ICITSI 2015

by Kurrsehi Falgenti

Submission date: 10-Apr-2023 01:39AM (UTC+0700)
Submission ID: 2059686272
File name: A-37.pdf (459.73K)
Word count: 4213
Character count: 22750

2015 International Conference on Information Technology Systems and Innovation (ICITSI)
Bandung – Bali, November 16 – 19, 2015
ISBN: 978-1-4673-6664-9

The Design of Production Modules of ERP Systems based on Requirements Engineering for Electronic Manufacturing Services Company

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***Abstract*—The Indonesian Government policy on Local Content Requirement (LCR) for the telecommunications equipment industry has an impact on the growth of Electronic Manufacturing Service (EMS) Companies in Indonesia. To improve the accuracy of information and efficiency of administration tasks, EMS Companies need an integrated system. It is well-known that Enterprise Resource Planning (ERP) is an integrated system that can improve the accuracy of the information and the efficiency of administration task. As a software to support back end process in EMS Companies, the adoption of ERP systems affect the value of the LCR. An ERP system made by local developers and implemented by a local company will contribute to the bigger increase of the LCR value compared to an ERP system made by foreign developers. Thus, the opportunity is open to local developers to build an ERP system for the EMS. In this article, we describe the design of a production module of an ERP system for an EMS Company. The design is based on requirements engineering at PT. TDK, one of the EMS Companies located in Serang City Indonesia. The requirement engineering process is conducted through brainstorming and a series of interviews with key users. The result is further confirmed through a focus group discussion with key users from the Production Department accompanied by the head manager of Production and Finance. Information obtained from the interviews and focus group discussions are then used to create business process flow diagrams and functional requirement that describe business processes and actor activities in Production Department. This paper focuses on the analysis and design of a production module for the Production Department because the first phase of ERP implementation in PT. TDK focuses on the department.**

Keywords— Requirement engineering; ERP; EMS; Production Modules; Business Process

I. INTRODUCTION

Service-oriented manufacturing is an emerging paradigm in the world of manufacturing industry [1]. This paradigm is growing as the industry tends to be more competitive by reducing overhead costs. Reduction of the overhead costs is done by transferring various service activities that were previously performed by the company's internal staff to another company that specializes in specific activities.

In the electronics industry, the service-oriented manufacturing paradigm can be seen with the growth of Electronics Manufacturing Services (EMS) companies. EMS is a company offering manufacturing services to Originals Equipment Manufacturers (OEMs) and concentrate on providing more comprehensive services [2].

EMS Companies in Indonesia are growing as an impact of the Minister of Industry Regulation on the calculation of Local Component Requirement (LCR) on electronics and telematics devices [13]. In this regulation, the government sets the level of local content within a specific value for telecommunications equipment sold in Indonesia. Indirectly, this government policy is aimed to encourage foreign vendors or Original Equipment Manufacturer (OEM) to assemble their device in Indonesia. For OEM who does not have strong capital to build a factory in Indonesia, local EMS provides an option to assemble their products in Indonesia. Thus the product to be marketed in Indonesia satisfies the LCR in accordance with the government regulation.

This situation makes local EMS companies improve themselves to provide the best service to the OEM. To improve the accuracy of the information and the efficiency of administration task, the EMS companies must modernize its internal information system. In the warehouse, the information regarding to the goods in and out should be well-documented, so that the movement of goods can be traced. On the production line, work should be supported by a reliable production planning system. So too are the accounting and finance, whereas this section should be able to provide reports in real time. Each part is integrated with one another. The integrated system will provide a competitive advantage for manufacturing [3].

Enterprise Resource Planning (ERP) is a strategic information system that can integrate business processes in each section within the company. The uses of ERP systems allow the control of time and space on inventory easier. Katalnikov [4] had identified one of the potential advantages

of using ERP systems is saving on inventory. ERP systems also reduce labor and overhead cost [5].

As a software that supports the production process, ERP systems can also increase the value of LCR. ERP systems which are built locally and implemented by local companies will contribute more to increase the value of LCR compared to those built abroad and implemented by local companies. With the Indonesian government policy on local content rules, it provides the opportunity for local developers to build an ERP system for the EMS companies.

Some companies choose to implement an ERP system package. Failure of ERP system package implementation often occurs because of the customization process is more focused on aligning the functions rather than aligning the requirements of the organization [12].

Usually, functions that already exist in an ERP package are the best practices that have been widely used by many other companies. Therefore, the ERP packages should be able to facilitate most tasks in a company that uses the ERP package. In general, however, stakeholders consider their current practices should also be accommodated within the ERP package, so implementers customize the ERP package according to the current practices. The customization ideally should be no more than 30%. Excessive customization could be the cause of the failure of the ERP packet implementation.

ERP system built from the scratch is supposed to be easier to meet the requirements of the functions inherent in the ERP systems and the requirements of the organization's. The harmonization of the organization's requirements and functions should be done at the analysis and design stage of ERP systems live cycle. Analysis and design are two important stages to build an ERP system from the scratch.

Unlike the off-the-shelf ERP software package such as SAP, the stages of analysis and design in the traditional way is done directly by system analysts and software developers. At this stage, conciliation is needed to equate the viewpoint among stakeholders involved in the design process. The success at this stage will relate to efficient communication with stakeholders and the failure at this stage will lead to the development of a system that cannot meet the functionality aspect or a system that does not reflect the objectives and activities of the organization.

2 Traditional software development generally uses a waterfall model. This model consists of six phases: planning, analysis, design, implementation, deployment, and maintenance [15]. In Indonesia, several studies have discussed the design of the ERP systems. These studies are more focused on the design of ERP systems for Small and Medium Enterprises (SMEs), such as the study by Siswanto and Maulida that designed and classified requirements of ERP Modules for micro, small, and medium enterprises in the field of fashion [6] and the study by Ruldeviyani and Sandhyaduhita that created sales module ERP system for SMEs [7]. For manufacturing company, Budiarta and Iriawan designed and built manufacturing information system [8], however that system is a stand-alone system and it is not integrated with other parts of the company.

In the design phase, there is Requirements Engineering (RE). RE is an attempt to conciliate stakeholder viewpoints involved in the design [15]. According to [9], RE is a set of activities that develop the understanding of the requirements between stakeholder and developer, and managed by the manager. RE is one of the most crucial steps in software development process [10, 11]. RE consists of five stages; they are elicitation, analysis and negotiation, documentation, verification and validation, and management process [11].

The recommended techniques in running RE is a technique that is easy to implement [11], such as brainstorming for elicitation, project team meeting for the analysis and negotiation, technical specification for the documentation, evaluate the documentation for verification and validation, and management meeting for the management.

In this paper we will apply the RE process to design the production modules of ERP system in PT. TDK, an EMS company located in Serang, Banten Province, Indonesia.

II. Research Metodology

RE conducted in this study is RE based on Business Process Model [16]. Our consideration in using the RE to design production modules is because we built a complex ERP system, integrating many divisions in PT. TDK. We consider the phases in the RE are effective in extracting the user needs, mapping it into a business flow diagram and constructing the functional requirement.

The RE starts with elicitation process. Elicitation process begins by analyzing the business processes that are running through brainstorming with some key users. The analyzed business processes are mapped into the as-is process by following the flow of work in the Production and Finance Department. Business processes in Production and Finance Department are grouped into number specific processes. The users have a role as an actor who runs the specific processes. A series of interviews are conducted with users to capture the needs of the actors involved in this specific process (Fig. 1).

The next step is analysis and negotiation. In this step, the developers explain to the users through focus group discussion (FGD), business processes that will be integrated with the ERP system and the functions that will be incorporated into the ERP system in accordance with the needs of users obtained at the elicitation step.

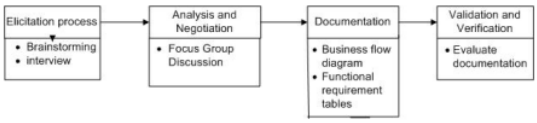

Fig. 1 Requirement engineering process and technique

System Analyst and R&D manager create business flow diagrams based on data from brainstorming, interviews, and the FGD obtained from the previous steps. The business flow diagrams are the initial models to build an ERP system. The System analyst also create use case diagram as the basic functions in providing appropriate user needs in the

production module of ERP system. Functional requirement is presented in a use case diagram, because of the space limitation, in this article it is presented in the form of tables.

At the verification and validation stage users are asked to perform verification and validation design of the production modules. Their involvement in this stage is very important to ensure the functional requirement designed meet with the needs of the users. We do not include the process management in RE as the process management takes place in the implementation and deployment phase; currently, PT. TDK is in the implementation process.

III. Analysis and Result

There are six business processes that are analyzed in this study (Fig. 2). Five of the six processes are discussed and then integrated to production modules of the ERP system. Those five business processes are document preparation (process 1.0), material preparation (process 2.0), assembly planning (process 3.0), assembling (process 4.0), and final check (process 5.0). Due to space limitation, only invoicing business processes related to billing charges of the accounting and finance process (process 6.0) is discussed in this study.

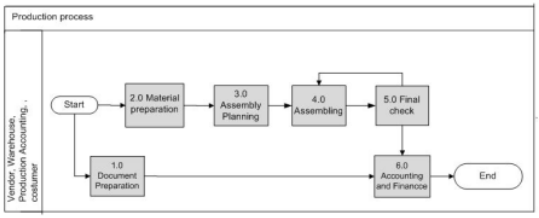

Fig. 2 High level business process

A. Document Preparation Process

Items assembled in manufacturing service companies are OEM's goods from overseas. Before the items entering the factory, they will be inspected by Indonesian customs (Fig 3). There are two inspection processes, the inspection of documents (process 1.3) and the physical inspection of goods in a bonded warehouse (process 2.2). OEM goods are place into the EMS warehouse after the two inspections. Customs will issue an expenditure approval letter after passing the customs inspection (process 1.5). Assembling process can be carried out after the letter is issued.

There are two types of goods from OEM; they are trading goods which are intact units in the form of finished goods to be sold directly and assembly goods in the form of components or parts that have not been put together. The Accounting and Finance Section will separate documents based on the two types of goods (process 1.6). The packing list of assembly goods is selected and separated according to their lot-number (process 1.7). There are also different accounting treatments for both goods. Trading goods are only charged with import charges while for the assembly goods, in addition to import charges, they are also charged with assembly charges.

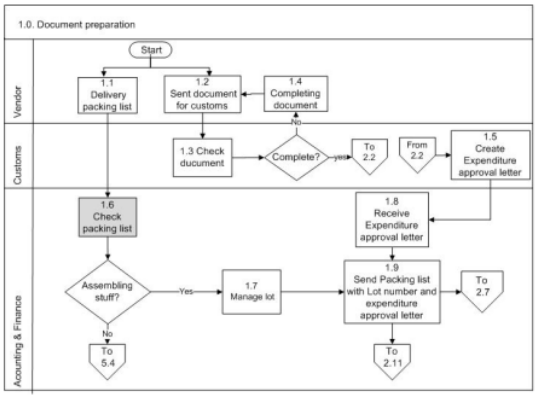

Fig. 3 Document preparation business process

Expenditure approval letter and packing list already checked by the finance staff is then sent to the warehouse and production (process 1.8 and 1.9). For the Head of Warehouse, the two documents as a warrant to take goods in bonded warehouses and check the quantity while for the Head of Production it is used to check the part quality.

B. Material Preparation Process

The delivery of goods is done by OEM after sending documents to relevant parties (process 2.1 in Fig. 4). Before entering EMS Warehouse the goods will go through physical inspection done by Customs to make sure that the goods are legal. It is done by ensuring the goods recorded in the packing list document (process 2.2). The goods in the warehouse are then checked by the Warehouse Department in terms of quantity (process 2.5 and 2.8) and by the Quality Control (QC) staff in term of the quality (process 2.11). It is done on a sampling basis.

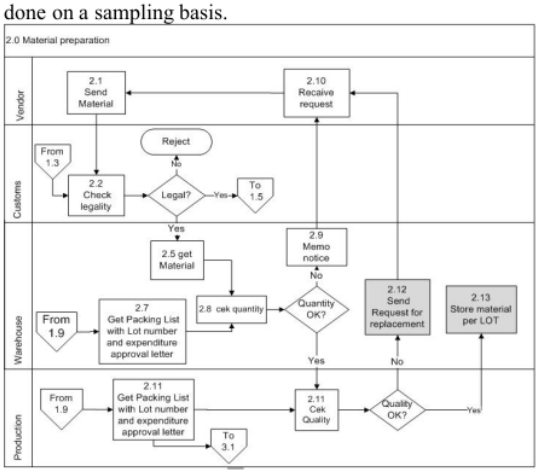

Fig. 4 Material preparation business process

If there is a lack of goods or there are goods that do not pass the quality check, then the Warehouse Department will

send a memo notice (process 2.9) or replacement request (process 2.12), respectively, to the OEM. Once completed, the Warehouse Department will store these items based on their lot number (process 2.13).

C. Assembly Planning Process

Assembly planning consists of two separate processes (Fig. 5). *First,* formula planning process for making Formula Assembly (FA). *Second*, production schedule planning process for determine the schedule of assembling. Both processes should be done by production manager before assembling process.

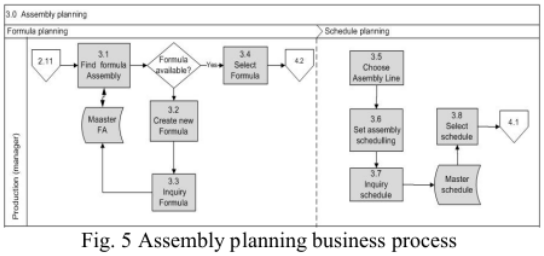

Fig. 5 Assembly planning business process

In the formula planning, the Production Department creates the FA based on packing list document and lot number that are sent to the Production Department. For assembly goods with an old lot number, the FA can be found in the FA master (process 3.4); while for goods with a new lot number they must be assigned a new FA (process 3.2). Assembly with a new lot number is usually an assembly goods for new type of product, thus creation of a new FA is required. The new FA is then stored in the FA master database (process 3.3). After the Head of Productions find or create a new FA, he should make a schedule planning.

On the schedule planning the Head of Production determines the line of production (process 3.5) and the date of production (process 3.6). The assembly planning process is done by inquiring the master database schedule (process 3.7). The master schedule made by the production manager is based on the production line capacity and manpower required.

D. Assembling Process

The assembling process is done after the FA and the schedule for the assembly goods has been made by the manager (Fig. 6). The Line Supervisor checks the schedule and formula assembly (process 4.3) to make a material request to the warehouse. If the assembling process is completed in one day, the Line Supervisor requests a full delivery of materials (process 4.4); otherwise the supervisor requests the material to be delivered partially (process 4.5).

The process of sending materials to production is based on FIFO. Materials to be assembled are the materials with the oldest lot number (process 4.6). During the assembly process (process 4.10), the Quality Control (QC) Staff performs a series of tests for quality control (process 4.11). If problems are found, the unit that has been assembled is immediately sent to the repair room (process 4.13). The repairman notes the problems found and provides a solution to fix it. A damage note is attached to request components or units replacement (process 4.14). Good spare parts are packed (process 4.12) and sent to the warehouse (process 4.17) while for the damaged parts they are shipped back to OEM for requesting the part replacement (process 4.14 – 4.16). Once the assembly process is completed, the units are packed and ready to be sent to the finished goods warehouse.

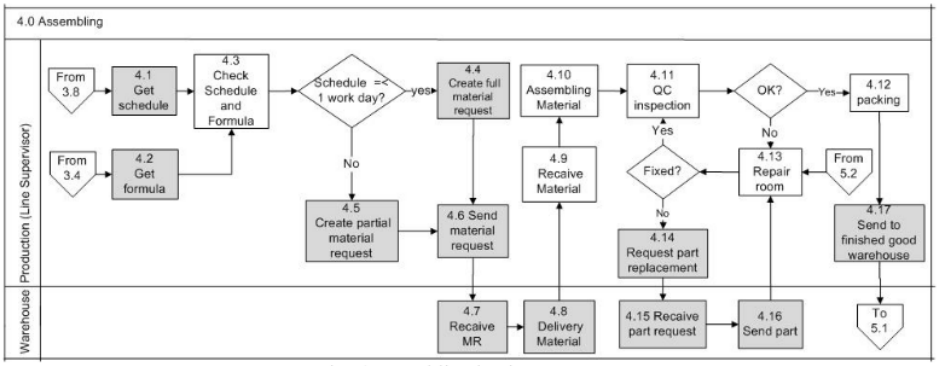

Fig. 6 assembling business process

E. Final Check

Before the finished unit enters the finished goods warehouse, the Quality Assurance (QA) staff checks the sample units already finished (process 5.1 in Fig. 7). If problems are found, the unit is immediately sent to the repair room, while for a good unit it is directly sent to the finished goods warehouse (process 5.3). Goods will be shipped to the customer based on the order from OEM after all import fee and assembling fee have been settled (process 5.4).

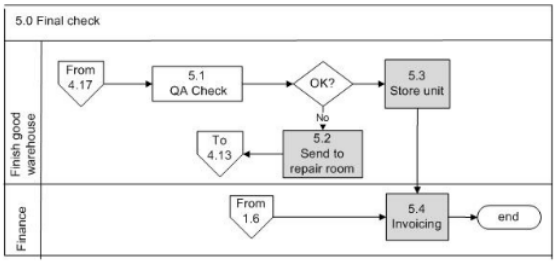

Fig. 7 Final check business process

F. Functional Requirement

The activities described in the business process flow diagram discussed above consist of manual processes. Some of these processes will be integrated by providing functionality in the ERP system. Processes in the grey box in the flow diagrams are the processes that will be automated and integrated in the ERP system. Table 1 – 5 show the business functional requirements on each business process.

Table 1 Document Preparation Process

Process	Function	Actor
Check packing list	create invoice	- finance staff

In this process, the finance staff sorts documents of trading goods and assembly goods. The assembly goods will enter the production process but it is not for the trading goods.

Table 2 Requirement on Material Preparation Process

Process	Function	Actor
Get packing list with lot number and expenditure approval letter	- upload packing list	- warehouse staff
Sent request for replacement	- request for replacement	- warehouse staff
Store material per lot number	- transfer in	- warehouse staff

The *upload packing list function* (Table 2) will be integrated at the production module. The uploaded packing list is already inspected by the Finance Department. After the upload, a quality and quantity check are perform to ensure the materials that are inbound to the warehouse are materials that are in perfect condition. The materials that are not qualify in terms of quality and quantity are request for replaced by running the *request for replacement* just a good material that is transferred from bonded warehouse to PT.TDK warehouse's, the transfer is done by running the transfer function in after quality and quantity check is finished.

Table 3 Requirement on Assembly Planning Process

Process	Function	Actor
Find FA, create FA, inquiry FA	- find FA - create FA	- production manager - production manager
Chose line, set assembly scheduling, inquiry schedule	- create schedule	- production manager

In the assembly planning, there will be three functions that will be conducted by the Production Manager (Table 3). First, *find the FA* with the unit that will be assembled. For the unit that is already assembled before, the FA are available in the database. For the unit that are being assembled for the first time, the Production Manager will need to make a new FA (by the *create FA function*). Once the FA is done, the Production Manager will create an assembly schedule using the *create schedule function*.

Table 4 Requirement on Assembling Process

Process	Function	Actor
Get schedule, get formula	- material request	- line supervisor
Partial material request, full material request	- material request	- line supervisor
Receive MR, send Material	- material transfer	- warehouse staff
Send request for replacement	- request part replacement	- repairman
Send part	part replacement	- warehouse
Sent to finish good warehouse	- transfer unit	- line supervisor

In the assembly process, the Line Supervisor can ask for materials to the warehouse by conducting the *material request function* (Table 4). In this function, there is an option to choose either partial or full request depends on how many units that are being produced based on the schedule that were made by the Production Manager. The warehouse staff sends the materials that are going to be assembled by conducting the *material transfer function*. During the assembling process, the defective materials will be transfered to the repair room. If the materials need part replacement, the repairman will conduct the *request part replacement function* by fill form and print it. The print document will be send to the warehouse. Warehouse staff recorded the part and approved the replacement by fill *part replacement function.*

Table 5 Requirement on Final Check Process

Process	Function	Actor
Check packing list, Invoicing	- create invoice	- finance staff

The *create invoice function* isn't a pair of the production process, but the creation of invoice is related to the finished goods after the production process is finished. Financial staff create two types of invoice based on the type of goods, invoice for trading goods and invoice for the unit which has been completed in assembling process

IV. Conclusion

Among the four steps in RE, the elicitation process is the step that took the most time. It is because this step investigates the base problems. For example, in PT.TDK there is no common perception in using the terms in the manufacturing, such as packing list and lot number. To conduct the elicitation process effectively, the company's stakeholder should have the same understanding and knowledge on the commons term.

In the analysis and negotiation of functional requirements, there has been an intensive discussion between the developer and user on explaining the gap between as-is and the to-be model. This step is also a time-consuming step after the elicitation step. This step will be more swift if the company has used the information system in supporting the business process. With the experience in using the information system application, the users will understand more the logic of the system in supporting the business process. The Production Department in PT.TDK has never used the information system application beforehand; to date the business process is only supported by spreadsheet.

A business function in the production area that we have analyzed is the assembling process. PT. TDK is an EMS company whose core business is to process assembly of goods so there is no production process from raw materials.

Best practice in the form of functions required in designing ERP systems in this study base on business process on the PT. TDK. The functions are integrated is not only ERP best practice, but there are specific functions related to government regulations. Best practices in this study can be applied to the other EMS companies by considering the specific functions.

Acknowledgment

Thanks to Mr Yunizar, Head of R&D Department PT. Tridarma Kencana. This study is the output of a competitive research grant of DIKTI, funded by the DP2M DIKTI through LPPM UNINDRA with contract no.03/kpl/LPPM/UNINDRA/ 2015.

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PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6