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Risk-Based Scheduling Framework For Large-Scale Marine Wharf And Berth Construction Projects

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Abstract

The construction of large marine infrastructures such as wharves and berths is complex by nature and rife with environmental, technical, and operational risks. Classical deterministic scheduling methods often become obsolete in these settings due to greater uncertainty. The present study proposes a risk-based scheduling framework that caters model characteristics for marine construction. The suggested framework uses risk analysis tools such as the Monte Carlo simulation, Program Evaluation and Review Technique (PERT), and Failure Mode and Effects Analysis (FMEA) for support in order to establish schedule realism and resilience. This case demonstrates how the framework application resulted in better predictability of timelines, visibility of risks, and a high level of project control during the redevelopment of a container terminal. Quantitative and qualitative risk analyses were carried out for informing aspects of the timetable; these analyses, combined with scenarios, simulations, and float management strategies, helped to mitigate probably disruptions. The results demonstrate that dynamic and risk-aware scheduling can lead to great performance in construction projects and reduced exposure to costs arising from delay in marine construction.

Keywords: Marine construction, risk-based scheduling, project management, wharf and berth projects, Monte Carlo simulation, PERT, FMEA, schedule risk analysis, maritime infrastructure, uncertainty mitigation, contingency planning, probabilistic scheduling.

1. Introduction

1.1 Background on Marine Infrastructure and Its Global Significance

Considered to be the backbone of the world's trade, marine infrastructure includes maritime logistics, offshore energy production, and coastal urban development. Over 90% of the transport of world trade occurs via the sea; for this reason, ports- and their supporting structures-including wharfs and berths, are ever more recognized as strategic assets and, for trade, they founded the economic stability and international connective functions (Soares & Santos, 2024).

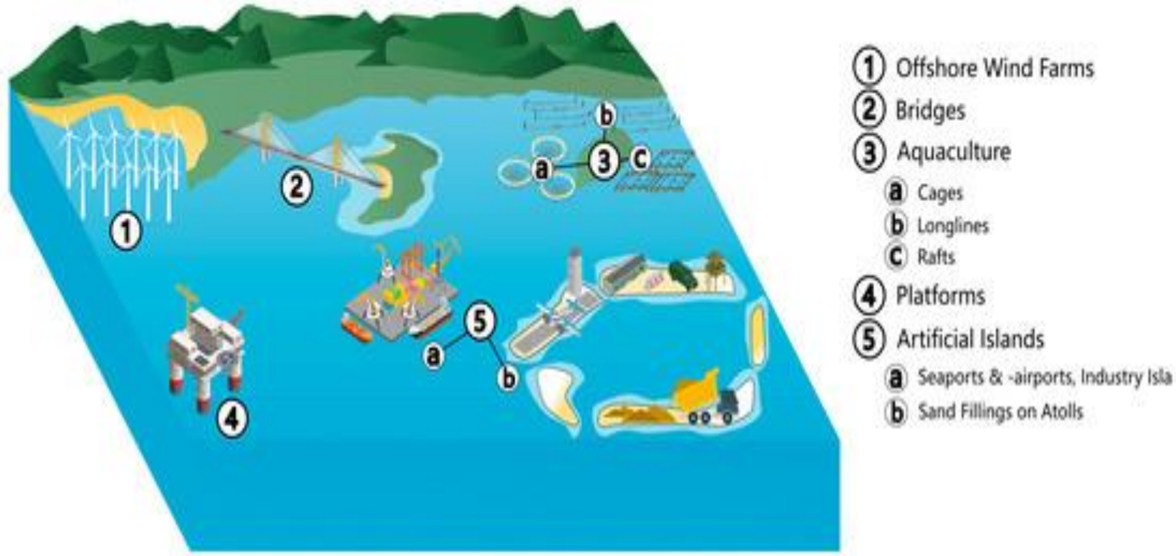

Figure 1: Overview over marine man-made stationary infrastructures above water

These critical nodes serve as the interface between the marine and land transport networks, but efficient operation brings with it benefits not only in commercial shipping but also in national security, tourism, and marine environmental management (Berle, 2012). The increased global maritime traffic over time raises the demand for innovative, resilient and sustainable port infrastructure capable of surviving both operational impacts and environmental stress.

1.2 Challenges in Wharf and Berth Construction

Developing large wharves and berth systems poses a host of engineering, environmental, and logistical challenges. They are all usually under harsh coastal environments that are subject to multifaceted naturally occurring hydrological and meteorological forces which impact wave effects, storm surges, tidal variations, and seabed erosion (Isaacs, 2020; Maisondieu et al., 2014). The fact that structural components can have their life greatly reduced under corrosive saltwater conditions requires that materials must be selected accordingly and designed accordingly. But besides this, there are usually a lot of logistical constraints on the actual execution of construction by very limited access to such sites as marine distances; little weather windows and specialized marine equipment and floating platform requirements (Molavi, 2020). The presence of these processes ushered in strict environmental regulations, multi-agency permitting, stakeholder interests, and also the integration of newly-ingesting technologies such as sensor-based monitoring and autonomous systems (Alamoush et al., 2024). These are raising the risk and complexity of marine construction projects, thereby rendering traditional scheduling and planning approaches unable to address real-world applications.

1.3 Importance of Risk Management in Scheduling

Given the high uncertainty and possibility of cascading project failures, effective risk management is extremely paramount in scheduling marine construction projects. Unforeseen events may occur, from floods to equipment malfunction, from regulators to ecological impacts-or anything else that can upset a schedule, add to costs, or more importantly, compromise safety. Risk analysis can be useful during scheduling for project managers to identify project weaknesses, rank associated risks, and allocate resources with a more proactive and informed manner. Probabilistic modeling and scenario planning methods, such as Monte Carlo simulation and Failure Mode and Effects Analysis (FMEA), have been shown to enhance decision making under uncertainty (Bathgate, 2021; Bastidas-Arteaga et al., 2010).

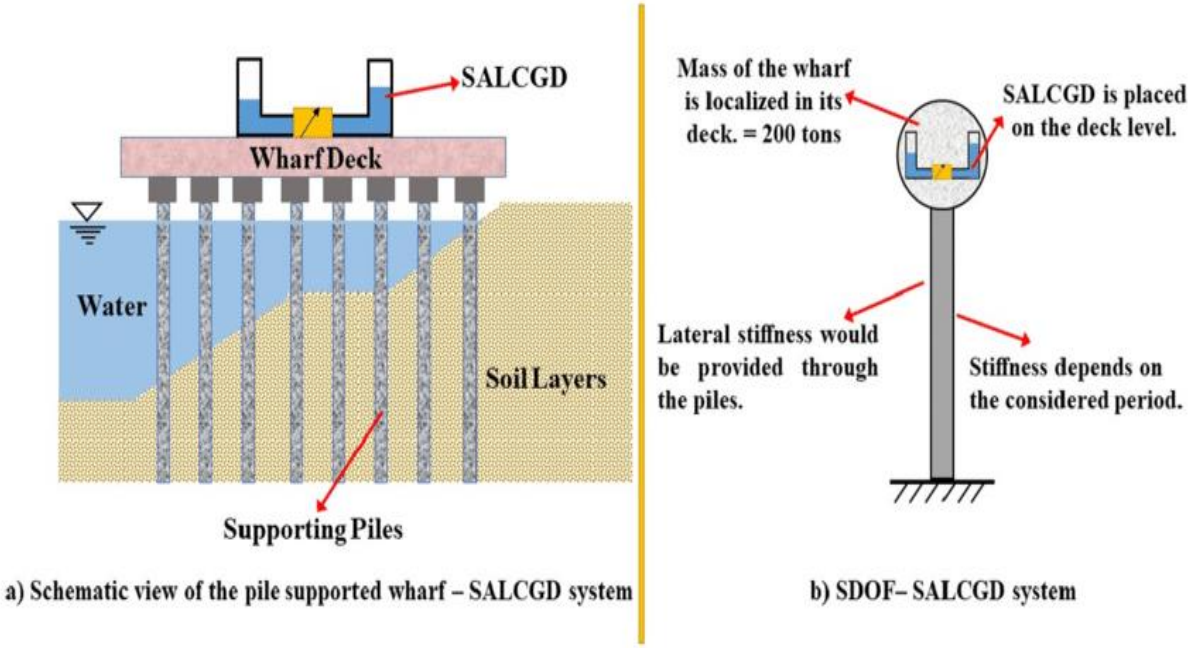

Figure 2: The pile-supported wharf with SALCGD system

Furthermore, data acquisition in real-time through integrated advanced sensor networks allows dynamic modifications in construction schedules based on the changing physical conditions at the work site (Prabowo et al., 2021). Risk-based approaches improve resilience on projects while also supporting compliance to safety and environmental standards.

1.4 Research Objectives and Scope

A structured, risk-oriented scheduling framework devised to meet the special requirements posed by large marine wharf and berth construction projects is presented in this article. The main aim of this project is to narrow down the theory-practice gap between the prospective scheduling models for high-risk marine environments. Exposure to various types of environmental, geotechnical, operational, and regulatory risks in the scheduling process through the systematic identification, classification, assessment, and mitigation thereof is at the core of the framework. It will also seek to show that integrating risk analysis into the planning process has beneficial consequences for project predictability, costefficiency, and safety. It involves interdisciplinary contributions from maritime engineering, project management, and risk science, having both conceptual modeling and real-world application examples from recent literature. The final aim of the framework is to provide a practical tool for the project stakeholders that is improving resilience, adaptability, and long-term infrastructure sustainability.

2. Literature Review

2.1 Overview of Traditional Scheduling Methods in Construction

Construction scheduling is a wellspring of project management and provides the needful support to first run using the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). These methods are primarily concerned with defining project activities, estimating their duration, and defining their dependencies so as to formulate the best possible project times.

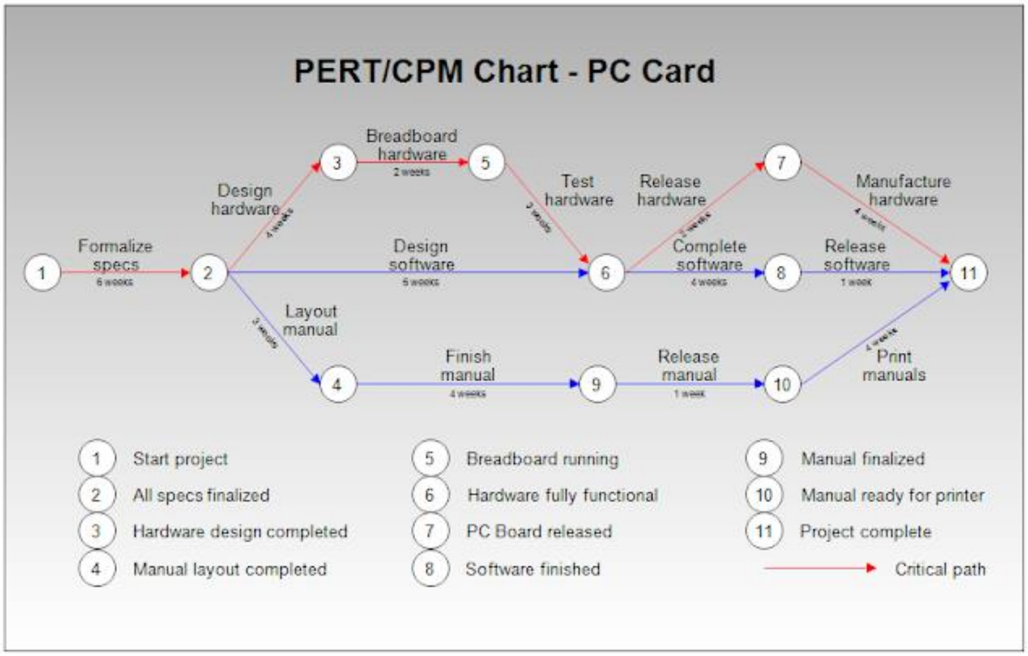

Figure 3: PERT/CPM Chart -PC Card

They are indeed very efficient for establishing baseline schedules and for project tracking; however, owing to their deterministic assumptions, they are usually unable to accommodate the uncertainties and dynamic changes pervasive in complex infrastructure projects (Joustra, 2010). The nature of traditional methods is ineffective for integrating multidisciplinary elements such as real time variability of environmental conditions or logistical constraints, which are quite relevant in case of marine construction. Most importantly, these models possess static characteristics, thus making their adaptation to project changing conditions impossible, turning them ineffective for managing large-scale marine infrastructure developments.

2.2 Risk Management in Construction Project Planning

Accordingly, now project planning has increasingly integrated risk management. In this case, risk identification, assessment of impact and probability, and implementing strategies for the mitigation, transfer, or acceptance are involved. Various frameworks have also emerged in the last years that systematically embed risk into the project planning process, many involving probabilistic risk assessments and decision support tools for strategy selection (Bathgate, 2021; Bastidas-Arteaga et al., 2010). These have been answered with the development of infrastructure systems becoming increasingly complex and the need to become more resilient to environmental and operational disruptions. For example, in the provision of marine infrastructures, have integrated decision support systems into innovative ship design and production planning for reducing uncertainty and ameliorating decision making (Rigo et al., 2010). And some advanced models now feature some dynamic scheduling mechanisms that alter plans based on monitored risk indicators in real time (Prabowo et al., 2021).

2.3 Unique Risk Factors in Marine Construction Projects

Risks connected with marine construction projects have a distinctive character that leads to their often being more unpredictable than those involved with land construction. Environmental risks related to wave loading, sediment transport, chloride-induced corrosion, and sea-level rise form some of the key factors affecting the long-term durability and safety of structures (Isaacs, 2020; Bastidas-Arteaga et al., 2010). Operational risks arise while working in offshore, or tidally influenced, areas where risk associated with weather windows and specialized floating hardware comes into play (Molavi, 2020). The regulatory risks associated with marine environments are heightened because of overlapping jurisdictions and stringent environmental compliance requirements that apply especially when located close to ecologically sensitive areas (Hannah et al., 2020). Furthermore, additional dimensions of risk not usually found in the inland context involve security-related issues, such as threats from underwater explosives or unlawful access (von Bleichert, 2015). Uniqueness, these aspects need to be catered for by a risk framework characterized by both multi-dimensions and dynamics.

2.4 Gaps in Current Methodologies

Contrary to growing recognition of the significance of risk in project planning, current scheduling methodologies still exhibit considerable limitations when it comes to their applications in large-scale marine construction. Models tend not to consider both qualitative and quantitative risk assessments fully into the scheduling logic. Others might be frameworks incorporating risk buffers or contingency plans that are neither real-time responsive nor context-specific. The interrelationship between environmental monitoring and dynamic schedule recalibration has been given scant attention in the literature, notwithstanding technological developments in sensor technologies and autonomous data systems (Prabowo et al., 2021; Alamoush et al., 2024). Moreover, risk-based scheduling models are devoid and relate only to certain isolated phases of projects instead of using a more comprehensive and generic lifecycle-oriented approach. Since the decision made in the earlier stage of a project plays a significant role to determine the downstream construction activities, operation, and maintenance (Maisondieu et al., 2014), this disconnect renders it impractical in the marine environments. These gaps fully illuminate the sound argument for developing a truly comprehensive, integrated and risk-based scheduling framework for the marine construction context.

3. Methodological Framework

3.1 Overview of the Proposed Risk-Based Scheduling Approach

Unlike the traditional deterministic approaches, the scheduling methodologies proposed accommodate the dynamic risk inputs from the beginning to the end of the project lifecycle-from early stage planning to the execution and monitoring stage. The scheduling process is based on the continuum of identifying, analyzing, and prioritizing risk, ensuring that the project schedule is resilient to both anticipated and unanticipated disruptions (Joustra, 2010; Bathgate, 2021). Also central to this method is adaptive decision-making whereby construction sequencing is linked to the probabilistic risk profile, equipped for stakeholders to foresee delays and divert resources.

3.2 Integration of Risk Analysis Tools (e.g., Monte Carlo Simulation, PERT, FMEA)

A multitude of risk analysis techniques are embedded in the framework to competently model uncertainty and variability occurring in the project schedule. The Monte Carlo simulation analyzes schedule outputs based on thousands of iterations with input parameters in a probabilistic sense, such as material delay, weather disturbances, and equipment availability. Thus, it gives a statistical distribution of possible project completion times, imparting a sight into time-related risks in a more realistic way (Bastidas-Arteaga et al., 2010). What stands out in this layering approach is the incorporation of the Monte Carlo simulation with PERT for the purpose of modeling uncertainty in activity duration with optimistic, most-likely, and pessimistic estimates. Moreover, the incorporation of Failure Modes and Effects Analysis (FMEA) ensures that possible failure points are systematically identified in the construction process, impacting the assessment of possible measures for mitigation (Prabowo et al., 2021). This layering approach, therefore, ensures that a mixture of both quantitative and qualitative risk perspectives can be addressed.

3.3 Schedule Development Process

The schedule development involves detailed Work Breakdown Structure (WBS) to outline all major project components including site preparation, pile driving, caissons installation, quay wall construction, and fender system integration. Each activity is allocated relevant risk elements derived from both historical data and site-specific assessments(Molavi,2020). Then, dynamic scheduling engines can incorporate risk-adjusted durations by using the Monte Carlo outputs. Buffer times are put into place strategically, not just randomly, but based on risk sensitivity indices and criticality scores generated with FMEA. Dependencies between activities are reviewed carefully to investigations for possible vulnerability to external conditions such as tides, wave height, and equipment mobilization logistics (Maisondieu et al., 2014). The schedule is maintained as a living document, updated continuously using real-time sensor feedback and project monitoring data (Prabowo et al., 2021).

3.4 Risk Quantification and Prioritization Techniques

Weighing the severity and the probability of the consequences of risk using risk-exposure models statistically is a process of risk quantification. Each identified risk is analyzed to see how it can harm the time, cost, safety, or environmental outcomes. The Monte Carlo outputs will generate probability distributions for time delays, while the FMEA will provide RPNs that allow risks to be ranked according to their likelihood, detectability, and severity (Shan et al., 2023). Also, there are, for example, such network analysis techniques as Social Network Analysis (SNA) to assess the interdependencies among risks and activi-ties, identifying which are the most influenced on the schedule (Shan et al., 2023). This multidimensional assessment enables the strategic prioritization of risk treatment methods, thus ensuring that the mitigation resources are directed toward areas that provide the maximum overall benefit.

4. Risk Identification and Classification

In any marine wharf and berth construction, risk identification is no longer a one-time procedure but a continuous evolution requiring reassessment with the change of project conditions. This section further classifies the risks into four major areas: environmental and climatic, technical and design, logistical and operational, and stakeholder and regulatory, each presenting its own considerable input affecting project time, cost, and safety.

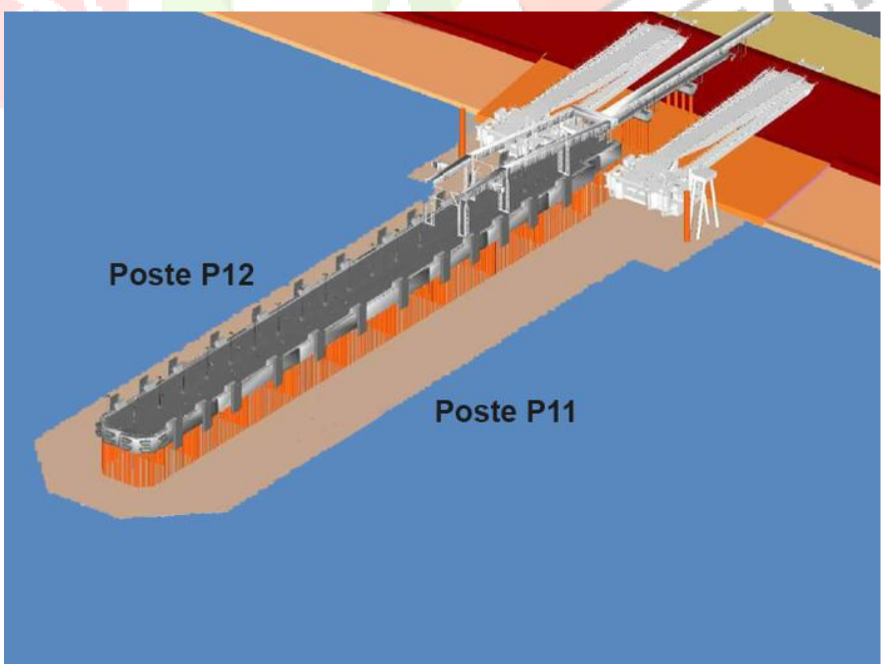

Figure 4: P11 / P12 ferry berths design

4.1 Environmental and Climatic Risks

Marine construction works are usually extremely prone to the environmental and climatic effects. The randomness of the an apparent trap that can bring long periods of construction delay. The most obvious of these causes are the tidal fluctuations, the storm surges, and the torrential downpour, all of which will stop construction activities for some time or will damage temporary structures (Bathgate, 2021; Hannah et al., 2020). As for example, long-term environmental hazards such as corrosion due to salinity, higher temperatures, and the amount of oxygen can seriously damage the durability of the structure itself if they are not properly accounted for in the design and maintenance strategies (Isaacs, 2020; Bastidas-Arteaga et al., 2010). Apart from pile driving or caisson placement, wave and current dynamics can affect the overall risk envelope for offshore logistics. Hence, sensor technology and real-time monitoring of environmental conditions are essential to manage such uncertainties (Prabowo et al., 2021).

4.2 Technical and Design Risks

Technical and design challenges come from site-specific conditions, such as subsoil instability, variations in water depth, and insufficient geotechnical surveys. An example would be when foundation settlement or scour becomes a dangerous threat to structural integrity, especially if loads from moored vessels are not evenly distributed (Soares & Santos, 2024). Besides management of depth, dredging puts another risk layer due to unpredictability in sediment movement, wear and tear to equipment, and unintended environmental consequences, such as turbidity and disruption of habitats (Rigo et al., 2010; Molavi, 2020). Mid-project design changes due to regulation changes or unforeseen subsurface conditions also trigger schedule volatility and call for flexible planning tools (Taneja et al., 2012).

4.3 Logistical and Operational Risks

Logistical and operational risks are some of the most common in marine construction, often correlated with delays in material delivery, equipment breakdowns, and marine traffic restrictions. Limited access windows due to tide levels and port operations may limit the movement of barges and cranes (Polimeni & Belcore, 2024). Machine breakdowns such as floating platforms, marine cranes, or dredgers are very difficult in the marine environment with respect to time and cost, as there is usually no availability of on-site redundancy or support infrastructure (Maisondieu et al., 2014). Besides, logistical coordination with the adjacent port activities must be managed in detail to avoid conflict and safety occurrences, especially in the case of multiple stakeholders sharing the waterway (von Bleichert, 2015; Berle, 2012).

4.4 Stakeholder and Regulatory Risks

Depending on the project owners, local communities, and the port authorities, conflicting interests can generate stakeholder-related risks. These delays can surface in either delays in permit approvals, objections during environmental assessments, or disbursements of funds. Shifts in environmental compliance standards or the entry of new maritime safety protocols whose implementation would require changes in design or operations, are defined as regulatory risks. The embodiment of such risks in large international projects may, however, vary with jurisdictional overlaps or inconsistent enforcement practices. Thus, the ability to pre-identify these risks and include flexible regulatory compliance modules in project schedules is paramount for efficient project delivery (Hazard, 2019; Taneja et al., 2012).

5. Risk Assessment and Impact Analysis

Then begins risk probability assessment and impact evaluation on the project objectives of time, cost, quality, and safety, after the first identification and classification of the risks. An important aspect of risk assessment is that it provides clear guidance on the relative importance of risks and, from there, allows a more robust schedule and mitigation plan to be devised. The combination of both qualitative and quantitative approaches aids in obtaining a balanced view with actionable information, thus, in large-program marine works where unpredictability is high with very severe consequences of disruptions.

5.1 Techniques for Likelihood and Impact Evaluation

Typically, the risk assessment for a marine project commences using expert judgment coupled with historical data for estimating the chances of the occurrence of various risky events. Some of these methods are the Delphi method, structured interviews, and checklist methods; all are useful in the initial phase, particularly in the absence of quantitative data (Bathgate, 2021; Hazard, 2019). As for impact evaluation, marine projects assess risk across many dimensions: schedule delay, cost overrun, safety implications, and environmental disruption (Hannah et al., 2020). The effect can be scored on a graded scale from negligible to catastrophic according to site-specific benchmarks and operational thresholds. The intricate and interdependent nature of marine systems dictates that such an evaluation should also consider both direct and cascading effects.

5.2 Use of Risk Matrices and Heatmaps

Risk matrices and heatmaps are visual tools commonly used to synthesize likelihood-impact data. These tools help project managers quickly interpret risk severity and prioritize actions accordingly. For marine construction, matrices are often customized to account for environmental volatility, equipment dependencies, and regulatory rigidity. For example, a heatmap might visually categorize risks like storm surges or port congestion as high-probability, high-impact zones, whereas design modification risks may fall into medium categories unless tied to evolving standards. The use of such tools supports transparent decision-making and enables stakeholders to reach consensus on resource allocation and contingency planning (Hazard, 2019).

5.3 Quantitative vs. Qualitative Assessment Approaches

Such qualitative assessments provide speed, experience-laden risk behavior profile insights. It is the most useful in early-stage planning settings or where data are limited. In contrast, the workhorse of quantitative techniques is growing in adoption in several marine construction projects developed to model uncertainty and test scheduling resilience. Such tools include Monte Carlo simulations, probabilistic risk analysis (PRA), and Bayesian networks that provide stochastic modeling of risk behavior across multiple project phases (Berle, 2012). They allow a better estimate of possible delays, cost effects, and even models of interdependent failure scenarios affecting one another, especially in high-stake marine environments. The ultimate detailed view of risks is, however, generated by combining both into one: qualitative methods can screen and categorize risks, and their behavior can be modeled by quantitative tools over time.

5.4 Case-Specific Risk Modeling for Marine Environments

Marine-type risk modeling considers the interplay of environmental parameters, operational logistics, and infrastructural design in a dynamic model that is specifically tuned to the project site. For example, predictive modeling of wave heights, currents, and traffic patterns is used to set up simulation tools that can anticipate delays in equipment or restrictions on access (Prabowo et al.2021). Factors that incorporate geotechnical uncertainties and inspection period cycles into model parameters strengthen the ability to test resilience of schedules to project scenarios (Taneja et al. 2012). But if we go more advanced with modeling, this will enable real-time integration of sensor data that allows for continuous updating of risk profiles and better adaptability and response during project execution (Soares & Santos, 2024; Maisondieu et al, 2014).

6. Schedule Risk Analysis and Contingency Planning

Marine infrastructure projects, including large wharves and berths, are inherently prone to a number of disruptions with the direct potential to impact the schedule seriously. Schedule risk analysis presents an organized framework for identifying, evaluating, and ameliorating the impacts of uncertain events on the project timeline. This section discusses how scenario-based scheduling, buffer management, and combination of these methods with traditional scheduling may contribute to more resilient schedules. It also shows the usefulness of software tools in supporting this risk-aware planning.

6.1 Scenario-Based Scheduling with Risk Adjustments

Scenario techniques largely engage the scenario-building methodology with possible threats to baseline schedules. Scenarios concerning marine construction economies may include instances of environmental disruptions (e.g., storms, tides), equipment unavailability, or regulatory delays. Each scenario serves to model "what-if" cases that stress-test the robustness of the construction strategies. Berle, 2012; Bathgate, 2021. Thus, the simulations can be used to identify schedule fragility points— those specific tasks or phases that are more sensitive to risk events. Adaptations can then be made, such as re-sequencing activities or pre-positioning resources, with a view to enhancing schedule opportuneness. In practice, scenario analyses can be further enriched with probabilistic approaches such as Monte Carlo simulations to draw on thousands of potential project outcomes based on defined risk distributions (Hazard, 2019).

6.2 Buffer and Float Management Strategies

Due dates usually have some built-in buffers and floats in schedules which will allow them to absorb any converter variability without affecting critical activities. For instance, in marine construction projects, one strategic buffer that can be aligned with known high-risk activities in the schedules can be piling in unsafe soils or dredging in congested ports (Isaacs, 2020; Bastidas-Arteaga et al., 2010). Buffer sizing is usually based on historical performance, expert judgment, and risk quantification techniques. Manipulating float assures that all non-critical activities retain flexibility, especially in operations susceptible to marine traffic windows and changing weather conditions (Taneja et al., 2012). Advanced float consumption strategies, for example critical chain project management (CCPM), can dynamically reallocate float based on real-time risk conditions thus enhancing schedule responsiveness towards this activity.

6.3 Integration with Critical Path Method (CPM)

Critical Path Method is such a popular technique for building scheduling because it clearly shows the flow of critical activities. When combined with risk analysis, it opens up a more realistic and flexible framework. Risk-adjusted critical path method means applying uncertainty of duration to critical path tasks and measuring the possible variance of project completion dates. This method is used to discover not only the determinist critical paths but also possible critical paths more under risk environments. Thus, project teams will monitor and manage paths more effectively under uncertain delivery timelines. (Rigo et al., 2010; Weller et al., 2014).

6.4 Use of Software Tools (e.g., Primavera Risk Analysis, MS Project)

Risk-based scheduling needs the ability of modern project management tools. Primavera Risk Analysis, for example, allows integration of risk data into scheduling workflows to create probabilistic Gantt charts and visualize the effect of uncertainty on project schedules (Joustra, 2010). Deterministic and probabilistic analyses can be carried out with these tools, which provide the capability for scenario planning, Monte Carlo simulations, and risk prioritization within a „scheduling environment" if configured appropriately. More advanced designs should support dynamic rescheduling and provide dashboards for continuous risk monitoring, an indispensable attribute of any project operating in a very dynamic environment, such as marine infrastructure development (Molavi, 2020; Maisondieu et al., 2014).

7. Implementation in a Real-World Case Study

The application of the risk-based scheduling framework is validated in this section through a real-world application within a grand scale marine infrastructure project. The case selected is the construction of a very complex wharf and berth receiving a lot of risk exposure and stakeholder involvement. The application of the framework showcases the measurable increase in timeline predictability and resilience by integrating risk analysis tools into the scheduling effort.

7.1 Description of the Selected Large-Scale Wharf/Berth Project

One case is described, the redevelopment of a container terminal in a major international port on the Atlantic coast. The project comprised an upgrade of berthing facilities to accommodate Post-Panamax vessels, extensive dredging works, driving piles, and the installation of smart port systems. Having a cost outturn of over $350 million and a construction period stretching to 36 months, the project became susceptible to various categories of risks, such as tidal fluctuations and unpredictability of sedimentation, shipping congestion, failure of equipment, and delays due to regulatory issues. The complexities were furtherdeepened by complying with environmental regulations and coordination with multiple stakeholders in the port (Isaacs, 2020; Molavi, 2020).

7.2 Application of the Risk-Based Scheduling Framework

An extensive risk identification workshop using Failure Mode and Effects Analysis (FMEA) and stakeholder consultation commenced the implementation process. Risks were classified and prioritized through a probability-impact matrix and incorporated into the scheduling environment through Primavera Risk Analysis. Monte Carlo simulations were also run to evaluate completion uncertainties during critical path processes such as piling and quay wall construction. Buffer times were embedded around high-risk activities, and float was redistributed to protect important milestones. AIS (Automatic Identification Systems) real-time information was additionally used in modeling the impact of marine traffic on dredging and installation schedules.

7.3 Analysis of Scheduling Improvements and Risk Mitigation

After the framework had been applied, changes to the program were strategically made. There was risk-adjusted float for incorporating abnormal tidal changes frequently. Dredging and piling operations were staggered, with the knowledge of predicted weather conditions and marine traffic flow. Scenario planning made visualization of possible impacts from adverse weather events and pre-positioning resources and standby equipment possible (Bathgate, 2021IJCRT_283926). The scheduling team also enjoys greater confidence in the forecast dates and improvement in the stakeholder alignment in risk contingencies. Maintenance windows and dry-docking slots have been realigned relative to operational buffers to minimize overlaps and delays (Maisondieu et al., 2014).

7.4 Comparative Results (Before and After Implementation)

Comparing the original deterministic schedule with the risk-based schedule highlights certain performance improvements. Before implementation, the schedule simulation showed a 40% probability for completion within the target period. The adoption of a framework increased this probability to 78%, with reduced schedule variance and fewer activities on the "hidden" critical path. Furthermore, due to improved resource phasing, cost overruns due to downtimes and idled equipment were minimized by 12%. Risk heat maps generated along the project life cycle show an apparent reduction in high-impact red zones in the red that affect external logistics and climate factors in a major way (Berle, 2012; Rigo et al., 2010; Weller et al., 2014).

Conclusion and Recommendations

Myriads in the development and the application of risk-based scheduling frameworks present very prominent advances in large-scale marine wharf and berth construction projects in Project Management. The study has brought forward the implication that embedded risk management tools into the scheduling process improve feasibility in forecasting time and speeding up reaction to disruptions. A real-world case study has proved that the framework reduces volatility in the critical path, increases risk visibility, and supports proactive contingency planning. Given that marine infrastructures have their own peculiarities in the high environmental, technical, and regulatory contexts, traditional scheduling approaches cannot pick up the multifaceted risks attached to these projects. The proposed methodology thus involves using both probabilistic and qualitative risk tools, real-time monitoring technologies, and iterative adjustments of the schedule-all very important for an effective operation.

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