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An Agile Execution Framework for Managing Multidisciplinary Offshore Engineering Projects in High-Risk Environments

Andrew Tochukwu Ofoedu[1], Joshua Emeka Ozor[2], Oludayo Sofoluwe[3], Dazok Donald Jambol[4]
[1]Shell Nigeria Exploration and Production Company, Nigeria
[2]First Hydrocarbon, Nigeria
[3]TotalEnergies Nigeria
[4]D-Well Engineering Nig. Ltd. (Shell Petroleum Development Company of Nigeria), Nigeria
Corresponding Author: andrewofoedu@yahoo.com

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Abstract : Offshore engineering projects are inherently complex and high-stakes, involving multidisciplinary coordination, remote operations, and dynamic risk factors such as harsh weather, environmental regulations, and logistical constraints. Traditional project management methodologies often linear, rigid, and documentation-heavy struggle to accommodate the agility needed to respond to rapid changes and uncertainties that characterize offshore environments. This presents a conceptual Agile Execution Framework tailored specifically for managing multidisciplinary offshore engineering projects in high-risk settings. Drawing on core agile principles such as iterative planning, cross-functional collaboration, and continuous feedback, the framework adapts agile methodologies primarily Scrum and Kanban to the unique constraints of offshore operations. The model integrates agile roles and responsibilities with safety governance structures and risk-based prioritization to enable adaptive execution without compromising regulatory or operational integrity. It supports dynamic backlog management, incremental deliverables, and synchronized communication protocols across engineering, procurement, construction, and installation (EPCI) disciplines. Implementation strategies emphasize phased adoption, stakeholder alignment, and integration with traditional project management systems such as Primavera and SAP. A hypothetical case study demonstrates how the framework can enhance schedule adherence, improve safety outcomes, and reduce coordination delays in a multidisciplinary subsea infrastructure deployment. Key benefits of the proposed framework include increased responsiveness to environmental and operational changes, enhanced team alignment, and reduced downtime through early issue detection and mitigation. Performance metrics such as cycle time, team velocity, change request turnaround, and incident rates offer quantifiable indicators of success. The study concludes by outlining future directions, including integration with digital twins, AI-driven risk modeling, and the development of industry-specific agile standards. By fostering a culture of adaptability and continuous improvement, the Agile Execution Framework offers a resilient approach to delivering complex offshore engineering projects efficiently and safely in volatile and high-risk environments.

Keywords: Agile execution, Framework, Managing multidisciplinary, Offshore engineering projects, High-risk environments

1.0 Introduction

Offshore engineering projects, such as those involving oil and gas platforms, floating production systems, subsea installations, and renewable energy infrastructure, are among the most complex undertakings in modern industrial practice (ADIKWU *et al.*, 2023; Nwulu *et al.*, 2023). These projects span multiple engineering disciplines mechanical, electrical, structural, and marine requiring precise coordination among geographically dispersed teams and stakeholders (Okolo *et al.*, 2023; Nwulu *et al.*, 2023). Additionally, they are executed in some of the most hostile environments on Earth, subject to harsh weather, corrosive conditions, remote accessibility, and strict environmental and safety regulations. The stakes are high: delays, equipment failures, or miscommunication can lead not only to significant financial loss but also to safety hazards and environmental disasters (Elete *et al.*, 2023; Nwulu *et al.*, 2023).

The operational context of offshore projects adds layers of risk and uncertainty that are difficult to accommodate within conventional project management methodologies (Elete *et al.*, 2023; Ogunwole *et al.*, 2023). Traditional approaches, such as waterfall or stage-gate models, rely on rigid planning sequences and predefined deliverables. While effective in predictable settings, these methods lack the flexibility to respond dynamically to emergent challenges such as supply chain disruptions, sudden regulatory changes, or unforeseen subsurface conditions (Ogunwole *et al.*, 2023; Ojika *et al.*, 2023). Furthermore, the complexity of integrating multiple engineering domains each with its own deliverables, timelines, and dependencies often results in coordination delays, misaligned priorities, and costly rework (Ogunwole *et al.*, 2023; Egbuhuzor *et al.*, 2023).

In this context, agile principles offer a compelling alternative. Originally developed for software development, agile methodologies emphasize flexibility, iterative progress, stakeholder engagement, and continuous improvement (Okolo *et al.*, 2023; Elete *et al.*, 2023). When appropriately adapted, these principles can enhance responsiveness, communication, and risk management in engineering contexts. Agile execution frameworks encourage rapid feedback loops, adaptive planning, and incremental delivery qualities that are particularly valuable in offshore settings, where conditions change rapidly and the cost of error is high (Nwulu *et al.*, 2023; Oyeyipo *et al.*, 2023).

The rationale for adopting agile principles in offshore engineering is therefore grounded in the need for a more adaptive, collaborative, and resilient execution model. Agile frameworks can help overcome the limitations of conventional models by enabling better cross-functional coordination, more frequent reassessment of priorities, and improved integration of stakeholder input across project phases.

The objective of this study is to propose a tailored Agile Execution Framework designed specifically for multidisciplinary offshore engineering projects operating in high-risk environments. The framework aims to facilitate iterative planning, cross-functional collaboration, and real-time decision-making while ensuring compliance with regulatory and safety standards. It integrates agile roles and artifacts with engineering-specific requirements and project management tools to create a hybrid model suitable for the offshore industry.

By embedding agile principles into the core of project execution, the proposed framework seeks to improve delivery efficiency, enhance safety and environmental performance, and build resilience against operational uncertainties. It is not intended to replace existing engineering standards and processes, but rather to augment them with a more flexible and collaborative approach. This integration is critical for enabling offshore project teams to navigate complexity, manage risk proactively, and deliver value consistently in challenging and dynamic environments (Okolo *et al.*, 2023; Kokogho *et al.*, 2023).

2.0 METHODOLOGY

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was employed to systematically identify, screen, and synthesize relevant literature to inform the development of the proposed Agile Execution Framework for managing multidisciplinary offshore engineering projects in high-risk environments. A comprehensive literature search was conducted using academic databases including Scopus, IEEE Xplore, ScienceDirect, and Web of Science. Keywords and Boolean combinations such as “agile project management,” “offshore engineering,” “high-risk project environments,” “multidisciplinary project coordination,” and “agile in engineering” were utilized to capture a broad yet relevant range of peer-reviewed articles, conference proceedings, and industry reports.

The initial search yielded 1,278 records. After removing duplicates and non-English publications, 978 articles remained for title and abstract screening. Based on relevance to the research topic specifically the applicability of agile methodologies in high-risk, complex engineering environments 642 studies were excluded. The remaining 336 full-text articles were assessed for eligibility using predefined inclusion criteria: (i) relevance to offshore or high-risk engineering environments, (ii) discussion of agile or adaptive project management practices, and (iii) empirical, theoretical, or case-based contributions. Studies focused solely on software development or unrelated industrial sectors were excluded.

A total of 84 articles were included in the final synthesis. These were analyzed qualitatively to extract common themes, implementation strategies, success factors, and limitations of agile methodologies in engineering contexts. Additional grey literature from industry reports, guidelines from organizations such as the Project Management Institute (PMI), and offshore project documentation were used to contextualize findings and support the conceptual development of the framework.

This systematic review provided the foundational insights necessary for constructing a hybrid agile execution framework adapted to the needs of multidisciplinary offshore engineering projects, ensuring methodological rigor and relevance to both academic inquiry and industrial practice.

2.1 Background and Context

Offshore engineering projects are among the most intricate and capital-intensive endeavors in modern industrial sectors. These projects, which encompass the design, construction, and operation of structures such as oil and gas platforms, subsea pipelines, floating production storage and offloading (FPSO) systems, and offshore wind installations, are marked by a range of challenging characteristics (Ojika *et al.*, 2023; Uzozie *et al.*, 2023). Typically located far from shore, these installations must withstand extreme environmental conditions, including high winds, corrosive seawater, temperature fluctuations, and wave forces. The need to operate reliably under such circumstances necessitates advanced engineering, meticulous planning, and strict compliance with a host of international and regional regulations governing safety, environmental protection, and structural integrity.

One defining feature of offshore projects is their logistical complexity. Project components are often fabricated in different countries, transported across long distances, and assembled on-site using specialized vessels and equipment. This fragmented execution chain, combined with the involvement of multidisciplinary teams including structural, electrical, mechanical, marine, and geotechnical engineers creates an environment in which coordination is not only difficult but also critical to success (Adesemoye *et al.*, 2023; Onukwulu *et al.*, 2023). Delays, miscommunications, or failures in one part of the process can lead to cascading issues across the entire project lifecycle.

Traditionally, project execution in offshore engineering has relied on linear and phase-gated approaches such as the waterfall and stage-gate models. These methods divide projects into sequential phases design, procurement, construction, commissioning each with defined deliverables and review gates. While these approaches provide structure, traceability, and compliance with regulatory requirements, they often struggle to accommodate the dynamic and uncertain nature of offshore environments (Awe *et al.*, 2017; Akpan *et al.*, 2017). Changes late in the project lifecycle, such as supply chain disruptions, equipment failures, or regulatory updates, can be difficult to integrate without significant rework and delays.

Furthermore, the linearity of traditional methods restricts the capacity for adaptive decision-making. In many offshore projects, new insights and field data emerge continuously during execution. However, conventional models lack the flexibility to integrate these changes in real-time, leading to static plans that quickly become outdated. The reliance on up-front, exhaustive planning also increases vulnerability to risk, especially in contexts where many variables cannot be accurately predicted at the outset (Fiemotongha *et al.*, 2023; Onukwulu *et al.*, 2023).

Another significant limitation of traditional methods in offshore contexts is the constrained feedback loop between teams. Because responsibilities are often siloed by discipline and phase, communication breakdowns can occur between design and implementation teams, or between operations and engineering (Ogunwole *et al.*, 2022; Ojika *et al.*, 2022). This hinders the timely identification and resolution of problems, contributing to inefficiencies and elevated risk exposure.

In response to these challenges, there is growing interest in exploring more adaptive and collaborative project management methodologies. Agile methods, which prioritize iterative development, stakeholder collaboration, and responsiveness to change, offer a promising alternative. Originally developed in the context of software engineering, agile frameworks have been increasingly adapted for use in complex hardware and infrastructure projects (Ozobu *et al.*, 2023; Ogunnowo *et al.*, 2023). Their emphasis on short planning cycles, cross-functional teamwork, and continuous improvement aligns well with the realities of offshore engineering, where flexibility, communication, and real-time responsiveness are crucial.

However, the transition from traditional to agile approaches in offshore environments is not without challenges. The need for regulatory compliance, documentation, and formal risk management necessitates a tailored hybrid approach that blends the strengths of both agile and traditional models. Recognizing this, the development of an agile execution framework customized for multidisciplinary offshore engineering projects in high-risk environments is essential. Such a framework must address the logistical, environmental, and organizational complexities inherent in offshore operations while offering the adaptability and resilience needed to thrive in an increasingly uncertain world (Ojika *et al.*, 2023; Uzozie *et al.*, 2023).

2.2 Agile Principles in Engineering Context

Agile philosophy, initially developed in the context of software development, has increasingly found relevance across a broad range of disciplines, including engineering and infrastructure projects. At its core, agile emphasizes flexibility, cross-functional collaboration, iterative delivery, and responsiveness to change. These principles are embodied in the Agile Manifesto, which values individuals and interactions over processes and tools, working solutions over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan (Ojika *et al.*, 2022; Uzozie *et al.*, 2022). In engineering contexts particularly large-scale, multidisciplinary projects such as those in offshore environments these values hold transformative potential when appropriately adapted to sector-specific requirements (Komi *et al.*, 2023; Uzozie *et al.*, 2023).

In contrast to the relatively abstract and code-centric nature of software projects, engineering projects involve physical assets, strict compliance standards, extensive documentation, and substantial capital investment. Therefore, the direct application of agile methods to engineering projects is neither practical nor sufficient. Instead, a tailored adaptation is required, one that maintains the core agile philosophy while integrating the structured planning, risk management, and regulatory compliance necessary in engineering domains (Omisola *et al.*, 2020; ADEWOYIN *et al.*, 2020). This has given rise to hybrid project management models, combining agile's flexibility with traditional frameworks such as waterfall or stage-gate approaches.

One of the central adaptations in engineering involves the concept of iterative delivery. While software iterations can often be deployed weekly or even daily, engineering tasks may require longer cycles due to physical manufacturing, procurement lead times, or environmental dependencies (Uzozie *et al.*, 2023; Omisola *et al.*, 2023). Nevertheless, agile-inspired iterations such as incremental design reviews, modular component testing, and phased commissioning can still provide valuable feedback loops, improving responsiveness and reducing costly rework. Frequent stakeholder engagement and interdisciplinary collaboration, another agile hallmark, are particularly critical in engineering projects where design decisions impact multiple domains and project phases simultaneously.

Several agile methodologies offer structured frameworks to support the implementation of these principles in engineering projects. Scrum, perhaps the most widely known, emphasizes short work cycles (sprints), clearly defined roles (Product Owner, Scrum Master, and Development Team), and regular cadence meetings (daily stand-ups, sprint reviews, and retrospectives). While Scrum is often considered too rigid for engineering environments with longer cycle times, elements such as sprint planning and retrospectives can still be employed to structure design and integration phases (Uzozie *et al.*, 2022; Onaghinor *et al.*, 2022).

Kanban offers a more flexible, flow-based approach, focusing on visualizing work, limiting work-in-progress (WIP), and managing flow efficiency. This method is particularly well-suited to the engineering context where tasks may not conform to time-boxed sprints but still benefit from visual management and continuous delivery (Shiyanbola *et al.*, 2023; Omisola *et al.*, 2023). Kanban boards can be used to coordinate cross-disciplinary workflows, monitor interdependencies, and highlight bottlenecks across complex engineering teams.

Scaled Agile Framework (SAFe) and other enterprise-level agile frameworks such as Large-Scale Scrum (LeSS) and Disciplined Agile Delivery (DAD) are specifically designed for large, multi-team environments. SAFe integrates agile, lean, and DevOps principles to align business strategy with technical execution, making it especially relevant for offshore engineering projects involving multiple contractors, regulatory oversight, and global coordination. SAFe introduces structured roles and processes that facilitate agile implementation at scale while maintaining traceability and compliance key requirements in engineering-intensive sectors (Esan *et al.*, 2022; Adedokun *et al.*, 2022).

The relevance of agile principles and methodologies in offshore engineering lies in their ability to enable adaptive planning, foster early and continuous stakeholder involvement, and support integrated decision-making across disciplines. By enabling shorter feedback cycles, transparent workflows, and collaborative cultures, agile approaches can improve schedule reliability, cost control, and risk mitigation.

While engineering and software development differ significantly in execution constraints and deliverables, the core principles of agile flexibility, iterative improvement, and collaborative problem-solving offer substantial value when adapted appropriately. As offshore engineering projects grow in complexity and uncertainty, the strategic adoption of agile methodologies provides a pathway to more resilient, efficient, and innovative project delivery (Esan *et al.*, 2023; Chianumba *et al.*, 2023).

2.3 Proposed Agile Execution Framework

The proposed Agile Execution Framework for managing multidisciplinary offshore engineering projects in high-risk environments is designed to address the inherent complexity, uncertainty, and regulatory constraints of such projects while leveraging the flexibility and responsiveness of agile principles. Unlike traditional linear project models, this framework emphasizes iterative development, adaptive planning, and continuous feedback to ensure that engineering solutions evolve in alignment with shifting conditions, stakeholder inputs, and emerging risks (Okolo *et al.*, 2023; ADIKWU *et al.*, 2023).

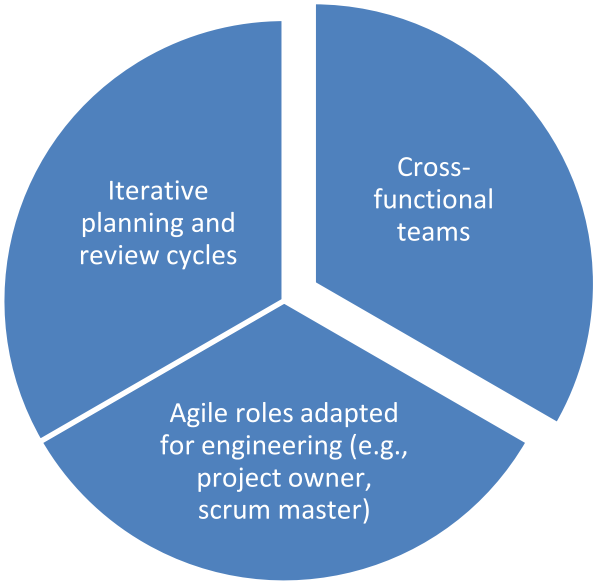

Figure 1: Core structure and components

At the core of the framework is a cyclical structure centered around iterative planning and review cycles as shown in figure 1. These cycles often called "sprints" in conventional agile are adapted to suit the longer lead times and physical constraints of engineering work. Each iteration begins with sprint planning sessions involving all relevant stakeholders, during which prioritized tasks from the project backlog are selected based on their value, urgency, and risk profile. The cycle concludes with review meetings and retrospectives that evaluate progress, identify bottlenecks, and adjust priorities for the next iteration (Komi *et al.*, 2022). These short feedback loops promote agility while maintaining alignment with long-term project milestones and compliance requirements.

A foundational element of the framework is the establishment of cross-functional teams. Offshore engineering projects typically involve multiple disciplines such as structural, mechanical, electrical, instrumentation, and safety engineering. The agile framework brings these experts together in integrated teams that operate with a high degree of autonomy and accountability. Cross-functional collaboration accelerates decision-making, reduces communication silos, and enables early identification of interdependencies or design conflicts that could jeopardize project integrity.

Agile roles are adapted to fit the context of engineering execution. The "Project Owner" assumes responsibility for translating stakeholder and regulatory requirements into prioritized technical objectives. This role ensures that all design and execution activities remain aligned with overarching project goals and constraints. The "Scrum Master" or "Agile Facilitator" supports the team by removing obstacles, fostering a collaborative environment, and ensuring adherence to agile processes. Engineering teams function as "development units" responsible for delivering tangible outcomes whether designs, simulations, prototypes, or installation packages within each sprint (Onyeke *et al.*, 2023; Ozobu *et al.*, 2023).

Governance and oversight are critical in high-risk offshore settings, where safety, environmental stewardship, and compliance cannot be compromised. The framework incorporates structured checkpoints, compliance gates, and audit trails to satisfy regulatory and quality assurance needs. Governance boards composed of technical leads, safety officers, and regulatory liaisons conduct periodic reviews of sprint outputs to verify that deliverables me*et al*l required standards. Documentation remains a vital aspect, but it is generated incrementally and contextually, rather than as a burdensome up-front deliverable.

Risk-based prioritization is central to backlog management within this framework. The project backlog is a dynamic repository of tasks, issues, design elements, and operational challenges. Items are continually assessed and ranked based on technical complexity, risk exposure, value contribution, and readiness for execution. This ensures that the most critical work receives timely attention while also allowing teams to pivot in response to new information or emergent issues. Risk modeling tools and probabilistic simulations can support this prioritization process, enhancing transparency and decision-making rigor.

Additionally, the framework supports scalability through modular deployment. Large offshore projects can be decomposed into “Agile Work Packages” aligned with system boundaries or functional areas. Each package follows the same iterative cycle and governance principles but can operate semi-independently, enabling parallel progress and risk containment (Akintobi *et al.*, 2023; Onyeke *et al.*, 2023). Synchronization across packages is achieved through coordination meetings and shared sprint milestones.

The proposed Agile Execution Framework introduces a structured yet adaptive approach to managing complex offshore engineering projects. By integrating iterative cycles, cross-functional teams, tailored agile roles, and risk-based backlog management, it enhances responsiveness, collaboration, and resilience. Crucially, the framework embeds governance mechanisms that uphold safety and compliance standards, making it a viable methodology for high-stakes, multidisciplinary offshore environments.

2.4 Implementation Strategy

Implementing an Agile Execution Framework in multidisciplinary offshore engineering projects requires a carefully structured strategy that addresses both technical and organizational complexities as shown in figure 2. Offshore environments present unique challenges such as remote locations, regulatory compliance, multi-vendor coordination, and stringent safety standards. Therefore, the transition to an agile model must be deliberate, supported by a phased adoption roadmap, comprehensive training, technological integration, and robust communication protocols suited for marine and remote operations (Onukwulu *et al.*, 2023; Onyeke *et al.*, 2023).

The first component of the implementation strategy is a phased adoption roadmap, which allows for incremental transformation rather than a disruptive overhaul. The roadmap typically begins with a pilot phase, selecting a single subsystem or work package (e.g., topside equipment design or subsea installation planning) where agile principles can be trialed with minimal risk. During this phase, sprint cycles, backlog grooming, and agile roles are introduced in parallel with traditional project structures. Lessons learned are documented and used to refine the approach.

Following the pilot, the second phase extends agile practices to multiple teams and disciplines. A scaling strategy such as the Scaled Agile Framework (SAFe) may be employed to coordinate across these parallel workstreams. The final phase involves enterprise-wide adoption, with organizational policies and governance mechanisms updated to reflect agile-compatible workflows, documentation, and reporting.

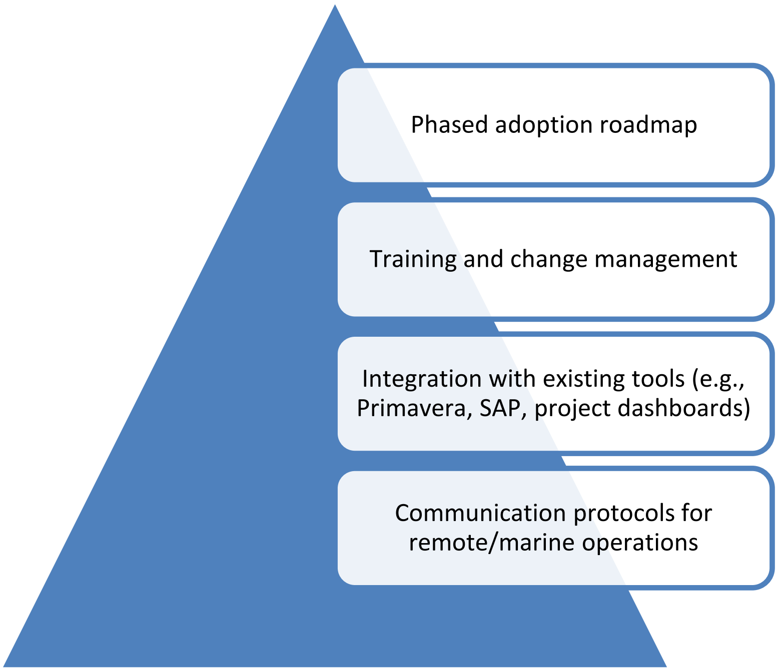

Figure 2: Implementation Strategy

Training and change management are central to ensuring successful adoption. Agile transformation requires a shift not only in processes but also in mindset. Traditional engineering cultures, often accustomed to hierarchical decision-making and detailed upfront planning, may resist the iterative and collaborative nature of agile. Structured training programs tailored for engineering professionals should include foundational agile concepts, role-specific responsibilities, and practical tools for backlog management, sprint planning, and retrospective analysis (Osimobi *et al.*, 2023; Onukwulu *et al.*, 2023). Executive sponsors, team leads, and functional managers must also be engaged as change agents to champion the initiative and model desired behaviors.

In parallel, integration with existing project management and enterprise tools is essential to minimize operational friction. Many offshore projects already utilize established platforms such as Primavera P6 for scheduling, SAP for resource and procurement management, and specialized engineering dashboards for performance monitoring. Agile-compatible plug-ins or middleware solutions can bridge these platforms with agile tools like Jira or Azure DevOps. For example, sprint milestones and task completions can be synchronized with Primavera's Gantt-based timelines, ensuring alignment between agile teams and stakeholders reliant on traditional project controls. Similarly, SAP integration allows procurement and logistics teams to respond to dynamic changes in work packages without jeopardizing supply chain integrity (Nwulu *et al.*, 2022; Awe *et al.*, 2023).

A significant enabler of agile execution in offshore settings is the establishment of communication protocols suited for remote and marine operations. Connectivity in offshore environments is often limited by bandwidth, latency, and redundancy constraints. Therefore, communication tools and protocols must be optimized for low-bandwidth conditions and asynchronous collaboration. Cloud-based platforms with offline syncing capabilities (e.g., Microsoft Teams, Confluence, or Notion) can be deployed for sprint planning, documentation sharing, and real-time status updates. Daily stand-up meetings can be replaced or supplemented with time-staggered check-ins and automated reporting dashboards. Additionally, protocols should account for the rotational workforce and time-zone differences between offshore platforms, engineering hubs, and vendor locations.

To further ensure success, the implementation strategy should include mechanisms for continuous improvement. Regular retrospectives not only assess the performance of agile practices but also gather feedback from engineering teams about practical challenges in applying agile principles to real-world constraints such as fabrication timelines or marine weather windows. These insights can then be used to adapt the framework and support tools, creating a learning-oriented culture that evolves in tandem with operational demands.

Implementing an Agile Execution Framework in offshore engineering projects demands more than process modification it requires a systemic shift supported by phased deployment, targeted training, technological integration, and adaptive communication (Nwulu *et al.*, 2022; Elete *et al.*, 2022). By managing this transition thoughtfully, organizations can unlock greater flexibility, responsiveness, and efficiency in some of the most complex and high-risk project environments.

2.5 Benefits and Performance Metrics

The adoption of an Agile Execution Framework in managing multidisciplinary offshore engineering projects offers a range of tangible benefits that significantly enhance project performance, resilience, and stakeholder value as shown in figure 3. High-risk environments such as offshore oil and gas developments, subsea infrastructure installations, and floating production systems require robust yet flexible management strategies (Elete *et al.*, 2022; Nwulu *et al.*, 2022). Agile principles when appropriately adapted can deliver enhanced adaptability, improve cross-functional collaboration, reduce project delays and cost overruns, and provide real-time visibility that supports informed decision-making.

Figure 3: Benefits and Performance Metrics

One of the primary benefits of the agile approach is enhanced adaptability and risk management. Offshore projects often experience rapidly changing conditions due to weather disruptions, regulatory modifications, equipment delays, and unforeseen technical challenges. Traditional linear project management models such as waterfall are poorly suited to absorb such volatility. In contrast, agile frameworks promote short, iterative cycles with regular reviews and backlog re-prioritization. This allows project teams to respond promptly to emergent risks and operational constraints. Agile's risk-based backlog management also ensures that high-impact tasks are addressed early, improving preparedness and reducing the likelihood of critical failure points later in the execution phase. Performance metrics in this context include frequency and duration of schedule deviations, percentage of backlog tasks re-prioritized due to emerging risks, and risk mitigation lead time.

A second major advantage is improved team alignment and collaboration. Offshore engineering projects involve multidisciplinary teams including structural, mechanical, instrumentation, environmental, and logistics experts, often spread across different geographic locations and time zones. Agile's cross-functional team structure and its emphasis on shared ownership, daily stand-ups, and sprint retrospectives foster stronger communication and collective accountability. These practices reduce siloed thinking and promote a systems-level understanding of project objectives. Key performance indicators (KPIs) include team velocity, task completion rates, communication frequency, and stakeholder satisfaction scores derived from retrospectives and reviews (Ajiga *et al.*, 2022; Akintobi *et al.*, 2022).

Reduction in delays and cost overruns is a measurable outcome directly linked to agile practices. Traditional project execution methods often struggle with inaccurate upfront estimations, rigid schedules, and dependency bottlenecks, resulting in costly overruns and delivery delays. Agile mitigates these risks through continuous delivery of smaller, manageable work packages that are validated at each iteration. Feedback is rapidly integrated, preventing late-stage rework. Agile's use of Kanban boards, burndown charts, and sprint metrics allows teams to identify slippage early and reallocate resources accordingly. Project metrics reflecting these improvements include earned value metrics (such as cost performance index and schedule performance index), percentage adherence to sprint goals, average duration of task cycle time, and cumulative cost savings through early issue detection.

Finally, the framework promotes real-time visibility and decision-making, which is critical in offshore project environments characterized by tight safety margins and high financial stakes. Agile dashboards provide stakeholders from technical leads to project sponsors with up-to-date information on progress, risks, dependencies, and resource utilization. Integration with project management software (e.g., Primavera P6), enterprise systems (e.g., SAP), and communication platforms (e.g., Microsoft Teams) ensures that data is both comprehensive and accessible (Adeniji *et al.*, 2022; Sobowale *et al.*, 2022). Real-time alerts and automated reporting reduce information lag and support data-driven decisions. Metrics used to assess real-time visibility include data latency (time delay between task completion and dashboard update), stakeholder response times to flagged issues, and decision turnaround metrics.

The deployment of an Agile Execution Framework in offshore engineering projects delivers transformative benefits. Enhanced adaptability improves responsiveness to risk, improved collaboration accelerates problem-solving, reduced delays optimize resource use, and real-time visibility sharpens decision-making. These outcomes are not abstract ideals—they can be tracked and quantified through a robust set of performance metrics that inform continuous improvement and justify the adoption of agile practices in even the most demanding engineering contexts (Akintobi *et al.*, 2022; Adewoyin, 2022). As the industry confronts increasing complexity, regulatory scrutiny, and economic pressures, the strategic integration of agility into offshore project execution is both a necessity and a competitive advantage.

2.6 Challenges and Mitigation Strategies

The implementation of an Agile Execution Framework in offshore engineering projects promises substantial improvements in adaptability, collaboration, and efficiency. However, the transition from traditional project management models to agile approaches introduces several challenges. These include organizational resistance to change, complexities in integrating cross-disciplinary teams, constraints imposed by regulatory environments, and the need to maintain rigorous documentation and auditability (Onukwulu *et al.*, 2022; Ogunnowo *et al.*, 2022). For agile methods to deliver sustainable value in high-risk offshore projects, these challenges must be identified and addressed through thoughtful mitigation strategies.

Resistance to change is one of the most persistent barriers to agile transformation. In the engineering domain, traditional hierarchical structures and a culture of predictability dominate, particularly in safety-critical sectors like offshore oil and gas. Personnel who are accustomed to fixed roles, rigid planning, and deterministic milestones may view agile as a threat to control, authority, or professional identity. This inertia is further reinforced when top-down leadership fails to communicate a compelling vision for change.

To mitigate this resistance, organizations must adopt a structured change management approach. This includes leadership endorsement, clear communication of the benefits, and stakeholder involvement in the transformation process. Agile training programs tailored for engineering disciplines emphasizing how agile enhances safety, accountability, and responsiveness can help reframe perceptions. Early successes from pilot implementations should be showcased to build momentum, while internal champions act as role models. Establishing feedback loops where team members can voice concerns and suggest improvements ensures that agile adoption is iterative and inclusive, rather than disruptive (Oyedokun, 2019, Okolo *et al.*, 2022).

The complexity of cross-discipline integration presents another formidable challenge. Offshore projects involve coordination among civil, mechanical, electrical, software, and marine engineers, along with supply chain, procurement, and HSE (Health, Safety, and Environment) teams. Each discipline has its own workflows, tools, and constraints, making alignment within agile teams difficult.

Effective mitigation begins with forming cross-functional agile teams where all necessary expertise is represented. Clear role definitions (e.g., Agile Project Owner, Technical Scrum Master) and the use of integrated digital platforms support cohesion. Daily stand-ups and sprint reviews offer structured forums for collaborative decision-making, reducing the risk of misalignment. Modular work packages and shared repositories enhance transparency, while systems engineering methods such as model-based systems engineering (MBSE) can help bridge discipline-specific representations and languages (Awe, 2017; Okolo *et al.*, 2022).

Implementing agile in regulated environments such as offshore engineering further complicates adoption. Regulatory bodies require conformance to detailed documentation, traceability of design decisions, and adherence to industry standards (e.g., ISO, API, DNV). Agile's emphasis on working solutions and minimal documentation may appear incompatible with these requirements.

However, agile and compliance are not mutually exclusive. Mitigation strategies include integrating compliance checkpoints into sprint planning and using the Definition of Done (DoD) to include regulatory deliverables. Digital tools such as product lifecycle management (PLM) systems can automate document versioning and audit trails. Agile roles must collaborate with regulatory experts to ensure that compliance is embedded within workflows, not appended afterward. Agile frameworks can also be hybridized with stage-gate processes, where each gate includes both engineering and regulatory milestones, ensuring traceability without sacrificing flexibility (Nwulu *et al.*, 2022; Ogunwole *et al.*, 2022).

Finally, maintaining documentation and auditability while iterating rapidly is a critical challenge. Offshore engineering projects require detailed technical records for commissioning, operations, and future modifications. Agile's iterative nature can lead to fragmented or inconsistent documentation if not proactively managed.

To mitigate this risk, documentation should be treated as an integral part of the development process, not a final output. Teams can adopt a "living document" approach, using wikis and version-controlled repositories to update designs, tests, and validation records incrementally. Tools like Jira, Confluence, and GitLab can automate the capture of sprint outcomes, linking design changes with task histories. Regular documentation reviews should be embedded within sprint retrospectives, ensuring completeness and traceability.

While agile execution in offshore engineering projects presents significant challenges, these can be effectively mitigated through structured change management, integrated multidisciplinary coordination, proactive compliance strategies, and continuous documentation practices (ADEWOYIN *et al.*, 2020; OGUNNOWO *et al.*, 2020). With the right strategies in place, agile methods can thrive even in the complex, regulated, and safety-critical context of offshore project environments.

Conclusion

This study has presented an Agile Execution Framework tailored for multidisciplinary offshore engineering projects operating in high-risk environments. The proposed model integrates core agile principles such as iterative planning, cross-functional team structures, and adaptive prioritization into the unique context of offshore engineering, where complexity, uncertainty, and safety considerations are paramount. By adapting agile methodologies like Scrum and SAFe to engineering disciplines and embedding mechanisms for governance, compliance, and risk-based planning, the framework addresses the limitations of traditional linear approaches and supports more dynamic, resilient project execution.

The long-term implications of adopting such a framework in offshore project management are considerable. It enhances the industry's ability to respond to operational disruptions, regulatory changes, and stakeholder demands with greater speed and coordination. Moreover, it improves transparency and accountability through real-time dashboards and structured feedback loops, while reducing schedule delays and cost overruns that are common in large-scale marine operations. By promoting continuous learning and iterative delivery, the framework also fosters a culture of innovation and risk-informed decision-making, critical for the sustainability of future offshore developments.

Future research should focus on advancing this framework by integrating artificial intelligence (AI) for predictive planning and resource optimization. AI-driven analytics can support real-time risk assessments, forecast project bottlenecks, and optimize workflows dynamically. Additionally, digital twin technology could be incorporated to simulate physical assets and project scenarios, enhancing planning accuracy and operational foresight. Finally, the establishment of industry-wide standards for agile engineering execution in regulated offshore environments would promote broader adoption, interoperability, and benchmarking. These future directions will not only extend the utility of the agile framework but also catalyze a paradigm shift in how complex offshore projects are conceived, executed, and evolved in the face of an increasingly dynamic global energy landscape.

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