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A New Framework for Dynamical Resources Planning System in Shipbuilding Industry

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Abstract

Shipbuilding industries in Malaysia face challenges and difficulties on planning the production line. Shipyard has been struggling in order to achieve efficient planning in all process of shipbuilding. Hence, a Dynamical Resources Planning System (DRPS) framework has been proposed to overcome the production planning problems. The aims of this study are to identify current problem in existing planning system, propose an innovation for production planning and DRPS framework development. A case study on current project has been conducted at a leading naval shipyard. As per management focus group concern, the development of DRPS framework is based on zone construction scheduling approach. Furthermore, the Interface Control, Test and Trial (ICAT) scheduling is introduced in order to strengthen up DRPS framework and execution. While, the effectiveness of the proposed DRPS framework is presented by the project performance analysis. As a result, the shipyard successfully delivered the ship on schedule compared to the previous ship with thirteen months delay. The shipyard also effectively manage to avoid liquidated damages which estimate up to RM63 million.

Keywords: *Production Planning, Dynamical Resources Planning System, Industrial Engineering, Shipbuilding, Monitoring and Control.*

1 Introduction

The shipbuilding industry was found newly in our country. The industry is classified as one of the prime movers in driving the development of the shipping sector and increasing trade. Malaysian government has classified the shipbuilding industry as a strategic industry in the Third Industrial Master Plan (IMP3) from

2006 to 2020 [1]. However, shipbuilding companies in Malaysia faced challenges and shortcomings such as shortage of skilled personnel, high cost of project management and operation; and fierce competition from regional countries due to low labor cost. In Malaysia, a total of 120 registered shipyards located in two regions which is Peninsular and East of Malaysia [2]. There are no proactive strategy and motions made aggressive in ensuring improvement, so the industries still fragmented. There is a chance of learning process by considering the successful experience from the shipbuilding experts in the world region like China and Korea.

Two important criteria to be consider as characteristic of shipyard to still maintain into competitiveness are higher productivity and less cost during production process, especially in naval shipbuilding. The control and monitoring in planning is most important as well as dynamic system approach. Currently, naval ship production is facing the difficult challenge of building ships on time and at budgeted cost. Shipyard has been struggling in-order to achieve efficient planning in all process of shipbuilding.

There are three philosophies describe the shipbuilding in general. First, shipbuilding process is well known as a complex process [3]. Second, shipbuilding is a one-of-a-kind process. Ryu et al. [4] explained on make-to-order manufacturing. Liu et al. [5] and Nie et al. [6] describe typical complicated manufacturing, unique and time consuming. Third, shipbuilding is build up from block assembly unit as a basic of ship construction unit. Kim et al. [7] divide the shipbuilding process into design stage and manufacturing stage. Dong et al. [8] classified shipbuilding as complex process in design, production engineering and planning. Koh et al. [9] elaborated block assembly process on design, cutting, assembly, outfitting, launching and finishing process. Work in block as describe by [10] to be proper organized as it consumes much processing time and resources at early stage. Nowadays, ship outfitting process become necessary requirement for ship construction that to be deployed stages by stages started at early phase of erection until ship launching [11]. The improvement in the ship outfitting process at earlier stage will reduce cost of entire shipbuilding process and eliminated waste in time.

By decades, the planning model, system and approach have been introduced to keep the process of monitoring and control production be more effective. Among that are spatial planning system [4, 10], simulation model [12, 13], dynamic production planning model [5, 13, 14, 6], aggregate production planning [15] and integrated hull, outfitting and painting (IHOP) scheduling [16, 17]. From the above planning model, we can conclude the following observation. First, all of them are stressed on the best planning method to handle the complexity of shipbuilding process. Whichever the model and method choose, the aim and objective is still the same with emphasize on the productivity, integration of manufacturing process, with less cost and reduction deliverable lead time. Second, the planning system introduced is expected being operated well through integration with existing enterprise resources planning (ERP) system. Commonly understanding that all shipyards are utilized set up their computation ERP systems at the beginning of business operation. The planning system designed is an integration tool to improve the performance of ERP. Third, most of the studies in shipbuilding improvement of planning were base on experimental case study. They accommodate the case study in the nation's shipyard to collect the real-time data. Among of them [3] access to Sembcorp Marine Ltd, Singapore, at Daewoo Shipbuilding and Marine Engineering Co, Korea [4], at Korea shipyard [9] and at Dalian Shipbuilding Industry Co, China [5].

As such for this research, we study on adoption and application the proposed dynamical resources planning system (DRPS) into existing planning system ERP called MARS Planning system for efficiency of production planning innovated and the research case study was conducted in industry environment at Boustead Naval Shipyard, Perak, Malaysia. The objectives of this study are to identify current problem in existing planning system, propose innovation for production planning and form new framework DRPS. The remainder of this paper is organized as follows: Section 2 discusses the related work. Section 3 presents the weaknesses of existing framework and propose the innovation require to production planning. Section 4 describes the proposed framework for DRPS. Section 5 explains the result, analysis and discussion based on the case study and finally, a conclusion of the study and future work will be discussed in Section 6.

2 Related Work

Planning involved the method of scheduling, co-ordination, arrangement and integration of a set of activities. Planning is not only related to the arrangement of activities in schedule but was wide to the co-ordination and integration of such activity with another activity to make it happen. The activities to be manage properly with resources and subject to the constraint. Resources can be defined as pre-requisite to such activities including manpower, material, drawing, information, services, equipment and tool [18]. The fundamental management aspect on research management in construction as [19] was same as previous studies [20] and [21] involve planning, organizing, directing and controlling.

Dynamic schedule mode determines schedule at run time [22], schedule and planning may change, stepping forward or alternative change of sequence of activities. It also creates flexibility to the system which can react to the changes made in activities. The similar views are also shared by [23] on two mode of dynamic scheduling which is online mode and batch mode. Online mode refers to real time plan and run while the task arrives while batch mode considers on the partially plan, tasks are collected and derived into part by part and react to the changes happen while execute the task. This is become important part of the planner. In shipbuilding industries, the scheduling always to be in dynamic mode with the following reasons, first the construction timer used for planning purpose are rough estimated without consider details on execution planning and second constraint on non-conformity following quality inspection during construction which cause rework and corrective job. In this paper, dynamic planning is referring to the tactically driven on each process of planning; robustness of model, method and work execution; and intensive systematic way in monitor and control the execution of plan. The past studied describe the dynamic concept in the context of project management which is involve in the project planning, monitoring and control of project execution. According to [24] every phase of planning execution consists of planning, executing and monitoring and control. Each phase has a selection of process and the process must be planned in detail to ensure the complete rotation of execution on each phase working on. Thus, the resolution of each process with different behavior and struggle process of execution plus with strong and fully control within process is called dynamic execution. Wheel of dynamic execution [24] is as shown in Fig. 1.

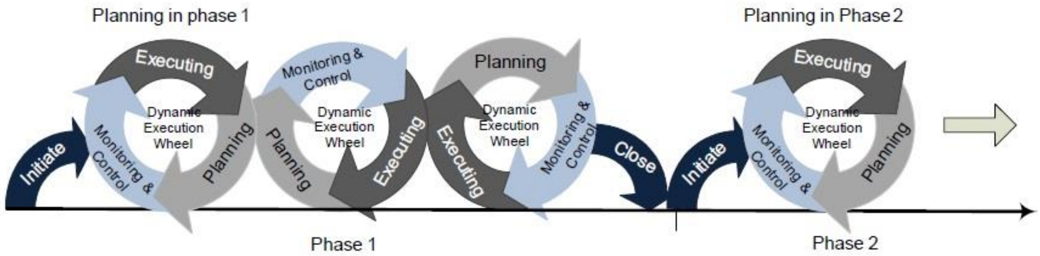

Fig.1: Dynamic execution wheel [24]

Dynamic monitoring and control is the process of tracking, reviewing and regulating the progress to meet the performance objective defined in the planning and schedule. Li et al. [25] stated that a need of tactically driven and systematic way in monitor and control the project execution rather than intuitively driven and fire fighting process. While applying the dynamic approach, the project performance can be periodically accessed and not as statically accessed. The dynamically access as [25] and [5] means that the evaluation of project performance was made from time to time with the systematic and strategic way to attain a good result. The assessment is done regularly and formally, being analyzed frequently, and the report result was discussed publically and aligned to the specific action on improvement or maintain the performance. Monitoring and control is very important, Kim et al. [16] spell about the real-time performance monitoring with correct strategy.

Among the planning model describe earlier, the zone construction concepts were selected in this case study. Early studies provided the planning model on IHOP and modern shipbuilding. Both models were exploring by [20], [26], [16] and [17] focused on IHOP while [21] and [27] on modern shipbuilding. The benefit of zone construction approach is improved productivity, improved quality, logical sequencing of work, optimizing the information process, effective management of progress review, palletizing the outfitting material, minimize defectiveness and work load balance.

3 Understanding Existing Framework

In this section, we describe the method on gathering idea and problem formulation on study needed by obtain from literature and observational study. Current problem in existing planning system was search deeply, identify and analyze accordingly until to the innovation of production planning prior to development of framework.

3.1 Weaknesses existing framework

The planning framework is the initial platform of scheduling before upload into the ERP system. In 2010, the shipyard utilized MARS Planning as a consolidation of MARS ERP version 7.2. Fig. 2 shows the screen of MARS 7.2 and MARS Planning.

Fig. 2: Screen of MARS 7.2 and MARS Planning

The existing framework as illustrated in Fig. 3, compose the process of planning and scheduling in flat flow. The process occurs from rough planning in create the work package into work order and job ticket. In the job ticket level, the only pre-requisite of material, engineering information and resources start to be finalized before commencing the job.

The focus group involved senior management was formed in shipyard to discuss the lack and shortcoming in existing framework and brainstorming the best strategy to overcome the main problem on the weakness of planning method. The series of meeting and workshop were held five times between August to September 2013, involving serious discussion with selected key personnel comprising of discipline unit head and senior staff.

From our observation, exposure to working field situation, archaic analysis of document such as procedure review, progress report and schedule; and experience study on the past framework, we found that the point of weakness recorded as follows. First, project management structure on create dynamic monitoring and control. This is including the organization of the project running and fulfills the requirement for the project such as material, information, manpower plan and space management. Second, production method which is involve the implementation of production planning as according to the strategic planning and details level of execution. The strong fundamental in production planning may resulted the smooth and co-ordinate process in every level of production method.

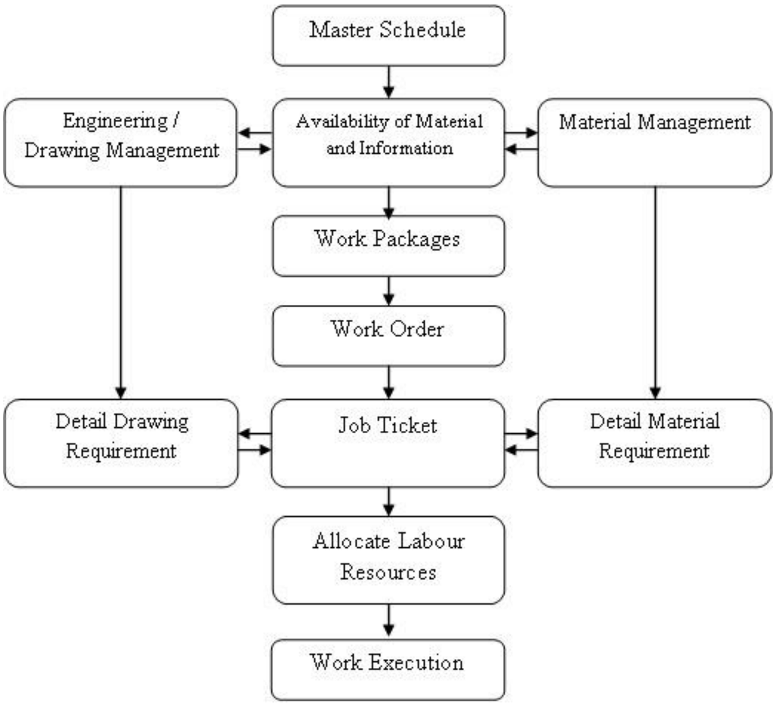

Fig. 3: Existing framework

Space for improvements that will become a value add to the process can be simplified as:

(1) Project management: improve and change in manage, monitor and control the project [16]; actively in problem solving; eliminate the communication breakdown and do proper process of information exchange within the project. [28]. The success in project management will contribute to the project success [29, 30, 31].

(2) Production method: improve the lack of worksite control; improve the capability to monitor and control; and introduce the dynamic planning which is clearly method and procedure on work execution level scheduling [18], [32]

(3) Production planning: integration in planning and scheduling; improve and make good the integration activities on scheduling purposely for production utilization at work site. Production friendly guidance as action plan [16] or plan control [32]. Research by [11] and [33] explain the important of production planning in monitor and control the job execution.

The early studies on zone construction and modern shipbuilding state the process on assembly and installation stage. Based on [11] studies, some criteria need to be fulfilling to give the positive impact in conducting outfitting process on zone basis Among of the criteria as the prerequisite before outfitting process are readiness of production planning, ship hull technology, workshop technology, documentation and material supply related to outfitting process. All these related documentation and prerequisite require method. How excellent the continuous process after that can't be defined clearly. More method and control element to be established to cater the next process of test and trial which is involved the setting to work, harbor test, commissioning, inspection and sea trial. The Interface Control and Test and Trial (ICAT) schedule has been drawn up. Emblemsvag et al. [34] discussed on the important of maintain the key milestone event set to the master schedule, including of the test and trial activities. The proper planning is suggested in-order to monitor and control the event inclusive of testing, inspection and quality control. ICAT schedule will lead the testing event on harbor test and sea trial. Callaghan et al. [35] recommended at this stage require test program, trial planning and followed by trial report. Monitoring and control tools during harbor phase were test protocol and quality inspection report. While during sea trial activities, taking consideration from [35], a schedule of event being formed up. This schedule of event consists of detailed trial activities to be carried out on the day of sailing including protocol, arrangement of trial target and established communication line. Upon completion of sea trial, daily sea trial report shall be produced to highlight the findings, problems or defects. The findings are to be discussed for problem solving, rectification and solution as part of dynamic monitoring and control. The proper management of event and program will ensure the inspection and testing being carried out smoothly and without any defect or remaining item occur, thus fulfill adherence to the quality [28, 31].

The other weaknesses are about engineering to lead in related to design information and material take off. Yue et al. [17] observed in modern shipbuilding to have production design center which become in the middle of production engineering and procurement. Shipbuilding engineering management must be established well to support production. Yue et al. [36] insist shipbuilding practice to provide material planner in order to organize the material requisition plan from master schedule and forecast material take off. A wide range of planning strategy require information flow and material procure flow in line with the activity plan.

The checklist of information need, and material procures was defined earlier in outfitting stages [37]. Well known that ships are built based on engineering to order system, the important of engineering management to manage entire process of design [38]. At this juncture, the material and pallet plan [14, 6] are to be inclusive in planning from the beginning based on information develop by engineering.

3.2 Innovation of production planning

The case study was conducted on running project KD LEKIR, one of two ship undergoing ship life extension program (SLEP). Base on finding, observation and recommendation from existing framework, the important improvement was impressive the production planning system with the hierarchy of innovation. Supported by observational exercise and guide from literature, the three-hierarchy level was proposed. The hierarchy as illustrated in Fig. 4.

Fig. 4: Hierarchy of innovation production planning

Planning role in project management was discussed by [18] and [33]. In the same field, they elaborated three level of planning, i.e. project planning, look-ahead planning and commitment planning. Project planning produce master schedule, used by project manager on a surface view. The idea also supports by researcher such as [32] and [34]. The fundamental of this planning put on strategic level. Look-ahead planning is actually a monthly schedule, as [18], [32] and [38], elaborated it as schedule for four to eight weeks ahead. Emblemsvag et al. [34] called that as period plan. Burguete [33] mention on phase schedule with the task duration within partially from overall length of total duration. The detail planning put on tactical level, whereby the details activities that need to be performed and is a must, should be done. Manpower plan should be tactically layout in this stage.

Lastly, weekly schedule is most important hierarchy, mention as detail execution level. This is because at this stage the monitoring and control action take place and there should be a routine meeting [38] to check and coordinate the work progress [33, 34]. Any delay or problems on job execution are to be table up as action plan [16] and to be discussed in meeting. Alarcon et al. [32] utilized plan control against the work progress by the week. This fundamental on innovation will be a basis in development of proposed framework.

4 Proposed Framework

4.1 Research design for DRPS framework

The proposed DRPS framework was designed base on improvement need for existing framework and requirement on innovation of production planning system. The important role in this framework is production planning and production engineering. The combination of these two parts were contributed to the strength and robust the DRPS framework. Main fundamental of DRPS are macro planning and design, detailed production scheduling, monthly discipline schedule, weekly work execution and dynamic control and monitoring.

The research design for DRPS framework as shown in Fig. 5 with the scope of this study outlined in red dash line.

The ship will be divided by zone, basically with three main zones on machinery space, electronic room and accommodation area. The elementary activities and information were filled up into individual zone and come to the stage on design the work process and analyze the production system inside zone. Master schedule was prepared according to zone basis and establish zone completion date in zone schedule. Detailed work procedure (DWP) consists of detailed work to be performed and the required man-days was prepared and be a fundamental in preparing the schedule. The above processes accomplish the macro planning and design part. Detailed production scheduling require planner to build the production friendly working schedule into IHOP and ICAT schedule. IHOP guide the production process such as fabrication, assembly and installation while ICAT control the test and trial activities such as inspection, setting to work and commissioning.

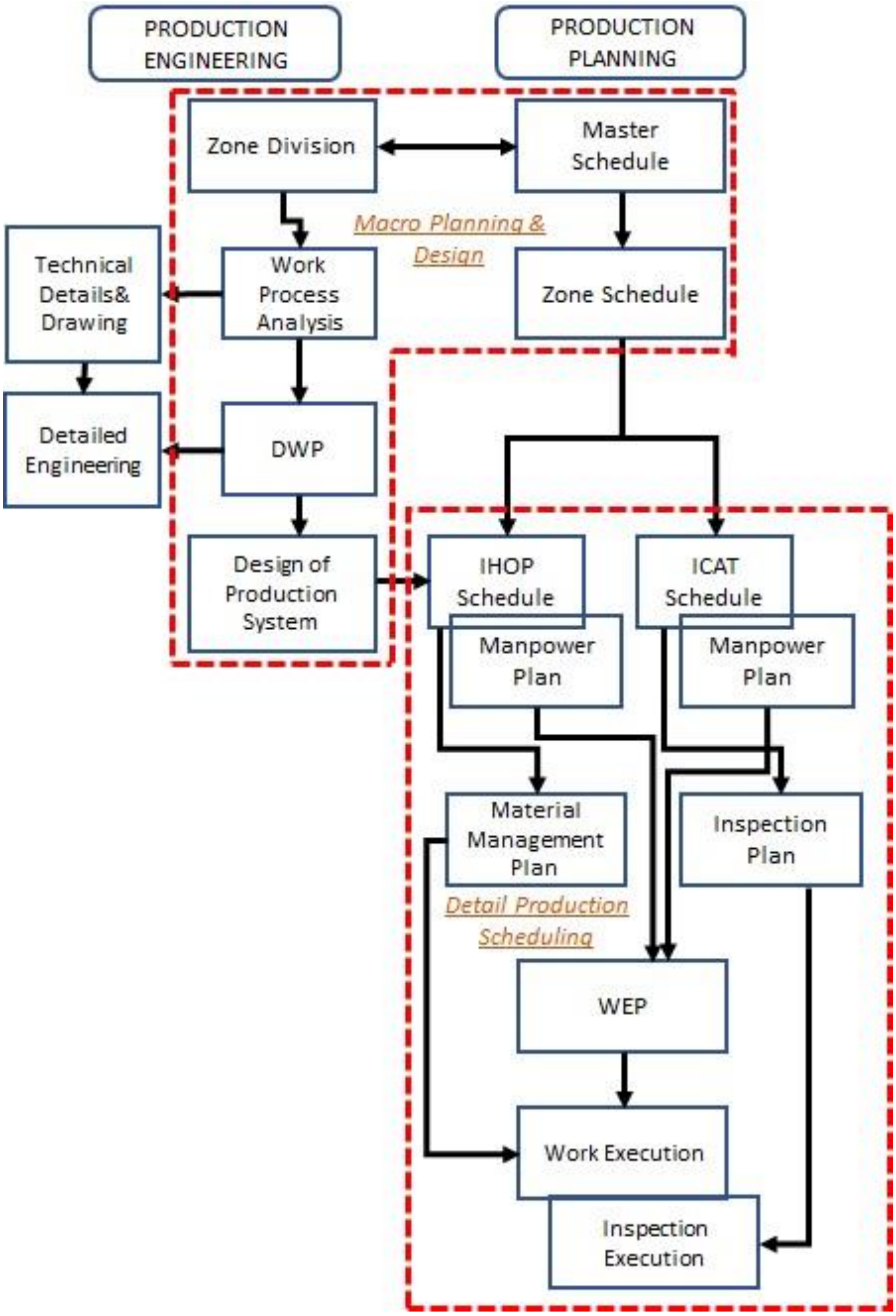

Fig. 5: Research design for DRPS framework

Inspection plan involve of quality inspector job was mentioned clearly as the requirement of work demarcation in physical work and inspection activities [39]. Monthly discipline schedule refers to the formation of manpower plan from IHOP and ICAT schedule by leveling the manpower in horizon time line for each discipline. Next, weekly work execution is cover up work execution program

(WEP) which is prepared by supervisor or foreman. WEP will be distributed to working group as an instruction to each worker for work execution. Material management plan is a schedule for predict material delivery consume for installation process. The information such as start to order date and required on site date were set in the plan in line with master schedule and IHOP schedule. The inspection activities which is required for the project was listed into inspection plan, extract from ICAT schedule. Finally, dynamic monitoring and control are actions performed at the project management and work execution level designed to provide assurance that information on the operations is appreciate, appears reasonable and is consistently prepared. The method called as visual management as describe by [37] purposely for monitor and control effectively. Continuous monitoring enables management and project team to continually review a project operations and activities. The elements in this task are project manager meeting, daily morning briefing, morning cleaning, weekly progress review and management support.

4.2 Final DRPS framework

The proposed DRPS framework was working well while preliminary review. On the feedback and improvement, the framework need to be loaded into the computation planning system for better monitoring and control on real time basis. Based on the review and implementation of DRPS, the framework has been modified and refined. Fig. 6 shows the final framework with the scope of this study outlined in red dash line.

On the execution work, the job ticket will be release from MARS Planning and deliver online to job process owner recipient. The framework is intended to provide practitioner with a better understanding of DRPS and clear guidance. On programmer side, the input from DRPS framework then being upload into MARS Planning with the new value added.

The computation process of update patches to version 7.2.0.40 was done as per shown in Fig. 7. It involves the improvement on quality inspection report (QIR) patches, fixed re-baseline and resource management view for project planning.

The final framework seems robust with the alignment line of responsibility on planning execution, engineering design, material requisition and inspection activity. Planner play important role in dynamic monitoring and control all the process from monitoring on ground planning to updating in system scheduling and vice versa.

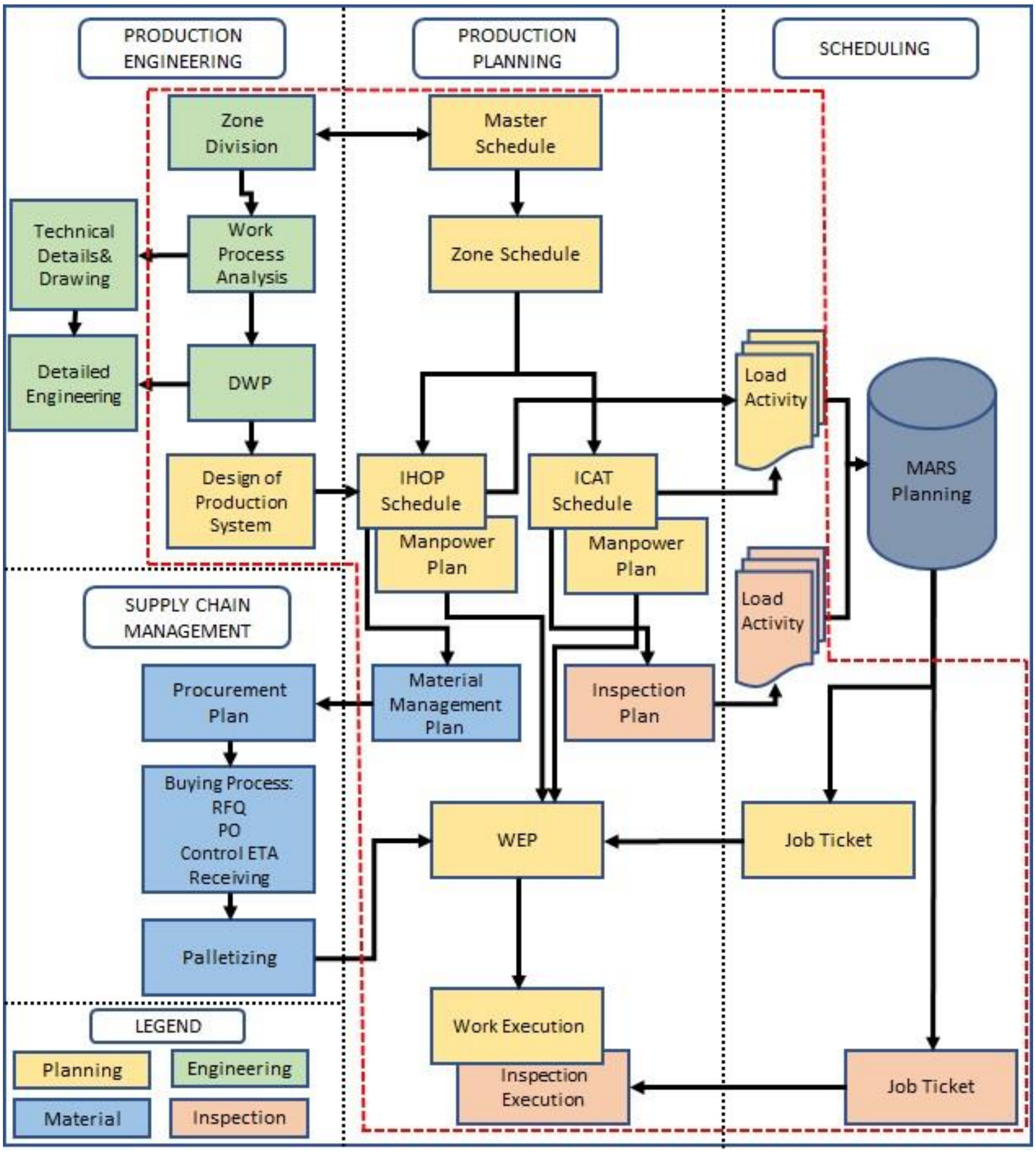

Fig. 6: Final DRPS framework

Dear AVEVA MARS*Planning Users,

Kindly be informed, AVEVA MARS*Planning successfully be update to version 7.2.0.40.

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****************** Content of New Update Patches **************************************
MPBNS-15 - QIR values displayed in MARS*Planning
MPBNS-16 - Fixed rebaseline for activities without a baseline
MPBNS-19 - Resource Management View for Project Planning

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INSTALLATION
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Run \\asluma01\document\marsplanning\deployment\setup.exe if AUTOUPDATE operation is fail
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Do contact our helpdesk at 7072/7074 if you required our assistance.

Fig. 7: MARS Planning update to version 7.2.0.40

5 Results, Analysis and Discussions

In this research, the performance and effectiveness of DRPS framework is validated by project performance analysis and comparative analysis. KD LEKIR project started in October 2011, suffer critical delay at variance -16.11% behind time by middle of 2013, development framework and rationalization process since November 2013, then start to implement DRPS in January 2014 and was successfully handover to the government and Royal Malaysian Navy on time in October 2014.

Table 1: Monthly progress report summary on implementation DRPS in 2014

Progress	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Installation	17.17	39.96	62.57	75.29	79.59	93.45	97.43	99.38	99.86	100.00
Test & Trial	0.00	0.00	13.37	45.21	64.53	78.87	86.18	94.72	98.35	100.00
Overall	11.94	27.78	47.58	66.12	75.00	89.01	94.00	97.96	99.40	100.00

On implementation DRPS, installation stage was guided by IHOP schedule and planning while test and trial stage by ICAT schedule and planning. From analysis of progress report in Table 1, we observe that the recovery installation work make debut in February and March with recorded monthly progress 22.79% and 22.61% respectively. Test and trial program started in March and contribute to the progress with aggressive activity in April and May, with monthly progress 31.84% and 19.32% respectively. We conclude the result by four phase of execution which is recovery stage, dynamic monitoring and control, integration on harbor and sea trial and finishing for completion. In January to March, all discipline pressed out to recover the remaining installation work prior to enter test and trial stage. When coming to April until Jun, dynamic monitoring and control involve micro management was applied to seek the overlapping and interfacing job between installation and test and trial. On overall progress by ended Jun, we achieve 89.01%, closely to 90% means that ship is ready for sea trial. System check for the remaining job in July and integration with sea trial conducted until early September. Finally, the balance days towards completion date focusing on finishing job and punching out the remaining.

Measurable of project success criteria base from past study [28], [29], [30] and [31] such as meeting schedule delivery on time, meeting quality target, meeting functional performance and fulfillment customer satisfaction. Han et al. [31] elaborate project success into three criteria i.e. project management success, product success and market success. Han et al. [31] accumulate adherence to schedule and quality as a project management success, customer satisfaction and functional performance as a product success and revenue, profit and reputation as a market success. Project management success and product success become success factor to project in [29] research. From analysis of progress report and event review, the following result as shown in Fig. 8 is obtained against project success criteria.

Fig. 8: Project success of KD LEKIR

KD LEKIR is the second ship undergoing SLEP project after KD KASTURI. The comparative analysis between two projects is as shown in Table 2.

Base on the result, the implementation of DRPS framework in KD LEKIR project shown much better performance than the KD KASTURI project which is suffer 13 months delay and with the huge number of remaining item reflect to the unsatisfied quality product. Shipyard had successful delivered a second ship on time avoiding liquidated damage amounting to RM63 million.

Table 2: Comparative analysis the performance DRPS and existing framework

Project	Framework	Delay time	Sea trial event	Remaining item
KD LEKIR	DRPS	0	30 times	10
KD KASTURI	Existing	13 months	38 times	67

Figure 9 shows the structure of DRPS into MARS Planning system and the distribution of information for the job execution and feedback response. At this juncture, real time progress updating will be done by process owner either from production unit or quality inspector at the time of complete the job.

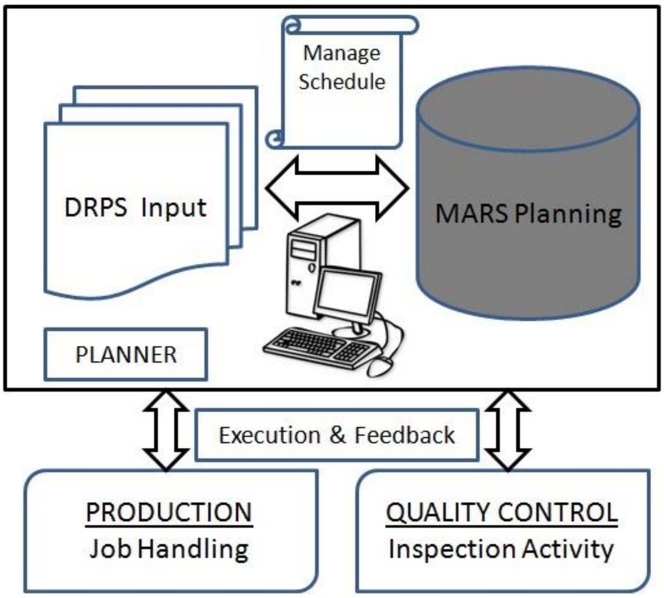

Fig. 9: Structure of DRPS into MARS Planning

Online reporting method was applied to process owner whereby each job ticket to be processed into system visualization screen i.e. job handling for production unit as shown in Fig. 10 and inspection test request for quality control unit as shown in Fig. 11.

Fig. 10: Visualization screen job handling

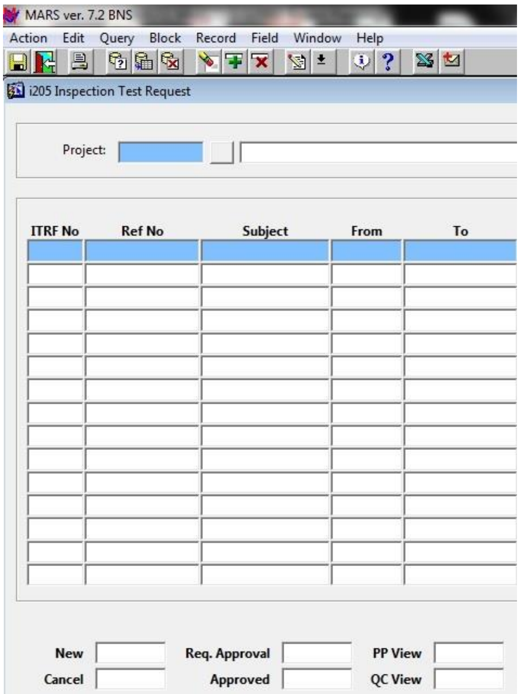

Fig. 11: Visualization screen inspection test request

6 Conclusion

In this study, we propose a DRPS framework oriented to the shipbuilding industries. The framework emphasizes the dynamic monitoring and control of production planning in manages both planning and scheduling. Value added ICAT methodology in planning was able to co-ordinate specialty on test and trial stage beside production and installation stage earlier. The study has managed to find and investigate the weaknesses on project management, production method and production planning system. An innovation to the production planning is suggested. The project success was positively influenced by the usage of correct way project management tools [29] run the project such as DRPS. Finally, DRPS framework has been established and utilized in the real planning on shipbuilding project of a shipyard. The DRPS was tested as feasible and effective in a case study conducted at Boustead Naval Shipyard in Perak, Malaysia. It was thereupon concluded that the proposed DRPS framework could efficiently and successfully replace the existing framework. The final DRPS was also linked up to the ERP system, successfully integrated into shipyard computation MARS Planning system.

In future work, to further test the implementation of production engineering involvement extended to material planning for procurement process until palletization. It also recommended expanding the study scope of DRPS framework for ship repair industry.

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