstandardized processes result in messy management for the product's assembly with improper material supply. Information sharing with reliable delivery is crucial for the information transferring processes. Standardization is the key consideration in managing the process. The involved parties' responsibility should be identified in the process.

Keywords Process Mapping, Information Flow, Change Management
Pages **72** p. + appendices 2 p.

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The writing of this thesis has provided a wonderful opportunity to explore the project management for handling information and process to support the manufacturing operations between the inter-company plants of Sandvik Mining and Construction. It has also provided the opportunity for gaining the useful experience of detecting the opportunities and difficulties that the co-operation faces.

At the same time, I had experienced the great challenges of writing a thesis, including objective identification, topic scale measurement, different organizational understanding, and different processes approaching for gathering the information. The opportunities and difficulties for joining operations are very much different from writing a thesis. However, all of them have helped me to understand much better about self-ability and self-management. The most important achievement from this thesis work is my understanding and improvement of co-operation with different people (from different cultures with different languages) within the inter-company plants of Sandvik.

I am so appreciative that Elina Pyykkö gave me the opportunity to work on this topic. All of the colleagues from production departments in different locations have been very supportive. The logistics manager and quality manager along with Elina Pyykkö as the whole steering group has provided all kinds of necessary help and suggestions for my thesis work. Many thanks belong to Elina Pyykkö, Jenni Mustonen and Anne Kuosmanen, and all the colleagues from different departments in different locations for spending their time and effort in helping me. From this thesis work, I got the opportunity to know people from different inter-company plants, and the study has included plenty of interviews and pleasant discussions. At the same time, I also like to thank my thesis mentor Tapani Honkanen for his great encouragement and valuable comments during my thesis process. There are still so many people who had helped me during my thesis process from the company, sorry that I cannot mention all of them here. I am appreciative of their help and patience. At last, I would like to thank my family and friends with the great supporting during my thesis work.

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Chunling Liao

ABBREVIATIONS

ASC	Assembly Center
ATO	Assemble-to-order
BOM	Bill of Material
DMR	Defective Material Report
EC	Engineering Change
ECN	Engineering Change Notification
ECR	Engineering Change Request
ERP	Enterprise Resource Planning
HB	Home Base
MPC	Manufacturing planning and control
MPS	Master Production Schedule
MRP	Material Requirement Planning
NPI	New Product Introduction
PDM	Product Data Management
SC	Specification Change
SCM	Supply chain management
SMC	Sandvik Mining and Construction
UGM	Underground Mining

CONTENTS

1 INTRODUCTION

Nowadays, the rapidity of technological evolution that combines with rising customer expectations has created global competitive pressures for companies to win the business. For the kind of manufacturing companies, global product allocation is one of the most important strategies to meet the specific market and customer requirements along with the reduction of total costs.

Global product allocation asks for new organizational operations with process' design and implementation, by which changes will occur. When managing the changes within an organization, the management of people and processes is the primary element to determine the operations' success. The proper process helps people to understand the input and output of the operations thoroughly, and connects every section within the organization to work more efficiently. Moreover, the proper definition of cross-functional processes is essential for winning the competitive advantages in a supply chain.

This thesis was initiated by Sandvik Mining and Construction (SMC), Finland. The author of this study has been involved in the working tasks in different inter-company plants to handle the material delivery and warehouse management before this study was launched. The previous working experience contributes the better understanding of the machine structure and correlative components both from the mechanical and electrical views.

Moreover, the previous degree study from school for the theoretical knowledge (including the subjects of supply chain management, process management, change management and so forth) has provided an understanding of the organizational functionalities within the chain. It also has offered the basic comprehension of the corresponding responsibilities from different departments with different positions to operate in the chain, which could be reflected in the information transferring processes.

This thesis will be primarily constructed into two major parts: the theoretical information will be first introduced as the guideline, and the practical operations will be presented in the later part to show the study and working results which based on the guidance. The main research method is primarily contributed by personnel interviews and relevant meetings to gather the most important information for studying the current state processes.

1.1 Thesis background

In Sandvik Mining and Construction plant A, the New Product Introduction (NPI) Projects had set up one by one in order to transfer the assembly and operations of two loaders' product types from home base (HB) A to Assembly center (ASC). These two product types have been operated the machines' manufacturing and assembly in ASC for more than two years.

Recently, in Sandvik Mining and Construction plant B, the first New Product Introduction Project also have been set up to transfer the machine's manufacturing and assembly for one new product module of drill rigs (DDxxx) from home base (HB) B to ASC. However, other than Loaders, this machine module is not only a new product for HB B but also for ASC to have the assembly. DDxxx is a more complicated machine type than loaders both from mechanical and electrical perspectives. Therefore, this brand new NPI project has been expected to meet more challenges and risks for managing the project and relevant operations' transferring.

Efficiently managing the changes from HBs to ASC is a very critical step for the NPI projects' management. Hence, all of these NPI projects had set up their project's own organization and product's assembly transferring processes to handle all kinds of changes. Furthermore, in order to run the projects smoothly within the inter-company plants from different production departments, the project members are formed from not only HBs but also ASC to co-operate together.

As a result of the culture and language difference, some serious communicating challenges can be expected when handling the NPI projects' transferring processes. Furthermore, managing the changes asks for more attention and effort to smoothly allocate the product's manufacturing and assembly process. Information delivery and accuracy have been considered to be the most critical element for determining the information flow efficiency, by which enables the better cooperation and management for the whole project. Synchronously, the required material can be handled and delivered precisely to reduce total work force and cost.

This thesis is concentrating on the study and analysis of the current state information transferring processes that for managing the machine's specification changes and engineering changes from the NPI projects. The objective is to explore the existing problems and the possible hidden problems within the current state processes.

Furthermore, according to the requirements and suggestion from the higher management level within the inter-company plants of SMC, then estimates and develops an appropriate solution for the prospective information flow management. Therefore, the current state information transferring processes will be examined, and then redefined according to the process improving requirements.

Lastly, the final target of this thesis is to form the standardized information transferring processes for managing change requests that both concerning machines' specification and engineering perspectives. The further expectation is to have the unified processes for managing the change request information within relevant sections for all the NPI projects from HBs to ASC in future.

1.2 Empirical research

The definition of empirical research can be understood as research based on experimentation or observation. Usually, the following series of elements need to be identified for designing a research proposal, (PPA 696/697 STEPS IN EMPIRICAL RESEARCH):

- Identification of purposes. What exactly needs to be found out? What is the researchable problem?

- Theory background. What does the relevant literature in the field indicate about this problem? Which theory or conceptual framework can be linked?

- Data collection. What could be the solution for gathering information?

- Data analysis. What kind of data is needed and useful? How to identify the finding?

- Recommendation. What recommendations can be made for this purpose? What suggestions can be made for further research on this topic?

In this thesis, the integration of theoretical information and practical operation will be presented. The theoretical knowledge will be mainly based on the author's own understanding from degree study in the school, as well as the correlative reading material from the company. And the empirical research for doing this thesis will be primarily by self-observation and personnel interviews.

The previous working tasks' involvement from the company has provided the experiential knowledge and so deeper insight for better understanding of the NPI projects. Figure 1 shows the constructive steps of the research approach for doing the thesis by the combination of theoretical knowledge and practical exercise from the company.

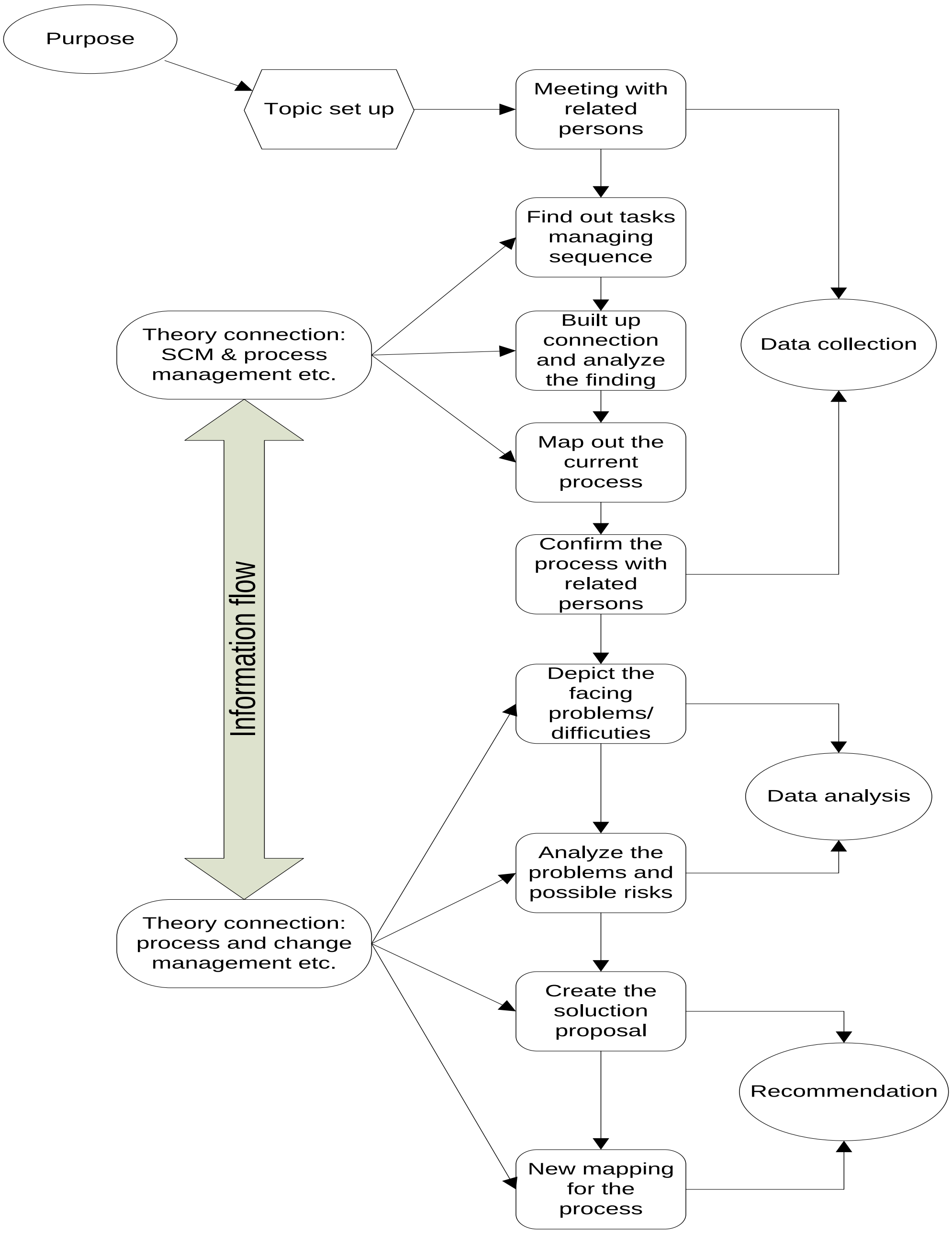

Figure 1 The constructive model for research approach.

1.3 SANDVIK Group

Sandvik is a successful global company with a strong position in its selected areas. Today it has 47000 employees and representation in 130 countries. Sandvik's annual sales in 2010 were approximately SEK 83 billion. Its goal is to develop and produce high value-added products to increase customers' productivity and profitability. (Sandvik group 2010.)

The Sandvik Group conducts operations within three core areas (figure 2):

- Sandvik Tooling
- Sandvik Mining and Construction
- Sandvik Materials Technology

Figure 2 Sandvik's core areas (Sandvik group, 2010)

Sandvik Mining and Construction is a business area within the Sandvik Group and a leading global supplier of equipment, cemented-carbide tools, service and technical solutions for the excavation and sizing of rock and minerals in the mining and construction industries. Its range of products includes rock tools, drilling rigs, loaders and trucks, crushing and screening machinery and bulk-material handling systems. (Sandvik Annual report 2010.)

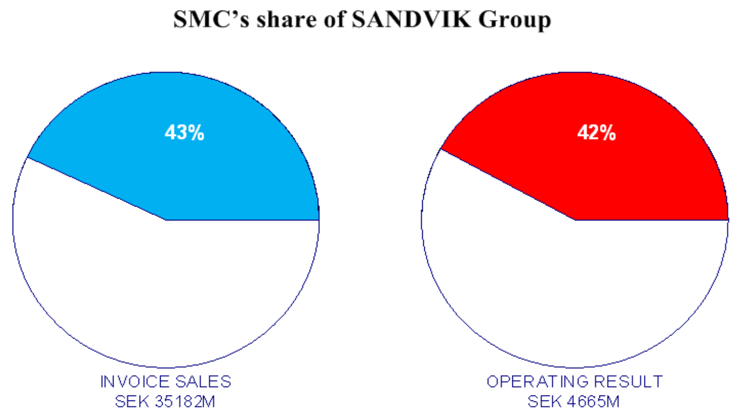

Figure 3 SMC's share of Sandvik Group (Sandvik annual report 2010)

Currently, SMC has three segments, including underground hard rock mining, underground soft rock mining and surface mining. The partial section of ASC and home base A, B's production plants, which belong to the SMC business segment provides solutions for underground mines.

The SMC plant B for underground mining (both hard rock and soft rock) is mainly to manufacture drilling machines for mining and drilling. The final products are referred as drilling rigs or rigs. The plant A manufactures loaders, and ASC works mainly for manufacturing loaders, drill rigs, and other product types from other worldwide HBs of SMC. Since the emphasis on studying the information transferring processes for managing new product types' manufacturing and assembly, this thesis will mostly take into account of DDxxx from HB B to ASC for the NPI project in the UGM segment.

Figure 4 Tampere Plant of Sandvik (Sandvik Mining and Construction presentation 2010)

2 SUPPLY CHAIN MANAGEMENT

Logistics can be seen as the predecessor of supply chain management. It is designed to achieve an efficient and effective goods distribution system. Generally, logistics encompasses all material-related activities of order processing, inventory management, warehouse and material handling and physical distribution. However, compared to logistics, supply chain has a wider concept, it encompasses all activities involved in the flow and transformation of goods from the raw material stage to the finished product as well as associated with information flows, cash flows and product flows within an organization. (Ashish Bhatnagar 2009, 2-5.)

Moreover, supply chain management has a wider scope of integration. Ashish Bhatnagar (2009, 2) defined SCM as the integration of key business processes of planning, implementing and controlling efficient flow of raw materials, in-process inventory, finished goods and related information from the original point to the consumption point in order to fulfil customer requirements. In general, there are two kinds of movements within a supply chain, including the physical movement of material or finished goods as figure 5, and the movement for information that drives flow up the chain (figure 6).

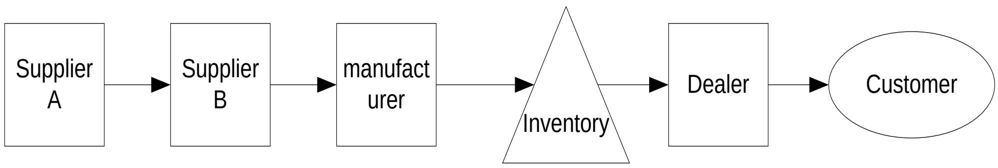

Figure 5 Physical movements in supply chain (Adapted from Sadler, Ian 2007. 7)

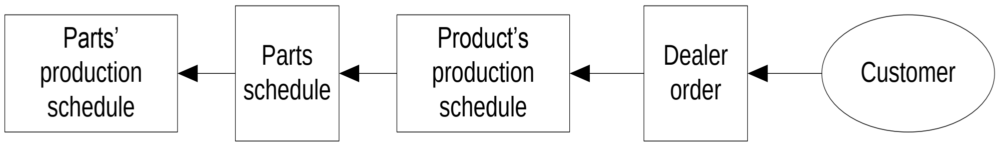

Figure 6 Information drives flow up the chain (Adapted from Sadler, Ian 2007, 7.)

2.1 The integration of supply chain

Usually, in order to win competitive advantages from the market, most of companies need to emphasis on the improvement from following aspects:

- Reducing the cost and bullwhip effect
- Increasing service level

- Better application of resources
- Responding effectively to changes in the marketplace

Recently, the challenges for companies to improve their overall performance are more commonly from integrating the front end of the supply chain which means customer demand, to the back end of the supply chain, which is the production and manufacturing section of the supply chain (Simchi-Levi & David Kaminsky & Philip Simchi-Levi & Edith 2003, 41). Therefore, supply chain integration can be also understood as working collaboratively with customers, suppliers, trading partners and service providers to ensure the effective flow for delivering goods and services to consumers.

The objective of supply chain integration is to synchronise the requirements of the customer with the flow of material from suppliers in order to achieve a balance between the goals of high customer service, low inventory investment and low unit cost. Supply chain integration provides a key opportunity for leaders and managers of companies along the chain, to work together through shared information and joint provision and delivery of goods and services for customers. (Sadler Ian 2007, 2-19.) When managing the synchronization for supply chain integration, information synchronization is one of the most important aspects throughout the whole chain for improving the integration performance.

Usually, when designing the supply chain integration, the inherent variability for demanding a product and the variable nature of purchasing, provision and delivery time need to be considered as an important aspect. Moreover, the information system (which is a new element of supply chain integration to provide the update information within the whole supply chain) enables companies to be responsive to customer orders rather than to anticipate orders by making goods in advance. Consequently, all involving parties in the chain can synchronise their operations, then inventory can be reduced along with eliminating duplicated practices. (Sadler, Ian 2007, 18-19.)

On the other hand, supply chain integration asks for high competitive operations in bounding, designing and operating for the major stages in the location, transformation and movement of raw materials and finished goods (Sadler, Ian 2007, 19). Therefore, high performance of supply chain integration for managing the information flow is essential to ensure the effective responding to fulfil customer requirements.

2.2 The performance drivers of supply chain

Logically, strategic decision and operational decision are the two primary aspects for making decisions in supply chain management. Strategic decisions are designed as the direction for supply chain policies, and these decisions are linked to corporate strategy. Operational decisions focus on the daily basis, it makes an effort in managing product flow efficiently in order to achieve the goal of strategic decisions.

When making the decisions for designing the daily operations within a supply chain, there are five significant focus areas for the company in order to achieve the capabilities and effectiveness of the supply chain.

– PRODUCTION. When defining the product types and quantity for a certain market, master production schedules need to be created for considering the plant capacities, workload, quality control and equipment maintenance etc.

– LOCATION. Production's allocation will lead to the movement of material and finished good, by which cost increased. However, on the other hand it could reduce the total costs by material or product's location allocation due to the different custom's tax regulation.

– INVENTORY. Material types and quantity for inventory level need to be considered carefully in order to reduce cost. However, safety stock may be needed to prepare in order for satisfying customer requirements.

– TRANSPORTATION. The delivery solution for moving the material or goods from one location to another, hence, having better decisions for choosing the proper transportation mode will help to reduce the workload and cost.

– INFORMATION. The sharing of timely and accurate information within a supply chain will improve the organizational cooperation, and contribute greatly for better decision making.

Chopra and Meindle (2009, 7) defined these five areas as performance drivers that can acquire the needed capabilities for a given supply chain. Figure 7 illustrates the connection between these five drivers within the supply chain.

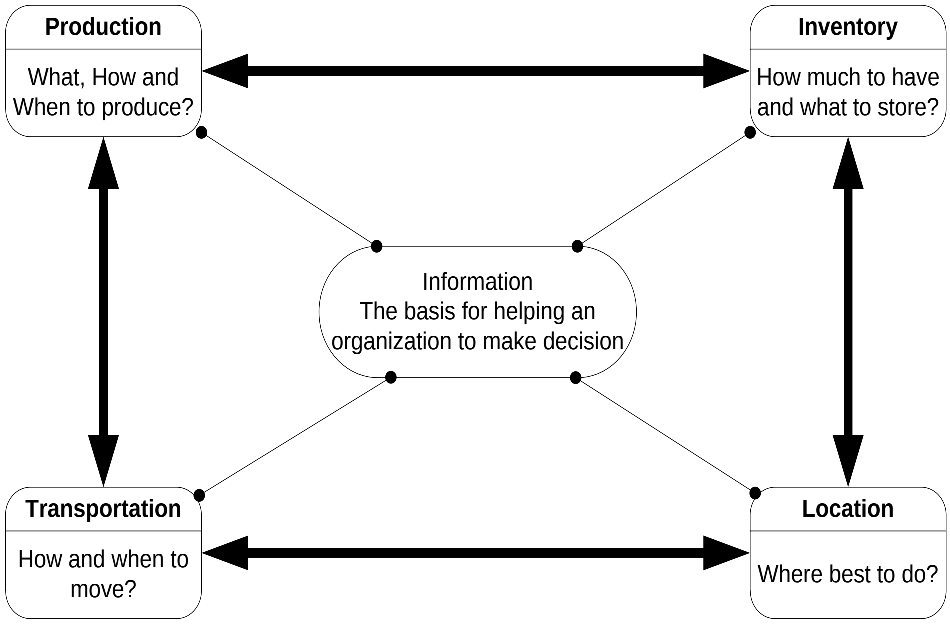

Figure 7 Major drivers of supply chain. (Adapted from Ashish Bhatnagar., 2009, 11.)

As one of the most important drivers, information connects all day-to-day activities and operations within a supply chain. It improves the speed and accuracy of the supply chain, and provides the basis when decisions' making regards to the other four supply chain drivers. The application purposes of information in a supply chain can be summarized as follow:

- Daily activities' coordination
  By cooperating with the other four drivers in the supply chain, the available data of product's supply and demand can be used for a company to decide the production schedule, inventory level, transportation and stock location etc. For example, the information of daily assembly workload scheduling will provide the material requirement information for Kanban parts with daily material handling.

- Forecasting and planning
  Based on the available information, the tactical forecast will be made to guide the setting of master production schedule in order to meet future demands. For example, the order information from customers or forecasting will contribute to the material requirement information for supporting the production demand.

Eventually, sharing the updated and accurate information synchronously in every section of a supply chain for all kinds of management and operational activities will help to decrease the total costs and risks and increase the competitive advantages for winning the company's business.

2.3 Information flow

Information communication is essential for helping and enhancing all the operations in a supply chain to work properly. Understanding the importance of effective information flow contributes greatly to identifying the efficient application of information.

Information is one of the supply chain drivers that enable the other drivers (including production, inventory and transportation) to work together for creating an integrated supply chain (Sadler, Ian 2007, 153). Thereby, information flow can be summarily understood as the driver for material flow to work for the product's manufacturing operations. It starts with the end customer and works up the supply chain as shows in figure 6 of chapter 2.

According to the applying purposes of information, three levels of information can be identified:

- Data is the first level. It is the collection of the company's real orders or inventory.

- Information is the second level. It is the valid summary of data for communicating to the place where it is needed for management action.

- Knowledge is the third level. It means the companies' capability with the understanding for handling the complex situation.

The application of information from first level and second level are the most common solutions to support the day-to-day activities in the manufacturing environment. And the third level can be normally seen as the direction guidance from the higher management level for managing the strategic decisions.

2.3.1 The essential elements in the information flow

In general, when having a new product type's introduction and manufacturing in manufacturing companies, it is important to set up a project with its own project organization for taking care of correlative management and operations. Therefore, the information flow, under the project's management, can be seen as one link to manage all the essential elements among the project organization.

There are five essential elements constituting the information flow which present the major activities for managing a project in product manufacturing. Table 1 lists these elements, along with the related documents used and their contents.

Table 1 Essential information in one link (Sadler, Ian 2007, 129)

Element	**Document**	**Content**
Order-taking	Customer order	List of products, quantities and delivery location required by the customer
Purchasing	Purchase order	List of materials, components and delivery point required by manufacturing
Scheduling	Production schedule	Infrastructure to manufacture products in a particular sequence and quantity
Inventory	Inventory record	Quantity of each kind of material or product and bin location at a storage area
Delivery	Invoice	Confirmation to be customer of the quantity of each product delivered to its store

2.3.2 The information framework

The objective of information flow in a supply chain is to have the information sharing across the whole supply chain. There are four basic supply chain stages and four decision phases to form the information framework as illustrating in figure 8. It is proposed to have the analysis for identifying whether sufficient information is available for every section throughout the whole chain.

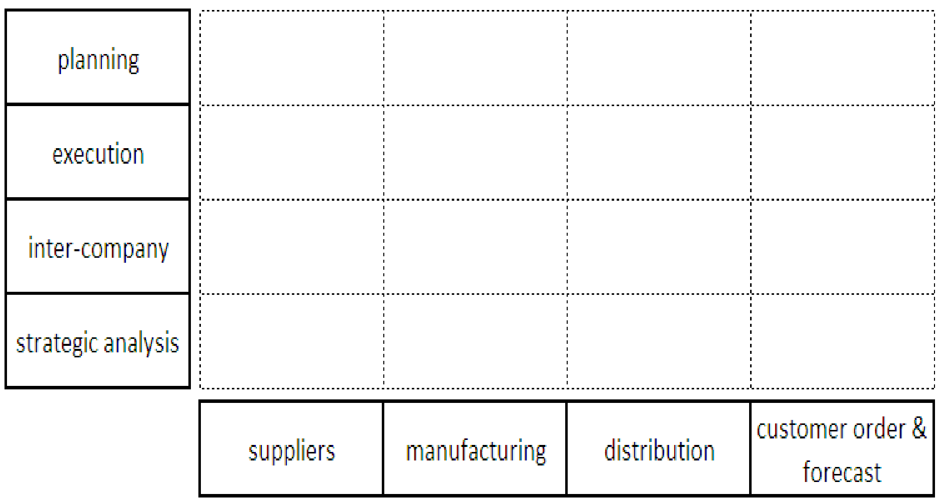

Figure 8 Information framework of a supply chain (Adapted from Sadler, Ian 2007, 127)

1) Four supply chain stages:

– Supplier information is about the information availability for items with purchasing, stock, lead-times and prices.

– Manufacturing information indicates the size, cost, lead-time and location for manufacturing a product.

– Distribution information contains the information concerning about logistics solutions, transportation mode etc.

– Demand information is mainly deal with the information concerning customer with the possible forecast.

2) Four decision phases:

– Planning is the focus on capacity, inventory and deliveries from the medium-term perspective.

– Execution emphasis on transaction records with short time frame.

– Inter-company means to move and use information between separate companies.

– Strategic analysis is proposed to model future situations by applying the information from other phases.

The information framework is a tool to indicate where each of the available sets of information sits in the matrix, and which lack information and data sets that can be coordinated (Sadler, Ian 2007, 127-128).

2.4 Information system

A variety of information systems and technologies has been introduced to manage the movement of information to the right places in the right forms so that the chain and its stages can be organised, measured and controlled. An information system is the involvement of people, equipment and procedures to gather, sort, analyse, evaluate and then distribute information to the appropriate decision-makers in a timely and accurate manner for making the right decisions. (Sadler, Ian 2007, 125.) The emphasis and importance of managing information is to ensure the application of direct, immediate and accurate information.

2.4.1 Enterprise resource planning (ERP)

The ERP system had evolved from MRP and MRP II systems by improving the overall advantages and overcoming the limitations of the previous systems. ERP is one of the most important information systems to manage the much more complex data structure throughout the information flow.

Generally, an ERP system can be seen as the integration of all the functional modules across the company to use a common database that is updated in real time. At present, the utilization objectives of ERP systems are pressured to (Sadler, Ian 2007, 130-131):

- Having all needed information for decision-making in one place.
- Being ‘fully relational’ so that data entered no matter where, will automatically update all other uses of the same data in other parts of the company’s database.
- Integrate information from numerous divisions or subsidiaries of a company.
- Incorporate new versions of software.

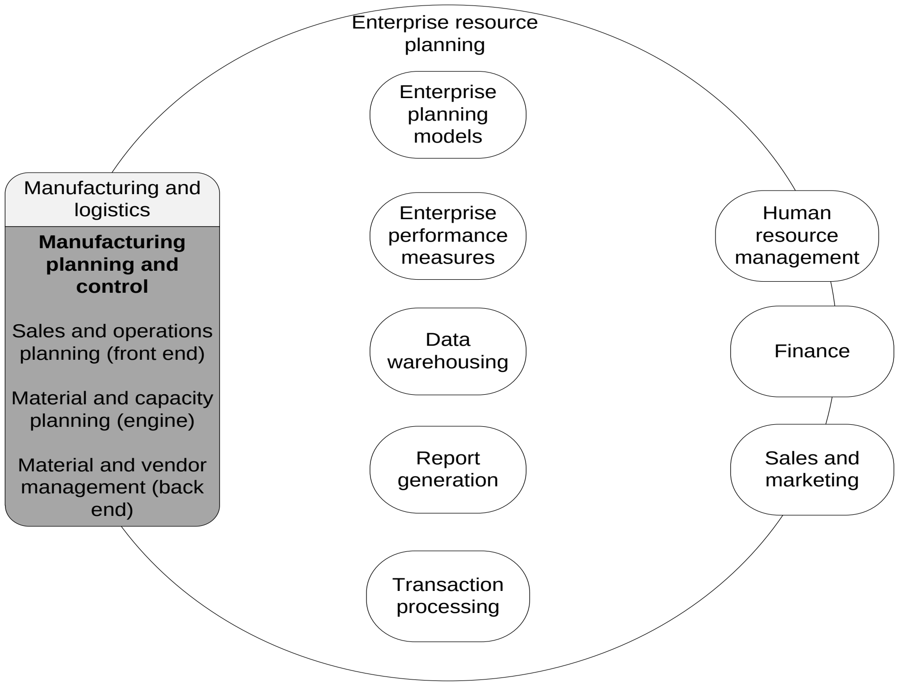

Figure 9 The scope of ERP application, (Adapted from Jacobs et al. 2009, 15.)

ERP can be used as the backbone of the information system. A typical ERP system is made up of functionally oriented and tightly integrated modules. The application of ERP system impacts every function in an organization from order-taking to accounting and from procurement to warehousing. Figure 9 shows the scope of ERP application.

2.4.2 Product data management (PDM)

A PDM (product data management) system is an application for managing product information and the implemented processes. The PDM systems have been developed to manage the large volumes of information more effectively and to meet demands for faster development of more complex products. These systems provide access to and control of information and support different kinds of processes. (Crnkovic Ivica 2002, 17-21.)

Typically, the PDM system is used for database records that include the information of product configurations, specifications, CAD drawing, general documentation and so forth. In a way, it manages all product information required throughout the life cycle of a product. (Crnkovic Ivica 2002, 17-18.) Figure 10 shows the scale of the PDM involved in the processes of product life cycle (PLC).

The major consideration of the PDM system in this thesis is the application for managing the machine's specification and the drawings of corresponding components / parts.

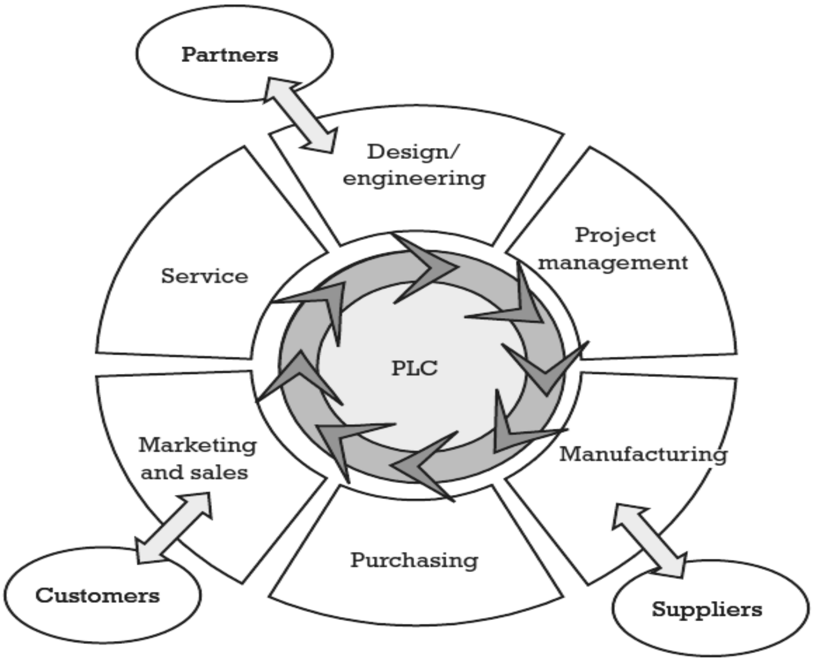

Figure 10 The involvement of PDM in PLC (Adapted from Crnkovic Ivica 2002, 20.)

2.5 Manufacturing planning and control (MPC)

The manufacturing planning and control system focus on planning and controlling all aspects of manufacturing, including material management, machines and people planning, and the coordination with suppliers and key customers. All of these activities are changing all the time and responding differently according to the different market requirements and company strategies. Hence, the better understanding and application of an effective MPC system is the key to have success in the kind of products manufacturing company. Furthermore, effective MPC systems coordinate supply chains-joint efforts across company boundaries to achieve the competitive advantages (Jacobs et al. 2011, 1).

As classified by Jacobs et al (2011) in the book of Manufacturing planning and control, the typical activities which supported by MPC can be divided into three time horizons.

- In the long term, the responsibility of the MPC system is to provide information for making decisions on the appropriate amount of capacity to meet the market demands of the future.
- In the intermediate term, the MPC system addresses the fundamental issue to match supply and demand in terms of both volume and product mix.
- In the short term, the resource's detail schedule is required to meet production requirements. For example, the master production schedule works as a statement for production with the detail production planning.

Moreover, for managing the day-to-day activities, the MPC system has to keep tracking resource usage and execution results. It should have the detail report on material consumption, labour and equipment utilization, completion of customer orders, and other important measures of manufacturing performance. In addition, the MPC system has to provide the customer requirement information which concerns changes for a certain product or service to the involving parties / operators in a supply chain.

2.5.1 The MPC system framework

As illustrated in figure 11, this framework is a schematic of the general MPC system. Nowadays, it is very typical to have the MPC system imbedded in an enterprise resource planning (ERP) system. In terms of understanding the MPC system, the framework in figure 11 has been divided into three phases: Front end, Engine and Back end.

The phase of front end, builds up the overall company's direction for manufacturing planning and control. Demand management assists all kinds of correlative activities in a supply chain to have demand on manufacturing capacity. Resource planning decides the needed capacity to produce the required products for now and future, it provides the basis to match the manufacturing plans and capacity. Sales and operations planning determines the manufacturing role to meet the company strategy, it helps to balance the sales or marketing plans with available production resources. The master production schedule states the future type of the end product, which will be manufactured, its support is demanded by sales and operations plan. (Jacobs et al. 2011, 3-4.)

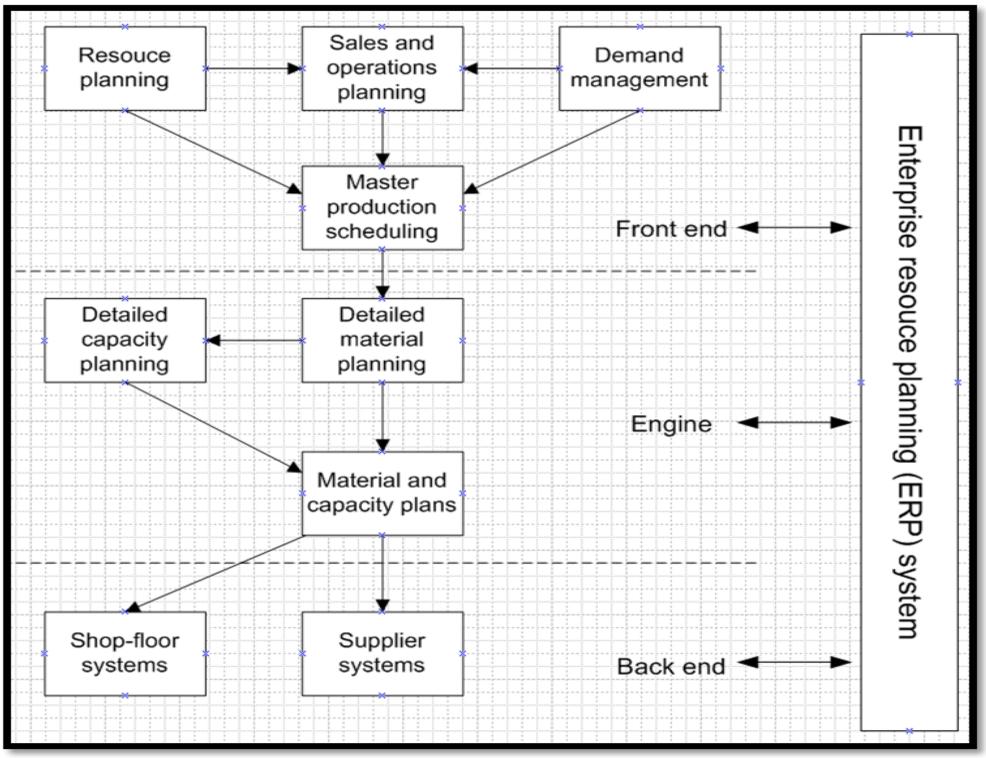

Figure 11 Manufacturing planning and control system (Adapted from Jacobs et al.2011, 4.)

The phase of engine focuses on detailed material and capacity planning. For example, from the manufacturing company, which has a wide variety of products with many parts for every product, the material requirements planning (MRP) is used to fulfill the requirements of detailed material planning, since there may be thousands of managed parts and components. In other words, MRP determines the time-to-time plans for all required component parts and raw materials to produce all the products in the master production schedule. (Jacobs et al. 2011, 4.)

Back end, which is the bottom phase of figure 11 draws the execution systems of MPC. Generally, the application of the products manufactured and production processes determines the configuration of the systems. There are two kinds of information for the supplier system to provide to the company's suppliers in the bottom phase of the MPC system, including updated priority information and future plans.

- The updated priority information helps the suppliers to understand better with the company's current conditions for managing changes.

- The future plans help the suppliers to understand the company's expectation and requirements. It also helps the supplier to have better production plan in order to provide the right material in good time.

The shop-floor systems are used for managing the material utilization to produce machines in different work centers, and the routine events as starting and completing orders for parts will reflected in the schedule along with other problem conditions. (Jacobs et al. 2011, 5.)

The MPC system framework has high integration with different kinds of available software (for example, the ERP system) to link the business activities together, by which enables the inputs provided from MPC system to all of the company's functions that need the information.

2.5.2 The production environments in MPC

Basically, there are three kinds of production environments which affect the design of the master production schedule in the MPC system by the identification of the production approach, variety of product types, and the market focus of the company (Jacobs et al. 2011, 154). Simultaneously, it determines the solution and application type of information to support production in the supply chain.

- Make-to-stock. It means the companies that provide the product for their customer from finished good inventory.

- Make-to-order. It is the companies that have all the activities (from raw material to the finished good) to manufacture the product which according to the customer's order requirement.

- Assemble-to-order. This includes the kind of companies that combine a number of options together to meet the customer's specification.

The involving organization in this thesis is the kind of assemble-to-order project organization, its manufacturing environment is typified by plenty of possible end item configurations (according to customer requirements), all made from combinations of basic components and subassemblies.

The high possibilities of the end-item make the end-item configurations' forecast very difficult, as well as the required material for managing the stock level. As a result, it is very important for the company to maintain flexibility, starting basic components and subassemblies into production, but generally not starting final assembly until a customer order is received (Jacobs et al. 2011, 155).

2.5.3 Master production schedule (MPS)

Usually, the previous yearly sales and production volume have a very high impact on determining the setup of the optional components' list when concerning the marketing focus. The accuracy of the master production plan plays a critical role for forecasting the future production volume, as well as the material requirement to fulfil the production requirement.

In the manufacturing planning and control system, the master production schedule can be seen as a statement of production. It specifies the products with the completed quantity, the completion time, the product type and the supplied solution to meet the future demand. Mainly, there are two considering levels for defining the master production schedule, (Jacobs et al. 2011, 153) such as:

- From the conceptual level, the MPS is the translation of the company's sales and production plan to the future plan for producing specific products.

- From the operational level, the focus is to have the MPS record for developing to be compatible with the material requirements planning system and to provide the information in order to coordinating with sales.

The MPS differs from forecast, it mainly concerns the production capacity and cost, sales and operation plan, material requirement plan, as well as other resource possibility.

In the assemble-to-order manufacturing environment, the MPS unit is stated in the planning bill of material, it has a set of common components and options. The option's application planning in the MPS incorporates buffering techniques (safety stock) to ensure the maximal response flexibility for actual customer orders (Jacobs et al. 2011, 155).

2.6 Material requirement planning (MRP)

Materials Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master production schedule requirements (Kumar, S. Anil.)

On the other hand, MRP can be seen as a basic tool to carry out the detailed material planning function to meet the production requirements for achieving the end products. Its objective is to provide the proper material at the right time according to the schedule for the end products, by which it contributes as below:

- MRP defines exactly the needed component quantity with the right time for running the production, this helps to maintain the inventory level as low as possible.

- By MRP, the lead time both for manufacturing and customer order can be reduced since the due date identification for an order will help for calculating the schedule backwards.

- From MRP, the application of one planning interface contributes to the creation of more realistic delivery schedules

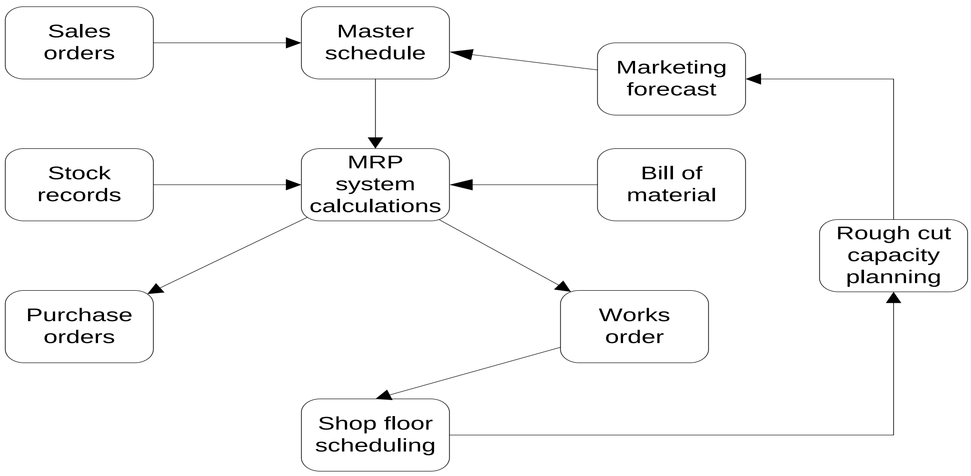

Figure 12 The logic of MRP for concerning material handling (Adapted from Manufacturing requirements planning. Accessed on 09-Dec-2011).

Figure 12 presents the major logic of MRP application which mainly concerning the material management. The bill of material and the inventory status are the two basic inputs for MRP. For example, two wheels could be required for a bike. For each wheel, a hub, tire, valve stem could be stated in the bill of material. In order to make 200 bikes, we need to know the current inventory level in order to find out how many wheels are available, and the quantity needed to be produced.

2.6.1 Material handling and safety stock

Material handling encompasses the material planning, material control and delivery. Material planning is the scientific way to determine the requirements of raw materials, components, spare parts and other items that for meeting the production needs within economic investment policies (K. Shridhara Bhat 2009, 14).

The bill of material (BOM) is a listing of all the subassemblies, intermediates, parts, and raw materials that go into a parent assembly showing the quantity of each required to make an assembly (Bozarth Cecil C. & Handfield Robert B 2006, 461). For example, the BOM of a desk computer, it shows a screen and other hardware in the required material list. This list states the clear information for which are the main components and which are the direct ones to produce a certain product.

When first generated, the BOM accompanies the production plan; then it is mainly handled by the material coordinator and buyers proceeding on to the components' purchasing and delivery then from suppliers to the production area to manufacture a product. Figure 13 shows the BOM structure for manufacturing product A.

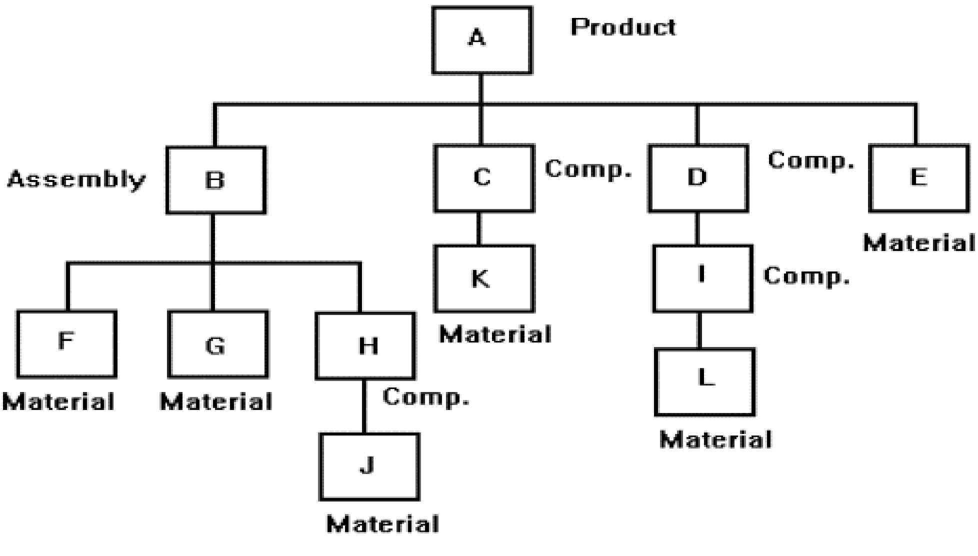

Figure 13 The logic of MRP for concerning material handling (Adapted from Janean F. Lulloff. Business Management.).

Material control is the function of maintaining a constantly available supply of raw materials, purchased parts and supplies that are required for the manufacture of products (The American production and inventory control society). The main purpose for material control is to share inventory and purchasing information within a supply chain, by which ensure the required materials for production are available in the right place, at the right time, with the right quantity and quality.

Controlling material is not only the material managing in the warehouse or production area; there is also the material moving within the material management process by which means material delivery with different relevant parties are involved in the supply chain. Material moving could mean the material delivery locally or globally. One important aspect of material control is to have the inventory level control with the right material quantity in order to reduce the inventory cost, as well as decreasing the risk for a lack of material.

Lead time can be measured as the time between the customer order's launching date and the order's due date both for managing the material and finished goods. Hence, lead time is one of the most important elements to measure the customer service level. With the right product, quantity and price, the shorter lead time for managing the operations to meet the customer order's requirement will result in better customer relationship management that enable more competitive advantages in the market.

In general, raw material, work-in-process and finished product are the three overall categories for inventory. Safety stock also refers to buffer stock as one kind of stock types when managing the inventory level. The major purpose of safety stock is to have the compensation in order to manage the demand and supply uncertainty. As Max Muller (2003) discussed, another purpose can be "holding it to "decouple" and separate different parts of your operation so that they can function independently from one another".

3 PROCESS MANAGEMENT

Process as defined by Sadler, Ian. (2007, 2-10) is a method by which a supply chain strategy is constructed by a group of managers and approval obtained for the resultant action plans. Within the supply chain integration, every process can be considered as encompassing the coordination and management of information communication and physical product flow, along with the chain leadership.

Moreover, in the manufacturing companies, a process can be seen as the logical organization of people, materials, equipment and information into work activities designed to produce a required product (Juran Joseph M & Berkeley 2000, 3).

Generally, process exists almost everywhere inside a company. A process can be understood as transforming an input into a desired output (as figure 14) in order to satisfy the customer requirements, it provides a method to introduce standardization into the operations of a given company or a supply chain. One way to define a specific process (like order fulfilment) is to consider the end-to-end set of activities that satisfy customer needs. The end-to-end process is quite common within the supply chain management.

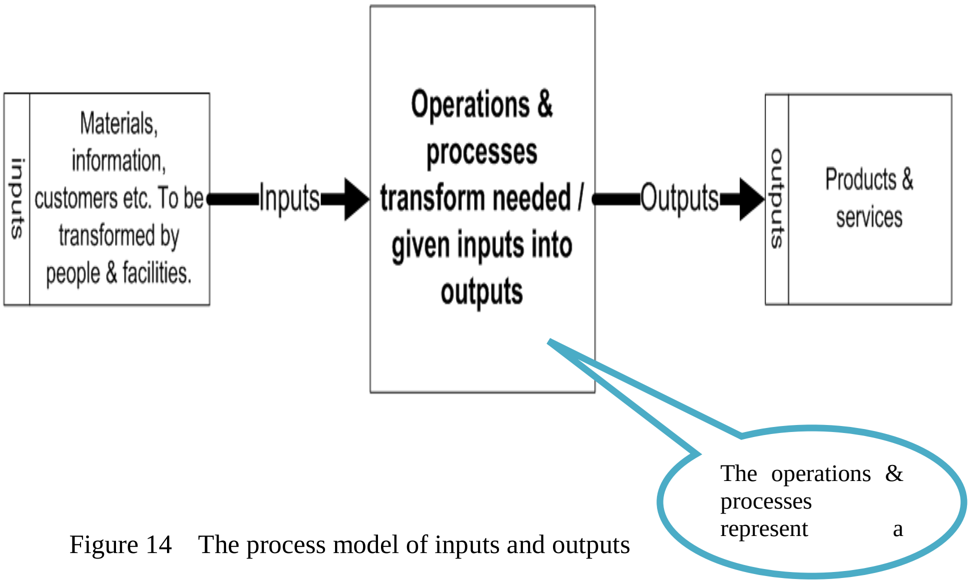

Figure 14 The process model of inputs and outputs

The primary purposes of process management are emphasis on managing the process with effectiveness, efficiency and adaptability. The effective process is to have the output for meeting customer needs. The process is efficient when it is effective with minimum cost. The adaptable process will remain effective and efficient in the case of the many changes that occur over time. Thereby, a process orientation is vital if management is to meet customer needs and ensure organizational success in a supply chain. (Juran et al. 2000, 3.)

Defined by Juran et al (2000, 8), there are five steps involve in the process design or redesign, such as:

- Defining the current process
- Determining the process’ objectives and process flow
- Establishing process measurements
- Analysing process’ measurement and other data
- Designing the new process

Therefore, the new process plan is the output of the process design with the five steps. After the new process had been set up and implemented, managing the new process development could be conducted in three major activities in operational management (Juran et al. 2000, 20), including:

- Process control
- Process improvement
- Periodic process review and assessment

As the continuous changing of customer needs, the process development meanwhile has to be refined to reflect these changes.

3.1 Process mapping

Process mapping is used to depict the real behavior of the process. Process mapping at a basic level involves the description of the relationships between the different activities, by which identify the different types of activity that happen during the process, and show the flow of materials / customers / information through the process. The real purpose of process mapping is to design the future state. It is a visualization exercise: a version of the current state and of the future state. (John Bicheno & Matthias Holweg 2009, 94.) There are several levels when considering the process mapping.

- High or first level. When considering the large processes with the complex process map, the aggregated processes need to be created to describe bigger sets of processes. It will only state the inputs and outputs.

- Second high level. A process is reduced into an activity which has both inputs and outputs.

- Third level. At this level, a process will be mapped with the activities at a detail level.

- Micro level. The very small process activities will be mapped at this level, which can describe every possible motion or step in performing an activity inside the process.

After the identification of the proper level for the intended process, there are some key principles for having the process mapping (Michael L. Gorge & David Rowlands & Mark Price & John Maxey 2005, 35), such as:

- Process walking observation is a must, and talk to the staff to find out the daily operations.

- Get into detail of the mapping objective instead of only trying to figure out a perfect flowchart.

- Have a clear understanding of the boundaries of the process map.

- Involve a cross-representation of those who work in the process to create the map.

- Get the process maps involve into the real work and practices, just use it. Which means the new process can be applied in reality.

The steps for creating or mapping a process (Michael et al. 2005, 40-41) as below:

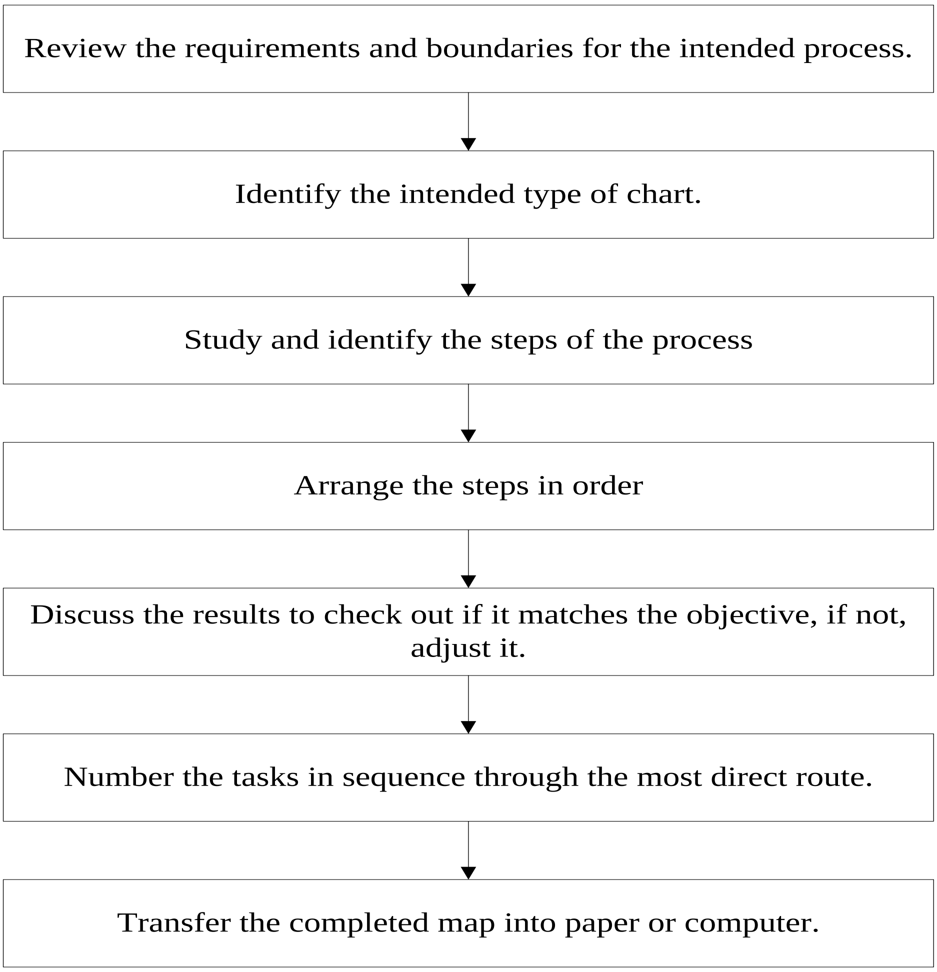

Figure 15 illustrates the some common symbols for the process mapping which are derived from systems analysis.

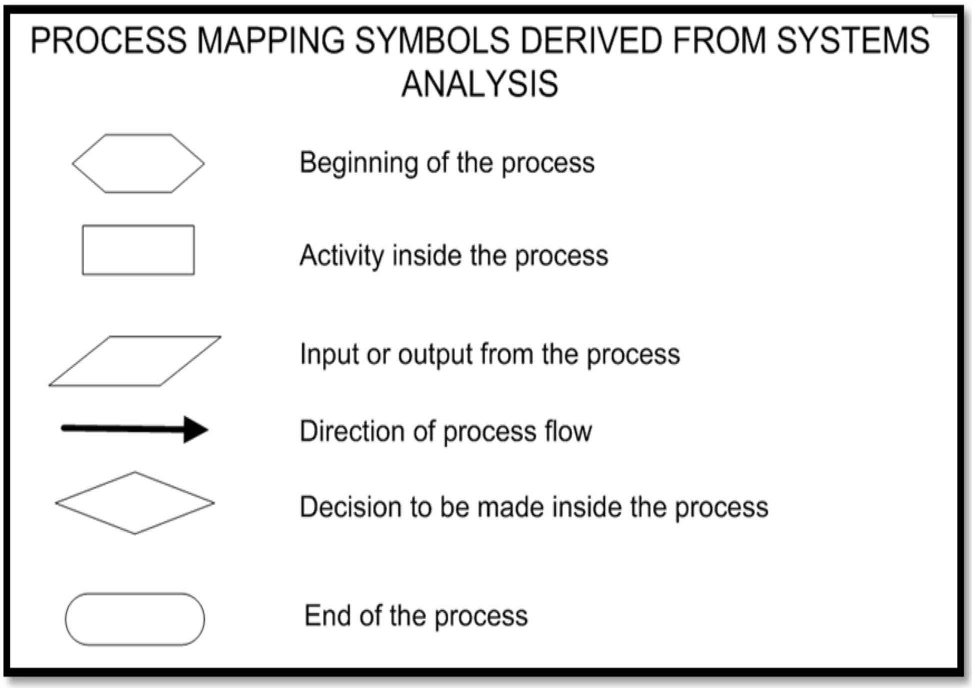

Figure 15 The process mapping symbols

Figure 16 shows a simple example for applying the process mapping symbols in creating a process.

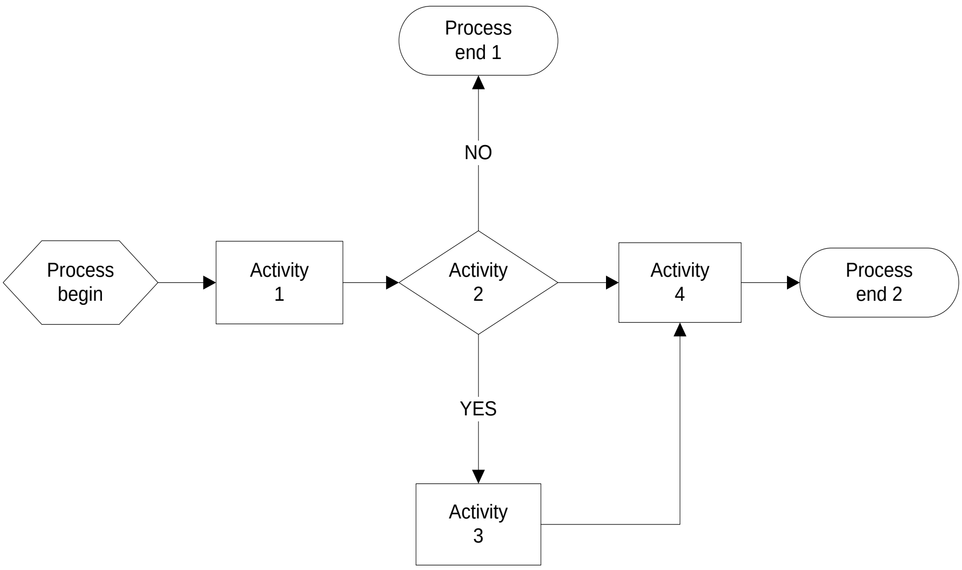

Figure 16 The application example of process mapping symbols

3.1.1 Swim-lane flowcharts

The swim-lane or deployment flowchart emphasizes the work position or role with the corresponding responsibilities. It is effective at showing the many handoffs, transports, queues and rework loops in a process. The swim-lane flowcharts are especially useful when the intended process goes across three or more functions. (Michael et al. 2005, 43-44.) Figure 17 shows the example of swim-lane flowchart.

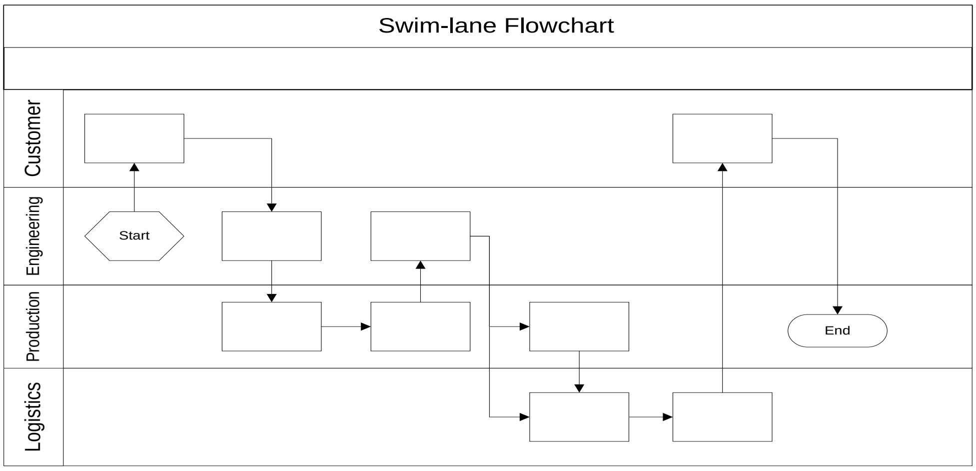

Figure 17 The example of Swim-lane flowchart mapping

It is essential to have the clear identification for the different departments or working positions with the corresponding functionalities and responsibilities involved in the process. Communication paths are especially important in the process with plenty of handoffs.

3.2 Process measurement

Performance review is the tactical task of checking whether planned performance is achieved then revising any failures found (Sadler, Ian 2007, 129). The joint performance of all supply chain members determines the overall performance of a supply chain. Normally, different supply chain members have their own performance measuring by their own objective and vision. Therefore, the overall performance of a supply chain could be better, or worst if the joint members are having conflict between each other instead of cooperation.

Performance measurement acts as a tool for direct improvement values, all measurements should be customer-focused, including the ‘real’ customer from external and the internal customers within a company (Wealleans, David 2000, 13).

The measures for the process performance can be adjusted to the operational level (Tuulia Åhlman 2007, 24). When measuring the processes' performance of an information flow within a supply chain, the output satisfaction is one of the success elements for managing the processes. Generally, output measurements can be used to monitor the overall performance of the process from the long-term perspective. On the other hand, upstream measurements, also referred as subsidiary measurements, is a method of keeping the current process in control to ensure the satisfaction for output measurements, and it also helps to identify the longer-term improvement for the process (Wealleans, David 2000, 55).

Time is one of the performance objectives and it is a universal and explicit measure (Tuulia Åhlman 2007, 24). It is an important success factor for managing the process efficiently within an information flow. For example, the responsive time that is needed for handling the customer requests throughout the information transferring process.

3.2.1 Fishbone diagram

The fishbone diagram also referred to as the cause-and effect diagram is a problem-solving tool for analysing process dispersion. It is a method to determine the main causes and sub causes leading to an effect. The main objectives of this tool can be defined as following (FISHBONE DIAGRAM):

- Identify the root causes of a problem.
- Emphasize on a specific issue without resorting to complaints and irrelevant discussion.
- Recognize areas where there is lack of data

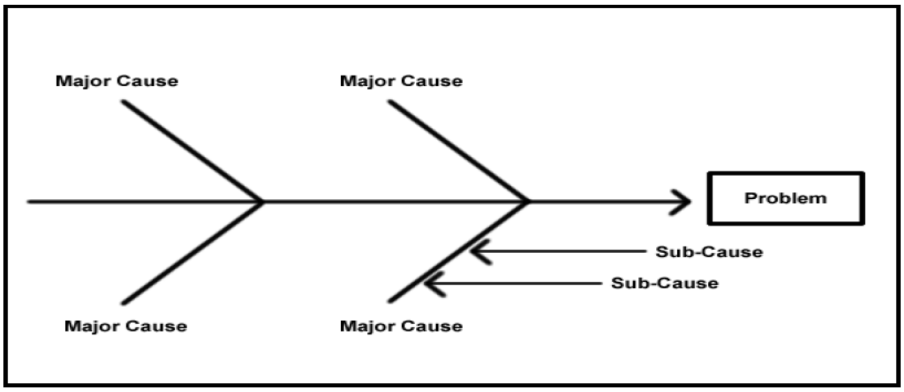

Figure 18 The structure of fishbone diagrams (Adapted from FISHBONE DIAGRAM)

Figure 18 illustrates the typical base format for a fishbone diagram, it is mainly structured by the main backbone (problem or effect) with main bones (major cause) and sub-bones (sub-cause).

4 MANAGING CHANGES

Nowadays' business environment encompasses all kinds of competition both locally and globally, the competitive initiatives could be the considerations from new product, processes, technology, systems etc. By which changes are inevitable, thereby it is necessary to have change management within an organization for managing the changes in good time for winning the business successes.

In an assembly-to-order environment, the major forces for changes which concerning the manufacturing for a specified product type are mainly from the customers' requirement. Customer needs and preferences are not stable, it is very important to fulfil the customer requirements in order to win the business. This will demand innovation or improvement in an organization, to have new or specified products continuously to meet the customer needs.

4.1 Definition and purpose of change management

The definition of change management can be understood as summarized in figure 19. Its full description is change management is managing the process of implementing major changes in information technology, business processes, organisational structures and job assignments to reduce risks and costs of change and optimise its benefits (Murthy C.S.V. 2007, 22).

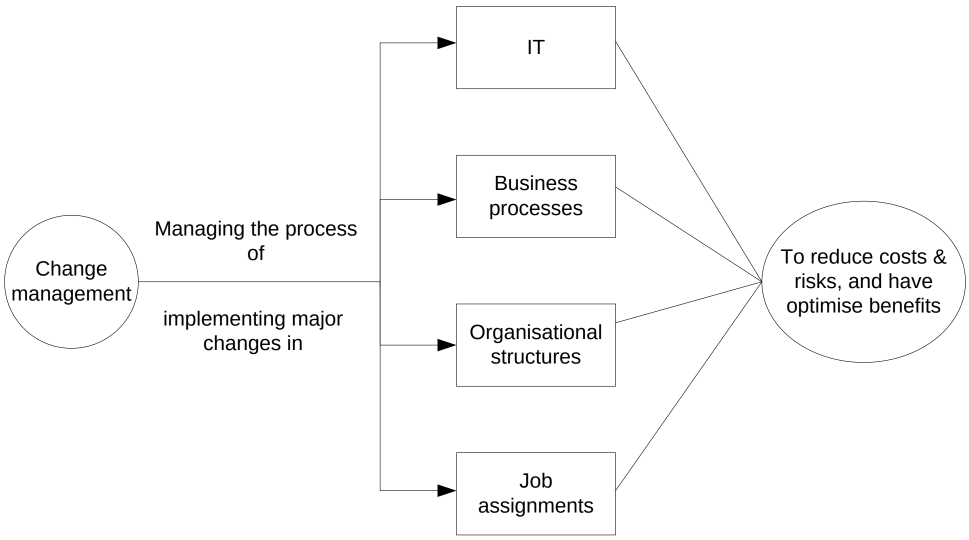

Figure 19 Definition of change management (Adapted from Murthy, C.S.V. 2007, 22.)

Moreover, change management had been defined as the proactive identification and management of modifications (Baca Claudia & Alameda 2005, 2). The purpose of change management is to have the process that used to control the project's changes under the project organization. It aims at the persons' understanding within an organization for:

- The reason for change happens.
- The way of change happens.
- And what needs to be done for making change to be a more welcoming concept.

These provide the insights into different frameworks and ways for approaching change at the levels of individual, team or project team, and organization (Murthy C.S.V. 2007, 22).

4.2 The process of change management

For managing a project with different kind of changes, the process of change management is to have the series of steps that taken to guarantee that every change requested is handled properly to the advantage of the project. Figure 20 illustrates all the necessary steps through the process for change management.

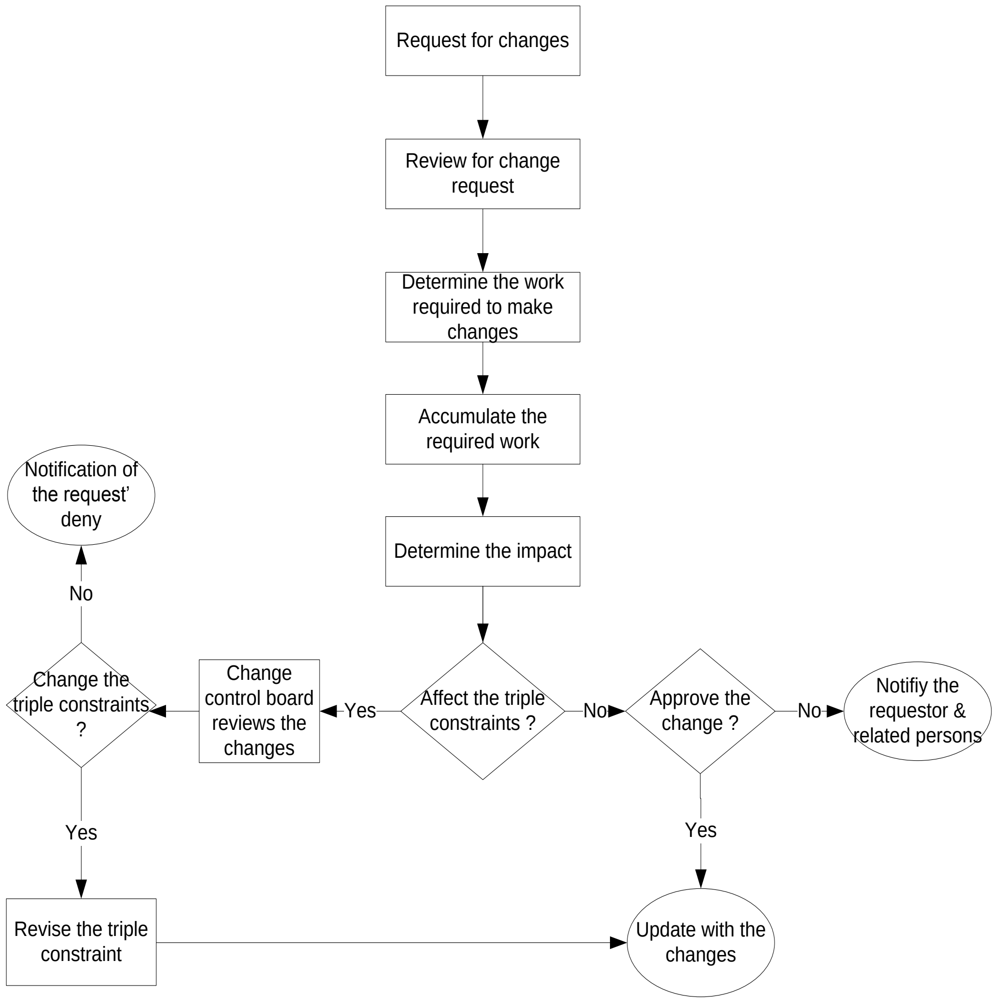

Figure 20 Change management process (Adapted from Baca et al. 2005, 60.)

The output of the change management process can be generated as shows in figure 20 (Baca et al. 2005, 47-48):

- Inform the requestor if changes are denied.

- If changes are approved, but will impact the triple constraints, revise the triple constraints and inform the requestor and the change control board.

- If changes are approved regardless of the impacts to the triple constraints, update and implement all the change requirements, and inform all the related people including the requestor.

In addition, it is important and necessary to consider the feedback path or interaction path for confirming the actual action corresponding with changes

4.3 The critical elements of change management

In the operational environment of an organization, the involvement of technology, process and people are the three critical elements for measuring the key dimensions of change management. By evaluating from the level of difficult, time to resolve and the business impact, figure 21 illustrates the key dimensions of change management.

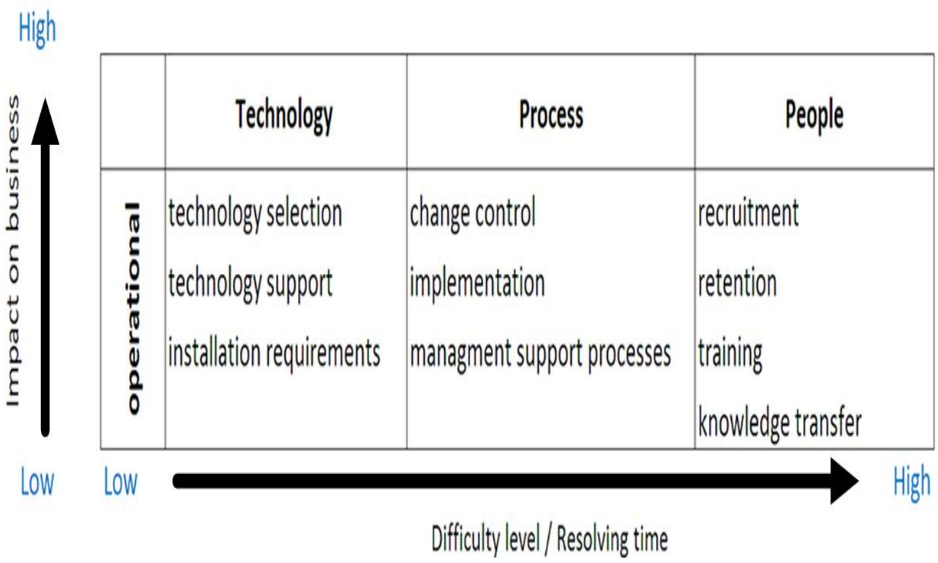

Figure 21 The key dimensions of change management (Adapted from Murthy, C.S.V. 2007, 23.)

The people, process and technology factors are involved in the implementation of change management, which is caused by introducing new information into an organization or a company.

For the operational change management, people are a major focus since the change's success or failure is ultimately caused by people within the process. People are involved in every step of the process to handle the tasks and communicate between each step in terms of getting change management successfully.

Timing management is another critical element to measure the effective of change management. How much time had been spent in handling the changes within a process or project in an organization will directly impact the final output of change management. Furthermore, the freezing time is one of the critical considerations for managing the process.

4.3.1 Freezing time

Freezing time is used to control the validity of change request and the responding speed in an assemble-to-order environment. Figure 22 shows the example of setting the freezing period to handle the real customer order with the desired specification.

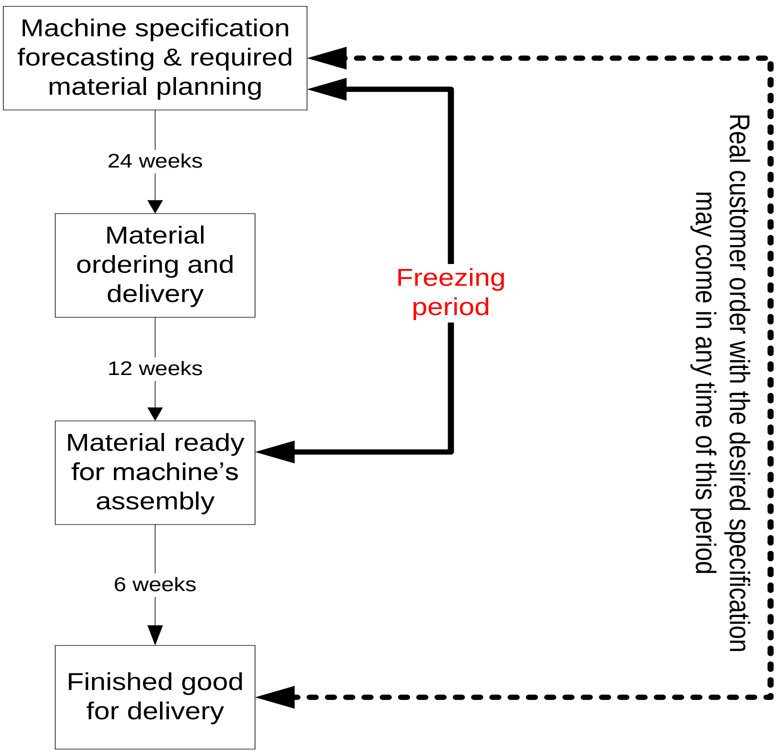

Figure 22 The example for defining the freezing period

The evaluation for building up the proper freezing period sometimes is very difficult since the satisfaction for meeting customer requirements is always considered the most important aspect for winning the business. Therefore, effective interaction with customers is also a critical element in change management.

4.4 Engineering change management

Managing engineering change has always been difficult for companies. It is common that manufacturers consider it as a regular source of inefficiency and irritation. However, recently more and more companies recognize that better change management in product development and engineering can drive top-line benefits, and so better process developing with visual speed improvement to market.

Good change management has always been a crucial process which now being viewed as a competitive tool to increase product profitability through improved market responsiveness in addition to improving efficiency. Change management is important to both initial product launch, and on-going product management, where quality and product improvement changes are critical to market success and profitability. (Aberdeen Group 2007, 5.) There are five key categories for identifying the executions of engineering change management in companies (table 2).

Table 2 Practices for managing engineering changes (adapted from Aberdeen Group 2007, 9-10.)

Process	• Formal change impact analysis • Formal change implementation plan • Cause analysis to identify corrective action
Organization	• Cross functional change review board • Separate meetings / functions for review and approval versus implementation of change • Change requests / order approved or rejected by product / program manager
Knowledge	• Formal use of data to track effectiveness of change control process • Centralized access to current status and approval routing • Centralized access to change history
Performance measurement	• Change request integrated to supporting information (documentation / product data / analysis)
Technology	• Selection of appropriate tools and intelligent deployment of those tools to support change management

One of the required actions for approaching the success of engineering change management is to have standardized processes. The standardized processes provide consistency in decision-making and continuous improvement in change management.

5 NEW PRODUCT INTRODUCTION PROJECTS

The New Product Introduction Project was designed to manage the new product type's completed set of manufacturing and assembly in the inter-company plants of SMC. It means the emphasis of the NPI project management will be the product manufacturing and assembly transferring management. Similarly, the NPI project was designed to have its own life cycle time as other projects. Within the project organization, all the processes and operations work together as a supply chain. From suppliers to have the material, manufacturers conduct all kind of operations and assembly for manufacturing the product, and then deliver the finished goods to the customer. Figure 23 illustrates the organizational design with the involving parties to manage the NPI project.

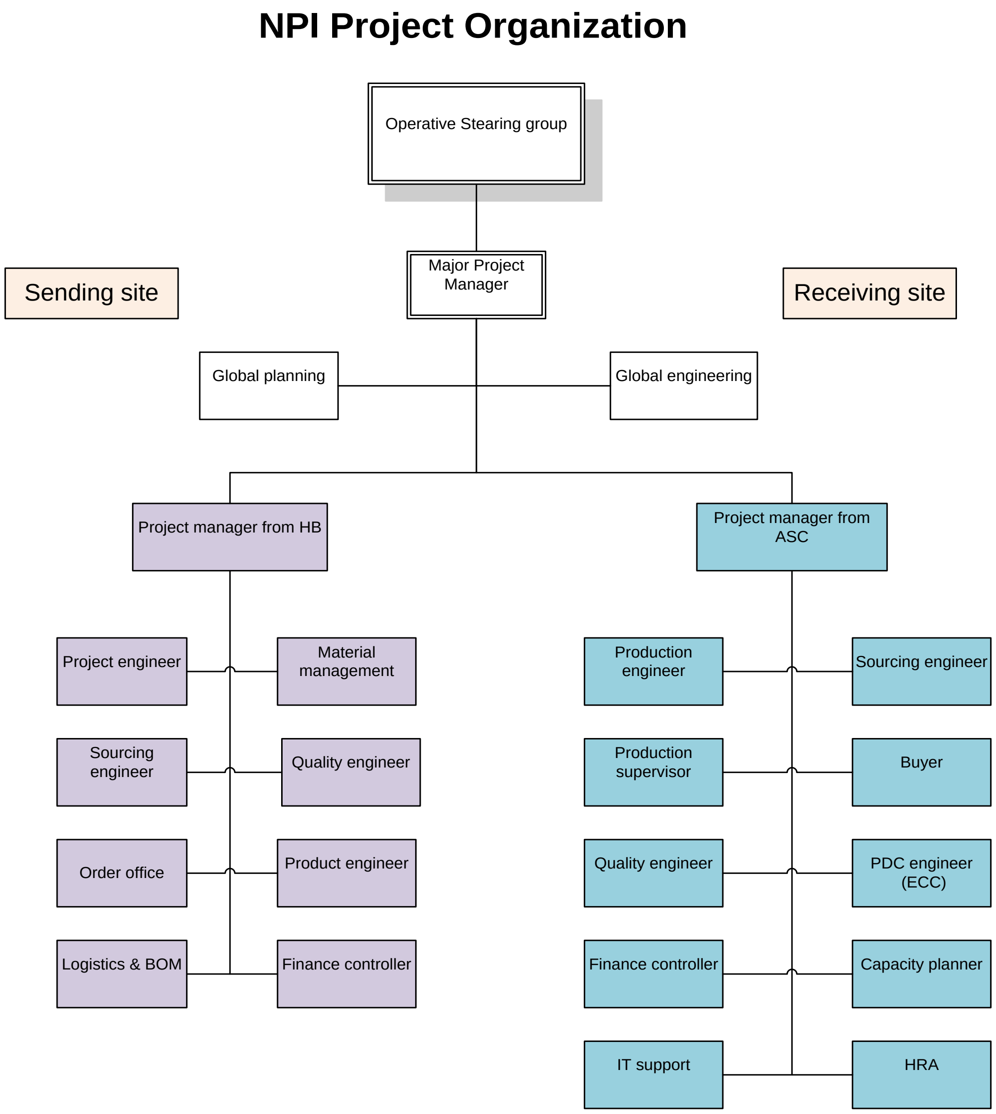

Figure 23 The example for understanding the NPI project's organization

5.1 Machine type introduction

At present, the loaders: LHx1 and LHx2 (show as figure 24) are the major machine types to have the NPI projects for transferring the products' manufacturing and assembly from HB A to ASC.

Sandvik LHD loaders are developed for the toughest of underground applications, with overall production economy, safety and reliability in mind. With FEA-optimized frames, powerful prime movers, advanced drive train technology, four-wheel drive, articulated steering and ergonomic controls, they are extremely rugged, highly maneuverable and exceptionally productive. With tramming capacities from 1 to 25 metric tons, they are available in both diesel and electric versions. (Sandvik Mining and Construction, 2010)

Figure 24 The loaders: LHx1 & LHx2 (Image source, SMC, accessed on 28-Oct-2011)

Sandvik drill-rig DDxxx (show as figure 25) is the twin boom jumbo with high drilling power. The new carrier layout is specifically designed for safe access to all service points, and all daily maintenance is conducted at ground level, without the need of opening any covers. Its features and value are emphasis on the accurate and fast drilling in drifting and small scale tunnelling with upgraded control system that result in high productivity for customers. Moreover, it is safe and easy to maintain. (Sandvik Mining and Construction, 2010)

The machine type of drill-rig DDxxx is the major consideration for identifying the changes with corresponding processes of the information flow in this thesis. In addition, the machine type of loaders LHx1 and LHx2 will be studied to contribute the reference from the management and operation views for handling change requests in information transferring processes.

Figure 25 DDxxx (Adapted from Sandvik Mining and Construction, 2010)

5.1.1 Specification and BOM handling

In general, the machine specification can be seen as a detailed and exact statement of a certain machine type with particulars and prescribing materials, dimensions and so forth for this machine to be manufactured. The machine specification is generated in accordance with machine structure synchronously, and the statement could be such as the clarification of standardized components and optional components of the machine.

From the machine specification of loaders, it contains the standardized components with detail dimensions, and the optional components with one or more options, which compare to the standardized components. For example, the bucket with the size of $1.5m^3$ is one of the standardized components for installing the loader type of LHx1, and the selected option for replacing this bucket could be the optional bucket with the size of $1.75m^3$.

Loader’s BOM handling is divided into 3-5 levels for managing the components. These levels had been identified according to the different functionality of components. Normally, the standardized components are involving in all levels of the BOM, but the optional components may just from the second level. For loaders: LHx1 & LHx2, there are five major standardized components, such as:

- Diesel engine
- Engine output
- Transmission
- Axles
- Tires

From the first or second level, one major component could be constituted by the assembly of many subordinate components. Then, level by level, from bottom up that the lower level's components to be assembled for generating the higher level component gradually until the completed machine is ready. All of the components with all the levels will be clarified and managed as BOM into the ERP system.

Compare to the loaders' specification and structure, the drill-rig DDxxx is one of the much more complicated machine types in UGM segment from SMC. DDxxx has the similar idea as loaders to construct its own machine specification, which also encompasses the standardized components and optional components for manufacturing and assembly. However, the optional components' management of DDxxx is more complicated and difficult from the components' interrelationship. When having changes in one part with the optional component, it may or will affect very much with other parts for managing the BOM, by which other standardized components may ask for changes at the same time.

Basically, there are four kinds of major components (from functional and physical consideration) to construct the machine of DDxxx, including:

– Engine
– Rock drill
– Feed
– Carrier

DDxxx's BOM managing can be understood in the similar way as loaders. In general, the BOM managing levels for DDxxx's components had been identified to be eight levels from top to bottom. However, the BOM's management within every level of DDxxx is very different from loaders.

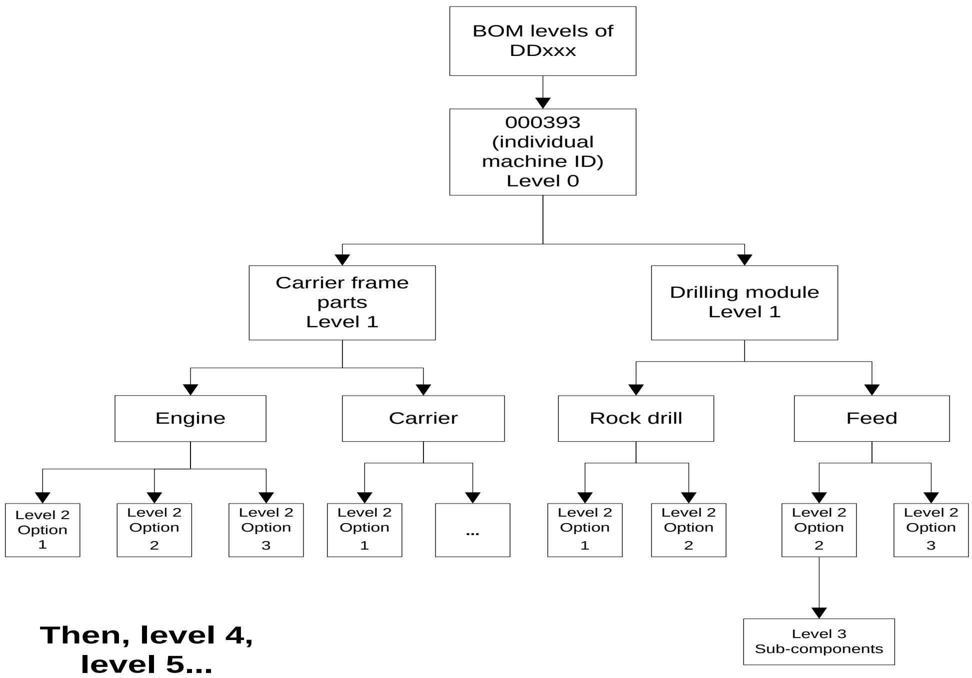

Figure 26 The example of DDxxx's BOM levels

Figure 26 shows the example of BOM structure with different levels. Start from the level 0 of the individual machine ID, which is mainly used in the manufacturing perspective. Next, the parts, which always have the unique item code for corresponding to the individual machine ID, are defined as the first level without optional consideration. The major components are within these parts, which can be synchronously understood as level 1. The optional components are identified to be structured in level 2. After picking up the option from level 2, the level 3 contains the sub-components, which are used to construct the optional component in level 2. Then, similar situation with the fourth level, the fifth level and so forth.

Usually, the estimation and management of the second level is the major consideration for choosing the desired optional components to manufacture DDxxx. Thereby, it is also the crucial for identifying the option list to have the product allocation in different locations within the company.

In addition, for loaders, generally one change possibility with the optional components will only affect one related standardized component. Although it may sometimes have the impact for other components, for example, when considering changing the open cabin with a wider size, the front frame may also need a bigger size in order to have the design and installation consistency. This impact normally is simple and easier to handle, it does not require very much technical support from mechanical or electrical perspectives.

Table 3 shows the ordinary logic to handle the changes of optional components for DDxxx (At the moment, this is not implemented for managing the BOM yet, however, it could be the future consideration for BOM handling.). With the changes of Part A, it will need the option 1 of Part B according to the option 2 of Part A's requirement. Furthermore, option 3 of Part C will be needed to cooperate for the machine installation. This logic solution also could be used to manage some optional changes for loaders.

Table 3 Optional components / parts' correlative impact

Options		Part A 1	Part A 2	Part A 3	Part B 1	Part B 2	Part C 1	Part C 2	Part C 3
	Part A 1	0							
√	Part A 2		0		√				√
	Part A 3			0					
β	Part B 1		β		0			β	
	Part B 2					0			
	Part C 1						0		
	Part C 2							0	
	Part C 3								0

5.2 Marketing focus and options' define

Marketing focus is one of the most important considerations for companies to allocate the product's assembly in different location, which could be both locally and globally. Generally, it could be the understanding as manufacturing a certain machine type with the beforehand estimated and specified options in a specified location that is based on the focus of the defined market area with the corresponding customer types.

For instance, when considering and identifying the possibility of optional components for drill-rig DDxxx to have the assembly in ASC, the focus market area which has the sale possibility of this machine will needed to be estimated beforehand, and the future customer's possible requirements also have to be evaluated in advance.

Furthermore, the corresponding parts / components / material for manufacturing this machine also needed to be analysed in order to addressing out the possible options. These determined options will be mainly or only available for the assembly of DDxxx in ASC. Therefore, once there is change request concerning the optional components from the customer, the specified customer group or market area can be checked out firstly. And then the corresponding option list will be needed to help for checking out the change's possibility, which primary concerning the machine's new lead time and the material provision for supporting the manufacturing.

At present, the DDxxx's NPI project is mainly concerning with the options availability, which is prepared for the specified customer groups. Hence, it is expected to have the clear definition with a specified option list according to the emphasis of marketing focus. However, there is also very high chance that customer's requests concerning the optional components can be completely different or new when compared to the manufacturing company's advance evaluation. In accordance to different request' possibilities, it will ask for another kind of consideration and change management method to handle the product's manufacturing allocation.

The engineering perspective is crucial for carrying out the optional components' evaluation with further definition. Usually, it is important to get the product engineering involve in the operations and processes' management for defining the optional components, and then to provide the confirmation for machine structure and specification's feasibility from the engineering's view of point. This is the first step to identify the option list. For example, the selected optional components or the customer requested components must have the use feasibility to be assembled for the machine in line with the machine's engineering design.

For the NPI project, the master production schedule (MPS) is used to illustrate the detail production schedule monthly or yearly which has the corresponding data for the machine type, assemble location, manufacturing quantity, statue of material handling and delivery, assembly period, finishing date, shipment date etc. Moreover, it is very important to have the MPS to work with the required material planning, which contributes greatly in completing the product manufacturing on time.

5.2.1 Material concerning for NPI Projects

Currently, more than x percentages of the material / components / parts for DDxxx's assembly in ASC are supplied from HB B, including the major critical parts. And more than y percentages of the material for Loaders are supplied from HB A. The lead time for these materials is normally more than z weeks, and some critical parts / components might even need much longer lead time.

For managing the NPI project, safety stock plays an important role in the material handling since the long lead time requirement for achieving the manufacturing material from HBs to ASC.

6 INFORMATION TRANSFERRING PROCESSES

This chapter will introduce the major objective of the thesis from the practical view, which is the primary concern for the company. Consequently, the current state processes for handling the information transferring will be presented, which is mainly concerning the changes both from specification and engineering aspects.

In accordance with the process mapping, more detail description for the problems' analysis of the current processes will be described. As well as the study from ASC which concerns the process implementation will present.

6.1 Introduction of the current state process' mapping

Corresponding to the company's global allocation strategy, more and more NPI projects have been / will be set up to take care of allocating the full set of products' manufacturing and assembly from HBs to ASC. A certain NPI project will respond for its own defined machine type. In terms of the company's technical strategy and correlative management limitation, the requirements of some specified material for manufacturing the loaders and DDxxx from NPI projects can be only supplied from HBs.

Meanwhile, the machine type's specification and engineering design along with the technical support are required only from HBs. Therefore, the demand of long lead time for handling the required material from suppliers to the production in ASC, and managing the delivery of finished goods to customers cannot be eliminated. By which, it raises the management and operational risks and difficulty of NPI projects and so asks for higher cost.

In order to manage the NPI project in a better situation to fulfil the company's strategy requirement, the efficient co-operation and communication had been identified as the most important aspects and biggest advantages for project management. Information sharing within the project organization contributes high capabilities for the operational co-operation. It enables all related parties to know the real situation related to their own tasks within the project, which ensures better understanding the connection with other working members of the project. The realization of the connections' importance will increase the communication efficiency for the whole project.

Process mapping is an important tool to help identify the detailed steps and connection within the project organization in order to map out the proper process for efficient information transferring. It helps to define the direction of the information flow, and states each step clearly with connection among all the involving parties. By mapping out the current state process of the information flow, the operational obstacle will be illustrated with better visualization, and possible risks can be noticed and analysed.

Then, the possible improvement plan will be studied and assigned to help the management of information transferring processes along with all kinds of operations. Finally, map out the future state process of the information flow by referring the improvement proposal.

6.1.1 Understanding the process' conception

For the study and research of information transferring processes, the machine's specification changes and engineering changes are the two major considerations to evaluate in this thesis. The analysis of machine's specification changes is mainly focus on the change request from customers, which concerns the specified optional components for product's assembly. The comprehension of machine's engineering changes will be mainly based on the shop floor's change request as well as other possible change requests, which focuses on the engineering perspective for the assembled components and correlative drawings. These components with the corresponding drawings are a part or very small part of the whole machine. However, sometimes they greatly affect the machine's structure and functionality.

The primary conception of this thesis is to have the study on the current state processes for information transfer, which concerns the DDxxx's NPI project. First from analysing the problems and risks of the current state processes, then build up the proposal for mapping the future state processes in order to achieve the information flow efficiency for managing the NPI project. Consequently, it is necessary and very crucial to have an early understanding of the organization's functionality and the involving parties' responsibility. Moreover, the organization's operational strategy and management perspective play a key role, which is the direction for the project management.

The empirical research of the current state process' mapping will start from gathering information mainly by personnel interviews with all relevant members in the company. Secondly, the important step is to analyse the available information and figure out (or build up) the connection or hidden connection between them. After that, map out the process to state clearly all steps and involving parties in the information flow.

Recently, the Loaders' NPI projects are managing in a quite good situation. These projects have spent more than two years for managing the transferring operations and HB A have provided the great support for these two projects. Therefore, the Loaders' projects are under the mature transferring management. In addition, the loaders' machine structure is much less complicated than drill-rig DDxxx, this helps to reduce the change possibility enormously from the engineering view.

All of the current state processes of information transferring for managing the specification and engineering changes will be mapped out into the document. The purpose is to have the unified and standardized processes for the NPI project management in future. Figure 27 presents the current inter-company structure for managing the current state processes of information transferring and the future expected version for handling the processes between HBs and ASC.

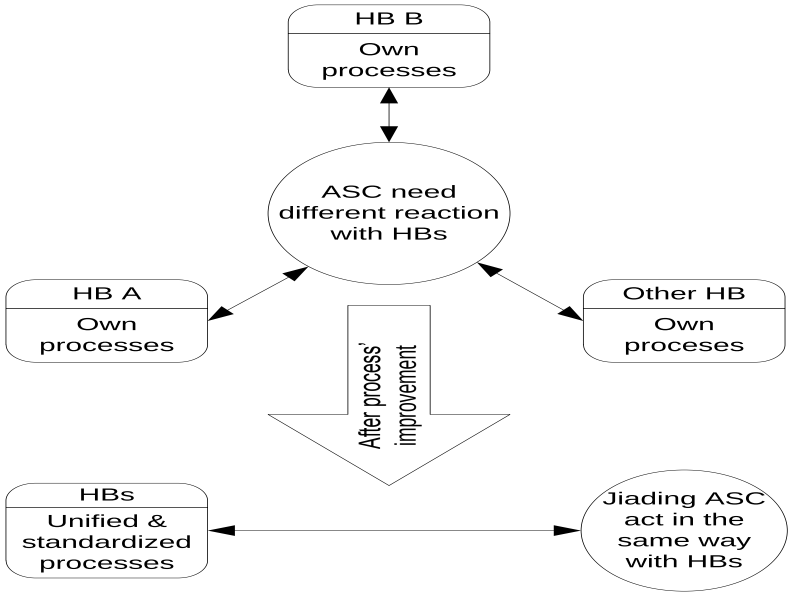

Figure 27 The future process' improvement target

The process mapping tool of swim-lane flowchart will be the major mapping structure to present the process's steps in different functions within the information flow for transferring the change information. By which it helps people to have a better understanding of the project organization and its different sections or departments along with their corresponding responsibility. Furthermore, it shows the information flow's direction and increases the clear visualization within the transferring processes.

6.2 The process' mapping concerning engineering changes

When managing the information transferring process for machine's engineering changes, there are two kinds of possibilities for causing the changes' generation, such as:

- Engineering changes' request from the shop floor concerning the mechanical or electrical issues with the components and related drawing.

- Engineering changes' request concerning the safety issues from all kinds of aspects.

At present, there is not any documented process to manage the information transferring for specification or engineering changes, not only DDxxx but also the loaders from the NPI projects. After all necessary preparation, the processes for managing engineering changes had mapped out as figure 28, more detail description and analysis of the current state process will be presented in the following section.

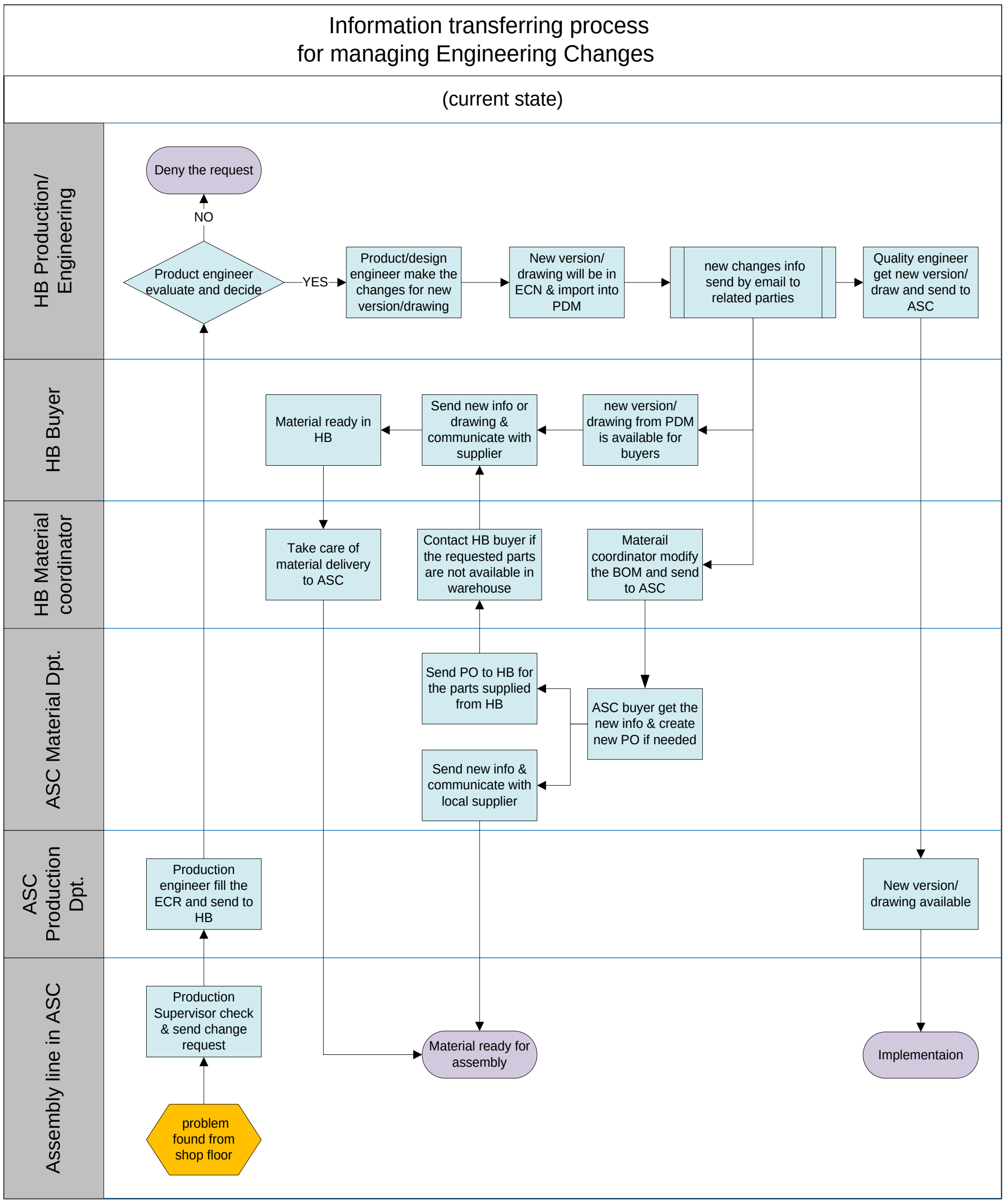

Figure 28 Information transferring process for handling engineering changes (current state)

6.2.1 Process' comprehension

As mentioned previously, the major causes for the engineering changes are from the shop floor. The causes could be the wrong material / components / parts for the machine's assembly, or the dis-match drawing with the parts, which cannot be used for the assembly. Sometimes, the causes could be the consideration from safety issues. Then, the relative process for managing the changes is different from the normal process, because it had been identified as an emergency, which asks for immediate attention and solution to manage the changes' request.

The information transferring process starts from the problems or doubt found by the assembly workers on the shop floor, and then report to the production supervisor. After checking the problems, the change request will be generated and sent to the production engineer in ASC. The change request needs to have the first stage analysis by the production engineer in ASC. After that, the production engineer will transfer the change request into the official format ECR (engineering change request), with a detailed description of the problem and send it to the relevant product engineer in HB.

The product engineer in HB will first evaluate the request, then the decision will be made to accept the change request or not. If it is accepted, the product engineer will create the change himself or assign the product design engineer to make the change. All of the changes will be depicted into document and attached into the official format ECN (engineering change notification) with detail description of the changes. The next step is to convert the changed information and relative drawing into the PDM (product data management) system by the product engineer.

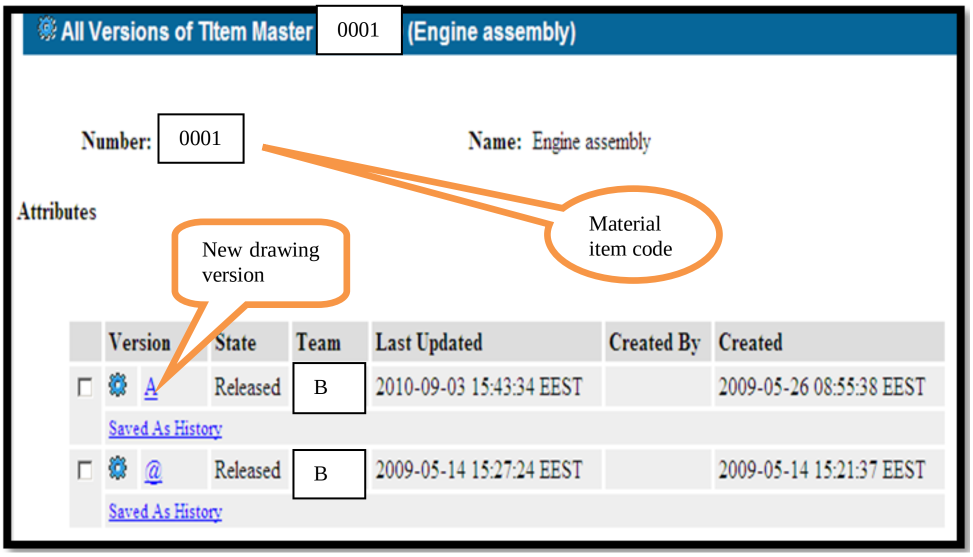

Figure 29 The changed drawing version in PDM

The BOM handler will charge for managing the new information of BOM in the MRP system if necessary. In general, there is not so much change concerning the BOM when handling the engineering changes' request. It is mainly about the drawing change with a new version, which means the material item code is not changed in BOM. Figure 29 shows the example of engine assembly's drawing changes with all version statement in the PDM system.

Currently, there is no such step in the process to handle the changed information automatically by the database system from HB B to ASC. All kinds of connection and communication proceed with the process and it is mainly by email. Therefore, with all the new information or drawing after the changes happened, the colleagues have to manually get it from the PDM system and send the PDF file attached to an email to the related colleagues in ASC. This increases the workload and time, which will eventually increase the total cost.

As shown in figure 28, the changed information with the drawing will be spread out to the HB buyer for the necessary change of material and its lead time. The material coordinator will take care of the BOM modification (this modification is only concerning the BOM information for the assembly work in ASC) if there is any change related to the material updated. As illustrated in the current state mapping (figure 28), the material coordinator takes care of the changed information delivery of BOM to the buyer in ASC, as well as the material delivery. At the same time, there is another role (quality engineer in HB) for taking care of the changed drawing from HB B to ASC production department.

Apparently, there is more than one interface to manage the changed relative information between HB and ASC in the current state process. There are a few weaknesses can be understood from the current state process mapping for engineering change management:

- First, the assembly line in ASC has no way to get the deny notification from HB if the product engineer decide not to accept the change request or impossible to make the changes.

- Second, there is no time measurement or limitation to handle the change request proceeding period. As well as the freezing time for requesting the change is unclear.

- Too many interfaces between HB and ASC cause the confusion of corresponding responsibilities.

- The feedback path concerning the changed information and drawing is not identified and implemented. Which means no one from HB knows if the changes have been implemented or not in ASC, even implemented, how about the timing management?

- Both HB and ASC’s involving colleagues could have confusion about the proper contact person from each other.

- Poor interaction between HB and ASC for the NPI project since ASC plays a passive role in the project management. They cannot do anything except waiting.

In allusion to all of the above problems, the solution proposal will be introduced in chapter 7 as the proposal for future state processes.

6.3 The process's mapping concerning specification changes

Referring to the machine's specification changes, the information transferring process is emphasis on two kinds of changes' causes:

– Changes' request from customer for individual requirement or specified needs.

– Changes' request from engineering view, which may affect vastly the specification with the machine structure and functionality.

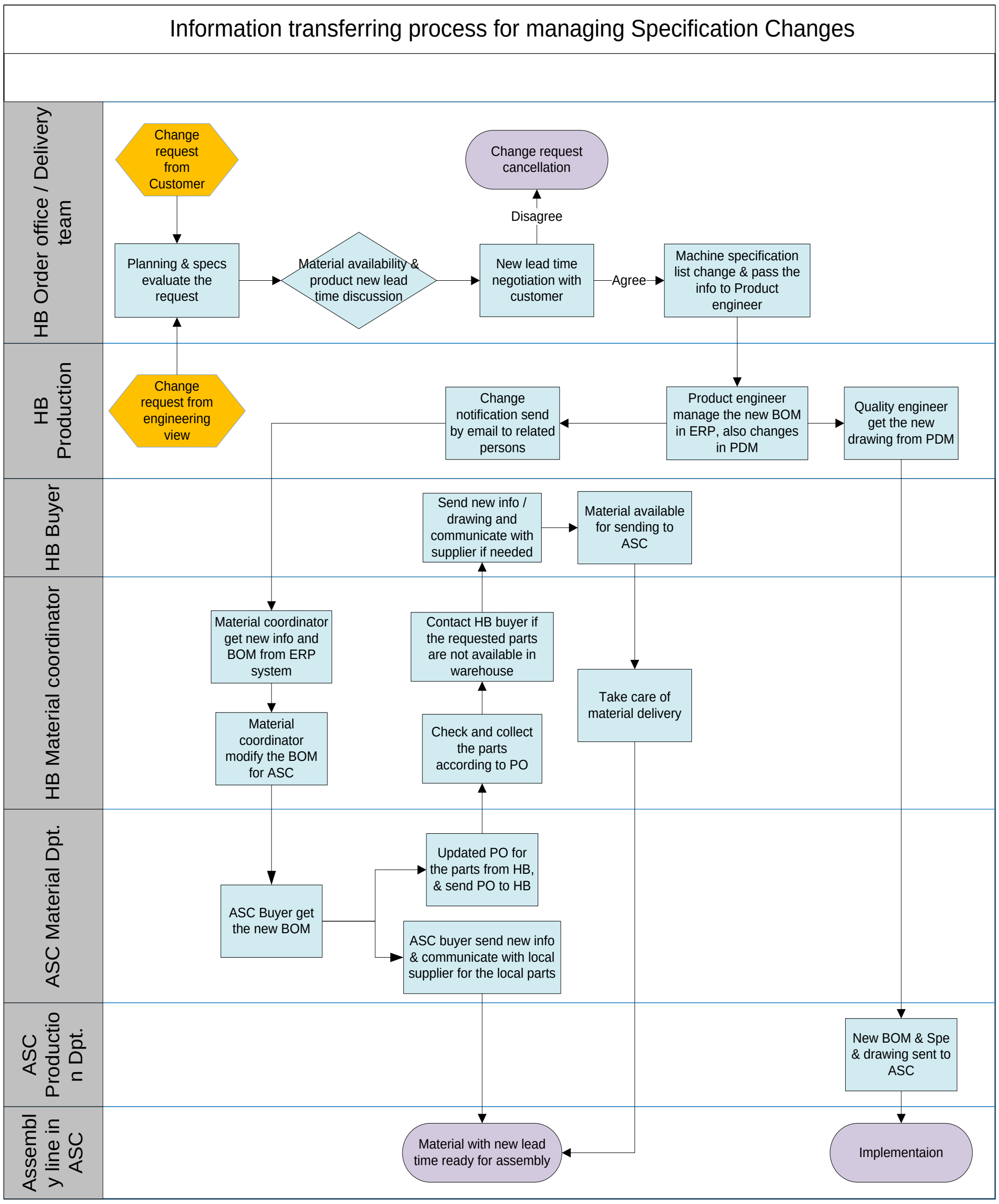

Figure 30 Information transferring process for handling specification changes

6.3.1 Process' analysis

Currently, managing the information transferring process for DDxxx's specification changes is the primary concern for the NPI project. Because DDxxx has very high complexity and requires very high tech to structure the machine, which both from the mechanical and electrical design in accordance with its specified application for customers. It has been expected to have many kinds of changes, which could occur during or after its manufacturing and assembly procedure.

Compared to the engineering changes, the causes of specification changes are different. It is mainly from the customer requests or the request from the engineering perspective when it refers to the major structure's change and redesign. Usually, the request concerning the major structure's redesign and relevant change is basic on the request from customers for changing parts to have the desired functionality from the machine.

HB order office is the key role for contacting customers to handle all kinds of changes related to the product. In general, the order office in HB will take care of the planning for the product type's manufacturing allocation. The decision for choosing a certain location is based on the available options which are defined beforehand for the specified market area and customer groups.

When they have received the change request from the customer, the order office need to have the brief evaluation of the change request, and then start to contact the corresponding sections for discussing the change possibility with final product's new lead time.

The decision to measure the change possibility is mainly from two aspects, including the changed material availability and the extended time for managing the required material to be available for the product's assembly, as well as the extra time for extra workload such as the uninstall / rework / extra work for making the machine.

The order office has to agree with the customer the new lead time for handling the changes. If both agree with the new delivery date, then the order office will inform the product engineer in HB about changing main points with the specification list. After that, the product engineer needs to manage the revised BOM in ERP and PDM system along with the drawing revise or change if necessary. From the process, the next steps and tasks are placed in the similar way as the solution for engineering changes.

One critical element is that the communication between the buyer and suppliers, it is very important to make sure that all the changed information and drawing which concerning the updated material requirement has been communicated with the supplier and the new delivery date of material got the confirmation.

In addition to the analysis of weakness in section 6.2.1 previously, there is still a few more typical defects need to be understood and improved in the process for specification changes.

- Overall, the inter-company systems without integration and connection can be seen as the major weak point within the process.

- Again, freezing period for managing the change request is one crucial issue.

- Well-defined involving group for discussing the change possibility is essential.

- The responding time, from assembly line to order office, from order office to customer, and from customer to order office for accepting the new delivery date or not, needed to be identified.

Material requirement is the most influenced element when change occurs. It is often that the current material / components / parts have to be revised or changed according to the request. The biggest challenge is to have the effective management for supplier relationship. The hidden risk for managing the material normally can be understood as the commitment with supplier for handling the material changes.

Usually, it has big challenges to make sure all the necessary information concerning the change request for material can be transferred in time to the supplier. In addition, it is difficult to confirm whether the supplier can understand the change request well and so react in the proper way for handling the material. Therefore, the secure way to have the required material on time for supporting the product manufacturing could be the consideration for having the safety stock on hand with the proper stock level for the optional components.

However, the estimation for calculating the safety stock to manage the stock level is un-stable if there are too many different kinds of change possibility. The un-regular customer order also increases the uncertainty for managing the stock level. Therefore, it is crucial to set up the options list with the certain change availability for a specified market area. The accurate rate of the master production schedule also contributes very much to forecast the future customer order, so that product quantity for manufacturing and related material planning could be handled efficiently.

7 DEVELOPMENT PLAN

The development plan is the focus on the improvement from the current state processes. Firstly, it is important to understand the causes and effects for information transferring efficiency before addressing out the suggestion for mapping the future state processes. As is presented in figure 31, the study of the cause analysis for affecting the information transferring efficiency is mainly concerning the four major aspects within a supply chain in an organization, including:

- organizational insight
- process design
- personnel communication
- information system

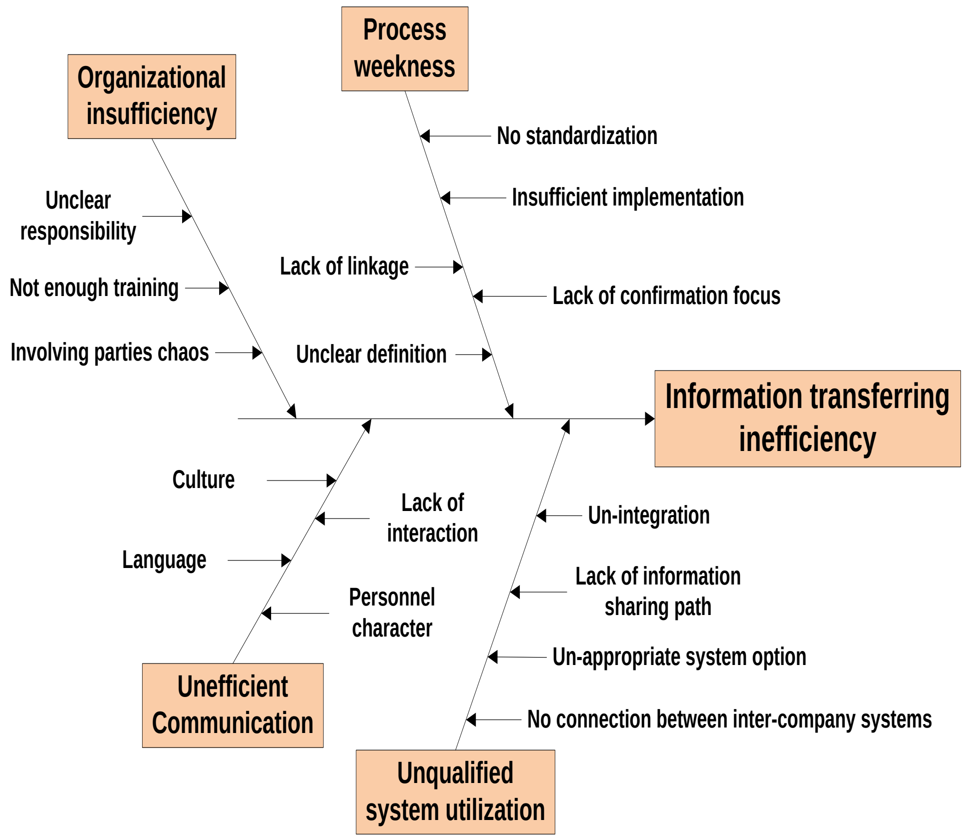

Figure 31 Inefficient causes for information delivery

In accordance with understanding the problem from the previous sections, the future state processes' mapping can be structured by identifying the effective process performance. Moreover, the performance measurement for the new process can be mainly considered from the process output with timing management.

7.1 Proposal for future state processes

To create the proposal for future state processes, the correlative persons from the company had contributed greatly to provide the useful information and suggestions for the future state process mapping. The following suggesting points are the combination both for the perspectives of specification changes and engineering changes.

Depending on the different management periodicity of the change availability, the proposal for considering the future state mapping can be divided into three phases in sequence.

PHASE ONE:

For managing specification changes in the process, the first phase starts from the beginning of change request until the step of discussing the change possibility. During this period, the emphasis is the options' predefinition for the order office to understand and estimate the possible impact for responding the change request from customers. There are two tasks need to be done, including:

– The well-defined option list, clearly states the optional components' availability for a certain machine type according to the global allocation strategy to have machines' manufacturing and assembly in a certain location.

– Careful selecting and training the related employees in order office to ensure the responsible person has the knowledge to understand the possible impact if making the changes, and capability to estimate the change possibility from the first stage.

At the same time, the responding time for checking the change possibility and reply to customer along with the customer decision for agreeing the new lead time could be estimated and standardized. Actually, the freezing period which is set up with the validity for committing customers' change request also needs to be identified and determined beforehand. The detail timing requirement and management should be discussed with all the relevant parties from the NPI project.

On the other hand, within the similar period from the beginning of the process to the step of estimating the problems and change request in ASC, the critical consideration for managing engineering changes in the process is the production engineer or production supervisor to have the qualified knowledge for the necessary identification. It is also necessary to have the timing estimation and identification for the production in ASC to get the on time notification concerning the request procedure from the product engineer in HB.

PHASE TWO:

The second phase of managing specification changes is the most important step in the information transferring process. This phase has only one step within the process, and the step is defined as the decision gate for discussing the change possibility. It is a critical step to determine the change availability and the requirement for making changes. Lead time and material requirements are the two major elements need to be measured in this step. Table 4 shows the involvement list with the necessary activities inside this step.

Table 4 Activities for checking out the change availability

Involvement	Activities	Purpose
Order office in HB	• Contact the material coordinator • Contact the product engineer • Contact the order desk in ASC	Check out the change possibility with the new lead time to discuss with customer
Material coordinator	• Contact the buyer in ASC • Contact the buyer in HB • Inventory checking from warehouse in HB	Find out the material availability for supporting the change, provide the needed info for late delivery
Product engineer	• Analyse the change request • Identify the impact for material, lead time, workload etc. • Prove the request and create change for drawing if needed	Confirm the change possibility from the engineering view, provide the new drawing for reaching the changes
Order desk in ASC	• Contact the production engineer • Contact the buyer in ASC • Contact the sourcing engineer	Check out the possible new lead time from assembly line, and inform order office in HB

The second phase referred to manage engineering changes is also one step as making the decision to have change or not. It is important to have the efficient co-operation between the product engineer and material coordinator in HB for identifying the change possibility and material availability. From this step, if the changes have been identified to be a big and important change, or have very much impact for the whole machine's assembly and so its current schedule (even if the required materials are available), the extra time for building the machine maybe be required for managing the changes in ASC. Thereby, the new lead time may need to be discussed again with co-relevant parties which may also include the customer if needed.

PHASE THREE:

With the new lead time confirmation for the change availability from the production in ASC, the last phase for developing the process is to identify every step properly with clear responsibility settlement to manage the information transference. This phase could be defined to have the similar functionality and steps in the processes both for managing specification changes and engineering changes. It is important to re-define the working content or responsibility for all the involving parties in the process. Clear understanding of the corresponding responsibility from the processes within the project organization increases the co-operation efficiency.

As few interfaces as possible between every HB and ASC from Sandvik Ming and Construction is essential for reducing the responsibility confusion. The obstacle of different cultures and languages is the major problem for the efficient communication in the inter-company management. Too many interfaces between HBs and ASC within the projects will cause the management chaos, and the hidden risk is that nobody is really taking care of any task for transferring, receiving, and implementing the updated information to support the machine's manufacturing.

Updated information sharing for material management need to be emphasized, the purpose is to manage the stock level accurately, and ensure the flexibility for material ordering and delivering. Therefore, the interaction and communication between the buyers (both from ASC and HBs) and the material coordinator from HB is crucial to manage the material availability for supporting the production. Again, more attention will be asked for managing the interaction with suppliers.

Meanwhile, the database system plays a key role for gathering, delivering and sharing the information among the organization. However, the ERP system which is the major system used in HB B currently has no direct connection with the local ERP system using in ASC. Similar situation for the database system application exists in other worldwide HBs when co-operating with ASC.

On the other hand, the application of PDM (product data management) system at the same time has the un-connected problem between HB B and ASC. Consequently, it is necessary to build up the connection or integration of system application in the inter-company plants so that to reduce the manual work in case of the possible mistake and risk. The integrated system application will also improve the operational performance by having the situation and problems' tracking in the system, which will ensure better visibility of task implementation for all the relative members within the projects.

Finally, the feedback paths with confirmation need to be well defined and implemented thoroughly in order to provide the real awareness of change implementation for all the relevant parties from the NPI project.

In addition to the consideration of different management periodicities, the improvement for the future state processes can be also summarily evaluated in the focus of managing people, time and system synchronously. Table 5 defines the management and operational perspectives from people, time and system for the development plan.

Table 5 Improvement considerations from people, time, system in the process

	Performance
People	• Better training for the professional working area, culture and language understanding, IT system application. • More interaction and communication within the project, exchange information and ideas by having regular meeting • Clear understanding for job responsibility, as well as the inter-connection • Organizational perspective need to be well-defined and comprehended especially for management level
Time	• Identify the freezing time • Managing the lead time and new lead time both for material and finished product • Responding time for the customer and internal management • Well-defined time for managing the changes with different responsibility • Clear timing statement for assembly actions in accordance with the change request
System	• Integration availability • Well-designed functionality • Well-defined functions and processes for change management • Application training for employees • As simple as possible for application • Comprehensiveness and universality

7.2 Future mapping

The mapping for future state processes will combine the considerations of specification and engineering change requests both from the Loaders' and drill-rig DDxxx's NPI projects. In terms of the major objective to have unified and standardized processes for information transferring, the future state processes will be decided to have only one process for managing engineering changes, as well as one for specification changes. These two kinds of processes will try to cover all the NPI projects from HB B of UGM segment to ASC in the future, and these processes will only be applied for managing the specification and engineering changes.

Usually, every project has its own life cycle time. Hence, the beginning and the ending of the project normally will be defined approximately before starting a project. However, the future state processes, which are defined in this thesis, are planned for the NPI projects to have the application synchronously for managing the changes as long as the machine's manufacturing and assembly is allocated in ASC. Therefore, the expectation for preceding these processes will be available even after the projects' condition.

Section 7.2.1 presents the future state information transferring process for managing the engineering changes, and section 7.2.2 presents the future state information transferring process for managing the specification changes. For both the following processes' mapping, PE^1 means the production engineer in ASC within the NPI project, PE^2 means the Product engineer from HBs. The swim-lane flowchart is the mapping tool to use in these processes' mapping, by which it is easier to understand the functionality and responsibility of the working implementation with the involving sections or parties in the processes.

In fact, the procedure of change implementation has the similar functionality and operations in both the information transferring processes for managing specification changes and engineering changes. Moreover, the project members act as the similar functional role to deal with similar tasks for managing the change implementation from the NPI projects. Therefore, the detail explanation with the critical steps in the future state processes may omit to avoid the reduplicative description.

7.2.1 The information transferring process for EC

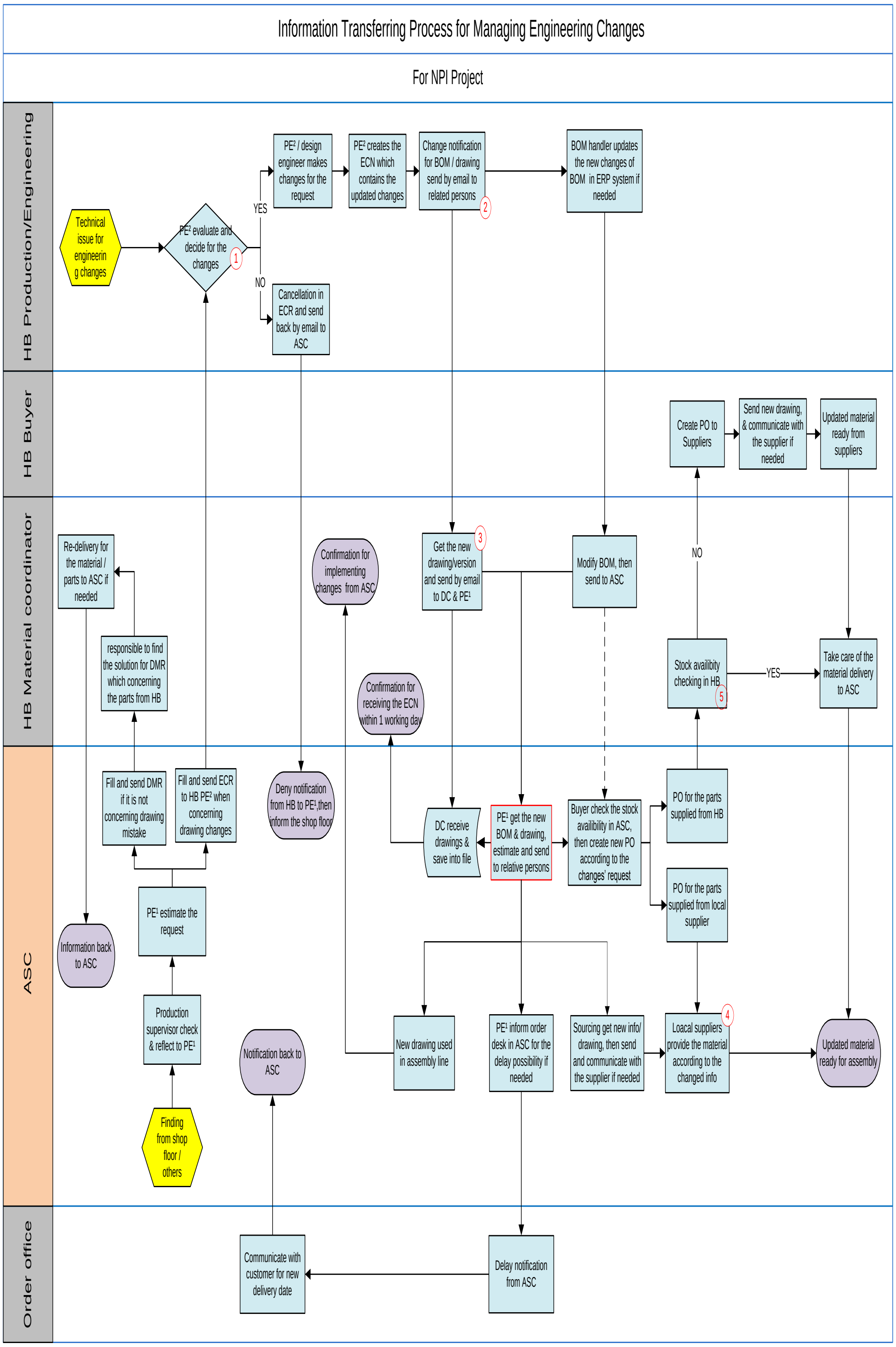

Figure 32 The information transferring process for EC (clear visible version can refer to Appendix 1)

The detail of some critical points as the read circle with numbering in the process is explained as below:

1) When the change request is received, the product engineer in HB needs to estimate the change request's possibility by checking out the material availability from material coordinator. By which means the material coordinator has to check the stock information, then discuss with the buyer the material ordering and delivering information if the stock is not available or there is stock needed to be rework.

2) After the product engineer confirms the changes and generates the ECN, the new drawing or new version of the same item code's drawing will be imported into the PDM system. Then, the correlative persons who are defined in advance for a certain project will get an email with short notification of the changes. All of these persons' email had been attached in the ECN beforehand, once the product engineer select the product type for making changes and so the ECN, all of these emails will be automatically state in the ECN.

   PS: In general, related person means all of project related members. However, for DDxxx's NPI project, only the project members from HB can receive this notification by email.

3) The material coordinator could be considered as the most critical and important role in this process to handle the changes which concerns BOM and drawing. This role also could be identified as the key interface from HB B to connect ASC for the NPI project.

   As the key interface from HB, the person needs to have the knowledge to understand the machine structure both from mechanical and electrical view. He or she needs to know the possible impact for BOM and drawing from the changes. Since the primary changed information will be mainly delivered by this role from HB, the material coordinator is required to have very good English skill in order to explain the change information thoroughly. He or she needs to identify the useful information from the changes in the purpose and:

- Provide the information for sourcing department to manage the changes with suppliers.

- Supply the information for the buyer to acquire the required material by material ordering and delivery.

- Ensure the assembly line to have the updated drawing for assemble work.

All of the above information needs to be described very clearly in the email, and sent to the related persons in ASC. If the relevant person cannot understand well with the changed info, or has any questions concerning the changed information or drawing, the material coordinator will be the major person from HB to find out the needed information.

4) This step could be understood in three aspects:

– If the required material concerning the change request is completely new from the previous material, the related supplier has to figure out the new solution for supplying the material.

– If the required material for the changes is only a bit different from the previous parts but with the similar function, the supplier could consider re-working the material after a better understanding of the changes and the relative drawing.

– If the required material is mainly concerning the quality requirement, although it may still need to have the same design and function for the parts, it is necessary for the supplier to find better or new solution for meeting the quality level.

Therefore, even if the new PO from the buyer is not necessary, the supplier still needs to make changes for the material according to the change requests.

5) For responding to the change request, the material coordinator has to check out the stock information both from the warehouses in HB and ASC. There are three kinds of possibilities with the requested material:

– Concerning the change request, the required material is available from the warehouse either in the HB or ASC. For example, safety stock contributes as an important part for the material availability.

– For the change request, the required material is not exactly available but with the high percentage that it may just need to be partially re-worked from the supplier, then it could fulfil the change requirement. This may ask for extra time to get the material ready for supporting the machine’s assembly. Therefore, it is necessary to keep in mind for identifying weather the planned lead time of the finished product will be affected by the material’s new lead time or not.

– The third possibility is that the required material is currently not available. The new material requirement from the change request need to look for new suppliers, or with the current supplier to communicate for the new material’s functionality and quality requirement and the new delivery date.

One of the critical issues for material management to support the production activities is the supplier relationship management. The efficiency of material management to respond to the change request could be one of the performance elements to measure the efficiency level of supplier relationship management.

It is essential in the process to have the updated information concerning the material requirement for the supplier and so with the supplier's understanding of the changes. Therefore, the efficient interaction between sourcing / buyers and supplier contributes a great advantage for managing the changes.

7.2.2 The information transferring process for SC

Compare with these two kinds of processes, the major difference can be seen from the generation of the change requests in the beginning of the processes. After the confirmation for changes' possibility, the later parts of the processes to manage the change implementation are defined with the same solution. Thereby, the detail explanation of the critical points in the future state information transferring process to manage the specification change will be emphasized on the steps as the red circle with numbering in figure 33.

1) This step is the most critical and important step within the process, as introduced in phase two of section 7.1, again the primary objective of this step is to satisfy the customer as much as possible to have the product's manufacturing and assembly.

2) "Time" is the key word in this step. The section of order desk from ASC may need to involve in all kinds of needed activities and discussions to find out the new lead time for delivering the completed product to the customer. Normally, the production engineer and the buyer in ASC are the two major parties to communicate and interact with the order desk for identifying the new lead time. Sometimes, even the sourcing will involve in the discussion if necessary.

   PS: As the production engineer for a certain machine type in ASC, the person also needs to work on the production procedure and process operational management in order to have well-understanding of the machine's assembly stages. Once changes occur, he or she should have the ability for measuring and defining the extra work and time requirement which corresponding to the change request.

   As long as the new lead time has measured, the order desk will transfer the information to the order office from HB. After the negotiation and confirmation from customer, the order office will inform the relative parties in HB and the order desk with the updated information to make changes or not. Then, the order desk will forward the information to the related parties in ASC.

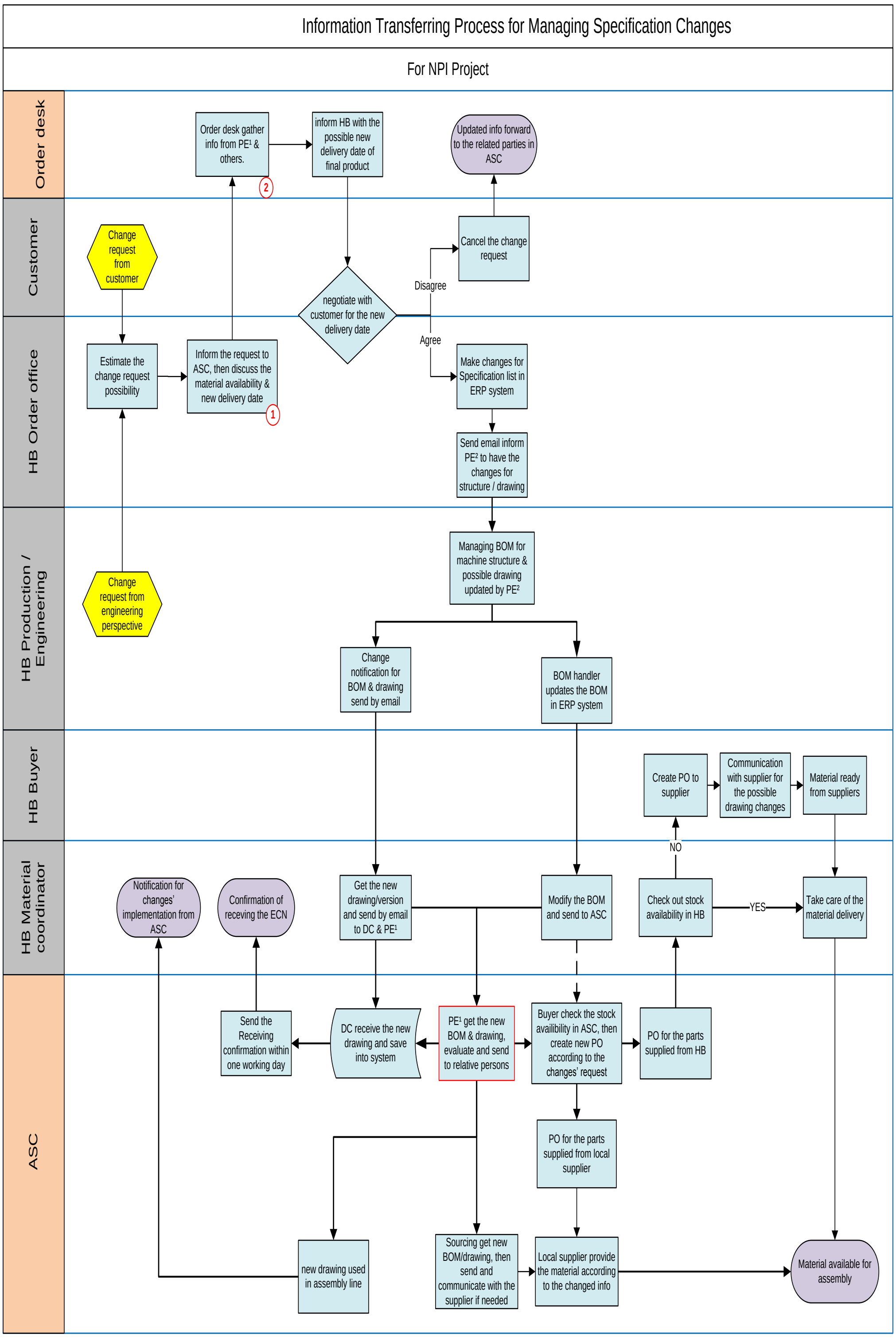

Figure 33 The information transferring process for SC (clear visible version can refer to Appendix 2)

Furthermore, any questions concerning the changed info of BOM and new drawing version from ASC (Sourcing, Buyer or Production engineer) can contact the material coordinator in HB for further explanation.

7.3 Continuous improvement

The improvement plan is based the on the future management expectation to implement and control the future state information transferring processes. The focus of the continuous improvement will be the predicted solutions, which are in allusion to the possible risk measurement for the future state processes.

Performance measurement of processes is an important tool to contribute on the process improvement. According to the existing problems of the current state processes along with the corresponding proposal for the future state processes, the performance measurement of the future state processes could be emphasized on the four critical elements as follows:

Table 6 The performance measurement for the future state processes

	Goal	**Purpose**	**Measures**
Involving parties	high level of management efficiency	well define	process steps' classification, responsibilities' definition
Time	high level of information delivery	efficiency	on time management for transferring the information within the whole process
Accuracy	high level of information usage	practicality	right information, proper delivery format or system
Output	high level of standardization	adaptability	application availability, movement smoothness, on time management, personnel understanding

Process' periodical review is the necessary action for identifying the implementing performance of processes, it is an important tool to control and improve the process. It could be performed mainly in four steps:

- Observe and check the existing implemented situation periodically.
- Maintain the process by confirming all the parties are playing properly with the process.
- Revise the process according to the updated situation and realistic requirements.
- Estimate and upgrade the process functionality for further improvements.

7.3.1 Risk development

When concerning the future state processes for managing the DDxxx's specification and engineering changes, there are risks which can be estimated as follows:

- Uncertainty with the change scale and change complexity of the machine's manufacturing. This will lead to misunderstanding and underestimation of the change impact for managing the machine's assembly. Therefore, it is important to have accurate estimation and forecasts for defining the possible limitation and scope to handle the change request.

- Inaccurate workload and work time estimation for managing the changes, which will lead to impossible on time delivery of the machine. The professional understanding both from mechanical and electrical perspectives of the machine structure will contribute greatly to ensure the scheduling accuracy and on time delivery.

- Unclear options define for the NPI project to have assembly allocation. This will mainly reflect in the difficulty for material handling and inventory control. However, it is important to have awareness of economy downturn with these defined options, which may lead to manufacturing call off of the machine type's production.

- Unqualified material management can be seen as the quality problem or unpunctual lead time. Sourcing and supplier relationship management play an important role for providing the requested material to support manufacturing. In this case, the sourcing role in ASC asks more attention for managing the changes.

- Timing inefficient management for proceeding with the changes, which means not well-defined timing for responding to the changes by product engineer in HB.

Back to the basic, if the defined person for a certain working position in the process cannot very well understand the machine with the changed information and the possible impact for material and new lead time, what could be the solution? Therefore, the personnel management with the proper training for the certain position with the well-defined responsibility is the key for reducing the possible risks.

8 CONCLUSION

For machine's manufacturing allocation in inter-company plants, most problems for managing the NPI project are caused by the inefficient information sharing and delivery between HBs and ASC for change management. The improper information transferring process especially affects the workload and working time for manufacturing the machine, which mainly reflects in material handling to support the assembly, and the new lead time to deliver the final product to the customer.

Moreover, unawareness and unstandardized information transferring processes are the primary problem for the project management. The problem is further complicated since there is no connection and support by the ERP system and PDM system within the inter-company plants.

Information, process and change management are the major elements to consider in this thesis. The empirical research solution had identified the proceeding process in this thesis, which is constructed by the theoretical understanding firstly to support the practical part in working out the intended processes.

From the practical part, the introduction of NPI projects with the machine type and corresponding material management indicates the necessary and importance to have the appropriate information transferring processes for managing the change request. The current state mapping for information transferring processes illustrated the framework of the existing information management. It provides the overview with better understanding for the involved parties and the corresponding tasks and responsibilities from the current state information flow.

The analysis of current state processes helped to identify the major problems and obstacles within the information flow. It showed that involving interfaces chaos and responsibility confusion are the major problems interrupting process efficiency. By responding to the existing problems in the current state processes, the proposal with the relevant solutions had addressed out which contributes to mapping out the future state processes.

The pre-identified and well-defined interface from HB to ASC is very important because this role is the key to ensure the useful information sharing and delivery. The well-defined processes for managing the changes can contribute greatly for material handling and inventory management, by which enables the shorter lead times for final product delivery at lower cost. Moreover, the timing management for requesting the change possibility and responding the change availability is also important to ensure the information transferring efficiency.

8.1 The research evaluation

The study in this thesis concerns the identification of the current state processes and the analysis of their problems. The major objective of this study is to have the future state processes to manage the changes. Collecting and understanding the critical information and management expectation from the inter-company production was the most challenging part of the study. The current process flowcharts were mapped out and the problems had been identified to support further mapping for the future state processes. Plenty of the useful opinions were gained from the personnel interviews, and the improvement suggestions concerning the future state processes were presented.

Better understanding of the NPI projects' objectives and conditions, and having an overall view of the information transferring processes from the inter-company plants was essential for understanding the difficulties that the co-operation faces. The study succeeds to provide an overview of the current information transferring processes for NPI projects that have not been identified before, also it works out the improved processes for future information transferring management concerning the machine's specification and engineering changes. Hopefully this study can provide the useful information and new ideas for other NPI projects from different HBs worldwide currently and future.

8.2 Recommendations for future

This study focuses on the information transferring processes for managing the specification and engineering changes. Database systems between the inter-company plants should be the most important tool that contributes to the information flow instead of the vast manual work. However, the functionality design and implementation schedule of the internal database system are not clear enough, the application scope is not defined yet. There was not any detail planning concerning the system integration between HB and ASC at the moment. There are many considerations and issues concerning the cooperation between HBs and ASC are limited by the company strategic decisions. However, it is important to re-evaluate the efficiency and impacts of these strategic decisions.

Because the material and warehouse management is very much different between HB and ASC, the inventory control could be one of the most important concerns for providing the needed material to support the assembly along with lower cost. In addition, the option of applying the external logistics service will cost responsibility confusion of the material handling, and the delivery procedure cannot handle efficiently with the updated information sharing.

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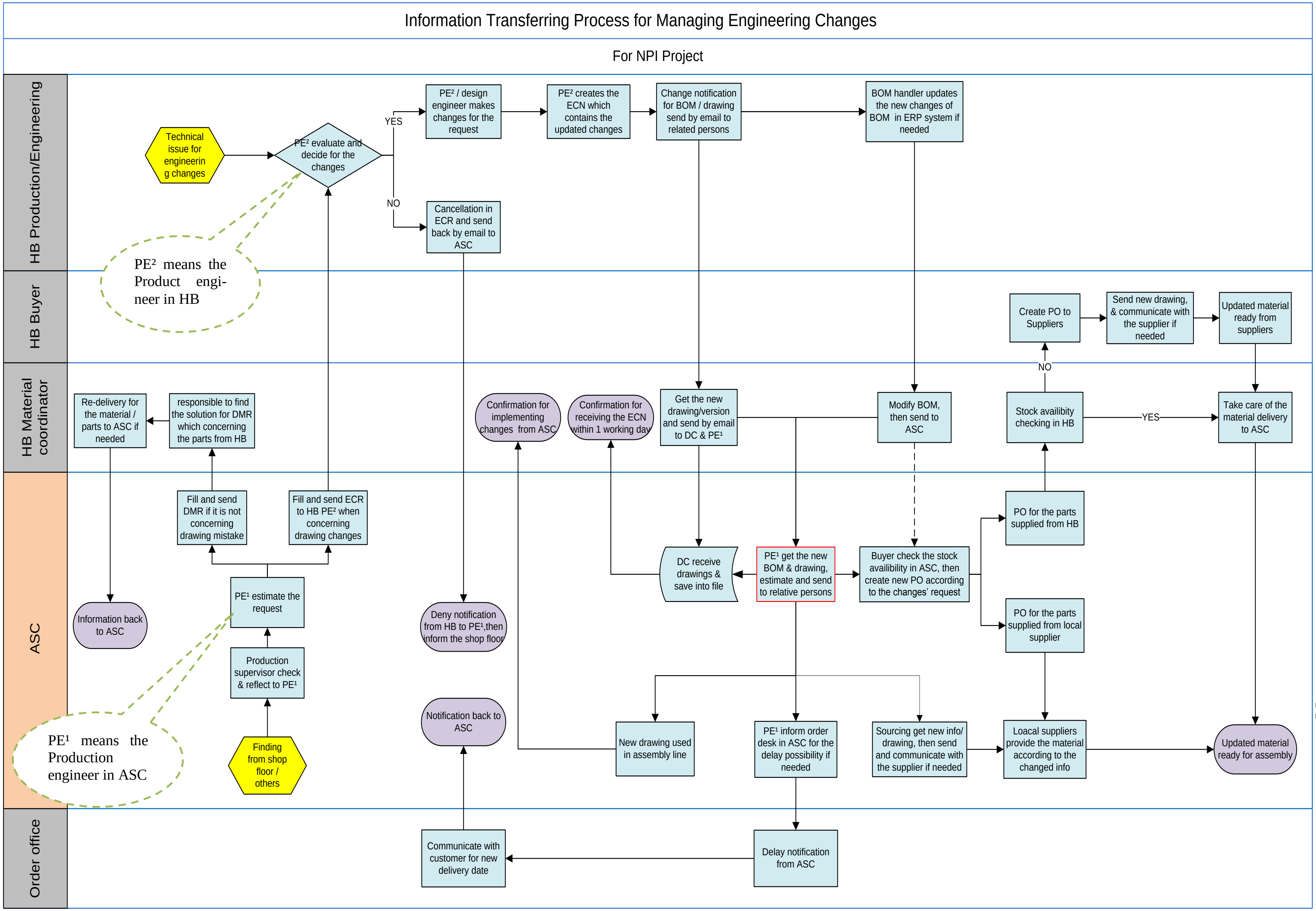
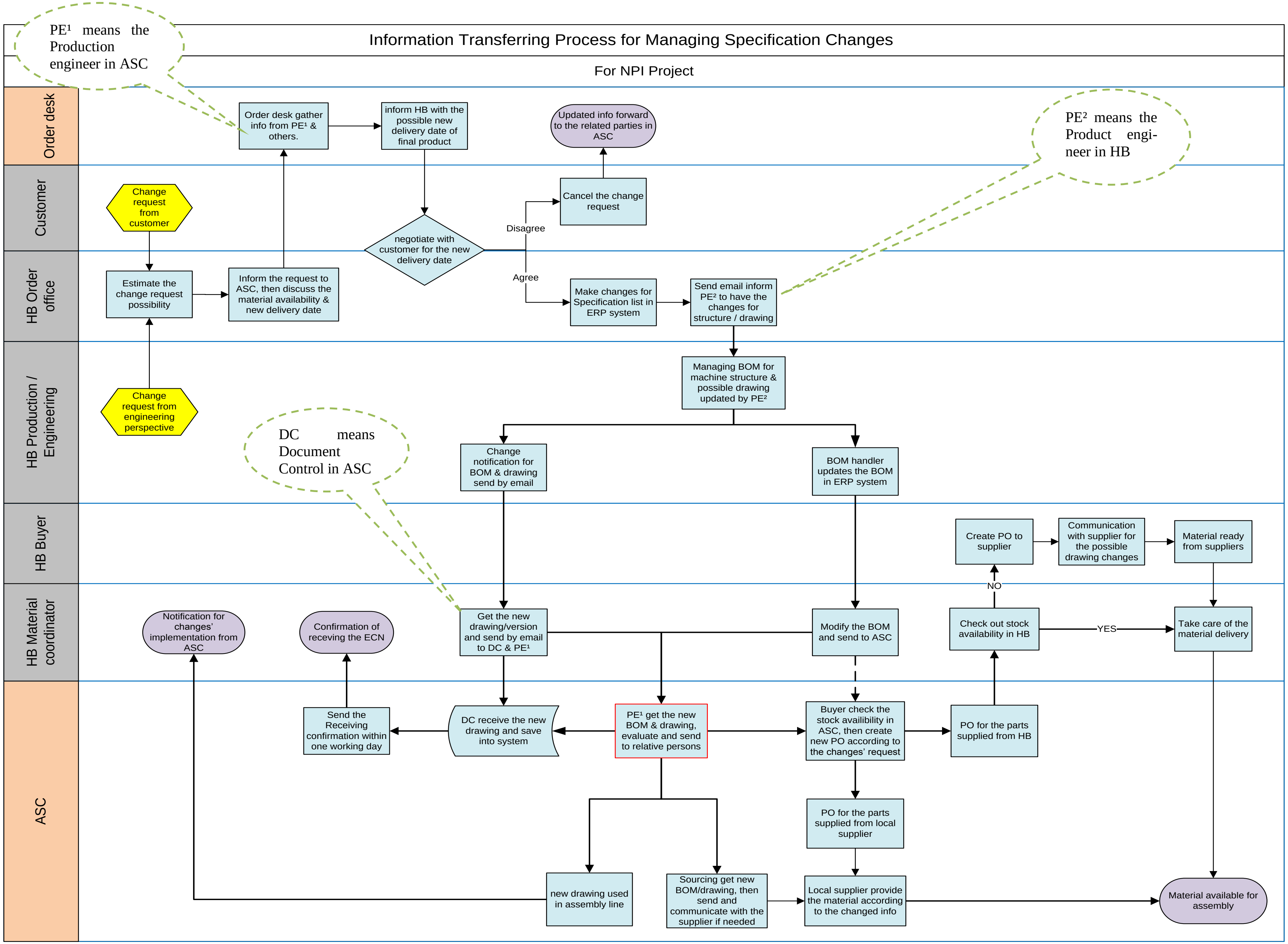
THE DEVELOPMENT OF INFORMATION TRANSFERRING PROCESSES



Appendix 1

THE DEVELOPMENT OF INFORMATION TRANSFERRING PROCESSES



Appendix 2

THE END