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Research on BOM Mapping Transformation for Ship Construction Process

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Abstract: Due to the problem about the core departmental "information isolated island" with BOM, various stages of ship product design section are convergence off and impeded the construction of agile ship the product. In this paper, first, establish the various stages of the ship product BOM structure model, based on a comparison of the structural model analysis, design a more practical conversion method, and then describe the conversion process about the ship product life cycle BOM view in order to quickly build a variety of BOM view.
Keywords: BOM; BOM tectonic model; BOM view of conversion

1. INTRODUCTION

With the extensive application of computer technology and advanced shipbuilding mode of rapid development, China's shipbuilding industry is facing shorter product development periods and delivery time, increase the complexity of such new challenges. Large design software shipbuilding industry have introduced CAD / CAM, tribo, PDM systems, and MRP / MRP Ⅱ/ERP and other departmental applications. However, these departmental information system, there exist sharing problems, leading to a big difference between product design data, manufacturing data and procurement data, and also the consistency and real-time is poor during the construction in the product life cycle, which seriously affected the process integration and efficiency of enterprise product design, production and management, resulting in increased costs of shipbuilding, the product of ship development cycle to extend and so on. In terms of basic design data for the initial ship BOM, using pre-defined rules of conversion to formed the formation process BOM, manufacturing BOM and procurement BOM, will greatly reduce the

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workload of various types of BOM designed, while maintaining the BOM view, has the consistency, accuracy and, to some extent, improved auto-generation efficiency of other BOM views.

At present, some scholars were studied the issue of BOM conversion from several angles(LIU,WANG, XING & YUAN. 2005) by identifying the similarities and differences between EBOM, MBOM file structure and process attributes , then studied conversion method between the two BOM (ZHU, CHEN & MAO. 2006) is based mold BOM dynamic characteristics of the data ,presents a version of mold BOM management methods and an automated rule-based reasoning progressive mold BOM generation and conversion methods (ZHAO, CHANG & LIU. 2007) from three aspects of the structure, related information and attributes, study the interpretation of mechanism from EBOM view to production preparation extended sub-view of the manufacturing bill of material (WEI, TAN & FENG. 2006) detailed analysis the difference between the design BOM, manufacturing BOM, inventory BOM, defines the mathematical model of BOM and gives a detailed design BOM, manufacturing BOM and inventory BOM conversion steps. These studies aimed to study the entire manufacturing sector, and did not involve product-specific ship BOM conversion research. In fact, according to the characteristics of ship construction process, shipbuilding BOM view has its own particularity. Therefore, this paper presents conversion methods on key BOM views during the process of ship construction.

2. THE FEATURES OF SHIPBUILDING ENGINEERING DESIGN AND MANAGEMENT

2.1 Characteristics of shipbuilding production organization

(1) Edge design, while the production, while change is one of the most significant features of the ship construction enterprises.

(2) Through the development of the project plans to control a range of procurement and production activities.

(3) Ship construction process is the parallel process of interaction between product design, material procurement and production operations.

(4) In the basic design, the need to identify the important pieces of pre-purchase. Important pieces of the procurement process is the process of cooperation between the designer and procurement

(5) In the modern shipbuilding mode, outfitting pieces of pallets involved in the process.

According to characteristics of the organization of shipbuilding production, ship design throughout the entire construction process, the rationality of its design and the timeliness of production will directly affect efficiency of the ship's production. The following will analyze a bottleneck in the process of the ship design to obtain a more reasonable solution.

2.2 The introduction of ship design process and its key technologies

According to market research and customer demands, the design department does the basic design firstly. The basic design requirement under the contract documents on the main scale and performance of the ship and decided the main structure of the ship and major mechanical and electrical equipment, while proposed the host and the large-scale mechanical and electrical equipment orders. After the basic design complete, design drawings and other documents will to be sent to classification societies and ship owners to review. After the completion of review, the design department will give a detailed design in accordance with basic design principles, study the detailed structure, scale of the ship and systems, and give an appropriate consideration to construction problems.

Enterprise Technology sector start production design based on detailed design. Modern shipbuilding

model calls for the production design must be designed to implement the basic principles of the region to design and intermediate product-oriented design. Production design also must be integrated with the shipyard production conditions, from the perspective of shipyard construction, and then on this basis, by region, stage and type of product to the decomposition and combination of production tasks to form packets (WOP) and work instructions (WOD). The product structure generated in this phase is MBOM, including the two elements, WOP and WOD. Program management department, respectively use WOP, WOD as objects for the preparation of the plan and work assignment, used to guide the on-site production operations.

The relationship between the design process and the BOM view is shown as Figure 1.

Through the description of the design process, the key points of product design process (basic design, detailed design and production design) can be summarized as the following:

(1) Integration of CAD, CAM, ERP

(2) Effective data management (product structure management, document management, design change management)

(3) Collaborative product design and manufacturing

3. THE FLEXIBLE GENERATION STRATEGY OF BOM FOR SHIP CONSTRUCTION PROCESS

To achieve the goal of key points in product design process, this paper presents the flexible generation strategy of BOM for the process of ship construction .The solution provides a bridge for the upstream activities of ship development and design (CAD) and the downstream activities (ERP System) of support for the operations between ships .

Ship construction process, from shipping products market research and customer demand, through this series process, basic design, detailed design, production design, materials procurement, manufacturing process until the quality control. The relationship between these stages, shipbuilding enterprise departments, applications and the BOM form are shown in Figure2.

Compared with other manufacturing industries, PPBOM, in the segmentation process of design BOM, according to certain rules the sub-components in the extract that are classified as intermediate product tray. The conversion between PPBOM and MBOM is no longer on the basis of the PPBOM, modify some of the nodes of PPBOM. But according to certain rules, merging to form a new node with the same level and the same type of nodes, a big rate of conversion.

Ship design process, each stage will generate different types of procurement BOM. In the basic design phase the procurement of major mechanical and electrical equipment BOM; in the detailed design stage, producing some of the steel hull procurement BOM, outfitting the purchase BOM such as some of the formation of tubes, valves and small auxiliary equipment; in the production design stage, according to the various operational phases generated corresponding of the procurement BOM.

Based on analysis four kinds of BOM tectonic model and to build mathematical models above-mentioned, research the conversion methods between ship EBOM, PPBOM and MBOM, and the generation of procurement BOM.

3.1 Description of the multi-view conversion process of shipbuilding BOM

In accordance with the conversion order of BOM view, the conversion process of BOM view include:

First, SEBOM extraction. Through the CAD system output data file on the design BOM, and then

extracted important pieces of the procurement BOM from the design BOM, provide the most basic BOM data for other BOM views.

Second, SPPBOM and SMBOM conversion.

(1) SPPBOM conversion. Based on the SEBOM, decomposed the hull of the leaf nodes (section) into parts, broken outfitting down into pallets, parts and components; and increase the product process information.

(2) SMBOM conversion. Based on SPPBOM, according to type of operation, using group technology, the middle of ship product-oriented, re-combination of processing components and installation of sub-regional, system, etc., forming work packages, and broken down into dispatching a single.

Third, the procurement BOM, the quality of BOM, cost BOM conversion. Procurement BOM mainly for SPPBOM, SMBOM home-made parts, purchased parts, and spare parts are carried out together to form the procurement of BOM; the quality of BOM is based on the SMBOM to increase the necessary quality control and requirements of the content; cost BOM for kinds of parts processing and assembly statistics on the costs of each SPPBOM and SMBOM.

Fourth, BOM data validation and feedback. BOM view will be exported from the manufacturing, quality control, production costs and many other side to test the product design, for those beyond the shop-floor manufacturing level of the product, high production costs of products, high product quality standards or had low quality standards products and so on, provide feedback information to the design department in order to modify the design data and improve the level of product design. Such testing and feedback mechanisms can make the product design data can be in a reasonable state of such links, product design, manufacturing and procurement.

EBOM, PPBOM, MBOM and BBOM are the most critical data in the ship design process, the following will detailed discuss the four BOM generation and the relationship between them, design more effective conversion algorithms.

3.2 Shipbuilding EBOM, PPBOM, MBOM and BBOM mapping and conversion

3.2.1 The structure model and mathematical model of Shipbuilding EBOM, PPBOM and MBOM (QIU & MA, 2008; YUAN, et al, 2000)

3.2.1.1 Shipbuilding EBOM (SEBOM)

Shipbuilding EBOM is the designer used to indicate the main structure and the main mechanical and electrical equipment of ship products, is normally provided by a professional shipbuilding institute (company) .SEBOM is a hierarchical system, its top is the whole ship. As has the different levels of decomposition of intermediate products in the hull and outfitting, SEBOM, composition of two main parts, sub-hull and outfitting. Hull in accordance with the total segment →section , outfitting in accordance with region and the hierarchy structure of system to construct SEBOM, the professional plan document hanging in the each node of the SEBOM to prepare for queries. Designer design product based on customer needs or design requirements, after complete product design work, EBOM extract relevant data from the design drawings.

Definition 1: SEBOM is expressed as a triple:

SEBOM=<CenterProduct，AssemblyRelationship，Information>

Where: CenterProduct that expressed as the collection of all levels of intermediate products in the process of ship construction. To hull, for example, including total segment sub-object collection section, can be further expressed as (Total segment1, total segment 2, ..., total segment N); (section 1, section 2, sub-... N). AssemblyRelationship is the collection of the assembly relation among intermediate product

objects, can be expressed as (Assem1, Assem2, ..., AssemG), assembly relation refers to hierarchical relationships and affiliation of the components, parts, components, sections, to some extent describes the assembly process and assembly sequence of the intermediate products. Information is the collection of associated information of the various intermediate products, the expression of information content associated with a specific node, mainly the design documents associated with nodes.

3.2.1.2 Shipbuilding PPBOM (SPPBOM)

Shipbuilding Technology BOM (Shipping Process Planning BOM, SPPBOM), SPPBOM is a process file that business process design department to organize and manage production of a product and its related components, which is based on SEBOM, according to each ship technological features of the enterprises themselves, the preparation of the product parts, components, sections, sub-regional as well as the final product processing and assembly methods, while SPPBOM identified components of information processing technology. SPPBOM breakdown structure is based on intermediate products (with segmented as the main hull , outfitting with tray as the main body)-oriented, according to the production design of technical information (management charts, design drawings, etc.),that is SEBOM tectonic model for the establishment of connections to form a variety of SPPBOM list. Hull use segments → components → parts, outfitting use a regional (at all levels of the region) → pallet → part → part of decomposition pattern to constructed SPPBOM.

SPPBOM, by extending SEBOM design information, added detailed information on processing and assembly process description to describe the contents.

Definition 2: SPPBOM is expressed as a triple:

SPPBOM = <SPPCenterProduct, SPPAssemblyRelationship, SPPInformation>

Where: Based on SEBOM, SPPCenterProduct, SPPAssemblyRelationship, increased trays, components, parts and components, and other intermediate nodes and assembly relationship information, SPPInformation increased process information (process model information, process information and process information for the document) in the information collection. Process model information is the basic process information of the each node of product structure tree, such as parts of the material, size, weight, the schedule of the ministry of components, etc. Document Information mainly refers to the processes documents that associated with the associated nodes, including technical documentation and process documentation. Process information mainly refers to the process control information that the task of process design activities, roles, permissions, task status in the tree nodes.

3.2.1.3 Shipbuilding MBOM (SMBOM)

Shipbuilding manufacturing BOM (Shipping Manufacturing BOM, SMBOM), SMBOM is a product bill of materials that production management departments to organize and manage the actual manufacturing and production management process to produce parts and components that needed for. To SPPBOM-based, given the characteristics of shipbuilding production organization, can divided SMBOM into 2-level, work packages (WOP) and work orders (WOD) ,work packages, sending work orders mainly include parts lists, processing technology, hours of work volume, materials inventory and other information.

SMBOM mainly based on SEBOM information, combined with product process information SPPBOM provided to modify the number of SEBOM assembly and relationship between pairs of components in SEBOM and decided manufacturing and installation method of spare parts, sections, sub-regional and final product. As the product's manufacturing structure, complex than the design results, and therefore also SMBOM more complex than SEBOM, it mainly reflects the products in the manufacturing process of the assembly structure and home-made pieces of processing of relevant information, SMBOM data structure as shown in Table 3. SMBOM is of great significance to production management, especially in the Material Requirements Planning (SMRP) calculations, only by SMBOM structure, we can accurately calculate the number and timing of demand of all material items, so as to

provide data basis to develop production plans and procurement plans.

Definition 3: SMBOM is expressed as a triple:

SMBOM = <WorkPack, Work, Assem, Info>

Where: WorkPack that expressed as the collection of the set of task packages in the ship construction process; Work is set to send work orders; Assem is the collection of the subordinate relationship between the task package and dispatching single object, can be expressed as (Asseml, Assem2, ... AssemG), to some extent describes the assembly process and assembly sequence of the process of ship construction.

Info is the collection of associated information of task package and sends work orders, such as hours of work volume, plans start and completion time, construction drawings and other information.

3.2.2 The Method of mapping and conversion between SEBOM, SPPBOM and SMBOM

Shipbuilding BOM view information is the composition of the relationship between nodes and node information. According to before and after the different changes of the mapping information of BOM view tectonic model described above can be divided changes into four kinds of mapping type:

Definition 1: Copy the map (CM)

In BOM view, the relationship between nodes and node attributes are not changed.

Definition 2: Genetic mapping (GM)

In BOM view, the relationship between the nodes has not changed, while the node attributes has a change in the mapping operation.

Definition 3: The derived mapping (AM)

In BOM view, the relationship between nodes change, on the basis of the original leaf node, increased a mapping operation in the relationship between nodes.

Definition 4: Decline the number of maps (DM)

In BOM view, the relationship between nodes is changed, in the relationship between some of the nodes remove the mapping operation.

Definition 5: re-mapping (RM)

In BOM view, the relationship between nodes and node attributes are not changed, the relationship between nodes needs to re-mix.

Research products converting BOM view will focus on the difference between sum up the source and target BOM nodes and the different node attribute information of the BOM, that is, to inspect the node structure and information before and after the map changes. First determine the mapping relationship between the two kinds of BOM, mapping function can be expressed:

$$D-BOM = f_{I-D}\left(I-BOM\right)$$

$I-BOM$ is initial BOM ， $D-BOM$ is export BOM ， f_{I-D} is mapping function .

3.2.2.1 SEBOM conversion to SPPBOM

SPPBOM is based on SEBOM structure, intermediate products for production-oriented design of the formation of various intermediate products, materials, scale, spare parts inventory and other management documents, charts and figures technical information. SEBOM conversion to SPPBOM is actually to resolve issues about the transformation of the problem. It is ranging from "How to

shipbuilding" to "how to organize shipbuilding production".

Between SEBOM and SPPBOM mapping function can be expressed as:

$$SPPBOM = f_{AM}\left(f_{HM}\left(f_{CM}\left(SEBOM\right)\right)\right)$$

Detailed algorithm is as follows:

1) The system first copy SEBOM relational table as an initial prototype of the SPPBOM, and then make mapping changes in the relationship of SEBOM. Complete mapping the contents of CM.

2) Increasing the node characteristics of property. If the node is a section and the system, then the need to increase the assembly process route. If the node is a spare parts and pipes, you need to increase the corresponding processing process route. Complete mapping the contents of GM.

3) To extract leaf node to node processing. If the material is a leaf node, mainly include sections and systems. If the tray, then fill in the section of the tray and the tray details; If the system, then broken down into subsystems. Complete mapping the contents of AM.

4) Until all the leaves nodes have been processed.

3.2.2.2 SPPBOM conversion to SMBOM

The light of a variety of production design data consists of a list of parts, materials, fixed tables and figures document of the intermediate products SPPBOM provide, in accordance with the type of operation and planning time, based on given the production GT, the formation of various departments of the work packages, all departments in accordance with the specific business segments for the formation of executable dispatching Single for work teams and groups.

Between SPPBOM and SMBOM mapping function can be expressed as:

$$SMBOM = f_{RM}\left(f_{AM}\left(f_{CM}\left(SPPBOM\right)\right)\right)$$

Concrete realization of these steps:

The system first copy SPPBOM relational table as an initial prototype of the SMBOM, and then make mapping changes in the relationship of SPPBOM. Complete mapping the contents of CM.

According to the demand, increase the properties of each node "operating sites", "cycle", "operational phase", in order to prepare for the follow-up treatment.

3) To set the operating cycle of each task package, according to the operational phase, the operating targets and planning cycle, the formation of the task package. A task package contains the operating volume, the required working hours, job start time and end time, construction drawings and other information.

4) According to dispatching single set requirements (each dispatching single operating cycle is generally 3 to 4 days, around 50 or so hours of work; to be worked within the teams and groups), sub-task package to form executable dispatching single for each specific work teams and groups.

The figure 7 shows the mapping conversions of SEBOM to SPPBOM, SPPBOM to SMBOM.

3.2.3 The generation of procurement BOM

In the process of ship construction, according to the priorities of supplies, procurement of goods in batches. In the production design stage, for the procurement of materials can be made in outsourcing parts, according to batch products decide whether made, or purchased, small batch may have purchased parts costs are low, but big batch can be self made complete. Therefore, the purchasing department must to be able to obtain dynamic purchasing BOM information based on these constraints. For the

manufacturing process requires raw and auxiliary materials, you need to according to the demand size of a period of time, through the forecast period to determine the next batch of procurement, to result in a procurement volume efficiency, reducing purchasing costs. Figure 8 is used IDEF methods [7] to build the procurement BOM generation process model. According to customer demand, market research and product structure rules that determine the parts list, generate the production BOM, and then read the production type of parts from the process of production BOM to determine the components parts, purchased parts, and spare parts, outer purchase of standard parts and materials and auxiliary materials, generate the list of purchased items and spare parts inventory and homemade materials, and then under the production plan in the Production BOM, stocks in the Inventory BOM, as well as safety stock standards and economic procurement volume, for joint data calculated and then give the amount of material to be procured and procurement execution time, generate purchase BOM.

Other types of BOM can access information according to their demand of BOM to convert, generally are based on the characteristics of the BOM to modify a natural property. Such as: the quality of BOM lists the various parts SMBOM quality requirements and quality control of information; cost BOM statistics the costs in PPBOM and SMBOM various parts processing and assembly. SPPBOM to purchase BOM conversion, you can use the following rules: In the SMBOM, begins with the end product node, use breadth-first or depth-first manner, a one to search at various materials, when a material is SMBOM tree leaf nodes, then recorded the identity and quantity of materials information in the procurement BOM data table. Which belongs to outsourcing and foreign co-material, material that is identified in the material for its SMBOM identity, and its demand is the amount of material in SMBOM in statistics; for the self-made parts, according to the type of process BOM records of raw materials to identity and statistical quantity.

4. CONCLUSION

This paper analyzes the similarities and differences between the key BOM view tectonic model in the process of ship construction, and based on build mathematical models, design conversion method for the ship product BOM. This method is highly specific, high practical value, can be achieved quickly build a variety of BOM view, so that product data can provided a more effective solution to "information isolated island" problem in the enterprises that make BOM as the core of the departmental, which ensure the consistency, integrity and continuity of the product data in the ship construction process, shortening the product design data transfer efficiency.

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FIGURES

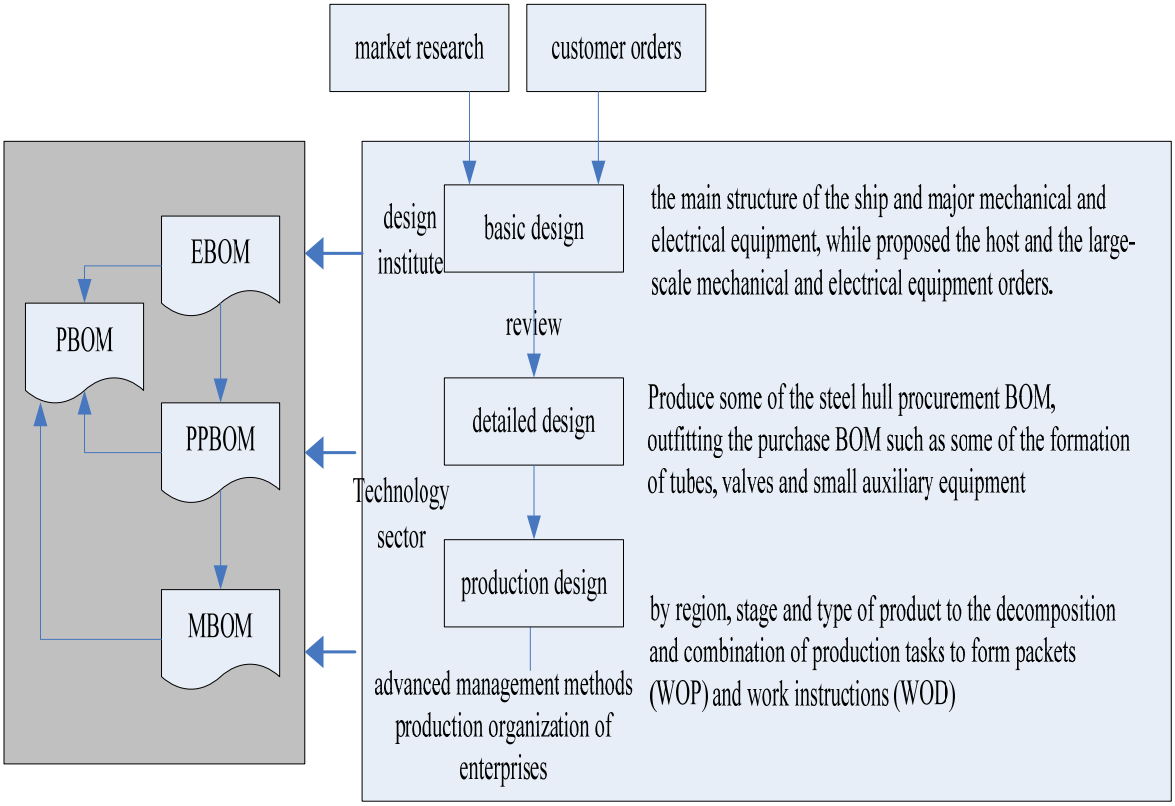


Figure 1: The relationship of ship design process and shipbuilding key BOM views

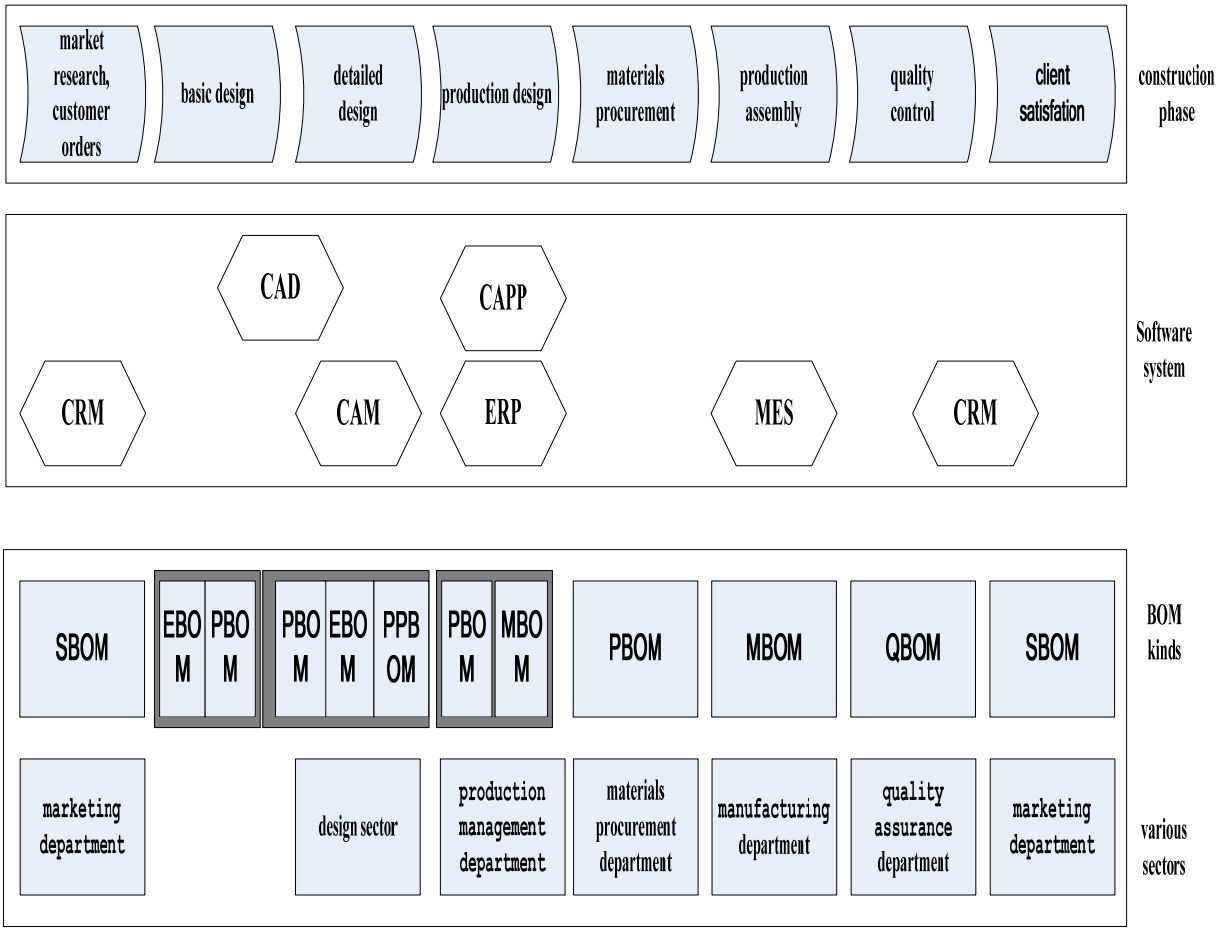


Figure 2: The correspondence between product construction phase, BOM view, and the various sectors

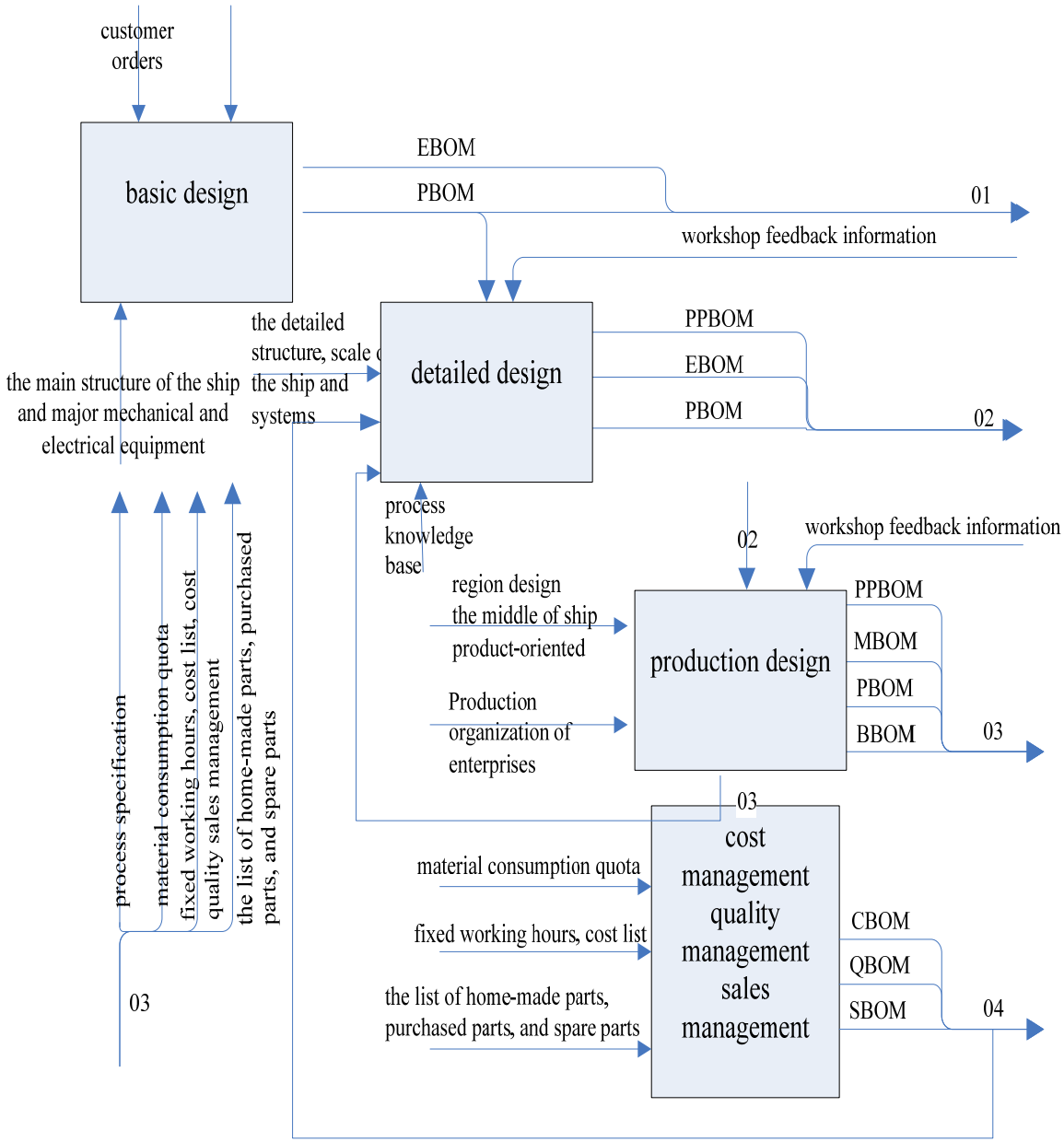


Figure 3: BOM view mapping diagrams

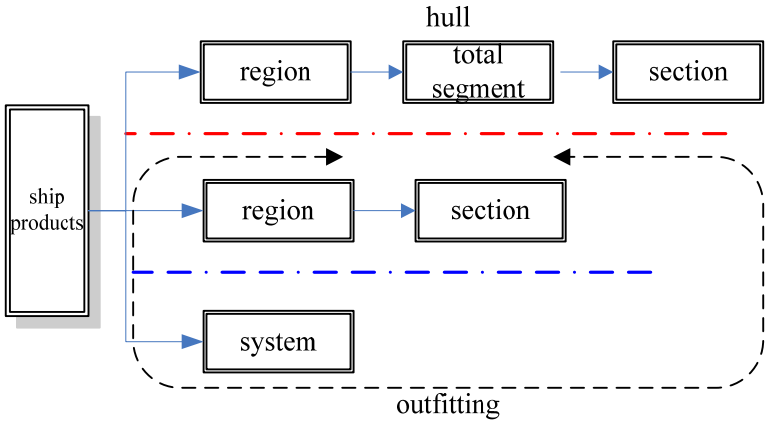


Figure 4: SEBOM construct model

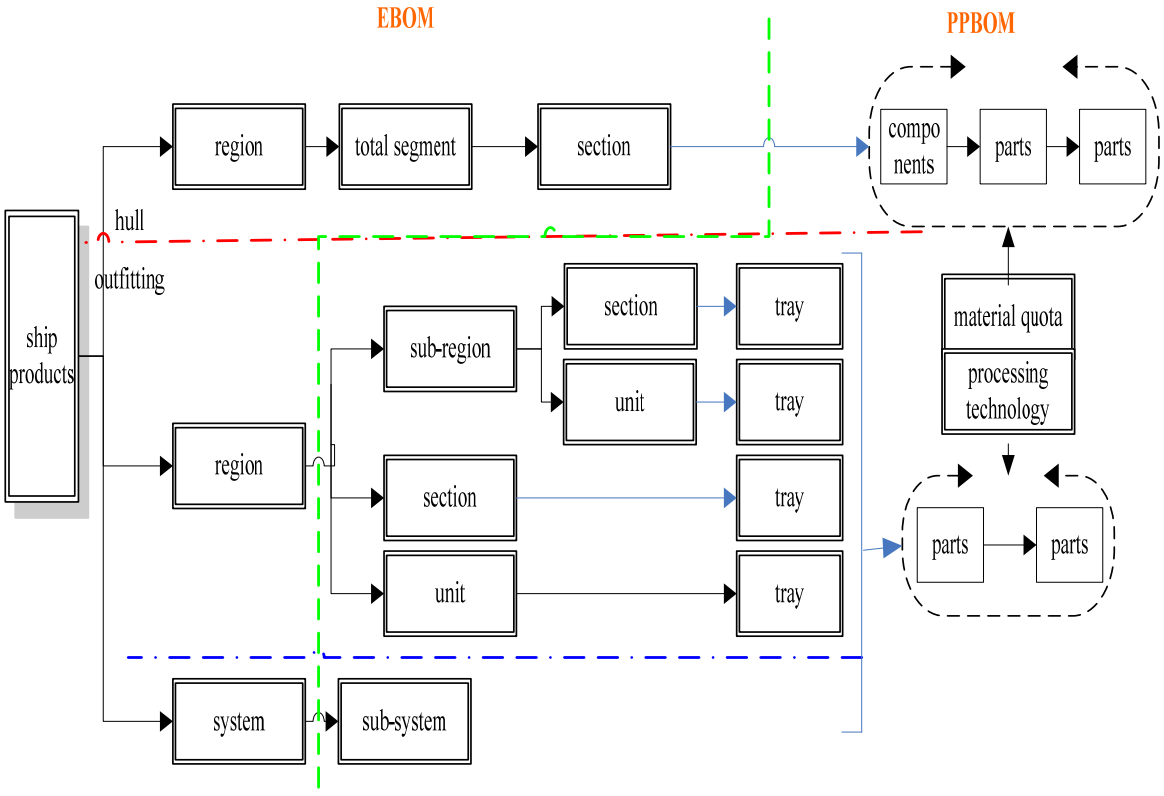


Figure 5: SPPBOM tectonic model

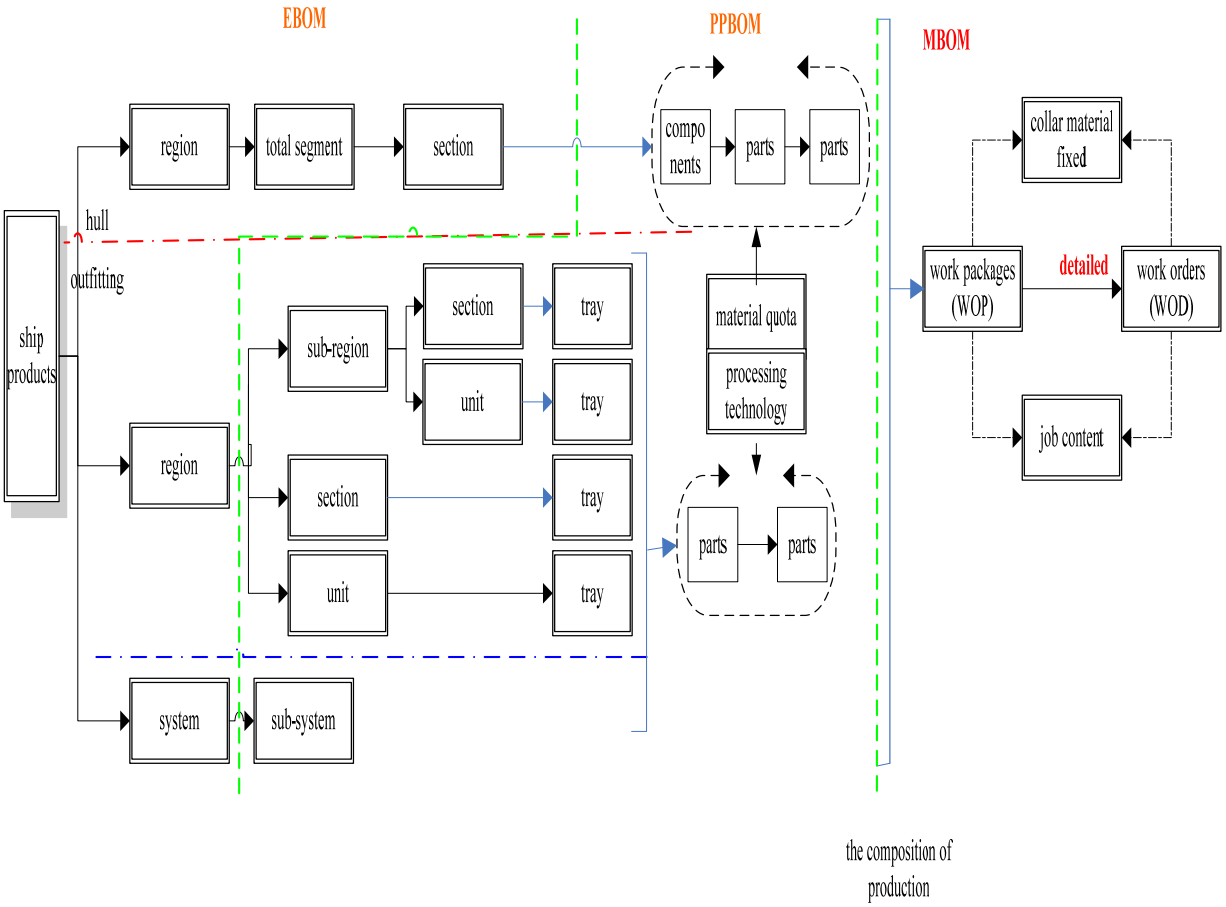
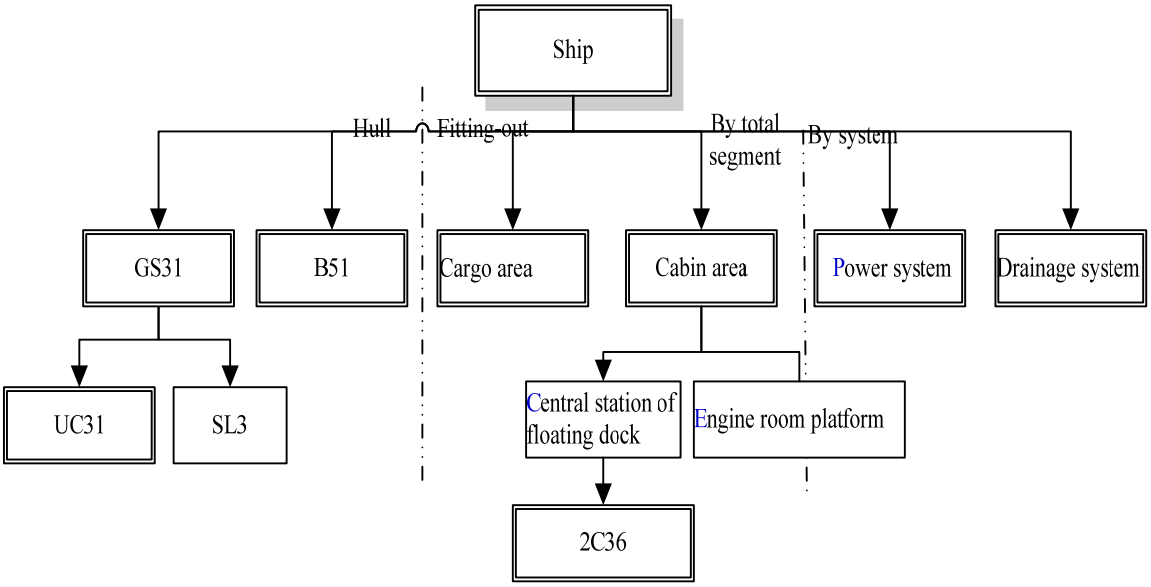
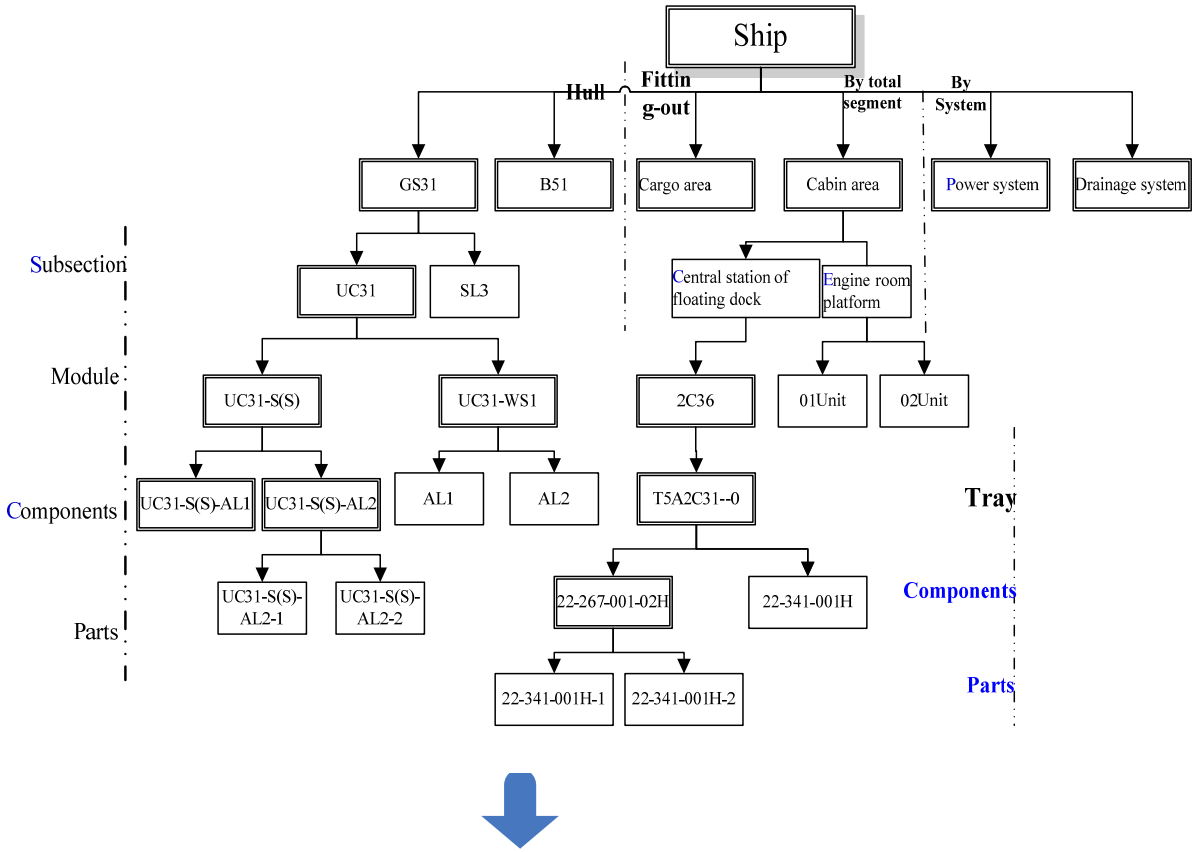


Figure 6：SMBOM tectonic model



Unit



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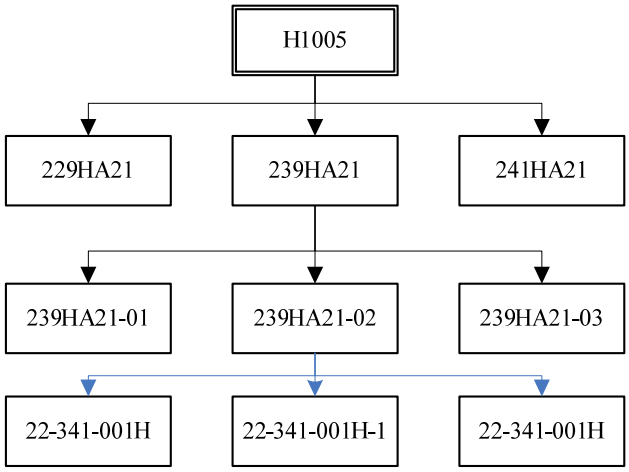

Figure 7: Examples of the mapping transformation about EBOM, SPPBOM and SMBOM of a ship

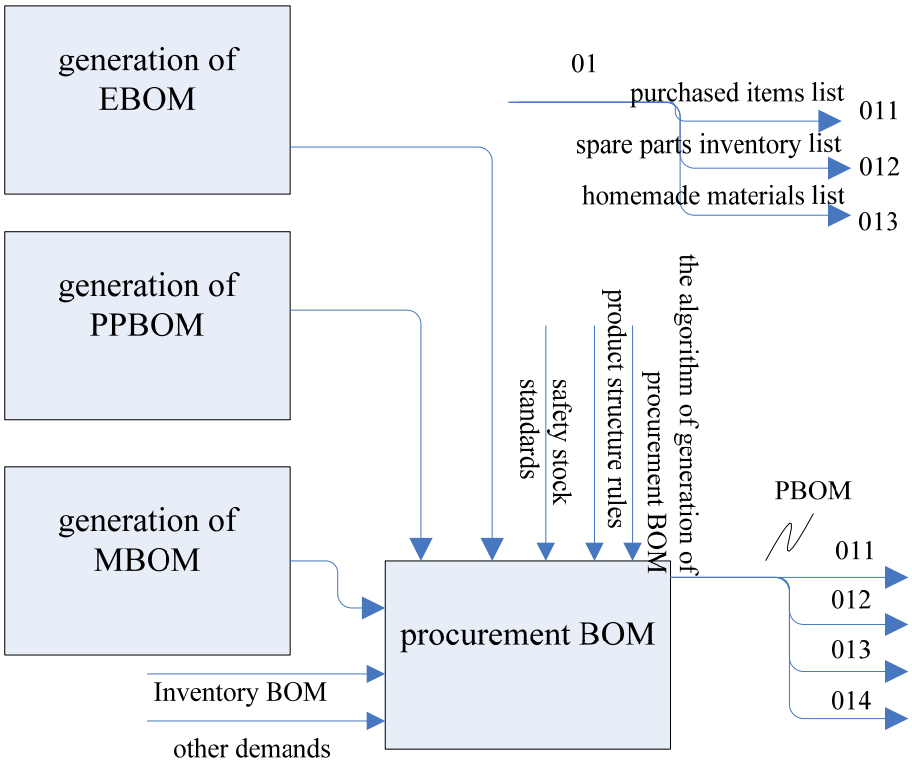

Figure 8: The generation of procurement BOM