Full Life Cycle Research Based on the Contradiction of Engineering General Objective

Ranfei Guo*

School of Safety Engineering, Lanzhou Resource and Environmental Vocational Technical University, Lanzhou, 730021, China
**Corresponding author:giraffe818@163.com*

Abstract: *In the management of the entire life cycle of an engineering project, the contradiction of the overall engineering objectives is a complex and important issue. The study of the engineering life cycle based on the contradiction of overall engineering objectives aims to comprehensively analyze each stage of the project life cycle, identify the points of conflict among various objectives, and propose corresponding solutions to optimize the overall engineering objectives. This research on the engineering life cycle based on the contradiction of overall engineering objectives is a complex and significant topic. Through in-depth research and practice, it can promote the continuous improvement and development of engineering life cycle management, providing strong support for the successful implementation of engineering projects.*

Keywords: *Overall engineering objectives; Life cycle; Engineering project; Objective control*

1 Introduction

In the field of engineering, life cycle management has become a key means to ensure the successful implementation of projects and maximize their benefits. The concept of engineering management based on the life cycle integrates modern management science, systems theory, cybernetics, and information theory into a comprehensive engineering project management approach. Within the framework of construction cost management in China, the life cycle of a construction project can be divided into the decision-making, design, construction, and operation stages. However, engineering projects often face various challenges and conflicts while striving to achieve their overall goals. These conflicts may arise from multiple aspects such as quality, cost, time, and environment, which are interrelated and mutually restrictive, making it difficult to achieve a perfect balance throughout the life cycle of the project. To resolve these conflicts and achieve the optimal result of the overall engineering objectives, it is essential to analyze the life cycle stages based on the contradictions of the overall objectives. This paper proposes effective management strategies and technical measures to address these contradictions, which is of practical significance for improving the overall benefits of engineering projects.[1]

2 Analysis of Contradictions in Overall Engineering Objectives

Overall engineering objectives refer to the comprehensive evaluation of the outcomes achieved based on pre-established goals and specific technical requirements. They reflect the basic characteristics of modern engineering technology, the structural system of engineering technology, and

the technical features of life cycle engineering. They also reflect the purpose and tasks of the work and embody the working principles. As a multi-dimensional and complex control system, the main contradictions in achieving overall engineering objectives in current project management are as follows: the conflict between the total investment goal of construction and the operating management and technical service fees; the contradiction between the construction and operation of the project and other social costs; and the mismatch between the rigid project management models and the increasing complexity and scale of projects. These contradictions represent the main challenges in achieving overall engineering objectives and are key difficulties in the process.

2.1 Three Main Contradictions in Achieving Overall Engineering Objectives

2.1.1 Conflict Between Total Investment Goal and Operating Management and Technical Service Fees

Key points in project investment control include setting investment control goals, breaking down investment targets, and implementing pre-control measures. For certain engineering projects, increasing total investment by improving quality (or technical specifications) can lead to lower operational maintenance costs (such as repair costs, energy consumption, material consumption, and labor costs) during usage. Conversely, significantly lowering quality requirements can increase maintenance costs, thereby raising the overall operational value of the project. This is mainly because high-quality projects consider safety and efficiency in design and construction, significantly reducing the demand for quality in later maintenance stages.

In China, there has long been a tendency to focus excessively on reducing construction investment while neglecting operational maintenance costs. This often results in functional and quality deficiencies in projects, leading to increased energy consumption and maintenance costs during operation. To improve this situation, it is necessary to balance construction investment with operational maintenance costs, ensuring optimal quality and functionality to reduce long-term operating costs.

2.1.2 Conflict Between Project Construction and Operation and Other Social Costs

Social costs of engineering projects refer to measurable costs borne by the public rather than project participants (i.e., owners or contractors) and the adverse impacts on people or the environment surrounding the construction site. Other social costs refer to additional expenses incurred across various social sectors due to the construction and operation of a project throughout its life cycle. These costs are typically not directly borne by the project's builders, investors, or companies but by government departments or other social organizations. For example, the release of waste gases from chemical plants or increased fuel and time costs for citizens due to the construction of highways are part of these social costs. These costs impact the overall development and operation of society and must be comprehensively considered during project decision-making.[2]

2.1.3 Mismatch Between Rigid Project Management Models and Increasing Project Complexity and Scale

Since the reform and opening-up policy, China has achieved remarkable success in major project construction, gained global attention. From the early "Five Vertical and Seven Horizontal" national

trunk highways to the current "Eight Vertical and Eight Horizontal" high-speed railway networks, and landmark projects like Beijing Daxing International Airport and Baihetan Hydropower Station, these major projects not only demonstrate China's engineering prowess but also set numerous world-class engineering records. With the widespread application of PPP and EPC models, project management is increasingly showing trends of growing scale and complexity, further driving the continuous development and innovation of China's engineering construction.

In many cases, effective management models suited to the increasing scale and complexity of projects have not been established. Simple transplantation of general project management methods or proportionally enlarging general project management approaches for large projects fails to account for the unique characteristics of large-scale and complex projects. This simplification and linear processing weaken the project's features, and underestimating the scale and complexity of projects is the primary reason for difficulties in achieving engineering objectives.

2.2 Balancing Stakeholder Needs in the Value System

Balancing the diverse needs of stakeholders in the value system presents inherent contradictions. The overall engineering objectives are interconnected and mutually restrictive; for example, shortening the project duration often leads to increased costs or reduced quality. Similarly, pursuing higher quality may increase the duration or costs. Balancing these needs in project management requires decomposing overall objectives, leveraging the technical advantages of various disciplines, planning reasonably, and dynamically managing the project to achieve functional quality, economic benefits, schedule adherence, and environmental sustainability, ensuring that all stakeholders' needs are balanced within the value system.[3]

2.2.1 Strengthening Quality Management and Controlling Quality Costs

Juran and others suggest a positive relationship between total quality cost and internal and external failure costs, and an inverse relationship with prevention and appraisal costs. This relationship reaches equilibrium at the intersection of the failure cost curve and the prevention and appraisal cost curve, representing the lowest total quality cost, also considered the optimal quality cost.

Quality costs encompass all expenses incurred to ensure and improve product quality and losses due to not meeting quality standards. These costs mainly include two aspects: control costs and failure costs, corresponding to expenses for preventing and correcting quality issues. Appraisal costs, including prevention and appraisal costs, fall under quality assurance costs, proportional to the product quality level—higher quality leads to higher appraisal and prevention costs. Failure costs, including internal and external failure costs, are loss costs, inversely related to quality—higher quality reduces failure costs. To manage quality costs reasonably, construction processes should first ensure the accuracy of construction drawings, minimizing cost increases due to design errors. Second, scientific construction methods and techniques should be adopted to improve efficiency and quality, reducing waste and rework. Lastly, quality education and training should be emphasized to enhance construction personnel's quality awareness and skills, ensuring project quality standards are met and reducing quality costs.[4]

2.2.2 Prioritizing a User-Centric Approach

Among all stakeholders related to engineering projects, users are undoubtedly the most critical.

Regardless of the project's purpose and outcomes, the ultimate goal is to meet user needs. User satisfaction is the core criterion for measuring project success; only by genuinely winning user approval can the project demonstrate its practical value. Therefore, in goal setting, feasibility studies, planning, and design processes, it is essential to think from the user's perspective, ensuring accurate market positioning, user-friendly design, and reasonable sales volume and pricing strategies to maximize user expectations and demands.

2.2.3 Investment Balancing Strategies for Mutual Benefit

To ensure investment benefits, investors must balance investment amounts, return rates, and risk reduction. They need to comprehensively assess project resources to establish reasonable investment expectations and make investment decisions through market research and risk management strategies. Contractors and suppliers focus more on factors like value, quality, corporate image, and relationships (reputation). These aspects not only affect the construction party's immediate interests but also their overall competitiveness in the industry. Thus, they must ensure project quality and safety, strive to complete projects on time within reasonable costs, and focus on building a good corporate image to maintain cooperation and reputation.

3 The Antagonism Between Overall Engineering Objectives and life cycle Management

While there is a synergistic relationship between overall engineering objectives and life cycle management, certain antagonisms exist in practice.

3.1 Difficulty in Setting and Achieving Objectives

Overall engineering objectives are often idealistic and comprehensive. However, during life cycle management, various unforeseen risks and challenges may arise, making these objectives difficult to achieve. The contradiction between objective setting and the difficulty of achievement can lead to confusion and frustration within the project management team during project execution.[5]

3.2 Resource Allocation and Optimization

Life cycle management emphasizes the optimized allocation and management of resources throughout the project's life cycle. However, in practice, due to limited resources, the project management team may need to make trade-offs between quality, schedule, and investment objectives. This contradiction in resource allocation and optimization can present challenges in balancing various interests.

3.3 Information Asymmetry During the Decision-Making Stage

Life cycle management requires consideration of the entire project life cycle starting from the decision-making stage. However, at this stage, the project management team may struggle to obtain comprehensive and accurate information to support decisions. Common decision-making errors include investing in unnecessary projects, selecting inappropriate construction sites, or determining unreasonable investment plans. These errors often result in unnecessary financial, human, material, and financial resource waste, and may cause irreparable losses. Thus, ensuring correct project decisions is a prerequisite for rational project cost estimation and control. Only by avoiding decision-making errors

can project costs be effectively controlled and project success ensured. This information asymmetry can lead to difficulties in the decision-making stage, impacting the overall implementation of the project.

3.4 Conflicts and Coordination of Interests

Stakeholders in engineering projects often have different goals and expectations, potentially leading to conflicts of interest during life cycle management. The project management team must coordinate and balance these interests to achieve the overall project benefit. However, this contradiction between conflicts and coordination of interests can increase the complexity and difficulty of project management. To address these antagonisms, the project management team must enhance communication, collaboration, and risk management at all stages of life cycle management to ensure the project progresses according to planned objectives and requirements. Additionally, the project management team should continually learn and summarize experiences to improve their life cycle management capabilities and better address potential conflicts and challenges.[6]

4 Synergistic Analysis of Contradictions in Overall Engineering Objectives and life cycle Management

The contradictions in overall engineering objectives and life cycle management have a close synergistic relationship. This synergy mainly manifests in how life cycle management balances and optimizes quality, schedule, and investment objectives at various stages of the project.

4.1 Core Concept Analysis

The core concept of life cycle management is to ensure the project progresses according to expected objectives and requirements from planning to operation and maintenance. This requires the project management team to comprehensively consider and balance quality, schedule, and investment at each project stage. For example, during the planning stage, the management team must establish the project's quality, schedule, and investment objectives and develop corresponding strategies and plans. These objectives and plans should consider the overall project benefits and long-term operational needs, avoiding the one-sided pursuit of a single objective at the expense of others.

4.2 Analysis of Different Management Stages

life cycle management requires monitoring and adjusting the project's quality, schedule, and investment at all stages. During the execution stage, the project management team must implement the project plan, ensuring it progresses according to the established quality, schedule, and investment objectives. The team must continuously monitor and evaluate the project's actual progress, promptly identifying and resolving any issues. If deviations occur, the project plan and resource allocation must be adjusted to ensure the project meets its established objectives and requirements.

4.3 Quality Control and Risk Management During the Monitoring Stage

The project management team must develop and implement stringent quality control measures to ensure the project meets predefined standards and requirements. The team must also comprehensively

identify, assess, and control project risks to ensure the project can handle various uncertainties and challenges smoothly. These measures help reduce project risks and costs, improving the overall project benefit. The core task of life cycle quality control is to implement comprehensive supervision and quality management throughout the project cycle, ensuring no quality control blind spots. To achieve this, all responsible parties must undertake their respective quality supervision responsibilities and be accountable for the quality behaviors and results of upstream and downstream units.

Currently, uncontrolled investment in Chinese engineering projects is widespread, primarily due to poor management and outdated methods, and, more crucially, inadequate risk factor assessments that affect and constrain projects. Consequently, recognizing, assessing, and controlling project risks has become an urgent task.[7]

4.4 Analysis of the Project Closure Stage in life cycle Management

The project closure stage in life cycle management emphasizes project conclusion and summarization. The project management team must finalize delivery to the client, ensuring it meets the client's requirements. Additionally, the team must review and summarize the project's objectives, plans, execution, and monitoring. These summaries help the project management team gain insights and improve future project management capabilities.

5 Conclusion and Outlook

Based on the contradictions in overall engineering objectives, this study explores life cycle process management and derives the following main conclusions:

The contradictions in overall engineering objectives, such as the interrelationship between quality, schedule, and investment, are pervasive. These contradictions exist not only at different stages of the project but also throughout the entire life cycle of the project.

To balance and optimize these conflicting objectives, life cycle management is particularly important. By comprehensively considering various stages and aspects of the project, life cycle management helps achieve the overall optimal benefits of the project. Although there is a synergistic relationship between life cycle management and overall engineering objectives, contradictions may also arise in practice. This requires the project management team to focus on coordination and properly handle these contradictions throughout the project's life cycle.[8]

As the scale and complexity of engineering projects continue to increase, life cycle management will play an increasingly important role. Future research can further explore the root causes and influencing factors of contradictions in overall engineering objectives, optimize methods and technologies for life cycle management, and promote interdisciplinary research collaboration to advance project management theory and practice. In conclusion, overall engineering objectives and life cycle management are complementary and inseparable. By applying the principles and methods of life cycle management, we can better balance and optimize overall engineering objectives, achieving long-term benefits and sustainable development for projects.

References

[1] Wang Sainan. Research on Cost Management of Highway Engineering life cycle [D]. Shijiazhuang Railway University, 2019.

[2] Zhang Qiong. Discussion on Investment Control in Construction Engineering [J]. New Accounting, 2010, (03): 23-24.

[3] Wu Kexian, Jin Weiliang, Shen Jian, et al. Social Impact Assessment and Social Cost Analysis of Engineering Projects [J]. Journal of Civil Engineering, 2022, 55(01): 117-128.

[4] Yang Qing, Gulinaer·Maimaiti. Research on the Construction of Quality Cost Management System in Steel Enterprises [J]. Market Weekly, 2024, (01): 104-108.

[5] Qian Yao. Research on Cost Control in the Decision-Making and Design Stages of Construction Engineering [D]. Southwest Jiaotong University, 2011(04).

[6] Han Guobo. Research on Quality Supervision Model and Methods of Building Engineering Based on life cycle [D]. China University of Mining and Technology (Beijing), 2013(10).

[7] Yin Zhijun, Chen Liwen, Wang Shuangzheng, Su Chunsheng. Research Progress on Risk Management of Engineering Projects in China [J]. Construction Optimization, 2002, (04): 6-10.

[8]Karlos Artto,,Tuomas Ahola,,Valtteri Vartiainen.From the front end of projects to the back end of operations: Managing projects for value creation throughout the system life cycle【Z】.International Journal of Project Management,2016(2).