# Research on the Collaborative Management Platform for EPC Projects Under Digital Twin Technology

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**Abstract.** In the context of global economic integration and the sustainable development of the construction industry, the EPC (Engineering, Procurement, Construction) contracting model has emerged as the preferred approach for managing large-scale and complex projects. This study develops a digital twin-based collaborative management platform to addresses the challenges inherent in traditional project management methods for EPC projects by digital technologies such as Internet of Things (IoT), AI, big data and cloud computing. The platform builds a four-level digital framework and integrates four core functional modules: schedule management, cost management, quality management and safety management. By real-time data transmission, dynamic simulation, and intelligent decision-making, the platform facilitates multi-source data integration, dynamic model updates, and enhanced collaborative management. It effectively mitigates issues such as information silos and inefficient collaboration. Empirical case studies demonstrate that the digital twin collaborative management platform significantly improves management efficiency, reduces cost-related risks, and ensures project quality and safety.

**Keywords:** Digital Twin, EPC Projects, Collaborative Management.

## 1 Introduction

The EPC (Engineering Procurement Construction) model, integrating design, procurement, and construction, is widely used in large and complex projects. It reduce risks and improving efficiency[1]. However, these projects face extended timelines, many specialties, difficult technology, complex management. Traditional project management methods often lead to information silos, poor collaboration, and weak dynamic control, resulting in delays, cost overruns, and quality or safety issues[2-4].

To address these challenges, *the Guiding Opinions on Promoting the Collaborative Development of Intelligent Construction and Building Industrialization,* issued by the Ministry of Housing and Urban-Rural Development and twelve other departments, emphasizes integrating BIM with advanced technologies[5]. Digital twin technology, which combines IoT, big data, AI, and VR, has gained attention in fields like manufacturing, smart cities, and healthcare. When paired with BIM, it offers innovative solutions for EPC project management[6-8]. However, it faces challenges such as data



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integration difficulties, slow model updates, poor collaboration, and lacking a holistic framework research for collaborative EPC project management.

## 2 Framework of the Collaborative Management Platform

To support data-driven processes, real-time collaboration, visual interaction, and intelligent decision-making, the platform's architecture is structured into four distinct layers: the data layer, the model layer, the functional layer, and the application layer.

Data layer, as the foundational component of the architecture, is responsible for the collection, storage, and management of all raw data. It encompasses a wide range of data types, including building physical parameters, on-site environmental conditions, equipment operational status, and personnel activities, as depicted in Figure 1.

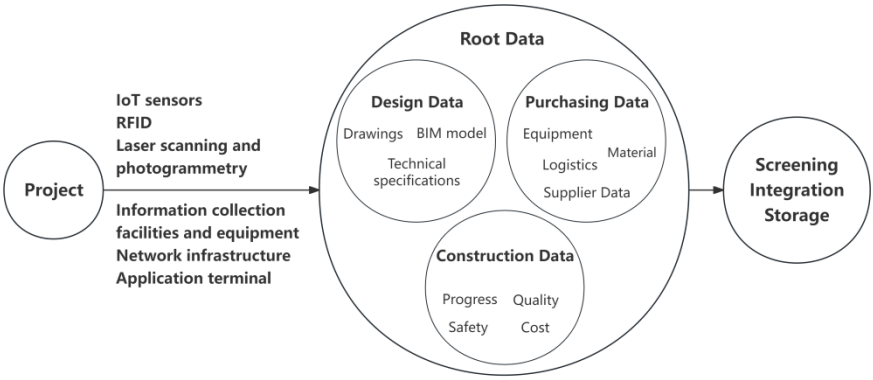


**Fig. 1.** Ideas and elements of data layer.

Model Layer, Leveraging the multi-source data provided by the data layer to conducts lightweight processing and data reuse. This model integrates geometric, physical, behavioral, and rule-based components, enabling real-time data updates, efficient lightweight processing and dynamic simulation and interaction, as depicted in Figure 2.

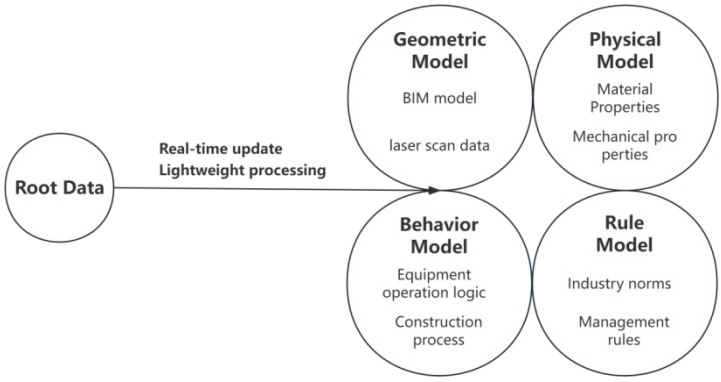


**Fig. 2.** Ideas and elements of model layer.

Functional Layer, The functional layer leverages advanced technologies such as cloud computing and big data to process vast amounts of data. It delivers accurate data support and decision-making insights for users while enabling seamless integration with external systems through standardized interfaces. It capability fosters enhanced collaboration both within the organization and with external stakeholders, as depicted in Figure 3.

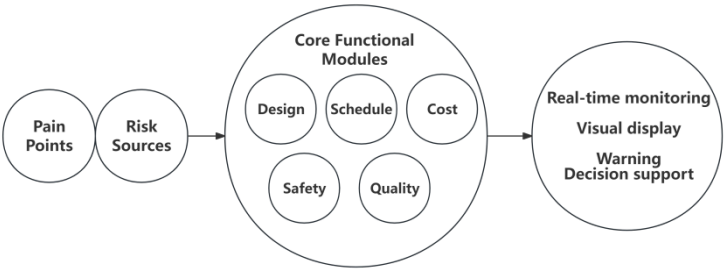


**Fig. 3.** Ideas and elements of functional layer.

Application Layer: The application layer is tailored to meet the collaborative management requirements of all participants in EPC projects. It offers customized application interfaces and tools, encompassing design, construction, and operation management modules. Examples include BIM-based virtual simulation technologies, integrated information management platforms, and intelligent operation and maintenance platforms.

# 3 Operational Mechanism of the Collaborative Management Platform

## 3.1 Schedule Management

Schedule management is vital in EPC projects, using multi-source data and dynamic simulation to monitor progress and enable real-time adjustments. During planning, BIM models and historical data create initial schedules, while machine learning optimizes resources to minimize conflicts. In construction, real-time data from sensors, GIS, and drones are compared with plans to detect deviations and trigger milestone alerts. Predictive data also provides optimization recommendations, supporting dynamic adjustments and resource reallocation.

## 3.2 Cost Management

The digital twin-based cost management system integrates data from design, procurement, and construction to enable precise cost prediction and dynamic control. Early in the project, machine learning analyzes financial data from similar projects to build cost prediction models. During implementation, sensors and BIM models monitor material, labor, and equipment usage in real time. It generates cost reports, identifies deviations,

simulates cost control strategies, and provides optimization recommendations to support decision-making.

### 3.3 Safety Management

Based on BIM model, integrated environment, equipment and personnel data, security risk identification, classification, real-time monitoring and early warning to reduce the occurrence of security accidents. In the early project phase, VR is combined with BIM to identify risk points and potential hazards on the construction site. During the implementation phase, sensors monitor safety conditions in real time, automatically issuing warnings for potential risks and providing emergency response plans. Additionally, it supports virtual training programs, such as safety education, safety briefings, and emergency drills.

### 3.4 Quality Management

The platform integrates design, construction, and inspection data to enable real-time monitoring, feedback, and quality issue resolution. In the early project phase, quality standards and specifications are digitized to facilitate online inspections, rectifications, and approvals. During the implementation phase, IoT sensors and QR code scanning are used to link data to the BIM model, tracking parameters such as pile foundation settlement and temperature changes in mass concrete. It ensures full traceability throughout the quality management process.

## 4 Application Case: A Hospital EPC Project in Yunnan

### 4.1 Project Overview

The Yunnan hospital project, located in a complex residential area, is spanned 30,000 square meters of land and 60,876.5 square meters of building area. It's divided into two zones: Zone A (outpatient and medical technology buildings) and Zone B (inpatient building), both are steel-concrete structure. The project faces challenges such as a limited construction site, intricate coordination among multiple disciplines, and the need for high-precision BIM-driven detailed design.

### 4.2 Construction Approach

To address the specific needs of all stakeholders and optimize management processes, as illustrated in Figure 4. It integrates BIM models with real-time data on schedule quality, safety, cost, and energy efficiency. This integration enables the dynamic updating of management data, providing all stakeholders with a transparent and comprehensive view of the project's progress.

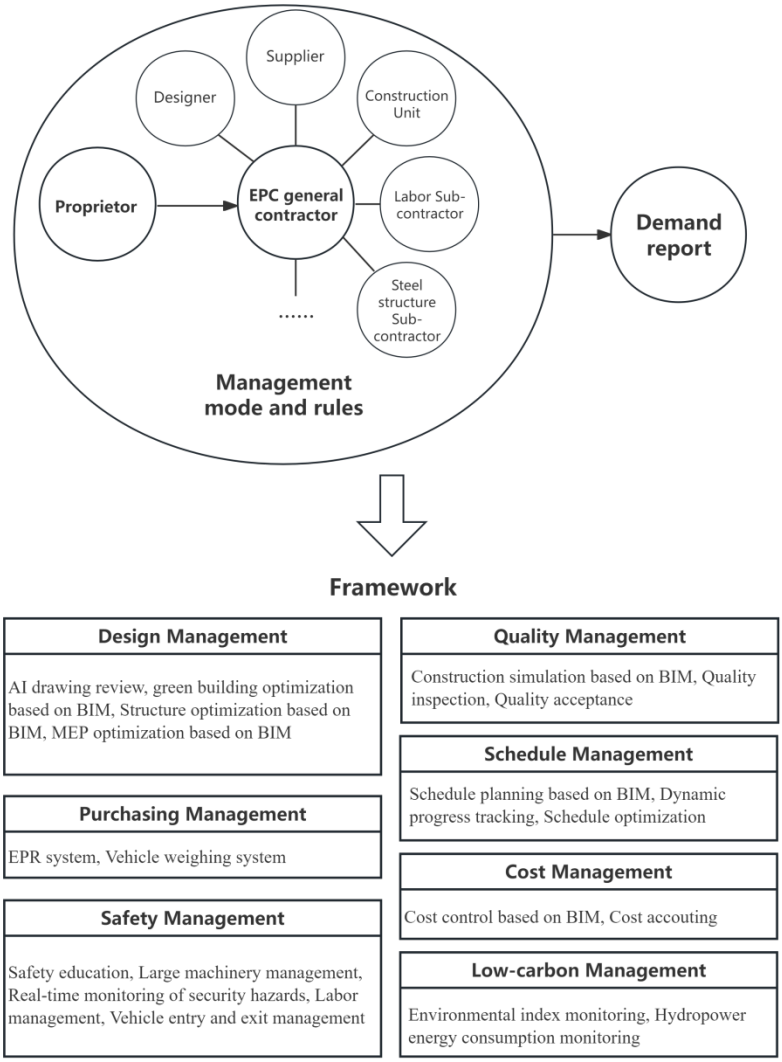


**Fig. 4.** The framework of collaborative management platform of a hospital EPC project in Yunnan Province.

### 4.3 Digital Hardware and Software Configuration

Hardware, software, and supporting facilities serve as the foundation of digital construction. These typically include information collection devices, network infrastructure, application terminals, and related software systems. Based on the digital construction management objectives of this project, various hardware facilities and devices were selected, as detailed in Table 1.

**Table 1.** List of hardware infrastructure application.

| Category | Serial number | Name |
|---|---|---|
| Information Collection Class | 1 | Video surveillance |
| | 2 | Face recognition access control equipment |
| | 3 | Site real name system attendance equipment |
| | 4 | Smart safety hat |
| | 5 | Vehicle identification equipment |
| | 6 | Vehicle weighing equipment |
| | 7 | Environmental sensor(Temperature and humidity sensor,PM2.5 sensor, Atmospheric pressure sensor, Noise detector, etc.) |
| | 8 | Safety sensor (Moment sensor, Tilt sensor, Displacement sensor, Pressure sensor, etc.) |
| | 9 | Resource monitoring (Water level sensor, Data collector, etc.) |
| | 10 | Drone |
| Information Transfer Class | 1 | Wired network Facilities (base stations) |
| | 2 | Wireless network facilities (WIFI, Bluetooth, etc.) |
| Application Terminal | 1 | Fixed terminal (computer, smart display board, etc.) |
| | 2 | Mobile terminal (mobile phone, tablet, etc.) |

## 4.4 Application Scenarios

### *4.4.1 AI Drawing Review*

The Rule Base uses AI to automatically review BIM models and design drawings, ensuring compliance with building codes and standards. It identified and flagged over 300 issues, including code violations, design errors, and omitted openings, enhancing design accuracy and regulatory adherence.

### *4.4.2 Multi-Disciplinary Clash Detection*

By integrating architectural, structural, and MEP BIM models, the platform enables cross-standard clash detection. It automatically identifies geometric errors, generates detailed conflict reports, and creates sectional views of any component.

### *4.4.3 Labor Management System*

The system uses biometric technology to verify personnel identity, ensuring only authorized access to the construction site. It monitors entry and exit records in real time, detects anomalies like unauthorized access or prolonged open doors, and enhances site safety. Attendance data is linked to the wage management system, supporting wage distribution.

#### *4.4.4 On-Site Material Management System*

The platform enables intelligent material management through AI-powered smart terminals, mobile and electronic tag tracking, data-driven decisions, and cloud-based knowledge extraction. It includes planning, procurement, inspection, inventory, and cost management. IoT automatically collects accurate data, allowing real-time monitoring of material arrival and usage, offering quantitative support for material management and settlement.

#### *4.4.5 Progress Visualization and Dynamic Control System*

Based on the BIM model, the platform integrates MSPROJECT or PRIMAVERA schedules, enabling Gantt chart visualization to intuitively display project timelines and key milestones. Project managers can input actual progress, and the system compares it with planned progress, issuing early warnings for delays at critical nodes.

#### *4.4.6 Real-Time Cost Dynamic Control System*

By integrating cost data with the BIM model, a 5D model is created to facilitate quantity calculation, multi-dimensional cost analysis, and real-time cost tracking. When design changes occur, the system swiftly recalculates quantities and updates the bill of quantities, ensuring accurate cost allocation for modified components. It predicts resource needs, identifies investment risks, and conducts financial analysis. And it monitors progress, actual costs, and completed quantities in real time, compares them, alerts for cost overruns.

#### *4.4.7 Water Resource Recycling and Monitoring System*

The platform integrates IoT-based rainwater controllers, sensors, valves, tanks, and pumps to create a smart system for rainwater collection, treatment, storage, and use. Rainwater is filtered, adsorbed, and disinfected to meet standards, then allocated for site greening, road cleaning, and vehicle washing. It maximizes resource use, reduces water pressure, cuts sewage discharge, and minimizes environmental impact.

### 4.5 Application Effect

The implementation of the collaborative management platform in this project has delivered significant benefits across multiple dimensions. By real-time data collection, dynamic simulation, early warning and intelligent decision-making, to effectively improve the organization and coordination of project participants, enhance project management capabilities, optimize schedule and cost, ensure quality and safety, reduce risks and hazards, and ensure management informatization and traceability.

## 5 Conclusion

As digital twin technology continues to evolve, its potential in EPC (Engineering, Procurement, and Construction) project management is poised to expand significantly,

driving innovation and delivering substantial value to the industry. The digital twin-based collaborative management platform addresses critical challenges in traditional EPC project management, such as information silos, inefficient collaboration, and limited dynamic control capabilities. By enabling real-time data interaction, dynamic simulation, and intelligent decision-making, the platform facilitates high-quality, efficient, and cost-effective project delivery. In the future, intelligent solutions for collaborative management of EPC projects based on digital twins can be further explored from the aspects of (1) AI, (2) expansion of multi-project collaboration functions, and (3) integration of digital twins with emerging technologies such as blockchain.

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