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Identifying and Formulating Information System of Ship Production Process for an Indonesian Small Shipyard

Mohammad Rizal Firmansyah[1*], Syamsul Asri[1], Farianto Fachruddin[1], Wahyuddin[1], Fadhil Rizki Clausthaldi[1]

[1]*Department of Naval Architecture, Engineering Faculty, Hasanuddin University, Indonesia*

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[*] Corresponding author:
mr.firmansyah@unhas.ac.id

Abstract

The ship production process in a shipyard involves complex information. The information is required to maintain the progress of the ship construction project by the plans. Unclear information on at least one of the stages in the ship's production processes will delay the completion of the project and hence affects the project cost. The consequences must be avoided since delays in shipbuilding time will reduce shipyard revenue. Even further, it can decrease shipyard competitiveness. Clarity of information at every stage in the shipbuilding process is essential. The information refers to the raw material and consumables needs, including the required workforce, production facilities, and equipment. Other information which also very important is the applied production method in completing the stages in the ship production process. The information is essential to determine the required costs for each activity in the shipbuilding process. Unfortunately, information is created and circulated manually from and to any department involved in the shipbuilding process in some of Indonesia's small shipyards. It takes time to distribute the essential information regarding the shipbuilding process to the related department. Hence, it directly influences the project duration. A digital information system for the shipbuilding process is required to overcome the problems. However, before a digital information system can be developed, identification and formulation of the information flow among departments must be first conducted. Hence, this paper aims to identify and formulate information and flow in each department involved in a ship production process.

Keywords:
Information system; Ship production process; Small shipyard

1. Introduction

A Shipyard is a place designed to build and repair ships. According to Schlott [1], a shipyard can be classified based on its Gross Tonnage or GT capacity into small, medium, large, and very large shipyards (Table 1). Based on this classification, with the capacity range of Indonesian shipyards between 50 – 50000 gross tons for new shipbuilding and 50 – 100000 gross tons for ship repair, the majority (approximately 90%) of Indonesian shipyards can be categorized as small shipyards. Almost 80% of them are very small shipyards since the shipyard capacity is smaller than 1000 GT. Further, approximately 60% of the very small shipyards category have less than 500 GT capacity. About 10% of the Indonesian shipyards can be categorized as small shipyards with capacities between 1000 and 5000 GT, and a small part of the rest were medium and large-sized shipyards (see Tables 2 and 3) [2].

Table 1. Classification of shipbuilding industry by capacity (GT).

Shipyard Size	Capacity (Gross Ton/GT)
Small	1000 ≤ GRT ≤ 5000
Intermediate	5000 ≤ GRT ≤ 30000
Large	30000 ≤ GRT ≤ 100000
Very large	> 100000

Table 2. Profile of Indonesian new shipbuilding shipyards.

	<500	**501–1,000**	**1,001–3,000**	**3,001–5,000**	**5,001–10,000**	**10.001–50.000**
Capacity (GT)	21000	17000	10000	37000	70000	180000
Capacity (DWT)	31500	25500	15000	55000	105000	270000
Unit	99	27	8	9	11	6

Table 3 . Profile of Indonesian ship repair shipyards

	<500	**501– 1,000**	**1,001–3,000**	**3,001–5,000**	**5,001–10,000**	**10.001–50.000**	**50,001–100,000**	**>100,000**
Capacity (GT)	48000	495000	455000	400000	900000	1270000	1560000	800000
Capacity (DWT)	620000	742500	682500	600000	1350000	1905000	2340000	1200000
Unit	121	45	25	6	7	6	3	1

Almost all small Indonesian shipyards have a business core of ship repair and new buildings. However, for the new shipbuilding shipyards, the applied ship production technology is still at level 2: hull block construction method and pre-outfitting. The modern shipyards already apply ship production technology level 4, which refers to the Integrated hull construction, outfitting, and painting (IHOP) method in the shipbuilding process [3]. Hence, to increase their competitiveness, Indonesian small shipyards must improve their internal conditions, evaluate the external conditions and find the best way to overcome the challenges.

Firmansyah and Djafar [4] have suggested several ways to improve internal shipyard conditions. Among them is increasing the applied ship production technology levels and getting involved in a collaboration network [5][6]. Increasing the applied level of ship production technology will shorter shipbuilding times and hence increase shipyards competitiveness. The reduction in shipbuilding time will increase the number of new ships built by Indonesian shipyards and directly support the Indonesian government's program of building a large number of new under 5000 GT ships to transport domestic cargoes across Indonesia [7].

Implementing a digital information system for the ship production process is one way to increase shipyard ship production technology. The applied information system has been proven effective in improving the efficiency of the ship production process. Among some of the developed information systems related to the ship production process is a virtual assembly simulation system for shipbuilding (VASSS) which can simulate crane operation and block erection in a virtual dock developed by Kim (2002) [8]. This system is an advanced application of digital information systems. Another system is regarding supervising the construction of new ships for multi shipyards. This system allows the shipowner to monitor real-time and comprehensively the progress of the ship construction projects built simultaneously in several shipyards. The process of supervising the ship's construction starts from laying the keel to ship delivery [9]. In addition, Wirayuda et al. [10] have designed an android-based application that can be used to assist material management activities in a shipyard where the coverage area starts from material requirements planning, material purchases, material inventory status, material requests, and retrieval.

In the ship production process, a large amount of information is used and flows in and between the departments involved in the shipbuilding process. Each shipyard handles this information and its flow

differently depending on the applied technology of the respective shipyard. In general, it is challenging to standardize the information and its flow that can be used for the entire shipbuilding project in a shipyard. This is caused by the irregularity of the shipbuilding projects environment as the unique characteristics of this industry. The shipbuilding projects are always ordered based, and a new ship design must be made for each project. The entire process from contract and design of the shipbuilding process occurs concurrently, and the level of shipbuilding activities are different among shipyards as well depending on the dimensions of the ship to be built. Most of the ship production process requires qualitative information making it difficult to extract information at the early stages [8].

Designing a general information system for the shipbuilding process will be advantageous, especially for small shipyards with the same production capacity. This information system will lead to the design and application of a computerized system in the entire shipbuilding process. Some of the benefits of this computerized system include early detection and correction of errors in the early stages of the process and hence save more costs, increase the efficiency of the decision-making process, and ultimately reduce shipbuilding time [8].

The digital information system will ensure the smooth flow of information between departments. It is vitally important because it determines whether the ship production process can be carried out according to the design shipbuilding master schedule or not. In the current era of industrial technology 4.0, a digital information system must support the smooth flow of information in shipyards. Hence, any information change in the ship production process can be updated automatically in each department. The application of digital information systems is compulsory in every shipyard as a form of adaptation in today's digital environment to remain globally competitive [11].

Unfortunately, information handling is still conducted manually, especially in Indonesian small and very small shipyards. Systems that support the flow and exchange of information between departments do not yet exist. Consequently, it takes time to transfer and notify any information changes of the ship's production process between departments. The delay in the flow of information on the ship's production process can result in delays in completing of the construction of a ship.

This paper tries to identify and formulate information and its flow in a ship production process in an Indonesian small shipyard. The identification and formulation of this information can further be used to design a digital information system for the ship production process. A digital information system for the ship production process will be advantageous, especially for domestic shipyards, to streamline the flow of information between departments. However, the development of digital information systems will need to be based on an appropriate information system development methodology under the conditions of Indonesian small shipyards [12].

This paper identifies information on the ship's production process, including information on the construction components and their flow between departments. Based on the identification, the information for the ship production process then being formulated.

2. Methods

Identification of ship production process information is carried out in several departments involved in the process in an Indonesian small shipyard. Data collection is conducted by interviewing the responsible personnel for each department. The data collected includes data on a ship design which is then broken down using the product work breakdown structure (PWBS) method. This PWBS method was developed by Chirillo [13] when he began to introduce this method in the shipbuilding process in the USA. In this method, ships are divided according to the works hierarchy to build the respective ship. For example, a ship can be divided into several ship blocks, a ship block can be divided into several ship sub-blocks, a ship sub-block can be divided into several panels, and a panel can consist of several basic components (base products). The level of this hierarchy is depends on the ship’s main dimensions. The bigger the ship, the more hierarchical division of the ship.

As the number of construction components is enormous, from hundreds to thousands of construction components (depending on the ship's main dimensions), it will be easier if the information related to these components is compiled in a standard code system. The coding system itself is a planned code consisting of symbols that identify design components and or product characteristics. Symbols in the code system are numbers, letters, or a combination of letters and numbers. A hybrid structure code system is commonly used because this system is suitable for shipbuilding work with high complexity. The code system uses a 17 digits format, and all use numeric symbols. The digits in this code system include information related to the shape and dimensions of each construction component and the fabrication or assembly process of the construction components [14].

Based on this data and information, formulated information diagrams for each department and the flow of information between departments are then constructed.

3. Results and Discussion

3.1. Identify production information and its flow between department

In this paper, the term department is used to describe the parts involved in the shipbuilding process in a shipyard. It needs to be emphasized because some shipyards use different terms such as division to describe the parts. Some even use both of the terms with different levels of management; for example, several departments are under one division. The division of this department was then tried to be made general and hence can be used in other small shipyards.

The departments involved in the shipbuilding process in a small Indonesian shipyard consist of the design and production planning department, the production department, the purchasing/logistics department, the quality control/accuracy control department, the material/interim product store department and the facility management department. In addition, identified information and flow of information on the management/executive are also conducted.

3.1.1. Information on the Design And Production Planning Department

Information on the ship production process is commenced from this department. The department makes the ship's master schedule document, detailed construction schedule, and fabrication assembly sequence. They are constructed from the ship breakdown using the PWBS method. Based on the breakdown, information related to the level of work to construct the ship can be obtained from the list of ship blocks, semi blocks, to the basic component as the smallest work level. This information is accompanied by information on the resources requirements including method, machine/equipment, material, man and money per unit of time and the whole projects.

The construction of information in this department is based on the input information from some other departments in the shipyard, such as information related to the ship orders, project deadlines, and available cost/unit of time are received from management/executive. The information flows are related to production resources constraints from the production department. Input from the quality control/accuracy control department is standard materials/resources information according to classification bureau, government regulation, and shipyard standards. Meanwhile, from the facility management department, the information is in facilities information. The ship production process information generated from this department then flowed to other departments according to the required information of each department respectively (Figure 1).

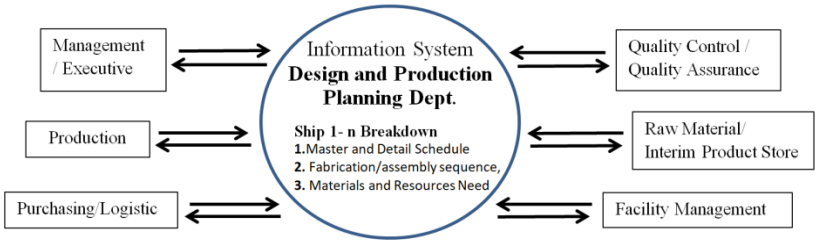

Figure 1. Information system in design and Production Planning Department.

3.1.2. Information on the Production Department

Apart from the design and production planning department, the production department receives information from several other departments, including the material /interim product store department, the quality control/quality assurance department, and the facility management department. Information from the design and production planning department in the form of product work breakdown structure (PWBS), master schedule, detailed construction schedule, fabrication/assembly sequence, material dimension and specification, detail dimension of product and interim product, and production resources, including material, equipment, machinery, man and money. Information from the material /interim product store department, including ship product components, required material, temporary interim product for the production process. Meanwhile, from the quality control/quality assurance department, the required information is related to resources, process, and cost control and assurance. The facility management department supplies information regarding the list of available facilities for the project construction process according to the detailed construction schedule and fabrication /assembly sequence for each ship construction project.

Production department conducting ship production process and the progress information for project implementation will be delivered to other related departments. In addition, the management/executive will also receive information regarding fabrication/assembly progress for each ship, including cost spent (planning and progress) during the construction project (Figure 2).

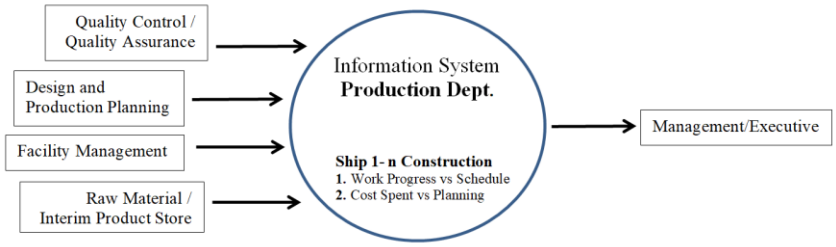

Figure 2. Information system in Production Department.

3.1.3. Information on the Purchasing / Logistics Department

The primary duties of this department are selecting and purchasing ship construction materials required in ship production. The process of purchasing construction component materials is carried out by first selecting suppliers by shipyard constraints, including time and cost constraints. The supply of materials from suppliers to the shipyard must be according to the shipbuilding schedule that has been previously made by the design and production planning department. The information flows from the design and production planning department are related to the master schedule, detailed construction schedule, fabrication and assembly sequence, and required resources. This information is used to

determine when to purchase specific materials. Before purchasing the material, prices and lead times for each supplier will be reviewed by the management/executive who will make the final decisions.

Once the material purchasing has been made, the information on the arrival of the material will be sent to the quality control/quality assurance department, checking the incoming material for compliance with the specifications determined by the classification bureau and or government regulations. The ship component materials approval will be given by the quality control/quality assurance department to meet the predetermined standards. Materials fulfilling the required standard will then be transferred to the material/interim product store department. This department will then manage the storage of materials according to the shipbuilding schedule (Figure 3).

Figure 3. Information system in Purchasing/Logistics Department.

3.1.4. Information on the Quality Control / Accuracy Control Department

This department has an essential role in the ship production process because it inspects, controls, and guarantees the quality accuracy of the ship's products from design to delivery to the shipowner, following the classification bureau requirements and government regulations. The department tasks to create and document quality requirements for all stages in the shipbuilding process from input, process, and output. Input relates to resource requirements consisting of materials, machines, equipment, and workforce. The process relates to quality requirements for interim products such as fabrication, sub-assembly, assembly to erection, and final testing of the ship (sea trial), while the output is related to the final product. References in determining product quality and at the same time becoming inputs in the formulation of quality standards are from the classification bureau, government regulations, and shipyard standards. In addition to the quality requirements of resources, additional activities from this department can also be related to controlling the cost of the ship production process, starting from the purchase of raw materials, fabrication and assembly costs, and resources costs.

Apart from classification bureau rules, government regulations, and shipyard standards, this department also gets information from the design and production planning and purchasing departments. The supply of the design and production planning department information includes ship breakdowns, master and detailed production schedules, fabrication and assembly sequences, raw materials, and interim product dimensions and specifications. Meanwhile, the supply of information relates to a list of materials in the purchasing process from the purchasing department.

This department's output information is flowed and used in other related departments. For example, in the production department, information on quality standards of input, process, and product output is used for quality control and assurance during the ship's production process. Quality control and assurance are related to resources control and process control, from fabrication to sea trial and production cost control and assurance.

For material and interim product store departments, quality information is used to ensure that all raw materials and interim products used in the production process are under the specifications previously determined by the design and production planning department. Likewise, the facility management

department is related to ensuring that the facilities and mechanical equipment used in the ship's production process follow the required minimum quality standards.

In addition to the previously mentioned departments, the department also interacts with the management/executive department regarding conformity between plans and progress, both related to the fabrication and assembly sequence and costs (Figure 4).

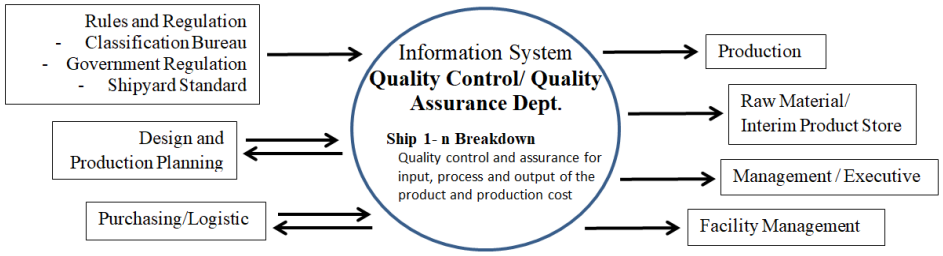

Figure 4. Information system in Quality Control/Quality Assurance Department.

3.1.5. Information on the materials and Interim Product Store Department

Information produced in this department is related to the list of receipts and requests for material resources or interim products from other related departments. Before material or interim product becomes the responsibility of this department, several other departments provide input, including from the purchasing/logistics department, related to the list of purchased materials for shipbuilding purposes. The design and production planning department transmits information related to the list of material or component requirements. Ship product or interim product for the production process following the designed shipbuilding schedule. From the facility management, facilities information will be supplied to this department.

Before this department manages the materials, the incoming materials will be checked by the quality control/quality assurance department to see their suitability with the needs of the shipyard and conformity with the required material standards based on the classification bureau rules and government regulations. After the materials, ship product components, and interim products are under the handling and responsibility of this department, they are then given to the production department, which will be used to produce ships according to the shipbuilding schedule. Further, information related to the use of materials and their conformity with the progress of ship production and their suitability with the use of costs is supplied to the management/executives (Figure 5).

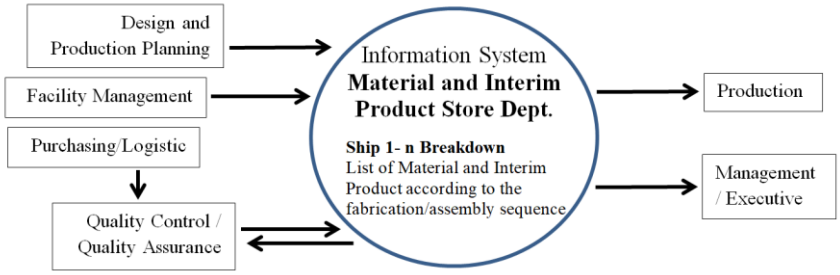

Figure 5. Information system in material and Interim Product Store Department.

3.1.6. Information on the facility Management Department

This department focuses on providing and managing existing facilities in the shipyard to support the smooth process of ship production. This department receives information from the design and production

planning department regarding the master schedule and details of the shipbuilding schedule and the fabrication and assembly sequence. This information will be used to manage the availability of production support facilities to assist the production process according to the ship production schedule. In addition, this department also obtains information from the purchasing/logistics department regarding the arrival schedule of purchased materials from suppliers. This information is then used to move materials from the material transportation mode to the material and interim product store departments and from this department to the production department. Another department that provides information to this department is the quality control/quality assurance department. This information relates to the feasibility of the production facility as a result of the inspection carried out by the quality control/quality assurance department to assist the overall ship production process.

Information from this department related to the condition of existing facilities to support the smooth production process according to the schedule and maintenance costs of the facilities will also be supplied to the management/executive. The information will be used by management to overview the condition of the facility to the management/executive so that the management can take necessary actions to anticipate delays in the ship's production process due to the non-functioning facilities of the shipyard (Figure 6).

Figure 6. Information system in Facility Management Department.

3.1.7. Information on the management / executive

Of all the departments involved in a shipbuilding process, the management/ executive plays the most significant role because the management carries out all the information and critical decisions related to the shipbuilding process.

In general, all departments supply information to the management, either explanatory information or information that requires intervention in the production process. Initially, the management will receive shipbuilding orders from the shipowner and the project payment terms. This information is then transferred to the design and production planning department in the form of project deadlines and available cost/unit of time. This information is then followed up on the shipbuilding process by providing design information, a construction schedule, and the costs required for the ship's production process per unit of time.

During the shipbuilding process, the management, which consists of several management levels, will get information from all departments according to the characteristics of each department. The information received by this department will depend on the level of information. Each management level will receive correct and appropriate information according to their individual needs [15]. However, in general, the information supplied to the management is related to the physical and cost progress of a shipbuilding project and its conformity with planning. This information is obtained from the production, quality control/quality assurance department, purchasing/logistics, and material/interim product store departments. Meanwhile, from the facility management department, the supply information is related to the condition of the facility, schedule, and maintenance costs for shipyard facilities (Figure 7).

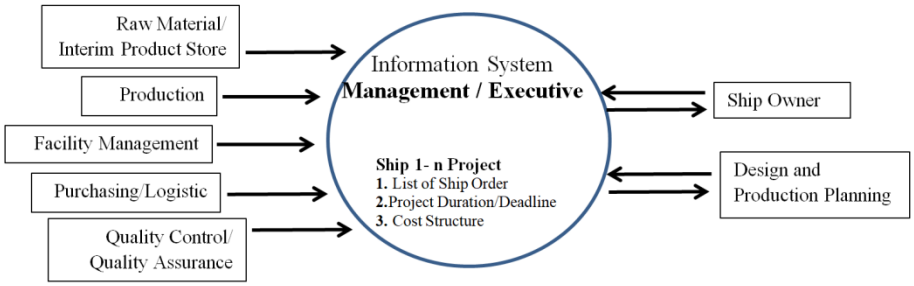

Figure 7. Information system in management/executive.

3.2. Formulation of ship production process information

The information system of the ship production process integrates all information on the departments involved in the ship production process at the shipyard. In the ship production process, information changes that occur in one department must be informed to the other relevant departments as a basis for actions or activities to be carried out further. Hence, the flow of information between departments must flow in real-time according to the needs of different departments. The smooth and accurate flow of information between departments will ultimately facilitate the supervision and control function during the ship's production process for the decision-making process [16]. Accurate and timely information will determine the ship's production process duration.

3.2.1. Forward information flow in ship production process

The information system of the ship production process consists of three stages: input of data/information on ship orders, processing the information, and output of the information according to the production plan. This system is identified and used with the assumption that the preliminary design of the ship has been made and the actual process of ship production begins immediately. All departments involved in the shipbuilding process are identified with their respective information flows, both information generated by the relevant department based on information input from other departments and the flow of information to other relevant departments.

In general, the forward information flow in the ship production process commences from the design and production planning department, which follows up the shipbuilding project information from management/executives. This department processes information related to ship breakdown, master and detailed production schedule, and material and interim product information. The information generated from this department is then transferred to other departments, for example, to the purchasing/logistics department to purchase materials, to the facility management department to prepare facilities to be used in the ship production process, and to the quality control/quality assurance department which will be used as a reference in the process of quality control and inspection in the production department. Information from these departments all ends up in the production department, which will carry out the actual process of ship production (Figure 8).

3.2.2. Integrating information system for ship productin process

The integration of all information produced by each department in an information system for the ship production process will increase the shipyard's performance. As previously discussed, the information generated and processed by each department and flowed to other departments is integrated into a ship construction project database. In this database, all information related and generated by each department and supplied to other departments is collected here, but the flow of certain information is only related to the needs of the respective department. Each department can access the source of information and its changes in the database.

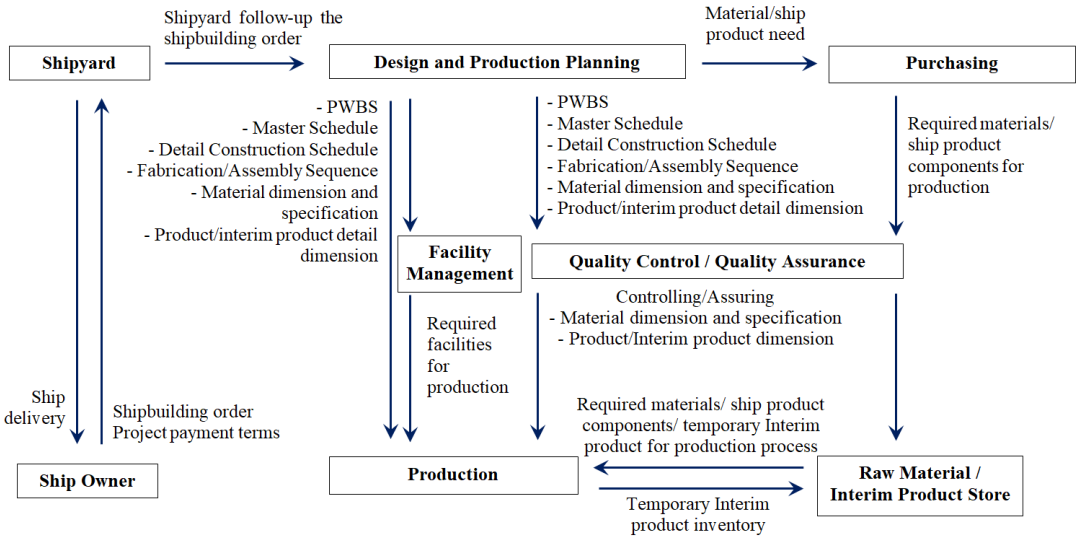

Figure 8. Forward information flow in ship production process.

However, the information must only be related to the respective department. In order to prevent unnecessary changes of information, for example, other departments make changes to the information in other unrelated departments, each department will have access only to the respective department. Specifically for shipyard management/executive, access will apply to all departments, although it is limited to the output of information in each department (Figure 9).

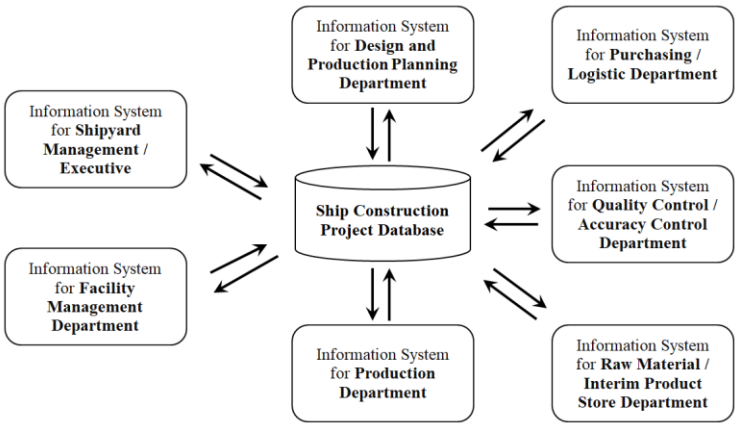

Figure 9. Integrating information system for ship production process.

In integrating the information system of the ship production process, data for each department is input into the ship construction project database. This data will later be processed into useful information for each department and the shipyard. One benefit of the generated information in the database is that it can be used to plan and evaluate ship production progress. The evaluation can be related to the actual implementation of ship production work versus production planning. In addition, evaluation can also be related to production work on costs and resource requirements and evaluating the implementation of actual work on the overall project duration.

The estimation process or optimization of the ship production process can also be carried out, such as estimating ship production costs based on the simulation of material purchase costs and the simulation of ship production cost based on variations in the shipbuilding network planning.

Indeed, the integration of this ship production information system must be actualized in a digital information system. Hence, all related departments' data input and access can be conducted efficiently, quickly, and precisely. In addition, this system is expected to increase shipyard efficiency, reduce operating costs, and ultimately increase shipyard competitiveness [17][18]. However, the formulation of ship production process information discussed in this paper can be used as a basis in the design of a digital information system for the ship production process.

4. Conclusions

The use of information systems is basically to increase shipyard productivity for the shipyard competitiveness. Shipyards' information systems have a significant role because it strongly supports the continuous interaction between departments. The flow of information is more accurate and fast. Hence, it can support business activities and attract more shipowners to use the shipyard services. Further, information systems can support and facilitate the manager's decision-making process and enable the manager to solve problems more quickly and precisely.

The currently developed information systems are not designed for the small shipyard. Hence, the development of the information system for the small shipyard will significantly benefit the shipyard. A digital information system for the ship production process according to the conditions of Indonesian small shipyards is needed. However, the information and flow of information between departments and the formulation of information discussed above can be used as a sound basis for designing a digital information system for the purpose.

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