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Mudlogging Service Performance Evaluation In Offshore Mahakam: A Case Study on The Consortium Contract Within PT PHM

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ABSTRACT: The PTEN-PTGS consortium's mudlogging services in Indonesia's Mahakam Block saw a sharp decline in performance (2022–2024), incurring USD 350,000 in rig standby costs, attributed to governance and competency gaps. This study identifies root causes and prioritizes solutions to restore operational efficiency. A mixed-method approach combines qualitative tools (Fishbone Diagram, Current Reality Tree) with quantitative Analytic Hierarchy Process (AHP) to analyze stakeholder inputs. The primary causes were unclear governance (lack of role clarity, delayed decisions) and insufficient training. AHP prioritized two solutions: (1) restructuring consortium governance (56.8% weight) to clarify accountability and (2) enhancing training programs (23.9% weight) to address skill gaps. The proposed governance model (e.g., permanent senior roles, streamlined communication) and joint training initiatives aim to reduce non-productive time by 85–90%, offering a replicable framework for consortium-based operations in mature offshore fields. The study underscores the criticality of structural and human capital alignment in sustaining service reliability.

Keywords: Mudlogging performance, consortium governance, crew competency, offshore operations, AHP, service reliability

INTRODUCTION

Indonesia's oil and gas sector plays a critical role in the nation's economy, contributing significantly to both national revenue and energy security (Rosdiana & Sidik, 2015; Sugiyono, 2021). However, the country is facing ongoing challenges as its oil and gas fields become increasingly mature, resulting in natural production decline rates. With only a limited number of new and substantial reserves being recovered, sustaining production levels has become increasingly difficult. The researcher emphasizes that operational efficiency is crucial for achieving economic outcomes within the industry. Any operational inefficiency directly impacts financial results, affecting both government revenues and contractor profitability (Wei et al., 2019; Ying Lai et al., 2014).

PT Pertamina Hulu Mahakam (PT PHM) is responsible for managing the Mahakam Block in East Kalimantan, which includes both swamp delta and offshore shallow-water areas. The Mahakam Block is one of Indonesia's most important offshore oil and gas assets, spanning swamp delta and shallow offshore areas (Migas, 2023). As of 2024, PT PHM operates five (5) offshore drilling rigs for the development and exploration of oil and gas wells. Mudlogging services are critical for the safety and success of offshore drilling operations, especially in Mahakam's mature and complex fields (Rachman et al., 2021). Since 2019, mudlogging services

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in Mahakam have been provided through three contracts: one awarded to PTGI and two contract awarded to consortium comprising PTEN, a national company, and PTGN, a global service provider.

During the first consortium period (May 2019–April 2022), the PTEN–PTGN consortium demonstrated strong operational performance. During the first period of the consortium, PTGN took entire leadership over operational matters. This included the preparation of new mudlogging units, the installation process, and oversight all rigs. All field operations were conducted under the direct coordination of a consortium technical coordinator from PTGN. Under two major contracts, the consortium achieved outstanding safety records, with zero Lost Time Incidents (LTIs) and zero Total Recordable Injury Frequency (TRIF) incidents. This period has accumulated over 66,000 operating hours and approximately 217,000 man-hours, with no major safety or operational disruptions reported. The consortium achieved remarkable operational effectiveness, maintaining 100% logging efficiency and 99.97% operational efficiency, with zero missed integrity events and no significant Non-Productive Time (NPT).

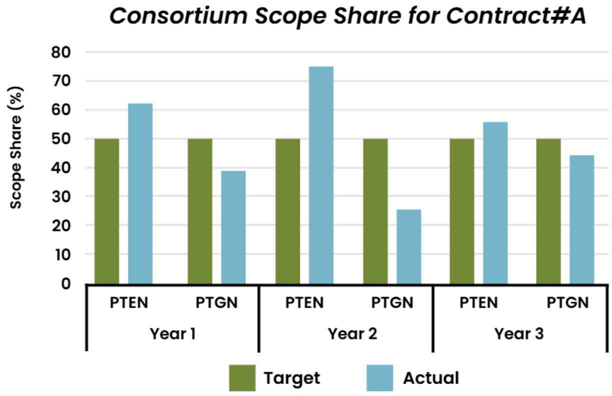

Figure I. Graphic consortium scope share for contract #A

During the first consortium period, the consortium between PTEN and PTGS successfully maintained high service quality while achieving nationalization objectives simultaneously. As outlined in Figure I, during the initial period of contract #A, the consortium successfully executed a structured transfer of knowledge and technology from PTGN to PTEN, which significantly increased local content. PTEN achieved a scope share of 56% to 75%, surpassing the initially planned 50%. PTEN expanded its role beyond initial expectations in terms of scope share.

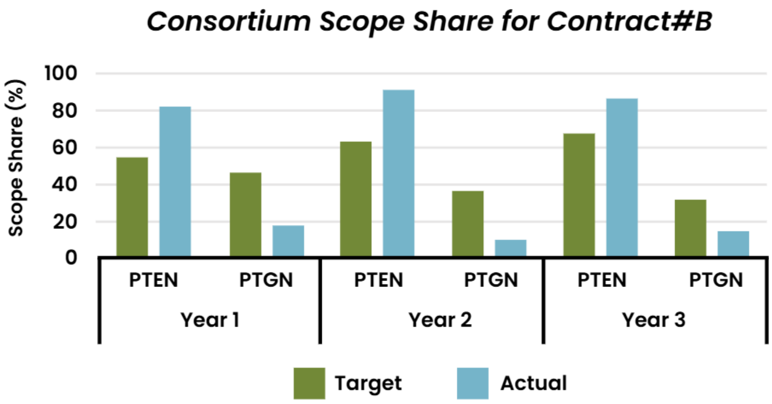

Figure 2. Graphic consortium scope share for contract #B

Similar to Contract #A, Figure 2 illustrates Contract #B in the first consortium period, where the consortium between PTEN and PTG consistently exceeded targets, delivering a scope share of between 81% and 91%. Significant milestones were accomplished under both contracts, demonstrating effective collaboration, which is particularly essential to managing operational complexities. In the initial phase of the consortium contract, the equipment, technology transfer, and personnel handover from PTGN to PTEN were carried out successfully, exceeding the originally agreed-upon scope of the consortium. The transfer of competencies played a vital role in improving operational readiness and boosting PTEN's confidence as a national company, while also effectively positioning the consortium for long-term sustainability (Drilling, 2011).

As part of the milestone in the first contract period of the consortium contract, PTEN acquired ownership of two mudlogging units previously managed by PTGN, for which the responsibility for preparing these units for new mobilizations was fully transferred to PTEN. Despite these achievements in the first period, as mentioned earlier, operational conditions significantly deteriorated in the second consortium period, which commenced in May 2022. During this subsequent period, mudlogging-related lost time increased dramatically from an accumulation of 9.5 hours between 2019 and 2022 to approximately 28 hours between 2022 and 2024. This significant lost time (23.5 hrs) occurred during an operation in the Hydraulic Workover Unit (HWU) drilling rig. This sudden decline in operational performance incurred substantial financial losses of approximately USD 350,000 (IDR 5.6 billion) due to rig standby and non-productive downtime. Mudlogging is critical information for drilling operations; any major equipment failure will lead to a stoppage of operations. Given this condition and the extremely high offshore rig operating costs in Mahakam (around USD 300,000 per day), these operational inefficiencies became a critical concern.

On the other hand, the performance of PTGI, which operated under identical offshore conditions has recorded zero lost time during the same period. This disparity in performance isolated the issue to the PTEN–PTGN consortium, indicating underlying operational and structural challenges unique to the consortium arrangement during the second period. The performance gap has become a crucial concern for PT PHM, as mudlogging inefficiencies threaten operational safety and cost efficiency in one of Indonesia’s most strategically important offshore oil and gas regions. Identifying and addressing the root causes, which are the primary reasons for this sharp decline is crucial. To achieve sustainable improvement, conducting a thorough root cause analysis is essential for regaining efficiency as demonstrated during the first consortium period, maintaining competitive service quality and ensuring the long-term sustainability of offshore drilling operations in the Mahakam Block.

The research identifies a critical gap characterized by increasing Lost Time and declining operational efficiency in mudlogging services managed under the consortium of PTEN and PTGS in shllow water offshore Mahakam drilling operations.

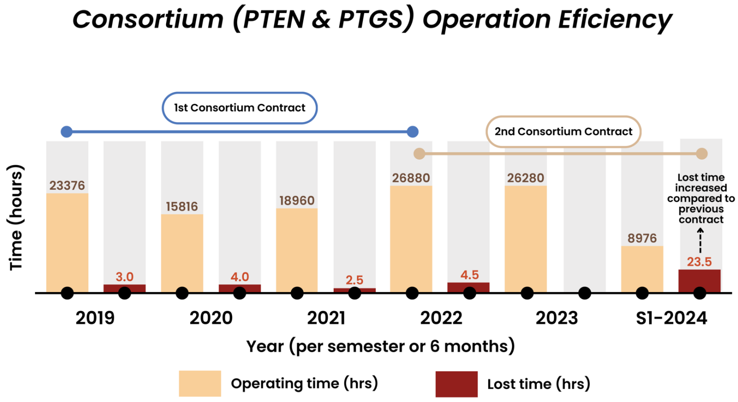

Figure 3. Graphic of (PTEN & PTGS) Consortium Operation Efficiency

Figure 3 illustrates the operational efficiency of the PTEN–PTGS consortium. The first consortium contract, from 2019 to early 2022, demonstrated stable operational performance, with minimal lost-time incidents totaling only 9.5 hours over the three-year period. The operational lost time increased significantly during the second consortium contract period (2022–2024) compared to the first (2019–2022) period.

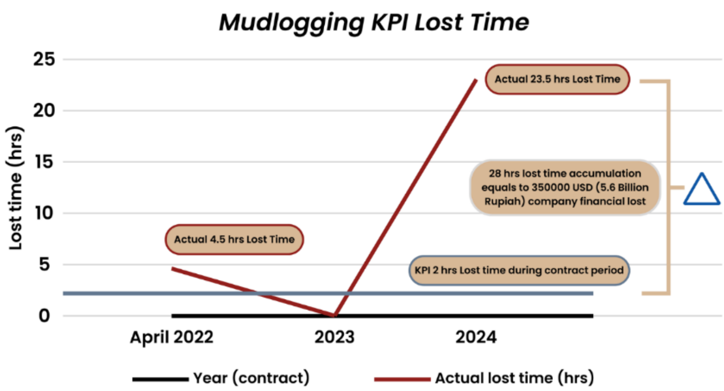

Figure 4. Graphic of Operation Mudlogging KPI Lost Time

Figure 4 illustrates the accumulation of lost time in the second period, which sharply increases to a total of 28 hours. This event is negatively affecting operational performance and profitability. This decline in performance resulted in operational downtime equivalent to USD 350,000 (IDR 5.6 billion) in standby rig costs, highlighting an alarming service quality gap that directly impacts drilling efficiency and project budgets.

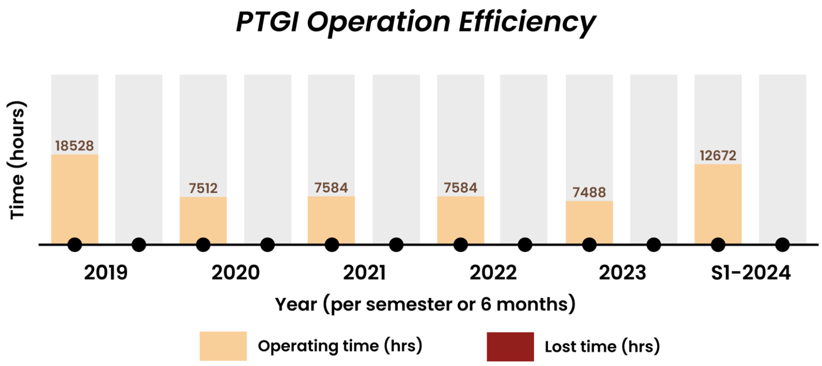

Figure 5. Graphic of PTGI Operation Efficiency

Figure 5 illustrates the operating efficiency of PTGI, a mudlogging company provider in the Mahakam Block, over the same period (2019-2024). Throughout the entire operational period, PTGI demonstrated stable and consistent operational performance, as evidenced by the accumulation of operating hours without any recorded lost-time incidents. The PTGI, a competing mudlogging contractor in the same offshore Mahakam drilling environment recorded zero lost-time incidents during the same period (2019–2024). The consistent achievement of zero lost time illustrates PTGI's capability to maintain high operational reliability despite operating under similar offshore conditions in the Mahakam area. This operational consistency suggests a clear disparity when compared to the PTEN-PTGS consortium. Comparable offshore industry highlights the necessity of robust management practices, operational discipline, and clear communication structures to sustain excellent operation (Chen et al., 2017).

PT PHM operates the Mahakam Block, a mature and technically complex offshore oil and gas field in East Kalimantan. Mudlogging services are critical in such environments, providing real-time geological and drilling information to prevent operational hazards. Studies emphasize that mudlogging is essential for detecting kicks and giving early warnings of drilling hazards, particularly in complex and high-risk offshore environments (Sosa et al., 2016; Zhou et al., 2015). In 2019, to comply with SKK Migas Regulation PTK-007 Revision 5, PTEN formed a consortium with PTGS to deliver mudlogging services for Mahakam offshore operations. According to PTK-007 Rev. 5, in consortium agreements involving Pertamina subsidiaries, the national company (PTEN in this case) must act as the consortium leader when bidding for contracts in the upstream oil and gas sector under the supervision of SKK Migas (Migas, 2019).

This regulation enables the involvement of Indonesian-owned entities in the upstream industry by participating in strategic contracts with local national companies through partnerships or consortium schemes with more technically advanced and internationally recognized service companies. Despite PTGS's strong technical capabilities and Mahakam offshore expertise, PTEN must lead the consortium due to local content requirements specified under PTK-007 guidelines (Migas, 2019). The goal was to combine PTGS's offshore technical expertise with PTEN's national presence. However, despite this strategic alignment, the consortium's performance has deteriorated during the second term of the contract.

Table 1. List of Companies, Stakeholders, and their responsibilities

Company Stakeholder	Role/Responsibility	Expert Interviewed
PT Pertamina Hulu Mahakam (PT PHM)	Contract owner and offshore operator responsible for overseeing drilling operations and contractor performance.	Contract Owner Coordinator Well Operation Senior Operation Geologist Wellsite Geologist Senior Drilling Supervisor Mudlogging coordinator
PTEN (Consortium Leader)	National company leading the consortium as per PTK-007 Rev. 5; responsible for consortium leader	Technical Advisor
PTGS (Consortium Partner)	International service provider contributing offshore mudlogging technical expertise and operational capabilities.	Mudlogging client coordinator
PTGI (Competitor Contractor)	Independent mudlogging service provider operating under a separate contract, serves as a performance benchmark.	Operation Manager

Based on the research's subject, the stakeholder involvement included Pertamina Hulu Mahakam as the contract owner, the consortium members (PTEN and PTGS), drilling operations teams, subsurface departments, and supporting service providers, illustrated in Table 1 Each stakeholder has its role and responsibility in the mudlogging operation and contractual matters. Key personnel and experts contribute to this research through individual interviews and surveys.

This research is crucial for improving operational effectiveness and management practices of the consortium in supporting PT PHM's offshore drilling operations. For the consortium, particularly PTEN as the national consortium leader, such operational inefficiencies directly reduce operational margins and affect client trust. Similar offshore projects emphasize the importance of clear leadership, standardization of operating procedures, and communication between contractor partners to prevent service failures (InEight, 2021; Institute, 2015).

The researcher uses structured analytical tools, which are substantiated by empirical data and pertinent literature, to comprehensively identify, refine, and evaluate the fundamental causes:

- The researcher employs the Fishbone (Ishikawa) Diagram (Serrat, 2017) to organize and illustrate potential causes.
- The researcher applies the Current Reality Tree (CRT) (Goldratt, 1990) to know the interdependencies and causal relationships between identified operational problems. This approach enables stakeholders to recognize and address underlying operational inefficiencies rather than merely addressing superficial symptoms.
- The researcher also uses the Analytic Hierarchy Process (AHP) (Saaty, 1980). This quantitative decision-making method facilitates structured pairwise comparisons of potential solutions, enabling stakeholders to effectively select and implement prioritized improvement initiatives based on clear, data-driven criteria.

Through these combined analytical approaches, the research identifies and prioritizes actionable solutions, providing stakeholders with recommendations to enhance operational performance and improve strategic consortium management. The current research introduces novelty by specifically addressing the governance and human resource challenges within the PTEN-PTGS mudlogging consortium, a gap not deeply explored in prior studies. While existing literature (Mousa & Othman, 2022; Zaid et al., 2020) discusses general human resource and governance issues in oil and gas, this study uniquely applies a mixed-method approach (root cause analysis and AHP) to pinpoint systemic failures in a consortium structure, linking governance clarity and training gaps directly to operational inefficiencies. Unlike broader studies (Chen et al., 2017; Hopkins, 2011), which focus on safety or subcontractor management, this research provides a tailored solution framework—including a proposed governance restructuring and joint training program—validated through stakeholder-weighted AHP prioritization, offering actionable insights for consortium-based service delivery in mature offshore fields like Mahakam.

RESEARCH METHODOLOGY

The research methodology described in this chapter clearly outlines the structured approach employed to investigate and address the specific mudlogging performance issues within the PTEN–PTGS consortium identified in Chapter 1, notably the significant increase in operational downtime (Lost Time) from 9.5 hours in the first consortium period to 28 hours in the second period, resulting in considerable financial losses (~USD 350,000). Recognizing the complexity of these challenges, particularly in terms of human factors, organizational behavior, consortium governance, and equipment and technology, the researcher employed a mixed-methods approach to explore these interconnected issues thoroughly. This chapter evaluates existing methodologies, explaining the rationale behind the selection of qualitative and quantitative methods to gather comprehensive data and systematically analyze the root causes. The chapter further outlines the research design, detailing the strategies employed for data collection and analysis to ensure robust, applicable, and practical recommendations closely aligned with the research objectives and addressing the operational and managerial complexities previously identified.

RESULT AND DISCUSSION

Analysis

This section presents the analysis of the decline in mudlogging service performance, utilizing both qualitative root cause analysis tools and quantitative prioritization methods. The root cause analysis employs the Fishbone Diagram and Current Reality Tree approach to identify the root causes and systemic interdependencies contributing to operational inefficiencies within the PTEN-PTGS mudlogging consortium. The multi-criteria decision-making tool, Analytic Hierarchy Process (AHP), is used to prioritize improvement strategies based on stakeholder input. The findings across these methods are discussed below.

Fishbone Diagram and Current Reality Tree

The Fishbone (Ishikawa) Diagram was constructed to categorize the potential causes of performance decline into key dimensions, thereby pinpointing underlying issues. The findings from the interviews and brainstorming, as presented in Appendix B, are then organized and mapped into categories using a fishbone diagram, as shown in Figure IV.1. Five main cause categories were identified: governance, manpower, methods, equipment, and environment.

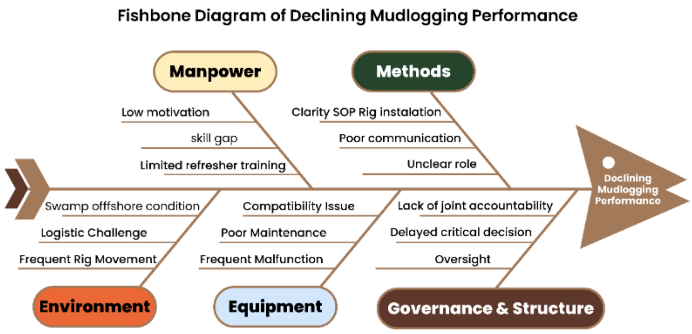

Figure 6. Fishbone Analysis for Declining Mudlogging Performance

The major issues under each category can be summarized as follows:

- Governance and Structure: Compared to the first consortium period, where PTGN led all operational matters and coordinated directly with the rigs, there was a shift in leadership responsibility to PTEN, especially for his own unit, in the second period. A lack of joint accountability, delayed decision-making, and oversight occurred during this period.
- Manpower: Respondents noted skill gaps among PTEN personnel and lower crew motivation due to differences in employment status (contracted vs. permanent). Many PTEN personnel were employed on a contract basis rather than as permanent staff, leading to frequent crew changes and the loss of experienced talent. Issues on insufficient training and refresher programs, as well as limited career development incentives. These human resource issues meant that field staff often lacked the experience or motivation to respond effectively to operational challenges.
- Equipment: Compatibility issues arose when deploying the mudlogging unit on the new Hydraulic Workover Unit (HWU) rigs. The unit ownership has been fully transferred to PTEN. Insufficient technical oversight during the HWU unit mobilizations led to setup mistakes and frequent malfunctions. Even though those equipment problems also affected or interfered with the HWU rig setup, any failure under mudlogging operation compounded by slow response to fixes (due to unclear responsibilities, as noted above) significantly increased Non-Productive Time (NPT)
- Methods: Issues with SOP clarity for new unit installation under consortium. The analysis revealed ineffective communication protocols, leading to poor communication among team members and unclear roles within the consortium's operations. For example, during main equipment failures, field teams were sometimes unclear about escalation paths, i.e., whom to notify first and how to coordinate between PTEN and PTGS teams. This process ambiguity caused confusion and delays in resolving issues on the rig, which impacts operational efficiency.
- Environment: Offshore swamp operations present unique challenges due to their logistical complexities. Rig movement relocation frequently occurs in these operations, bringing additional risk and disruption. While such environmental difficulties affected all contractors, the impact on the consortium was more severe because its internal weaknesses, including governance and training, left it less able to cope with these challenges.

The fishbone analysis identified governance weaknesses and role ambiguity as fundamental issues that amplified other problems, including equipment readiness, crew performance, and communication breakdowns. The need for structured interventions focusing on organizational governance and human resource development was observed in this root cause analysis. This thesis research also uses the current reality tree (CRT) approach to perform root cause analysis. The CRT analysis begins by defining the problems, commonly referred to as undesirable effects (UDEs). The undesirable effects are determined based on data collection, as discussed in the previous chapter.

Figure 7. Current Reality Tree (source: Author, 2025)

Figure 7 shows the current reality tree (CRT), which visually maps the interrelated causes leading to the decline in mudlogging service performance within the PTEN–PTGS consortium at PT PHM. At the root of the problem lies the issue of unclear governance structure, which triggered unclear roles across operational teams. This ambiguity led to poor coordination, delayed decision-making, and inconsistent communication, which collectively contributed to frequent operational errors. Contracted employment status and inadequate refresher training resulted in reduced crew motivation, competency issues, and increased turnover. Ineffective maintenance practices, primarily due to rushed unit preparation under limited oversight, lead to recurring equipment failures. The equipment issues, high crew turnover, and operational errors ultimately led to a significant increase in downtime and non-productive time (NPT), resulting in a decline in mudlogging service performance. This CRT analysis confirms that governance clarity, structured coordination, and consistent crew development are critical areas for performance recovery.

Alternative Business Solutions Proposal

To prioritize the most effective solutions, the researcher employed the Analytic Hierarchy Process (AHP) as a decision-making tool to quantitatively evaluate alternative solutions based on their relevance to resolving the identified issues. As detailed in chapter III, the AHP criteria were derived from both the literature review and empirical findings from the stakeholder interviews. The selected criteria are:

- Criteria 1 (C1): Organizational structure and reporting flow representing the clarity of roles, coordination mechanisms, and decision-making authority within the consortium.
- Criteria 2 (C2): Crew composition – reflecting the staffing model (permanent vs. contracted), field competency, and crew engagement.

- Criteria 3 (C3): Training and competency development addressing the availability, quality, and regularity of training programs for mudlogging personnel.

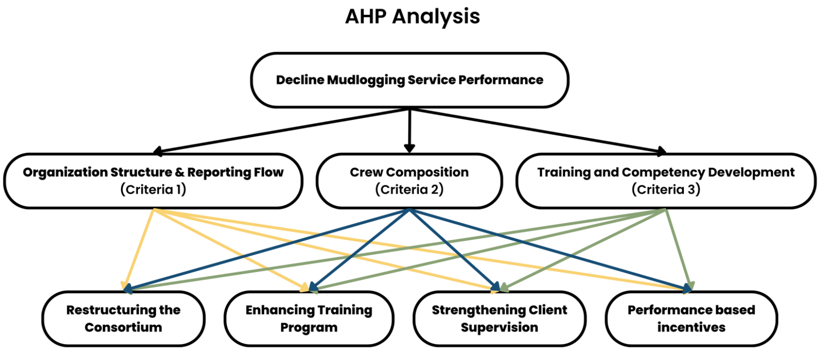

Figure 8. The Decision Hierarchy

The AHP decision hierarchy, as illustrated in Figure 8, outlines a structured and sequential approach for identifying the most suitable alternative solution to address the decline in mudlogging service performance. The AHP provides a structured framework for managing uncertainty and variability in the decision-making process. Assignment of weights and comparison values quantify the level of uncertainty linked to a decision. The main objective of reducing operational inefficiencies is supported by three critical evaluation criteria: organizational structure and reporting flow, crew composition, and training and competency development. Four potential alternative solutions were assessed under the following criteria: restructuring the consortium, enhancing training programs, strengthening client supervision, and implementing performance-based incentives. This structured analysis provides clarity in prioritizing the most effective and impactful solutions based on stakeholder inputs and expert judgment.

Table 2. Scale Value of Pairwise Comparison (Saaty, 1980)

Definiton	Index	Definition	Index
Equally Important	1	Equally Important	1/1
Equally or slightly more important	2	Equally or slightly more important	1/2
Slightly more important	3	Slightly more important	1/3
Slightly to much more important	4	Slightly to much more important	1/4
Much more important	5	Much more important	1/5
Much to far more important	6	Much to far more important	1/6
Far more important	7	Far more important	1/7
Far to extremely more important	8	Far to extremely more important	1/8
Extremely more important	9	Extremely more important	1/9

The provided table (2.1) illustrates Saaty's fundamental scale, used in AHP, to rate the relative importance between pairs of criteria or alternatives. This fundamental scale, developed by Thomas L. Saaty, facilitates the quantification of subjective judgments in complex decision-making scenarios. Ratings range from "equally important" (index value of 1) to "extremely more important" (index value of 9), with intermediate gradations indicating slight, moderate, firm, or very strong differences in importance. Reciprocal values (i.e, 1/3, 1/5, 1/9) reflect the inverse importance when comparing the same factors in reverse order, ensuring consistency in pairwise judgments.

In this thesis, the weights for each criterion in the AHP analysis were determined through a structured pairwise comparison process using Saaty's fundamental scale. Stakeholders involved from well operation coordinator, mudlogging coordinator, senior operation geologist, drilling supervisor, and client coordinators were asked to evaluate the relative importance of each criterion based on their expertise and operational experience. The responses were compiled into a pairwise comparison matrix, which was then normalized by dividing each element by the sum of its corresponding column. The average of each row in the normalized matrix was then calculated to generate the priority vector, which represents the weight or relative importance of each criterion. This process ensured an objective and consistent approach to prioritizing decision factors in improving mudlogging performance.

Table 3. Pairwise Comparison Matrix on Criteria

CRITERIA	C1. Organization Structure & Reporting Line	C2. Crew Comparison	C3. Training & Competency Development	EIGEN VECTOR
C1. Organization Structure & Reporting Line	1.0000	4.0000	4.0000	0.6551
C2. Crew Comparison	0.2500	1.0000	2.0000	0.2114
C3. Training & Competency Development	0.2500	0.5000	1.0000	0.1335
TOTAL	1.5000	5.5000	7.0000	1.0000
Lambda (Max) = 3.0541 ; **CI (consistency index) =** 0.0270 ; **RI (3 Element) =** 0.58 **Consistency ratio (CR) = 0.0456 (CR < 0.1)**				

The result in Table 3 illustrates a pairwise comparison matrix using the Analytic Hierarchy Process (AHP) to prioritize three criteria: organization structure and reporting line (C1), crew comparison (C2), and training and competency development (C3). The values reflect the relative importance, with C1 being the most important (0.6551), followed by C2 (0.2114), and then C3 (0.1335). The "Eigen Vector" column represents the normalized priority weights of each criterion, reflecting their relative importance based on pairwise comparisons. The consistency ratio (CR) of 0.0456, below the 0.1 threshold, confirms that the pairwise judgments are consistent and reliable.

Table 4. Pairwise Comparison Matrix on Sub-Criteria of Organization Structure & Reporting Line

C1. Organization Structure & Reporting Line	A1: Restructuring the Consortium	A2: Enhancing Training Programs	A3:Strengthening Client Supervision	A4: Performance-Based Incentives	EIGEN VECTOR
A1: Restructuring the Consortium	1.0000	5.0000	6.0000	7.0000	0.6411
A2: Enhancing Training Programs	0.2000	1.0000	2.0000	3.0000	0.1800
A3:Strengthening Client Supervision	0.1667	05000	1.0000	2.0000	0.1107
A4: Performance-Based Incentives	0.1429	0.3333	0.5000	1.0000	0.0682
TOTAL	1.5095	6.8333	9.5000	13.0000	1.0000
Lambda (Max) = 4.0771 ; **CI (consistency index) =** 0.0257 ; **RI (4 element) =** 0.90 **Consistency ratio (CR) = 0.0285 (CR < 0.1)**					

The results in Table 4 present the pairwise comparison matrix used to evaluate four sub-criteria under the "Organization Structure & Reporting Line" category. Restructuring the consortium (A1) was by far the top-ranked alternative for addressing governance and reporting issues. It achieved the highest eigenvector priority score of about 0.6411, which was significantly higher than those of the other alternatives. By contrast, enhancing training (A2*)* had a priority of approximately 0.18, while both strengthening client supervision (A3) and performance incentives (A4) were even lower, at approximately 0.11 and 0.068, respectively. This difference indicates a strong consensus that governance restructuring is the most critical solution for addressing the structural problems that have led to unclear reporting and slow decision-making processes. In addition, the consistency ratio for this matrix was CR = 0.0285, which is well below 0.1, lending confidence that different respondents consistently expressed a preference for A1 under this criterion.

Table 5. Pairwise Comparison Matrix on Sub-Criteria Crew Composition

C2. Crew Composition	**A1:** Restructuring the Consortium	**A2:** Enhancing Training Programs	**A3:**Strengthening Client Supervision	**A4:** Performance-Based Incentives	EIGEN VECTOR
A1: Restructuring the Consortium	1.0000	3.0000	3.0000	4.0000	0.4885
A2: Enhancing Training Programs	0.3333	1.0000	4.0000	3.0000	0.2925
A3: Strengthening Client Supervision	0.3333	0.2500	1.0000	1.0000	0.1127
A4: Performance-Based Incentives	0.2500	0.3333	1.0000	1.0000	0.1063
TOTAL	1.9167	4.5833	9.0000	9.0000	1.0000
Lambda (Max) = 4.1775 ; CI (consistency index) = 0.0059; RI (4 element) = 0.90 Consistency ratio (CR) = 0.0657 (CR < 0.1)					

The results in Table 5 present the pairwise comparison matrix used to evaluate the four sub-criteria under C2: crew composition. The AHP analysis reveals that "restructuring the consortium" (A1) retains the highest eigenvector score of 0.4885, indicating that it is perceived as the most effective solution to address crew-related challenges. This is followed by "enhancing training programs" (A2) with a weight of 0.2925, while "strengthening client supervision" (A3) and "performance-based incentives" (A4) received significantly lower weights of 0.1127 and 0.1063, respectively. The dominance of A1 here suggests that stakeholders believe many crew composition issues, such as inconsistent field performance or a lack of experienced personnel, ultimately stem from a **lack of clear structure and leadership**. For example, without a well-defined consortium organization, the consortium struggled to retain and empower its skilled staff, which implies that restructuring could improve crew stability and authority. The CR was 0.0657, indicating acceptable consistency in the judgments. This result reinforces the view that structural reform is a prerequisite for improving crew effectiveness; an organizational fix is necessary so that subsequent measures, such as training or staffing changes, can be effective.

Table 6. Pairwise Comparison Matrix on Sub-Criteria of Training & Competency Development

C3. Training & Competency Development	A1: Restructuring the Consortium	A2: Enhancing Training Programs	A3:Strengthening Client Supervision	A4: Performance-Based Incentives	EIGEN VECTOR
A1: Restructuring the Consortium	1.0000	1.0000	2.0000	4.0000	0.3361
A2: Enhancing Training Programs	1.0000	1.0000	5.0000	5.0000	0.4421
A3:Strengthening Client Supervision	0.5000	0.2000	1.0000	1.0000	0.1157
A4: Performance-Based Incentives	0.2500	0.3333	1.0000	1.0000	0.1061
TOTAL	2.7500	2.5333	9.0000	11.0000	1.000
Lambda (Max) =4.2352 ; CI (consistency index) = 0.0784 ; RI (4 element) = 0.90 Consistency ratio (CR) = 0.0871 (CR < 0.1)					

The results in Table 6 present the pairwise comparison matrix used to evaluate four sub-criteria under C3 training and competency development. The AHP analysis indicates that "enhancing training programs" (A2) emerged as the top alternative with a priority score of about **0.4421**. Here, *restructuring the consortium (A1)* was the second priority **(0.3361).** This suggests that when considering solutions specifically for competency gaps, stakeholders view training as the most direct remedy, although they still assign substantial importance to structural improvements in this area. *Strengthening client supervision (A3)* and *performance incentives (A4)* again lagged with similar low weights (0.1157 and 0.1061), suggesting that these are viewed as supplementary measures. The consistency ratio for this matrix was **0.0871**, which is below the 0.1 threshold and is therefore acceptable. Thus, under C3, the consensus was that **investing in training and development is critical to address the skill and knowledge deficiencies** that contributed to the mudlogging failures, with governance changes still playing a supporting role.

Table 7. Priority Ranking of the Alternative Solution

	C1. Organisation Structure & Reporting Flow	C2: Crew Composition	C3: Training & Competency Development
A1: Restructuring the Consortium	0,6411	0,4885	0,3361
A2: Enhancing Training Programs	0,1800	0,2925	0,4421
A3:Strengthening Client Supervision	0,1107	0,1127	0,1157
A4: Performance-Based Incentives	0,0682	0,1063	0,1061
Matrix = (4 x 3)			

	Criteria
C1. Organization Structure & Reporting Line	0,6411
C2. Crew Comparison	0,1800
C3. Training & Competency Development	0,1107
Matrix = (3 x 1)	

A1: Restructuring the Consortium	(0.6411 x 0.6551) + (0.4885 x 0.2114) + (0.3361 x 0.1335)	0.5681
A2: Enhancing Training Programs	(0.1800 x 0.6551) + (0.2925 x 0.2114) + (0.4421 x 0.1335)	0.2388
A3:Strengthening Client Supervision	(0.1107 x 0.6551) + (0.1127x 0.2114) + (0.1157 x 0.1335)	0.1118
A4: Performance-Based Incentives	(0.0682 x 0.6551) + (0.1063 x 0.2114) + (0.1061 x 0.1335)	0.0814

Alternative Solution		Rank
A1: Restructuring the Consortium	56.81%	1
A2: Enhancing Training Programs	23.88%	2
A3:Strengthening Client Supervision	11.18%	3
A4: Performance-Based Incentives	8.14%	4

In the final step of the AHP, the local priorities were synthesized with the criteria weights to produce a **global priority score** for each alternative. This overall ranking is presented in **Table IV.6.** The synthesis confirmed that **"restructuring the consortium" (A1) is the most preferred solution**, with the highest overall score of **0.5681.** This means that, considering all criteria, A1 accounts for approximately 56.8% of the decision weighting, significantly surpassing any alternative solution. The second-ranked solution is **"enhancing training programs" (A2)** with a global priority of **0.2388.** Together, these two options — governance restructuring and training enhancement — dominate the priority ranking, reflecting the research's finding that improving organizational structure and human capital are key to performance improvement. The remaining alternatives were less favored: "strengthening client supervision" (A3) scored 0.1118, and "performance-based incentives" (A4) scored **0.0814.** These lower scores suggest that while additional client oversight or incentive schemes may provide support, stakeholders do not view them as primary solutions to the core problems. The overall consistency of the AHP was verified, as the pairwise comparisons all had CR values less than 0.1, as noted, lending credibility to these results and strategies.

Summary of key findings

The analysis revealed several key findings regarding the decline in mudlogging performance within the PTEN–PTGS consortium.

1. The consortium's performance during the initial contract period (2019–2022) was notably successful due to transparent governance, strong operational leadership by PTGN, and well-established coordination pathways.
2. A sharp decline in performance during the second consortium period (2022–2024) was attributed to the complete transfer of operational responsibility to PTEN for mudlogging units that PTEN wholly owned. This transition was not accompanied by adequate technical support or oversight from PTGS, particularly during the mobilization and installation of the units on the newly deployed Hydraulic Workover (HWU) rig.
3. The primary root causes contributing to the decline were identified as governance gaps and unclear role definitions.
4. The results of the Analytic Hierarchy Process (AHP) quantitatively confirmed that the top priorities for improvement are restructuring the governance model and enhancing training and competency development. Finally, strong stakeholder alignment and consistent data validation throughout the research process confirmed the reliability and credibility of the findings.

Business Solution

Based on the above analysis, the business solutions focus on addressing the primary root causes: the weaknesses in the governance structure and the gaps in crew competency. By directly tackling these areas, the consortium can resolve the systemic issues that led to poor performance. Two major improvement initiatives are proposed, corresponding to the top-ranked AHP alternatives, along with an organizational realignment to support them:

The priority solution identified through the AHP analysis is the restructuring of the consortium's governance and operational model. Unclear authority lines and fragmented coordination were revealed in the Fishbone and CRT analyses. Key actions include establishing a new reporting hierarchy and streamlining communication flows between PTEN and PTGS, particularly during critical phases such as unit mobilization, installation, and operations on complex rigs like the Hydraulic Workover Unit (HWU). To strengthen accountability and performance, the consortium is advised to appoint a permanent consortium client and quality manager (from PTGS) as the single point of contact for PT PHM, responsible for overseeing service quality. In parallel, a field operations & equipment coordinator (from PTEN) should be designated to supervise daily rig-site activities and interface with drilling teams. These dual leadership roles, filled by experienced personnel, will help unify decision-making and enhance field responsiveness.

The second solution is to improve human factors through training and competency development for mudlogging personnel. The analysis identified gaps in crew competencies, irregular training practices, and elevated turnover rates, all of which contribute to operational inefficiencies. To address this, a joint training program is proposed between PTEN and PTGS, leveraging PTGS's global expertise and PTEN's understanding of local operational needs. Additionally, Mousa and Othman (2022) emphasize that sustainable training and reward systems have a positive influence on employees' sustainable behavior, thereby reinforcing the organization's commitment to sustainability and risk reduction.

The program will introduce structured onboarding for new staff and regular refresher training for existing crew, with modules tailored to the specific demands of the Mahakam offshore environment, including HWU operations, mature field operations, and emergency procedures. Competency assessments and certifications are essential for personnel in key roles, such as mud loggers and data engineers, to demonstrate technical proficiency through standardized evaluations.

Finally, researchers propose a revised consortium organization and communication structure, as illustrated in Figures IV.4 and IV.5. This new structure is designed to address the governance and communication breakdowns experienced during the second consortium period.

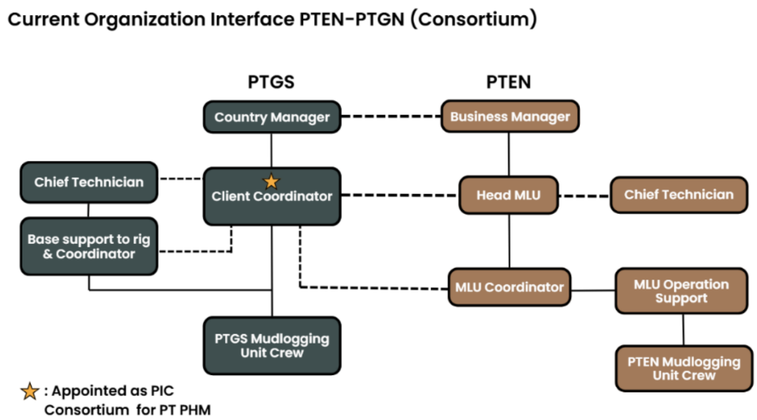

Figure 9. Current Communication Line for Consortium

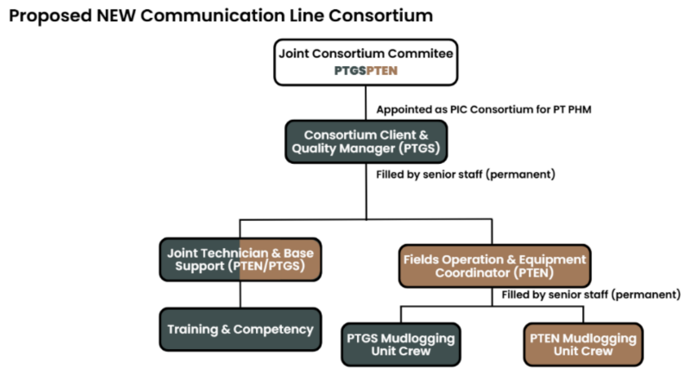

Figure 10. Proposed New Communication Line for Consortium

As illustrated in Figure IV.5, the proposed model emphasizes a joint governance approach while clearly delineating technical and operational responsibilities. A joint consortium committee (PTEN–PTGS) remains at the top, with a designated consortium client & quality manager (PTGS) appointed as the official point of contact (PIC) for PT PHM. To have better consistency and accountability, it is recommended that permanent senior staff fill this position. Under this manager, operational responsibilities are divided into two primary streams:

1. Joint PTGS & PTEN technician and base Support: responsible for equipment readiness, technical troubleshooting, and rig preparation.
2. Field Operation & Equipment Coordinator (PTEN): Overseeing daily rig operations and coordinating with rig site personnel. This position is also proposed to be staffed by permanent senior personnel to ensure authority and consistency. Both units feed into field-level functions: the PTGS mudlogging unit crew and the PTEN mudlogging unit crew. In parallel, a training and competency function is embedded under the technical line to ensure ongoing development and support for all personnel in the consortium, regardless of which company they are employed by.

This revised structure brings clarity to lines of communication, establishes senior points of responsibility, and rebalances technical oversight among consortium members. The clear delegation of responsibilities will reduce ambiguity, accelerate decision-making, and enhance operational reliability (Bell & Bodie, 2012). Additionally, the joint structure of PTEN and PTGS contributes to and shares accountability in delivering high-quality mudlogging services. The business solution proposed in this research demands a strong structural alignment and continuous capability development within the PTEN–PTGS consortium. These improvements are aligned with the expectation of resolving the inefficiencies currently affecting mudlogging performance and ensuring long-term service reliability for PT PHM's offshore operations.

The proposed business solutions address governance issues and crew competency gaps, resulting in increased downtime and financial losses during the second consortium period. Implementing a structured governance model, clear communication channels, robust accountability mechanisms, and systematic training is an effective way to replicate the conditions of the successful first consortium period (2019-2022), characterized by zero significant downtime and high operational efficiency. PHM and the consortium can implement stringent, consistent monitoring and adaptive management that could reduce non-productive time and associated financial losses. However, considering the complexities of offshore environments, unforeseen equipment failures, and logistical challenges, achieving 100% success might be overly optimistic. Achieving 85-90% is realistic, which is approximately equivalent to reducing financial loss by up to $315,000 due to lost time. Given historical performance data, where effective governance and well-trained personnel achieved nearly 100% operational efficiency, it is reasonable to anticipate an improvement of approximately 85–90%.

CONCLUSION

This research identified the decline in consortium performance as primarily caused by weak governance (lack of clear structure and accountability) and insufficient workforce training, rather than external factors. Using AHP analysis, the study prioritized two key solutions: (1) restructuring governance to clarify roles and decision-making, and (2) implementing training and competency programs to enhance technical skills and retention. Successful implementation is expected to improve operational efficiency, reduce incidents, and restore client trust in PTEN-PTGS's mudlogging services. For future research, the study suggests exploring digital transformation's role in optimizing governance and workforce performance—such as AI-driven training, IoT-based monitoring, and blockchain-enabled transparency—by comparing digitally advanced oil & gas consortia with traditional models to measure efficiency gains.

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