Critical Chain Project Management and Buffer Planning: Study Case at Security Accommodation Vessel Construction

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***Abstract*— Shipbuilding projects frequently encounter delays and cost overruns as a result of unpredictability in the construction process. This paper aims to explore the potential of Critical Chain Project Management (CCPM) and buffer planning to enhance scheduling in complex shipbuilding project. The research approach involves a case study of a Security Accommodation Vessel (SAV) construction project, complemented by expert interviews which were conducted to assess the risks and uncertainties affecting activity durations. The buffer sizes were then calculated using the Root Square Error Method (RSEM). Qualitative data was gathered through interviews with the expert to identify and assess potential risks and uncertainties impacting activity durations. This qualitative insight informed the application of the RSEM to determine appropriate buffer sizes. The planned project duration was reduced from 790 days to 678 days, representing a 14,5% improvement. The study focuses on the planning phase of CCPM and demonstrates the potential of combining CCPM, buffer planning, and expert input to create more reliable schedules for complex shipbuilding projects like SAV construction.**

Keywords—Buffer Sizing, Duration Reduction, Project Scheduling, Shipbuilding Project, CCPM, SAV.

I. INTRODUCTION

Shipbuilding, a crucial sector within the maritime industry, demands meticulous planning and execution due to its inherent complexity [1]. Suboptimal management can lead to delays, cost overruns, and quality issues stemming from the challenges of coordinating diverse activities, managing resources, and mitigating potential delays [2]. Therefore, robust project management methodologies are essential for controlling schedules and costs in this inherently uncertain and complex environment.

Manual scheduling methods commonly used in shipbuilding, despite hierarchical project planning, lead to frequent adjustments [3], lack scalability [4], and struggle with inherent project uncertainties [5]. This results in planning complexities, imbalanced workloads, limited optimization [6], dynamic demand shifts, and contractual compliance pressures, necessitating more robust and adaptable scheduling and control approaches [7]. Furthermore, shipbuilding projects are susceptible to various uncertainties, such as design changes, material delivery delays, and unforeseen technical issues, which can disrupt schedules and escalate costs.

While conventional project management methods like Critical Path Method (CPM) [8] and Project Evaluation and Review Techniques (PERT) are common [9], their deterministic approach and lack of resource constraint consideration often lead to unrealistic schedules. These methods fail to adequately address the dynamic resource allocation needs and inherent uncertainties characteristic of shipbuilding projects. Their deterministic nature, assuming fixed activity durations and neglecting resource constraints, can lead to unrealistic schedules and difficulties in effectively managing the dynamic environment of shipbuilding. The limitations of manual scheduling methods, particularly their lack of scalability and difficulty in handling project uncertainties, further exacerbate these challenges, potentially resulting in project delays, cost overruns, and quality compromises. To accommodate these problems, projects vulnerability Critical Chain Project Management (CCPM) offers a more robust solution by focusing on the critical chain, incorporating resource availability, and utilizing buffers to manage uncertainty and optimize resource allocation, ultimately improving project control and mitigating delays and cost overruns [10].

CCPM has emerged as an approach to address the inherent complexities and uncertainties that plague traditional project management methods, particularly in intricate endeavours like shipbuilding. Its core principles revolve around a fundamental shift in focus from individual task durations to the critical chain, which represents the longest sequence of dependent tasks and resources required for project completion [26]. Unlike the traditional critical path, which solely considers task dependencies, the critical chain incorporates resource constraints, providing a more realistic representation of project timelines [27]. This crucial distinction acknowledges the significant impact of resource availability, or lack thereof, on project progress [28]. CCPM tackles the pervasive issue of uncertainty by incorporating buffers into its strategic framework [29]. These buffers, strategically placed throughout the project,

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Figure 1. Security Accommodation Vessel.

act as shock absorbers, mitigating the impact of unexpected delays and variations in task durations [30].

By aggregating safety time into these buffers, CCPM avoids the pitfalls of overly optimistic task estimations, which often lead to unrealistic schedules and project overruns [31]. This proactive approach to uncertainty management enables project teams to respond effectively to unforeseen challenges without compromising the overall project timeline [32]. In essence, CCPM enhances project predictability and control by explicitly considering resource availability and managing uncertainties more effectively than traditional methods.

Buffer planning in CCPM is crucial for mitigating pre-execution risks and uncertainties [11]. Buffer management is a cornerstone of CCPM, providing a proactive mechanism for mitigating pre-execution risks and uncertainties inherent in complex projects, especially shipbuilding. It involves strategically allocating time buffers to protect the project's critical chain and feeding paths by analysing task dependencies [12], resource availability [13], [14], and potential variability [15]. Effective buffer planning is essential for creating a robust and predictable project schedule. It involves strategically sizing and allocating buffers to absorb potential delays and variations in task durations, thereby protecting the critical chain and the overall project completion date. The choice of method depends on the specific project characteristics and the level of uncertainty involved. Regardless of the chosen method, the goal is to create buffers that are neither too large, which would lead to excessive project duration, nor too small, which would offer insufficient protection against delays. CCPM employs different types of buffers, each serving a specific purpose. The project buffer, placed at the end of the critical chain, protects the overall project deadline. Feeding buffers are inserted at the points where non-critical chains merge with the critical chain, safeguarding against delays that could impact the critical path. Resource buffers, while less common, are used to address uncertainties related to resource availability. Pre-emptive buffer planning is crucial for enhancing project predictability and robustness. By anticipating potential delays and allocating buffers accordingly, project managers can create a schedule that is more resilient to unforeseen events. This proactive approach allows for more effective management of uncertainties, reducing the likelihood of project overruns and improving the chances of on-time delivery.

This research focuses specifically on this pre-emptive buffer planning phase, exploring various buffer sizing methods and allocation strategies to enhance project predictability and robustness. Furthermore, this research goes beyond simply managing buffers throughout the project lifecycle, concentrating on the crucial pre-execution planning stage where buffer sizing and allocation decisions significantly impact project outcomes.

This paper evaluates the effectiveness of CCPM and buffer planning in reducing the project duration and improving the scheduling predictability. We chose the construction project in a Security Accommodation Vessel (SAV) to illustrate our findings. This study contributes to the existing literature by employing a novel qualitative approach for assessing the average time to complete each activity. This approach involves interviews with domain experts to capture the nuanced realities of SAV construction and inform the buffer sizing process. This analysis aims to determine the potential benefits of adopting CCPM and pre-emptive buffer planning for enhanced project control and successful delivery in the complex shipbuilding environment.

II. METHOD

This case study focuses on the construction of a Security Accommodation Vessel, a specialized vessel type increasingly deployed in offshore oil and gas operations to provide safe and secure accommodation for personnel working in remote or high-risk environments. The figure of SAV shipbuilding projects is illustrated on Figure 1. SAV construction projects present unique project management challenges due to their complex design, stringent safety requirements, and the need for integration with existing offshore infrastructure. These complexities make SAV construction an ideal context for evaluating the effectiveness of CCPM and buffer planning in mitigating schedule delays and cost overruns. By examining the application of CCPM in this specific context, the research aims to provide valuable insights into the potential benefits and challenges of adopting CCPM in specialized shipbuilding projects.

A. Research Method

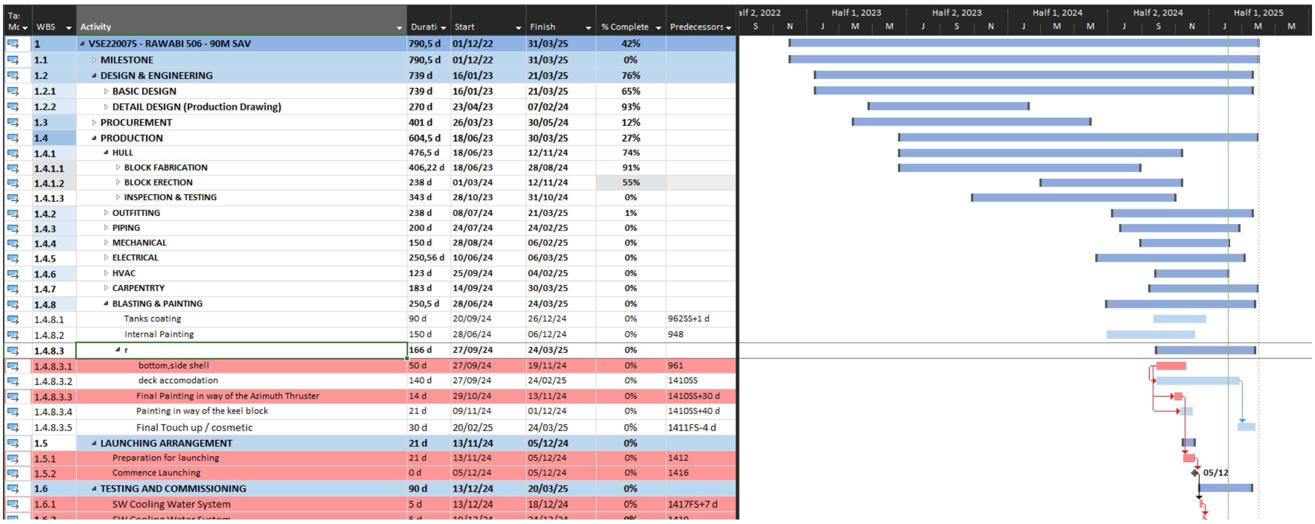
This research analyzes a Work Breakdown Structure (WBS) to identify critical and non-reducible duration activities [16]. Activity dependencies are then used to construct a network diagram for calculating project buffer requirements [17]. CCPM scheduling is performed and compared against manual scheduling, analyzing time reductions and overall project duration [18]. This comparison informs recommendations for CCPM implementation strategies.

B. Data Collection

To compare CCPM and manual scheduling performance for a SAV construction project, data were collected from project plans, schedules and documentation. Interviews with project personnel provided insight into scheduling, resource allocation, and improvement areas. The written interview result based on out questionnaire can be seen on attachment section. Historical data from similar projects, including WBS and other relevant information, supported the analysis of critical activities and task with non-reducible durations.

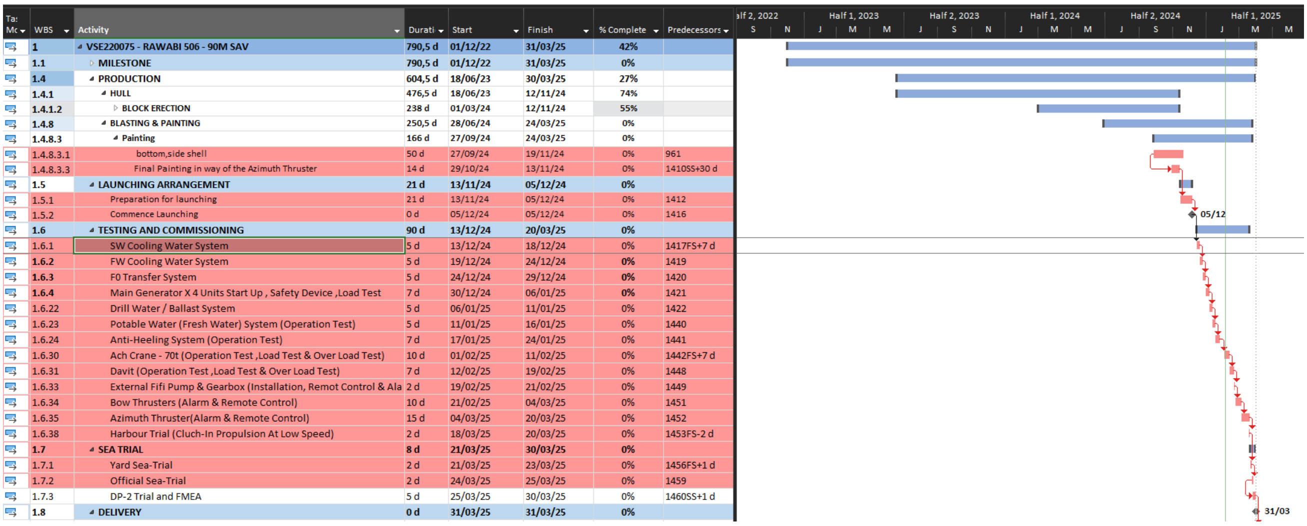
C. Critical Chain Identification

The critical chain, representing the longest sequence of dependent tasks, was identified using the Microsoft Project software. The activities within this critical chain possess zero float, meaning any delay on these tasks directly impacts the overall project completion date [19]. This inherent sensitivity underscores the importance of effective management and buffer allocation along the critical chain to mitigate potential delays and ensure timely project delivery [20]. By utilizing Microsoft Project's scheduling capabilities, the critical chain was readily determined without the need for manual network diagram construction [21].



WBS	Activity	Duration	Start	Finish	% Complete	Predecessors
1	VSE220075 - RAWABI 506 - 90M SAV	790,5 d	01/12/22	31/03/25	42%	
1.1	MILESTONE	790,5 d	01/12/22	31/03/25	0%	
1.2	DESIGN & ENGINEERING	739 d	16/01/23	21/03/25	76%	
1.2.1	BASIC DESIGN	739 d	16/01/23	21/03/25	65%	
1.2.2	DETAIL DESIGN (Production Drawing)	270 d	23/04/23	07/02/24	93%	
1.3	PROCUREMENT	401 d	26/03/23	30/05/24	12%	
1.4	PRODUCTION	604,5 d	18/06/23	30/03/25	27%	
1.4.1	HULL	476,5 d	18/06/23	12/11/24	74%	
1.4.1.1	BLOCK FABRICATION	406,22 d	18/06/23	28/08/24	91%	
1.4.1.2	BLOCK ERECTION	238 d	01/03/24	12/11/24	55%	
1.4.1.3	INSPECTION & TESTING	343 d	28/10/23	31/10/24	0%	
1.4.2	OUTFITTING	238 d	08/07/24	21/03/25	1%	
1.4.3	PIPING	200 d	24/07/24	24/02/25	0%	
1.4.4	MECHANICAL	150 d	28/08/24	06/02/25	0%	
1.4.5	ELECTRICAL	250,56 d	10/06/24	06/03/25	0%	
1.4.6	HVAC	123 d	25/09/24	04/02/25	0%	
1.4.7	CARPENTRTY	183 d	14/09/24	30/03/25	0%	
1.4.8	BLASTING & PAINTING	250,5 d	28/06/24	24/03/25	0%	
1.4.8.1	Tanks coating	90 d	20/09/24	26/12/24	0%	962SS+1 d
1.4.8.2	Internal Painting	150 d	28/06/24	06/12/24	0%	948
1.4.8.3	r	166 d	27/09/24	24/03/25	0%	
1.4.8.3.1	bottom,side shell	50 d	27/09/24	19/11/24	0%	961
1.4.8.3.2	deck accomodation	140 d	27/09/24	24/02/25	0%	1410SS
1.4.8.3.3	Final Painting in way of the Azimuth Thruster	14 d	29/10/24	13/11/24	0%	1410SS+30 d
1.4.8.3.4	Painting in way of the keel block	21 d	09/11/24	01/12/24	0%	1410SS+40 d
1.4.8.3.5	Final Touch up / cosmetic	30 d	20/02/25	24/03/25	0%	1411FS-4 d
1.5	LAUNCHING ARRANGEMENT	21 d	13/11/24	05/12/24	0%	
1.5.1	Preparation for launching	21 d	13/11/24	05/12/24	0%	1412
1.5.2	Commence Launching	0 d	05/12/24	05/12/24	0%	1416
1.6	TESTING AND COMMISSIONING	90 d	13/12/24	20/03/25	0%	
1.6.1	SW Cooling Water System	5 d	13/12/24	18/12/24	0%	1417FS+7 d

Figure 1. Microsoft Project for Scheduling Tool.



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1.4	PRODUCTION	604,5 d	18/06/23	30/03/25	27%	
1.4.1	HULL	476,5 d	18/06/23	12/11/24	74%	
1.4.1.2	BLOCK ERECTION	238 d	01/03/24	12/11/24	55%	
1.4.8	BLASTING & PAINTING	250,5 d	28/06/24	24/03/25	0%	
1.4.8.3	Painting	166 d	27/09/24	24/03/25	0%	
1.4.8.3.1	bottom,side shell	50 d	27/09/24	19/11/24	0%	961
1.4.8.3.3	Final Painting in way of the Azimuth Thruster	14 d	29/10/24	13/11/24	0%	1410SS+30 d
1.5	LAUNCHING ARRANGEMENT	21 d	13/11/24	05/12/24	0%	
1.5.1	Preparation for launching	21 d	13/11/24	05/12/24	0%	1412
1.5.2	Commence Launching	0 d	05/12/24	05/12/24	0%	1416
1.6	TESTING AND COMMISSIONING	90 d	13/12/24	20/03/25	0%	
1.6.1	SW Cooling Water System	5 d	13/12/24	18/12/24	0%	1417FS+7 d
1.6.2	FW Cooling Water System	5 d	19/12/24	24/12/24	0%	1419
1.6.3	F0 Transfer System	5 d	24/12/24	29/12/24	0%	1420
1.6.4	Main Generator X 4 Units Start Up , Safety Device ,Load Test	7 d	30/12/24	06/01/25	0%	1421
1.6.22	Drill Water / Ballast System	5 d	06/01/25	11/01/25	0%	1422
1.6.23	Potable Water (Fresh Water) System (Operation Test)	5 d	11/01/25	16/01/25	0%	1440
1.6.24	Anti-Heeling System (Operation Test)	7 d	17/01/25	24/01/25	0%	1441
1.6.30	Ach Crane - 70t (Operation Test ,Load Test & Over Load Test)	10 d	01/02/25	11/02/25	0%	1442FS+7 d
1.6.31	Davit (Operation Test ,Load Test & Over Load Test)	7 d	12/02/25	19/02/25	0%	1448
1.6.33	External Fifi Pump & Gearbox (Installation, Remot Control & Ala	2 d	19/02/25	21/02/25	0%	1449
1.6.34	Bow Thrusters (Alarm & Remote Control)	10 d	21/02/25	04/03/25	0%	1451
1.6.35	Azimuth Thruster(Alarm & Remote Control)	15 d	04/03/25	20/03/25	0%	1452
1.6.38	Harbour Trial (Cluch-In Propulsion At Low Speed)	2 d	18/03/25	20/03/25	0%	1453FS-2 d
1.7	SEA TRIAL	8 d	21/03/25	30/03/25	0%	
1.7.1	Yard Sea-Trial	2 d	21/03/25	23/03/25	0%	1456FS+1 d
1.7.2	Official Sea-Trial	2 d	24/03/25	25/03/25	0%	1459
1.7.3	DP-2 Trial and FMEA	5 d	25/03/25	30/03/25	0%	1460SS+1 d
1.8	DELIVERY	0 d	31/03/25	31/03/25	0%	

Figure 2. Critical Path automatically filtered in Microsoft Project.

TABLE 1
CALCULATION OF FEEDING BUFFERS PART 2

Task Name	w (duration)	a (average)	(w-a)/2	((w-a)2)/2
DESIGN & ENGINEERING				
BASIC DESIGN	739	370	184,5	34040,3
DETAIL DESIGN (Production Drawing	270	234	18,0	324,0
Feeding Buffer 1				370,8
PROCUREMENT	401	182	109,5	11990,3
Feeding Buffer 2				219,0
BLOCK ERECTION				
MAIN DECK	10	4	3,0	9,0
1ST DECK	10	4	3,0	9,0
2ND DECK	10	4	3,0	9,0
3RD DECK	8	4	2,0	4,0
4TH DECK	8	4	2,0	4,0
NAV. BRIDGE	4	4	0,0	0,0
WHEELHOUSE TOP	4	4	0,0	0,0
HELI-DECK	4	4	0,0	0,0
Feeding Buffer 3				11,8
INSPECTION & TESTING	343	338	2,5	6,3
Feeding Buffer 4				5,0
OUTFITTING	238	169	34,5	1190,3
Feeding Buffer 5				69,0
PIPING	200	200	0,0	0,0
Feeding Buffer 6				0,0
MECHANICAL	150	125	12,5	156,3
Feeding Buffer 7				25,0
ELECTRICAL	250	200	25,0	625,0
Feeding Buffer 8				50,0
HVAC	123	120	1,5	2,3
Feeding Buffer 9				3,0
CARPENTRTY	183	150	16,5	272,3
Feeding Buffer 10				33,0
BLASTING & PAINTING				
Tanks coating	90	80	5,0	25,0
Internal Painting	150	125	12,5	156,3
Feeding Buffer 11				26,9
External Painting				
deck accommodation	140	120	10	100,0
Painting in way of the keel block	21	20	0,5	0,3
Final Painting in way of the Azimuth Thruster	11	10	0,5	0,3
Final Touch up / cosmetic	30	7	11,5	132,3
Feeding Buffer 12				30,5
TESTING & COMMISSIONING				
Feeding Buffer 13				0,0

D. Buffer Planning

While Critical Chain Project Management typically employs three buffer – this Security Accommodation Vessel construction project utilized only a project buffer was at the end of the critical chain. This project buffer was calculated using the Root Square Error Method, as depicted in Figure 2. The RSEM Formula employs the worst-case duration (the pre-CCPM duration) and the average duration (the post percentage reduction duration).

$$Buffer = 2 \times \sqrt{\left(\frac{w_1 - a_1}{2}\right)^2 + \left(\frac{w_2 - a_2}{2}\right)^2 + \cdots + \left(\frac{w_n - a_n}{2}\right)^2}$$

Feeding buffers, which protect the critical chain from delays on non-critical paths, were deemed unnecessary due to the specialized nature of workforce [22]. Resource buffer, designed to account for resource Availability fluctuations, were also omitted, as the expertise of the assigned personnel ensure to overlapping or conflicting work assignments [13]. Furthermore, the RSEM-calculated buffer size remained unadjusted, reflecting the project team's confidence in the initial assessment and the absence of any specific risk factors necessitating further modification.

E. Scheduling Tools

Microsoft Project was utilized for scheduling, leveraging its features to CCPM principles [21]. Its functionality enabled critical chain identification, and the RSEM-calculated project buffer was added to the schedule [22]. Visualizing the buffered critical chain in Microsoft Project facilitated project monitoring, although the software lacks dedicated CCPM features like automatic buffer management [21].

F. Data Analysis

The analysis compared the CCPM schedule against a traditional schedule by focusing on the reduction [12]. This straightforward comparison highlighted the time-saving potential of CCPM by quantifying the reduction achieved through buffer management and critical chain scheduling [23]. This direct comparison served to underscore the potential time-saving benefits of CCPM by quantifying the extent of the reduction, which stemmed from the strategic use of buffer management and critical chain scheduling principles. The analysis deliberately refrained from delving into more complex statistical measures, such as analysis of variance calculations, to maintain a clear and concise focus on the overarching improvement in overall project duration. This streamlined approach allowed for a straightforward assessment of the time-saving advantages offered by CCPM in the context of shipbuilding.

TABLE 2.
CALCULATION OF PROJECT BUFFER

Task Name	w (duration)	a (average)	(w-a)/2	((w-a)2)/2
PRODUCTION				
HULL				
BLOCK FABRICATION				
BLOCK ERECTION				
BELOW MAIN DECK	195	195	0,0	0,0
BLASTING & PAINTING				
External Painting				
bottom, side shell	50	40	5,0	25,0
Final Painting in way of the Azimuth Thruster	14	10	2,0	4,0
LAUNCHING ARRANGEMENT				
Preparation for launching	21	20	0,5	0,3
Commence Launching	0	0	0,0	0,0
TESTING AND COMMISSIONING				
SW Cooling Water System	5	5	0,0	0,0
FW Cooling Water System	5	5	0,0	0,0
F0 Transfer System	5	5	0,0	0,0
Main Generator X 4 Units Start Up , Safety Device ,Load Test	7	7	0,0	0,0
Drill Water / Ballast System	5	5	0,0	0,0
Potable Water (Fresh Water) System (Operation Test)	5	5	0,0	0,0
Anti-Heeling System (Operation Test)	7	7	0,0	0,0
Ach Crane - 70t (Operation Test ,Load Test & Over Load Test)	10	10	0,0	0,0
Davit (Operation Test ,Load Test & Over Load Test)	7	7	0,0	0,0
External Fifi Pump & Gearbox (Installation, Remote Control & Alarm Test)	2	2	0,0	0,0
Bow Thrusters (Alarm & Remote Control)	10	10	0,0	0,0
Azimuth Thruster(Alarm & Remote Control)	15	15	0,0	0,0
Inclining Test	0	0	0,0	0,0
SEA TRIAL				
Yard Sea-Trial	2	2	0,0	0,0
Official Sea-Trial	2	2	0,0	0,0
DP-2 Trial and FMEA	5	5	0,0	0,0
Project Buffer				10,8

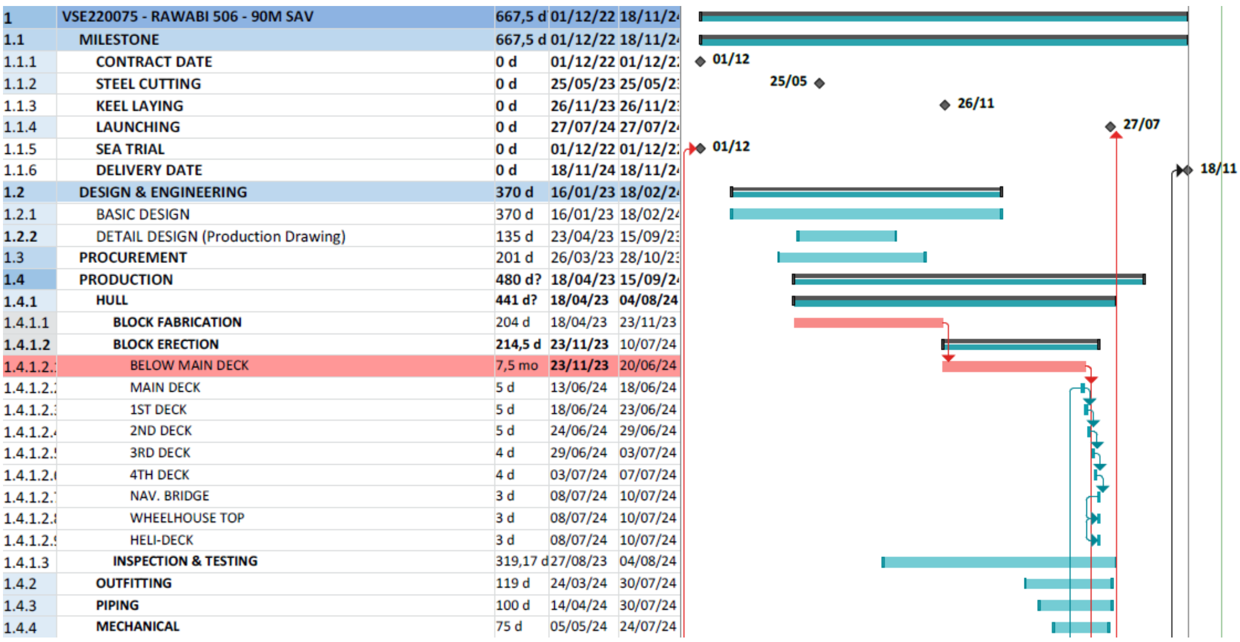

Figure 3. Project Rescheduling

III. Result and Discussion

This section details the implementation of the methodology outlined previously, including critical chain identification, buffer planning, and project rescheduling using Microsoft Project. The discussion analysis the impact of CCPM and buffer management on the project timeline explaining the observed time saving. It also addresses any limitations or challenges encountered during the implementation process.

A. Critical Chain Identification

The project's critical chain, comprising the sequence of interdependent task that determine of overall project duration, was identified and visualized as shown in the figure 3. This identification was based on an analysis of task dependencies and durations. The resulting critical chain then served as the basis for buffer planning.

B. Buffer Planning

Using the RSEM, the buffer planning calculated both the project and feeding buffer sizes. The project buffer was calculated as the square root of the sum of the squared duration variances of the critical chain activities. Feeding buffer, protecting the critical chain from delays on feeding paths, were calculated similarly, using the squared duration variances of activities on each feeding chain as shown in the table 1. This approach protected both project completion and the critical chain from the activity duration variability.

Table 1 and 2 present the calculated feeding buffer for non-critical activities, the purpose of which is to protect the critical chain from potential delays. These buffer function as time reserves, to absorb fluctuations in non-critical activity durations. This, in the prevent negative impact on the overall project schedule.

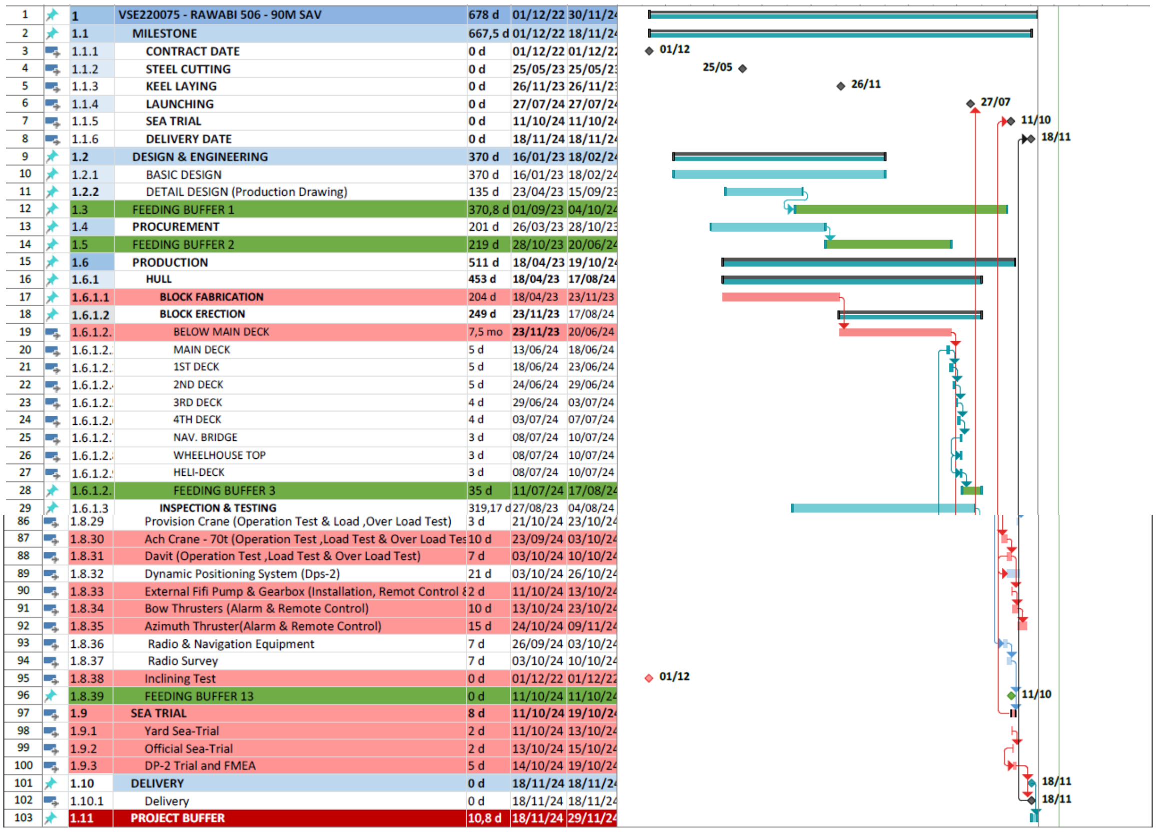

Figure 4. Buffer Positioning

TABLE 3
CALCULATION OF WORK TIME REDUCTION

Activities	Duration Before CCPM	Duration After CCPM	Reduction
DESIGN & ENGINEERING	739	370	369
BASIC DESIGN	739	370	369
DETAIL DESIGN (Production Drawing)	270	135	135
PROCUREMENT	401	201	200
PRODUCTION	604,5	511	93,5
HULL	476,5	453	23,5
BLOCK FABRICATION	406,2	204	202,2
BLOCK ERECTION	238	249	-11
BELOW MAIN DECK	195	195	0
MAIN DECK	10	5	5
1ST DECK	10	5	5
2ND DECK	10	5	5

Activities	Duration		Reduction
3RD DECK	8	4	4
4TH DECK	8	4	4
NAV. BRIDGE	4	3	1
WHEELHOUSE TOP	4	3	1
HELI-DECK	4	3	1
INSPECTION & TESTING	343	319,17	23,83
OUTFITTING	238	119	119
PIPING	200	100	100
MECHANICAL	150	75	75
ELECTRICAL	250,56	126	124,56
HVAC	123	62	61
CARPENTRTY	183	94	89
BLASTING & PAINTING	250,5	117,5	133
Tanks coating	90	45	45
Internal Painting	150	75	75
External Painting	166	112	54
bottom, side shell	50	50	0
deck accommodation	140	70	70
Final Painting in way of the Azimuth Thruster	14	14	0
Painting in way of the keel block	21	11	10
Final Touch up / cosmetic	30	15	15
LAUNCHING ARRANGEMENT	21	21	0
Preparation for launching	21	21	0
Commence Launching	0	0	0
TESTING AND COMMISSIONING	90	90	0
SEA TRIAL	8	8	0
Yard Sea-Trial	2	2	0
Official Sea-Trial	2	2	0
DP-2 Trial and FMEA	5	5	0
DELIVERY	0	0	0
Delivery	0	0	0

The design & Engineering department required the largest feeding buffer, with a value of 584.1 days, followed by Procurement with 219.0 days and External Painting with 103.6 days. The Buffers allocated for electrical, and Outfitting are 124.0 and 69.0 days, respectively. Mechanical, HVAC, and Blasting & Painting require shorter feeding buffer of 25.0, 33.0, and 26,9 days, respectively. The feeding buffers for Production – Block Erection and Production – Inspection & Testing are comparatively minimal at 11.8 and 5.0 days, respectively. Finally, it is notable that Piping and Testing & Commissioning do not require feeding buffers, with a value of 0,0 days.

Therefore, on table 3, a project buffer of 10,8 days has been calculated for the Security Accommodation Vessel construction project. This value will be used as the time reserve to protect the overall project from potential delays that may occur in the critical chain, so that it is expected that the project can be completed on time.

C. Project Rescheduling

Rescheduling in Critical Chain Project Management involves reducing non-critical activities by 50% to optimize resources and protect the critical chain. Reducing the duration of non-critical activities by 50% allows for the creation of feeding buffers, protecting the critical chain from delays originating in non-critical paths and increasing the probability of on-time project completion [13], [24], [25]. This requires differentiating truly non-critical activities with sufficient slack from essential supporting task, which are not reduced. While shortening the project timeline, this approach maintains the integrity of the critical chain and ensures project success.

D. Buffer Positioning

CCPM uses buffer to mitigate delays. Feeding buffers protect the critical chain from delays in non-critical chain, protect the overall project completion date. This strategic buffer placement prevents delays on non-critical activities from affecting the critical chain and absorb any critical chain slippage, safeguarding the project deadline.

E. Work Time Reduction

Work time reduction in CCPM is calculated by comparing project durations before and after CCPM. The difference represents the time saved, often due to manage on critical chain and using buffers to manage uncertainties. This study's findings demonstrate the significant potential of CCPM and buffer planning to enhance scheduling in complex shipbuilding projects, particularly in the construction of a Security Accommodation Vessel. The core novelty lies in the tailored application of CCPM principles to this specific context, resulting in a substantial reduction in project duration. The analysis of work time reduction, derived by comparing project durations before and after CCPM implementation, reveals a compelling narrative of improved efficiency. The observed time savings are not merely incidental but stem directly from the core tenets of CCPM: focused management of the critical chain and strategic use of buffers to absorb uncertainties.

Table 3 provides a granular view of CCPM's impact on individual activity durations. The data highlights a substantial decrease in the overall project timeline, primarily driven by significant time savings in the production phase, particularly in hull construction and outfitting activities. While some specific tasks, such as block erection, experienced a marginal duration increase under CCPM, the overall effect of the methodology resulted in a net positive outcome, significantly reducing the total project duration. This nuanced perspective underscores the importance of a holistic evaluation of CCPM's impact, considering both individual task variations and the aggregate effect on the entire project timeline.

The strategic placement of the project buffer, as detailed earlier, played a crucial role in achieving this outcome. While the final project duration of 678 days, inclusive of the buffer, represents an 11-day increase compared to the initial critical chain duration of 667 days (before buffer addition), it marks a substantial 112-day (14.2%) reduction compared to the existing scheduling method's 790-day duration. This result highlights a key aspect of CCPM: while individual task durations may fluctuate, the strategic use of buffers ensures that the overall project completion date is protected and significantly improved. This finding reinforces the value of CCPM as a robust scheduling methodology capable of mitigating uncertainties and delivering projects more efficiently, even in complex environments like shipbuilding. The study's focus on a specific vessel type, the Security Accommodation Vessel, further contributes to the novelty of the findings, offering valuable insights into the practical application and benefits of CCPM within a niche shipbuilding context.

IV. CONCLUSION

This research examined the potential of Critical Chain Project Management (CCPM) and buffer planning to enhance scheduling in complex shipbuilding projects, with a specific focus on the construction of a Security Accommodation Vessel (SAV).The primary objective was to investigate how CCPM, through its unique approach to task scheduling and buffer management, could improve project timelines in such a complex environment. The study implemented CCPM principles, implementing a strategic placement of a project buffer at the end of the critical chain and a reduction in the durations of non-critical activities, with the objective of optimizing the project schedule. This approach reflects the recognition that traditional scheduling methods often overestimate task durations to account for individual task uncertainties. On the other hand, CCPM consolidates these uncertainties into strategically placed buffers, allowing for more realistic task durations and a shorter overall project timeline. The project buffer provides a degree of protection to the project completion date, absorbing potential delays arising from task variations and unforeseen events.The reduction in non-critical activity durations has the effect of streamlining the project, with resources being concentrated on the critical path and potential disruptions being minimised.

The application of CCPM in this particular context resulted in a substantial 14.2% reduction in the overall project duration when compared to traditional scheduling methods. This significant time saving underscores the effectiveness of CCPM in managing the inherent uncertainties of shipbuilding projects and accelerating project completion.The findings strongly suggest that CCPM offers a viable and potentially superior alternative to conventional scheduling methods in this context. While the study focused primarily on project duration due to the lack of detailed cost data, the demonstrated time savings indicate a promising potential for cost reduction as well. Future research incorporating project cost analysis would provide a more comprehensive understanding of CCPM's overall impact on shipbuilding projects, enabling a more robust cost-benefit assessment of this innovative project management methodology.

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