



Theoretical Framework and Strategy Research on Project Portfolio Management in Engineering Design Enterprises

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Abstract. This paper delves into the theoretical framework and strategic research for project portfolio management within engineering design enterprises in the context of the VUCA environment, characterized by Volatility, Uncertainty, Complexity, and Ambiguity. It underscores the inadequacy of traditional project management models in addressing the complexities of modern engineering projects, advocating for a shift towards a project portfolio management approach. This approach is not just an aggregation of individual projects but involves the synergistic interaction and comprehensive optimization of multiple projects. The paper introduces a SRT (Strategy, Resources, and Technology) theoretical framework to guide engineering design enterprises in managing project portfolios under VUCA conditions. It also presents strategic recommendations for dynamic strategic planning, efficient resource allocation, enhanced risk assessment, and the promotion of technological innovation and knowledge sharing to ensure the success of project portfolios and enhance the competitiveness of enterprises.

Keywords: Engineering Design, Project Portfolio Management, Theoretical Framework, Management Strategies.

1 Introduction

With the rapid advancement of information technology, project management has entered the era of VUCA, an acronym for Volatility, Uncertainty, Complexity, and Ambiguity. Primarily, volatility and complexity are the most salient features, as the complexity and variability of contemporary projects have engendered uncertainty and ambiguity in management systems. For engineering design enterprises, which typically engage in intricate engineering projects characterized by interdisciplinary, high risk, long duration, and large scale, the operating environment has become increasingly volatile, uncertain, complex, and ambiguous. Consequently, the VUCA environment poses new demands and challenges for project portfolio management.

In traditional engineering design enterprises, a fixed project management model is employed, which focuses solely on the control of project objectives and struggles to

adapt to the current complex and variable engineering projects. As the interconnections between projects grow and the trend towards systemic engineering becomes more pronounced, the adoption of a project portfolio management model becomes highly necessary. Project portfolio management is not merely a simple aggregation of individual projects but involves the interplay and overall optimization of multiple projects. The project portfolio management in engineering design enterprises must consider how to achieve synergistic effects between projects and enhance overall performance under the constraint of limited resources. However, in actual design project portfolio management, challenges such as poor management effectiveness, irrational resource allocation, and inadequate risk management are often encountered. These issues urgently require theoretical guidance for resolution. This paper, oriented towards the value of project delivery, proposes an effective theoretical framework and strategy for project portfolio management to enhance the success rate of project portfolios and the competitiveness of enterprises.

2 Theoretical Foundation

2.1 Characteristics of Project Portfolio Management in Engineering Design Enterprises

A project portfolio represents a collection of interrelated projects that are managed in a coordinated manner, with multiple projects within the portfolio interconnected to produce a collective outcome. In contrast to individual projects, a project portfolio is dedicated to achieving incremental benefits. The Project Management Institute (PMI) defines a project portfolio as "a collection of related projects that are managed in a coordinated way to obtain benefits and controls not available from managing them individually."^[1] ^[2] According to PMI's definition, a project portfolio is characterized by two main attributes: 1) It encompasses multiple projects; 2) The projects within the portfolio are interrelated, with their schedules coordinated.

The final outcomes of a project portfolio are realized through the delivery of various interrelated project artifacts^[3], embodying an entity that can realize corporate benefits between individual projects and organizational strategy. As shown in Fig. 1. Multi-project management model.

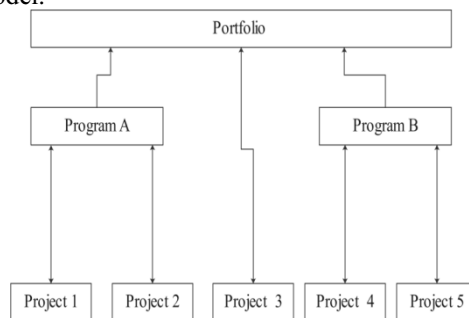


Fig. 1. Multi-project management model

Engineering design enterprises are dedicated to creating value for clients through the fulfillment of design consultancy contracts. The genesis of customer value lies in the value-creating activities of the engineering firm, which are interrelated and interconnected, providing products and services. Michael Porter has termed the intrinsic mechanisms and operational processes of such corporate activities as the value chain^[4].

The value chain of engineering design enterprises can be summarized as follows: Guided by customer needs and corporate strategic management, under the umbrella of internal control and risk management, quality and HSE (Health, Safety, and Environmental) management, and information flow and planning management, the flow of human and technological elements is utilized to implement main business activities such as design consultancy, project management, service support, and technological innovation. This approach aims to achieve corporate operational profits, enhance corporate value, and fulfill the vision, mission, and values of providing customers with high-quality engineering design^[5]. As shown in Fig. 2. Engineering Design Enterprise Value Chain.

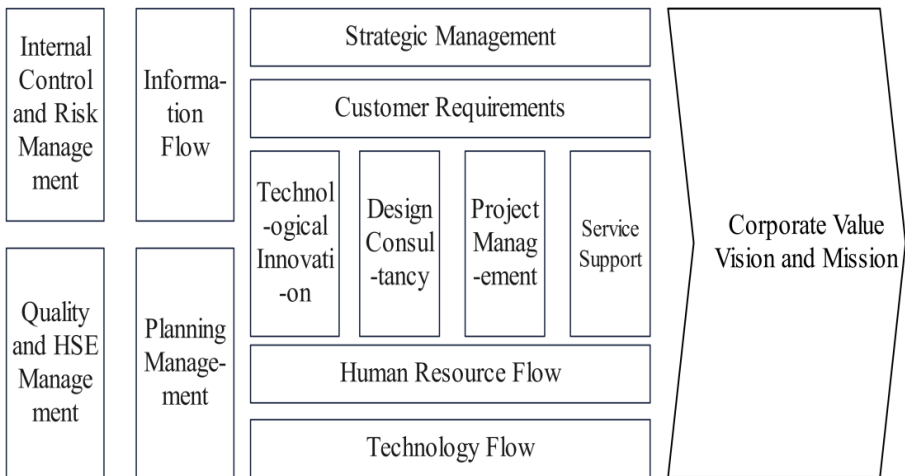


Fig. 2. Engineering Design Enterprise Value Chain

Project portfolio management within engineering design enterprises exhibits significant differences from construction and manufacturing sectors, particularly in terms of technical complexity, high synergy, and uncertainty^[6]. Initially, it encompasses multiple professional domains, necessitating interdisciplinary knowledge and skills within the team. Subsequently, the interdependence and synergy among projects demand optimized resource allocation and effective interfacing management between projects. Lastly, project portfolio management must account for long-term planning and continuous improvement to address the rapid shifts in market and technology, ensuring the scalability and maintainability of the project portfolio. These characteristics collectively form the unique challenges and opportunities in the project portfolio management of engineering design enterprises.

2.2 Key Success Factors

In the realm of project portfolio management within engineering design enterprises, the key success factors can be distilled into three core dimensions: Firstly, the establishment of clear project portfolio objectives and strategic positioning serves as the foundation for aligning the portfolio with the company's long-term strategy and for flexibly responding to market and technological shifts.^[7] Secondly, efficient resource management and optimal allocation, encompassing human resources, materials, and financial assets, as well as the strategic distribution and agile reallocation of resources, are crucial for ensuring that the project portfolio receives appropriate support at various stages.^{[8][9]} Lastly, comprehensive risk management and compliance, which includes risk identification, assessment, mitigation, and monitoring, as well as ensuring that project portfolio management adheres to industry standards and regulatory requirements, are vital for reducing project risks and ensuring the stable progression of the project portfolio.^[10] Collectively, these three factors determine the ultimate performance of the project portfolio, necessitating that the project portfolio management team focuses on these areas to guarantee the smooth implementation and achievement of the intended objectives.

3 Theoretical Framework Construction and Strategic Recommendations

3.1 Challenges and Opportunities of Portfolio Management in the VUCA Environment

In the VUCA (Volatility, Uncertainty, Complexity, Ambiguity) environment, the complexity and challenges of portfolio management have increased significantly, necessitating that engineering design enterprises not only respond to immediate changes but also predict and shape future market and technological trends. Initially, the fluctuating market demands and technological advancements in the VUCA context impose heightened requirements for the strategic alignment of project portfolios. Enterprises must continuously examine and adjust their strategic direction to ensure that the objectives of the project portfolio are synchronized with the corporate vision and can swiftly adapt to changes in the external environment. Subsequently, resource optimization extends beyond cost-benefit analysis to encompass the balance of resource allocation to meet the needs of various projects. With limited resources, prioritizing allocation to maximize the overall benefit of the project portfolio presents an issue that requires in-depth exploration.^[11] Moreover, traditional risk management methodologies may not fully accommodate the rapid changes characteristic of the VUCA environment. Portfolio management necessitates the development of more prospective risk assessment tools and models to anticipate and manage emerging risks. Lastly, technological innovation, while presenting significant opportunities for engineering design enterprises, also introduces challenges in integrating new technologies with existing workflows.^[12] The synchronization of technological advancements with portfolio management practices to prevent obsolescence and resource wastage is a critical issue.

Simultaneously, the rapid environmental changes also bring considerable opportunities for enterprises. Under the current technological wave, the development of big data and artificial intelligence technologies offers new opportunities for portfolio management. By analyzing historical data and market trends, enterprises can more accurately predict risks and opportunities, optimizing the decision-making process. The adoption of agile methodologies can render portfolio management more flexible and responsive to market changes. Through short-cycle iterations and continuous customer feedback, enterprises can adapt to demand changes more rapidly. By integrating knowledge and iterating, and by collaborating with leaders from other industries, engineering design enterprises can gain new perspectives and solutions, driving innovation. Furthermore, the development of technological platforms such as cloud computing, the Internet of Things (IoT), and mobile technology provides enterprises with new tools and platforms to support remote collaboration, real-time monitoring, and intelligent decision-making.^{[13][14]}

Therefore, to address these challenges and seize opportunities, engineering design enterprises must implement a series of strategies. Firstly, they should enhance organizational flexibility and adaptability by establishing agile project management mechanisms, nurturing diverse and multifunctional teams, and executing flexible resource allocation strategies. Secondly, they must strengthen risk management capabilities through systematic identification and evaluation of risks, formulation of risk mitigation strategies, and establishment of ongoing risk monitoring mechanisms. Lastly, they should foster innovation and knowledge management by encouraging employees to propose novel ideas and solutions and by instituting a knowledge management system that facilitates knowledge sharing and the exchange of experiences.

By employing these strategies, engineering design enterprises can more effectively navigate the challenges of the VUCA environment, ensuring the successful management of project portfolios and maintaining competitiveness and sustainable development in an ever-evolving market landscape.

3.2 Theoretical Framework for Project Portfolio Management in Engineering Design Enterprises

In the current rapidly evolving business landscape, engineering design enterprises are confronted with unprecedented challenges stemming from the four core dimensions of the VUCA environment. To effectively address these challenges, this section introduces a comprehensive SRT (Strategy, Resources, and Technology) theoretical framework, designed to guide engineering design enterprises in managing project portfolios within the VUCA context. As shown in Fig. 3. SRT Project Portfolio Management Model.

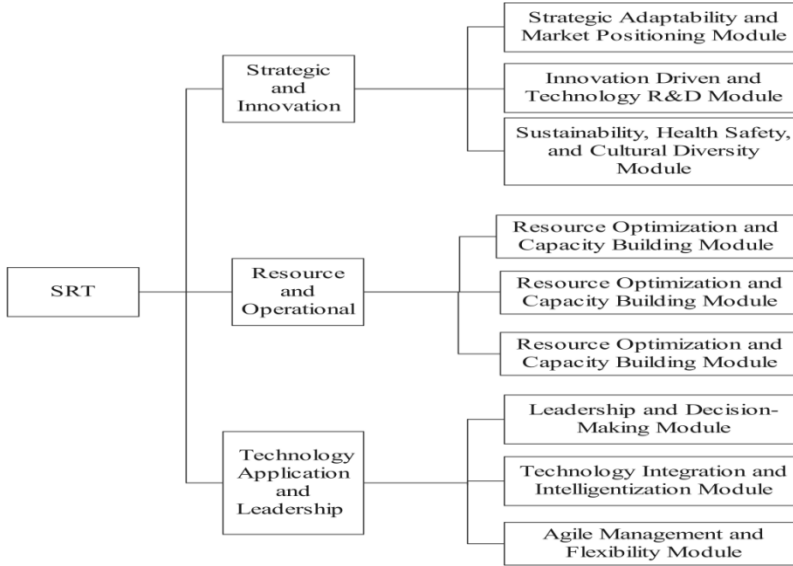


Fig. 3. SRT Project Portfolio Management Model

1. Strategic and Innovation Elements: Ensuring alignment of project portfolios with the long-term vision of the enterprise and market trends, while fostering innovation and sustainable development.

Strategic Adaptability and Market Positioning Module: Aligning project portfolios with corporate strategy and market demands.

Innovation Drive and Technology R&D Module: Promoting technological innovation and research and development to maintain the competitiveness of the enterprise.

Sustainability, Health Safety, and Cultural Diversity Module: Integrating the enterprise's social responsibility and sustainable development goals.

2. Resource and Operational Elements: Optimizing resource allocation, strengthening risk management and quality assurance, while enhancing customer satisfaction and project management efficiency.

Resource Optimization and Capacity Building Module: Concerned with the optimal deployment of human and material resources.

Risk Management and Quality Assurance Module: Including risk assessment, mitigation, and quality control processes.

Customer Relations and Project Management Module: Emphasizing customer relationship management and the efficiency of project execution.

3. Leadership and Technology Application Elements: Strengthening leadership development and decision support, leveraging technology to improve productivity, and enhancing responsiveness to change through agile management.

Leadership and Decision-Making Module: Enhancing leadership and decision-making capabilities to ensure the achievement of project portfolio objectives.

Technology Integration and Internalization Module: Deepening the application of technology to elevate the level of intelligence in design and project management.

Agile Management and Adaptive Flexibility Module: Adopting agile methodologies to improve the adaptability and flexibility of project portfolios.

The Strategic and Innovation elements provide direction and objectives for Resources and Operations. Portfolio management must ensure that resource optimization and operational efficiency are aligned with the long-term vision of the enterprise and market trends, while also promoting innovation and sustainable development. The effective allocation of resources and operational efficiency forms the foundation for the cultivation of leadership and the support of technological capabilities. Enhanced leadership and decision-making capabilities facilitate better management of resources and operations, and the application of technology can improve productivity and the ability to respond to market changes. Strong leadership and prudent decision-making drive the implementation of strategy and the realization of innovation. Concurrently, technological advancements can support strategic adaptability and the execution of innovation, ensuring that project portfolios can swiftly respond to market and technological shifts.

Employing the SRT framework for portfolio management ensures alignment with corporate strategy and market demands, providing a clear direction for portfolio management. It also aids enterprises in the effective distribution and management of human and material resources, increasing the efficiency of resource utilization. The SRT framework offers comprehensive guidance and support for engineering design enterprises in managing project portfolios within the VUCA environment, assisting enterprises in achieving successful portfolio management and maintaining competitiveness and sustainable development.

3.3 Adaptive Strategy Recommendations in the VUCA Environment

Engineering design enterprises must adopt targeted strategies to address the unique challenges posed by the VUCA environment.

1) Dynamic Strategic Planning and Market Adaptability

Enterprises in the engineering design sector should implement dynamic strategic planning to ensure swift adaptation to market changes. This involves the adoption of modular design methodologies, enabling rapid adjustments to project plans in response to shifts in customer demands or regulatory alterations. Concurrently, companies should establish cross-departmental strategic planning teams tasked with monitoring market trends, customer preferences, and technological advancements, thereby adjusting the strategic direction of the project portfolio accordingly.

2) Efficient Resource Allocation and Supply Chain Synergy

In light of the resource-intensive nature of engineering design projects, companies need to refine their resource allocation strategies to ensure the effective utilization of critical resources. By employing advanced project management software and resource scheduling algorithms, fine-grained resource management can be achieved. Additionally, establishing a close collaborative mechanism with supply chain partners through a shared platform facilitates transparent information and real-time communication, thereby enhancing the responsiveness and flexibility of the supply chain.

3) Enhanced Risk Assessment and Compliance Monitoring

Engineering design enterprises must develop a comprehensive project risk assessment system that encompasses technological risks, cost overruns, schedule delays, and compliance issues. Utilizing specialized risk management software in conjunction with expert systems allows for the quantitative analysis and real-time monitoring of potential risks. Furthermore, companies should establish compliance monitoring teams to ensure all project activities adhere to industry standards and legal requirements, thereby mitigating compliance risks.

4)Promotion of Technological Innovation and Knowledge Sharing

Technological innovation is crucial for engineering design enterprises to maintain competitiveness in the VUCA environment. Companies should invest in research and development and encourage staff participation in technical training and innovation projects. By creating an internal technical knowledge base and a database of best practices, knowledge sharing and the transfer of experience are promoted. Moreover, enterprises should actively explore collaborations with universities and research institutions to incorporate the latest scientific research findings and accelerate the translation of technological innovation into practical applications.

4 Summary

The paper concludes with a robust exploration of project portfolio management in engineering design enterprises facing the VUCA environment. The SRT framework, emphasizing Strategy, Resources, and Technology, is introduced as a comprehensive guide for effective management. It advocates for dynamic planning, resource optimization, risk assessment, and technological innovation to ensure project portfolio success. Aligning with current research trends, the paper suggests that adaptability and innovation are crucial for maintaining competitiveness. Future research should examine the long-term efficacy of the SRT framework and the potential of emerging technologies to further enhance project management.

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