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# Research on BIM Digital Collaborative Design System for Highway Tunnel Electromechanical

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***Abstract***

*To address the issues of low efficiency in manual CAD drafting, labor-intensive BIM modeling, insufficient multi-disciplinary collaboration, and fragmented management of design deliverables that currently characterize highway tunnel electromechanical design, this study proposes a BIM-based digital collaborative design system that integrates CAD digital design, BIM automatic modeling, a collaborative design platform, and a core database. Built on AutoCAD and Revit secondary development technologies, the system enables the automatic generation of layout drawings and intelligent quantity estimation for four major disciplines, namely lighting, fire protection, ventilation, and monitoring. Through fully data-driven modeling, it realizes the automatic mapping of CAD design data to BIM models and parameter-driven modeling. In addition, a data linkage mechanism between civil engineering and electromechanical disciplines and an inter-disciplinary clash detection algorithm are established, enabling one-click regeneration of electromechanical deliverables after changes to the main tunnel design. The results of application testing show that the system shortens the tunnel electromechanical design cycle by more than 60%, reduces BIM modeling time by 80%, and achieves a quantity estimation accuracy exceeding 99%, thereby providing an efficient and intelligent digital solution for highway tunnel electromechanical design with promising prospects for widespread application.*

***Keywords***

*tunnel electromechanical engineering, BIM, digital collaborative design, CAD secondary development, AutoCAD, Revit*

**Introduction**

With the strategic advancement of "Digital China" and the goal of becoming a transportation powerhouse, the deep integration of new infrastructure driven by digitalization with traditional infrastructure has become the main battleground for the development of the transportation infrastructure industry. The electromechanical auxiliary systems of highway tunnels encompass five major subsystems—lighting, monitoring, ventilation, fire protection, and power supply—which are critical to ensuring tunnel operational safety and efficiency. However, current tunnel electromechanical design still relies primarily on manual CAD drafting and manual quantity takeoff, with BIM modeling heavily dependent on manual operations, weak multi-disciplinary collaboration mechanisms, and decentralized storage of design deliverables. The overall level of informatization is inadequate to meet the urgent demands of the digital era for efficient, precise, and collaborative design.

As a core technology of digital design, BIM has been widely applied in the global building engineering sector since its introduction in the early 21st century (Eastman, Teicholz, Sacks et al., 2018). Eastman et al. (2018) systematically articulated the integrated application framework of BIM throughout the full lifecycle of building design, construction, and operation and maintenance, emphasizing the core value of data-driven modeling and information collaboration. However, the application of BIM technology in the field of highway tunnel electromechanical engineering remains in its exploratory stage. Volk et al. (2014), through a systematic review of BIM applications in existing buildings, pointed out that the extension of BIM from the building sector to infrastructure still faces common challenges such as inconsistent data standards and insufficient interdisciplinary collaboration. Bradley et al. (2016), in their review of BIM infrastructure applications, further noted that BIM applications for linear infrastructure (e.g., highways and tunnels) started later than in the building sector, with notable gaps remaining in parametric modeling, multi-disciplinary collaboration, and integrated data management.

In recent years, the International Tunnelling and Underground Space Association (ITA-AITES) has proposed the concept of Tunnelling Information Modelling (TIM), aiming to extend BIM methodologies to the full lifecycle management of tunnel engineering. Sanfilippo et al. (2025) systematically constructed a sustainable lifecycle management framework for TIM, clarified the transformation path from Project Information Model (PIM) to Asset Information Model (AIM), and emphasized the value of integrated digital tool applications across the design, construction, and operation phases of tunnels. Borrmann et al. (2015). proposed a multi-scale geometric semantic modeling method for shield tunnels, achieving the integrated application of GIS and BIM and providing a new paradigm for spatial data integration management in tunnel engineering. In the area of tunnel lighting design, Wang et al. (2016). proposed a BIM-based method for assessing tunnel light environments, which addressed the issue of traditional 2D CAD design being unable to holistically evaluate lighting conditions through 3D simulation, significantly improving both the scientific rigor and efficiency of tunnel lighting design.

In the field of tunnel ventilation and safety, López González et al. (2014) employed computational fluid dynamics (CFD) methods to conduct three-dimensional numerical simulations of the piston effect in longitudinal ventilation systems of subway tunnels, providing a refined analytical approach for optimizing ventilation system design. Deng et al. (2023), through experimental and numerical simulation studies, investigated the influence of water spray systems on flow fields in longitudinally ventilated tunnels, offering a theoretical basis for the coupled design of tunnel fire protection and ventilation systems. These studies provide important theoretical support and methodological references for the digital design of individual tunnel electromechanical sub-disciplines. However, systematic solutions are still lacking in terms of integrated multi-disciplinary collaborative design, automated CAD-to-BIM conversion, and centralized management of design deliverables.

To address the above technical bottlenecks, this study developed a highway tunnel BIM-based electromechanical digital collaborative design system. The system integrates four major modules—CAD digital design, BIM automatic modeling, a collaborative design platform, and a core database—and leverages secondary development technologies based on AutoCAD and Revit to achieve automated design and intelligent management for disciplines including lighting, fire protection, ventilation, and monitoring. Its core innovations lie in: achieving seamless linkage between civil and electromechanical information by automatically extracting tunnel main structure design data; employing a fully data-driven modeling strategy that automatically maps CAD design parameters to BIM 3D models; and, through a BS-architecture-based collaborative design platform, enabling centralized management and efficient sharing of technical documents, drawings, models, and data throughout the entire design process. Application test results demonstrate that the system significantly improves design efficiency and quantity takeoff accuracy, providing an integrated, full-process digital solution for highway tunnel electromechanical design.

## 1. Current Status and Limitations of Tunnel Electromechanical Digitalization Technology

### *1.1 Research Status at Home and Abroad*

Domestically, research on highway tunnel electromechanical design software has established a certain foundation. In 2002, Chang’an University developed the tunnel ventilation parametric design software VDSHT, which is capable of performing calculations and scheme comparisons for various ventilation types. However, this software possesses only computational analysis functions and lacks CAD drafting capabilities, rendering it unable to meet the practical needs of ventilation design drawing. In 2010, Shanghai Tongyan Civil Engineering Technology Co., Ltd. developed an auxiliary design software for road and tunnel lighting systems, which preliminarily realized CAD-based drafting functions for tunnel lighting design. Nevertheless, it is only a parametric drafting tool without a supporting database and supports only luminaire layout functions. In 2018, Hangzhou Dianzi University developed a tunnel lighting design software that implemented lighting simulation and design functions based on the Winform framework. However, its drafting relies on GDI+ and is not linked to CAD, nor can it automatically retrieve tunnel main structure design data. In the fire protection and monitoring disciplines, there is no specialized design software available domestically, only operations management software. Additionally, the Hongye cable tunnel design software can complete standard cross-sectional design for cable tunnels but lacks collaborative design capabilities with other electromechanical disciplines.

At the international level, research on BIM applications in tunnel and underground engineering has made significant progress in recent years. Alaghbandrad and Hammad (2018) proposed the Smart Multi-Utility Tunnel Information Model (SMUTIM) framework, which clarifies the information requirements and application scenarios of BIM in the full lifecycle management of utility tunnels, providing a systematic approach for integrated BIM management of underground utility corridors. Yin et al. (2024), based on BIM technology, proposed a spatiotemporal conflict detection and optimization method for underground pipeline construction. Through a 4D detection process and a mixed-integer linear programming model, they reduced the spatiotemporal conflict occurrence rate from 45.5% to 0%, significantly improving the efficiency of multi-disciplinary collaborative design. Xu et al. (2025) proposed an electromechanical-structural conflict coordination system integrating path planning and augmented reality (AR) navigation, achieving intelligent identification and on-site coordination optimization of MEP pipeline conflicts in complex intersection areas, offering a new approach for resolving multi-disciplinary conflicts in tunnel electromechanical systems.

In the realm of tunnel information modeling and digital twins, international research has evolved from single 3D modeling toward full-lifecycle digital management. The TIM framework proposed by the ITA-AITES working group (Sanfilippo R, Esfandiari M, Foria F, et al., 2025) emphasizes information continuity and data interoperability from the design phase to the operations and maintenance phase. Meanwhile, Altay and Surmen (2017), based on CFD methods, conducted effectiveness studies on new concepts for longitudinal tunnel ventilation, verifying the performance of novel ventilation designs in tunnel fire safety and demonstrating that intelligent ventilation system design holds significant potential in meeting the latest tunnel safety standards. The aforementioned international studies provide rich theoretical methods and technical references in areas such as tunnel BIM modeling, multi-disciplinary collaboration, conflict detection, and ventilation safety design. However, most of them focus either on the tunnel main structure or on a single electromechanical discipline, lacking systematic solutions that cover integrated collaborative design across lighting, ventilation, fire protection, and monitoring disciplines, and have not established automated transformation mechanisms from CAD design data to BIM models.

From the perspective of technological development trends, tunnel electromechanical design technology is exhibiting the following trajectories: first, evolving from single-discipline parametric tools toward integrated multi-disciplinary collaborative systems; second, transitioning from manual CAD drafting to data-driven automated drawing generation; third, advancing BIM modeling from manual operations to fully data-driven automated modeling; and fourth, upgrading design deliverable management from decentralized file storage to centralized database management platforms. In addition, the deep integration of Digital Twin technology with BIM is becoming a new direction for the digital development of tunnel engineering (Sanfilippo, Esfandiari, Foria et al., 2025; Borrmann, Kolbe, Donaubauer et al., 2015), enabling an information feedback loop between the design and operations phases through real-time data collection and dynamic model updates. Azhar (2011) pointed out that future development trends of BIM technology include integrated applications with emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI), which will open up broader technological pathways for the intelligent design and management of tunnel electromechanical systems.

*1.2 Limitations of Existing Systems*

Although extensive research has been conducted at home and abroad on tunnel electromechanical design software, the following common limitations remain. At the technical level, existing software mostly focuses on a single discipline (lighting or ventilation) and lacks an integrated design system covering multiple disciplines such as lighting, fire protection, ventilation, and monitoring. CAD and BIM design data are disconnected, and no effective linkage mechanism has been established between the main works and the electromechanical works, so that repeated manual modification is required after design changes. Core processes such as BIM modeling and quantity calculation still rely on manual operation and lack fully data-driven automation, resulting in high technical costs and low efficiency. At the application level, existing software generally lacks multi-disciplinary collaborative design functions, has insufficient extensibility, and finds it difficult to adapt to the multi-scenario requirements of different technical standards, tunnel lengths, and numbers of lanes. Furthermore, foreign software is detached from the mainstream domestic CAD design environment, does not meet domestic design codes and engineering practice requirements, and is therefore difficult to promote and apply directly. Consequently, developing a tunnel electromechanical digital collaborative design system that covers multiple disciplines and the entire workflow is of significant engineering value.From an international perspective, Volk et al. (2014), in their review of BIM applications, pointed out that BIM implementation in the infrastructure sector still faces systemic obstacles such as inconsistent data standards and insufficient information interoperability, which are particularly prominent in multi-disciplinary collaborative design of tunnel electromechanical systems. Bradley et al. (2016) further emphasized that the primary bottleneck in BIM applications for linear infrastructure lies in the lack of design automation tools and centralized data management platforms oriented toward multi-disciplinary integration. Moreover, the implementation of existing international BIM standards (e.g., ISO 19650) in the field of tunnel electromechanical engineering remains incomplete. Borrmann et al. (2015) noted that the application of multi-scale geometric semantic modeling in tunnel engineering is still in its infancy, and the data association mechanism between electromechanical facilities and the main structure lacks standardized definitions. Therefore, there is an urgent need to develop a tunnel electromechanical integrated design system that deeply integrates CAD digital design, BIM automatic modeling, and a collaborative management platform, in order to overcome the aforementioned technical bottlenecks.

## 2. Design of the BIM-based Digital Collaborative Design System for Highway Tunnel Electromechanical Engineering

### *2.1 Overall System Architecture*

The core objective of this system is to realize the automation, collaboration, and intelligence of highway tunnel electromechanical engineering design through highly integrated digital technologies. The system adopts a four-tier overall technical architecture, namely “client layer – service layer – core layer – BIM extension layer”. The client layer consists of a desktop client integrating CAD functions (through AutoCAD secondary development) and a web client supporting remote collaboration (implemented with Vue.js), and is responsible for user interaction. The service layer is built on the JNPF framework, takes RESTful APIs as its core, and is responsible for business logic processing and data management. The core layer encapsulates core business logic such as project management, tunnel design, and the design algorithms of each electromechanical discipline, serving as the core engine of digital design and collaborative mechanisms. The BIM extension layer realizes multi-CAD-platform adaptation and BIM model conversion through the Revit API, achieving the full-process transition from two dimensions to three dimensions. The various layers realize data linkage through standardized data interfaces and communication protocols, forming a complete technical chain of “front-end interaction – service scheduling – core computation – BIM output”.The overall technical architecture of the system platform is shown in Figure 1.

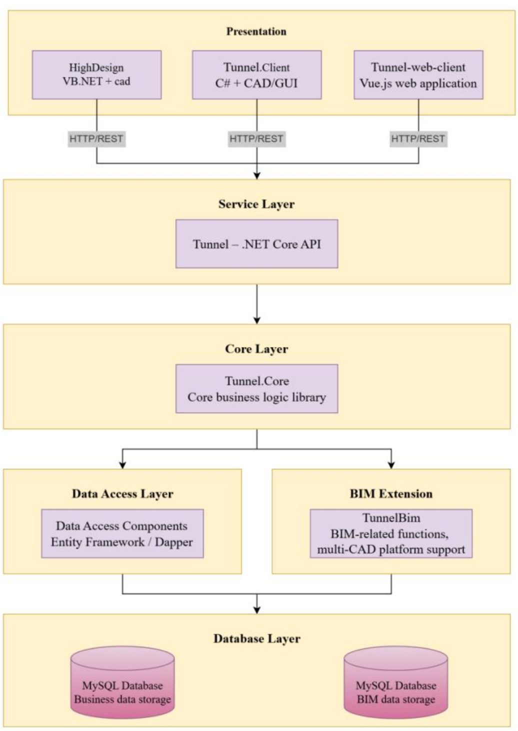



**Figure 1. Overall Technical Architecture of the System**

*2.2 CAD Digital Design Module*

The CAD digital design module adopts a three-layer architecture of “interaction layer – data processing layer – output layer” and covers the four subsystems of lighting, ventilation, fire protection, and monitoring. The interaction layer provides a visual operation interface (menu bar, parameter forms, and drawing preview); the data processing layer invokes the design algorithms of each discipline to perform core computations such as facility positioning, chainage calculation, and clash detection; and the output layer generates standardized engineering drawings based on CAD drafting algorithms and synchronizes them to the core database.

The lighting subsystem realizes the bidirectional symmetric automatic arrangement of luminaires by constructing a geometric boundary calculation model of the lighting zone. The system first calculates the length, starting point, and midpoint chainages of the lighting zone based on the tunnel portal chainages and the luminaire safety spacing parameters, then determines the lighting zone divisions (threshold zone, transition zone, interior zone, and exit zone) in accordance with the requirements of the specifications, and finally invokes the luminaire positioning algorithm to perform the bilateral staggered arrangement calculation and automatically generate the luminaire plan layout, cross-section layout, and luminaire list.The BIM model of the lighting facilities is shown in Figure 2.

The ventilation subsystem realizes the automatic calculation of fan arrangement based on a segmented CO concentration calculation model. The algorithm adopts a segmented concentration adaptation strategy according to tunnel length: a constant concentration design (CO = 150 ppm) is used when the length is less than 1000 m; a linearly decreasing model ($CO = -0.025 \times L + 175$) is used when the length ranges from 1000 m to 3000 m; and a minimum-threshold constant design (CO = 100 ppm) is used when the length is greater than 3000 m. Based on these concentration parameters, the system automatically calculates the number of fans and determines the fan chainages using a bidirectional symmetric arrangement algorithm.The BIM model of the ventilation facilities is shown in Figure 3.

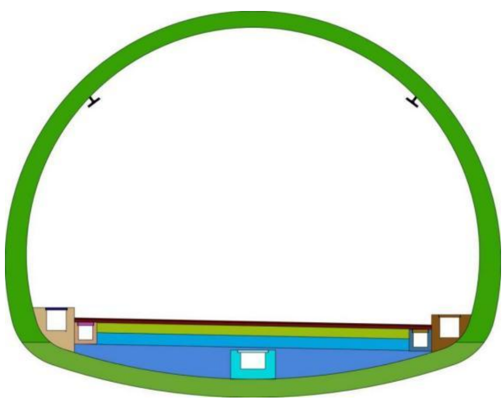


**Figure 2. Elevation View of the 3D Luminaire Model Layout**

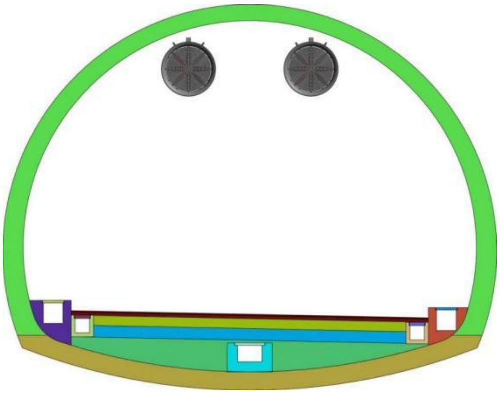


**Figure 3. Elevation View of the BIM Model Layout for Ventilation Facilities**

The fire protection subsystem realizes the automatic arrangement and spacing validation of facilities such as fire hydrants and fire extinguishers through a dynamic spacing calculation model of “remainder analysis – threshold adaptation – spacing adjustment”. According to the remainder relationship between the tunnel length and the preset spacing, the algorithm dynamically adjusts the starting distance of the facilities to ensure uniform distribution while meeting the safety distance requirements at the portals; it also supports bilateral staggered arrangement and the adaptation of facilities in special zones such as emergency parking bays.The BIM model of the fire protection facilities is shown in Figure 4.

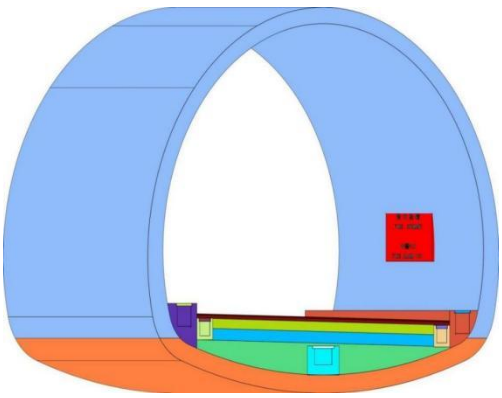
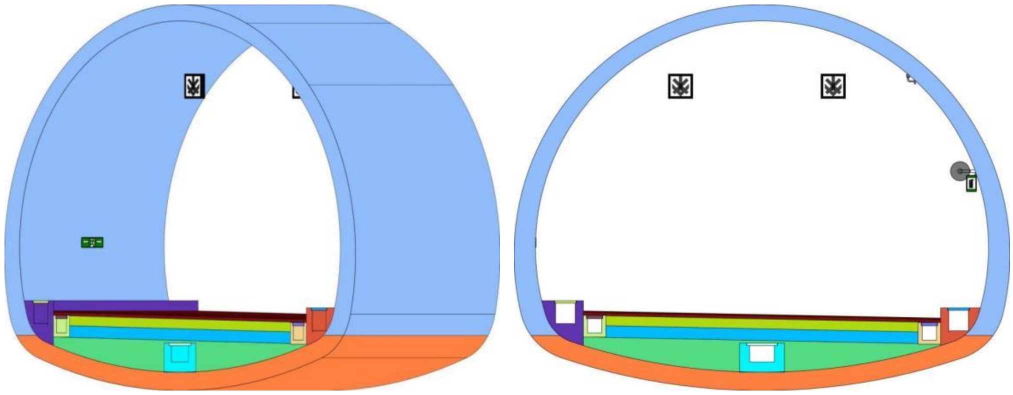
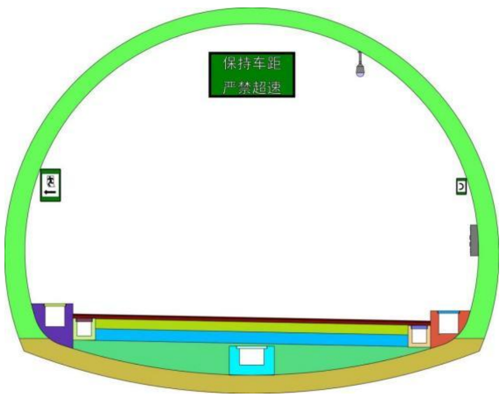


**Figure 4. Elevation View of the BIM Model Layout for Fire Protection Facilities**

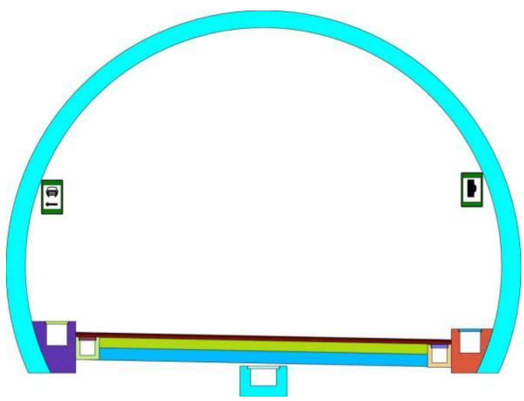
The monitoring subsystem adopts the design approach of “typed calculation + alignment-adaptive correction”, formulating dedicated chainage calculation logic for different types of facilities such as vehicle detectors, cameras, and variable message signs, and adapting to the special requirements of three tunnel alignment types—left line, right line, and single line—so as to realize the automatic arrangement of monitoring facilities without blind zones.The BIM model of the monitoring facilities is shown in Figure 5.



**(a)BIM Model of Tunnel Traffic Signals (b) BIM Model of Tunnel Surveillance Cameras**




**(c) BIM model of Tunnel Monitoring Signage**



**(d) BIM Model of Indicator Lights for Tunnel Transverse Passages and Emergency Parking Bays**

**Figure 5. BIM Models of Monitoring Facilities**

*2.3 BIM Digital Design Module*

The BIM digital design module is based on the Revit API and the .NET Framework and adopts an object-oriented design pattern to realize the automatic conversion of CAD design data into BIM models.

Its core algorithms include DirectShape geometry modeling, facility positioning, family instantiation, and coordinate transformation. The facility positioning algorithm is based on the relative coordinate transformation of the tunnel centerline and, in combination with the facility chainage, horizontal distance (XPos), vertical distance (YPos), and alignment type, calculates the precise spatial position and rotation angle. The family instantiation algorithm supports level-based placement (OneLevelBased) and work-plane-based placement (WorkPlaneBased), realizing the fully data-driven automatic arrangement of electromechanical facilities such as lighting luminaires, fire cabinets, fans, and cameras. Before modeling, the electromechanical facility family files (.rfa) must be loaded and managed by discipline, and the system automatically matches family types with design parameters to complete parameter-driven modeling.Its technical architecture is shown in Figure 6.

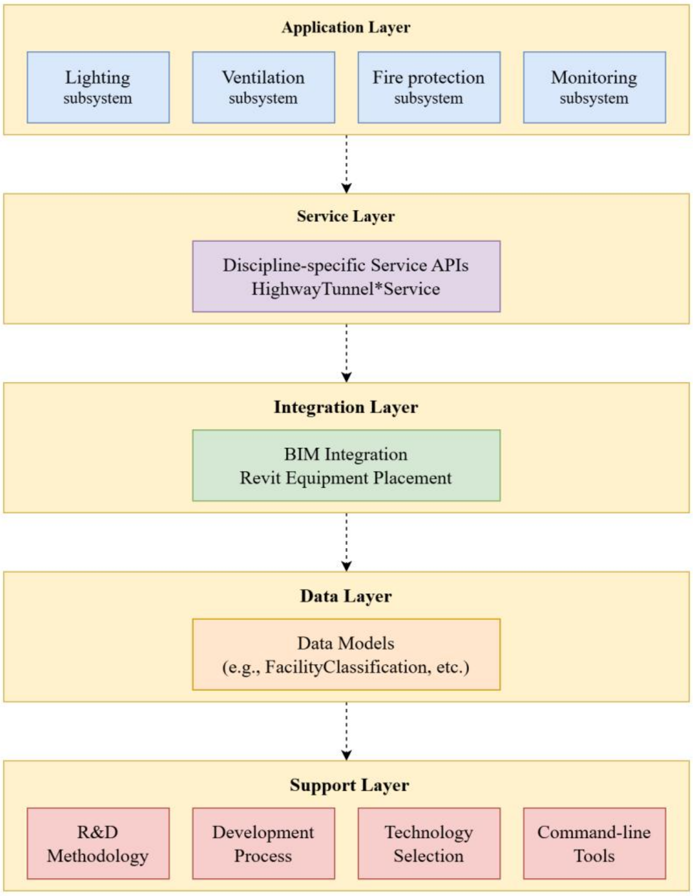



**Figure 6. Technical Architecture of the Highway Tunnel BIM System**

The system automatically drives Revit to construct BIM models based on CAD design data, so that the BIM models and CAD drawings share the same data source and remain consistent, with model accuracy meeting the requirements of design-stage applications. After a change in CAD design parameters, the BIM model can be updated automatically, ensuring the consistency of two-dimensional and three-dimensional design deliverables. Once BIM modeling is completed, the Revit walkthrough function or a Three.js-integrated web interface can be used to realize the simulation display of the overall arrangement of electromechanical facilities, supporting functions such as three-dimensional visualization, in-tunnel walkthrough, clash inspection, and design verification.

*2.4 Collaborative Design Platform*

The collaborative design platform adopts a B/S architecture and is responsible for the overall collaborative management, technical data management, and deliverable management of tunnel electromechanical digital design. Centered on the four disciplines of lighting, fire protection, ventilation, and monitoring, the platform provides integrated functions including project information browsing, parameter configuration, facility lists, quantity statistics, online viewing of CAD drawings, and lightweight display of BIM models. The platform establishes a data linkage mechanism between civil engineering and electromechanical disciplines—it automatically extracts the main tunnel design data (portals, structural segments, cross passages, etc.) for electromechanical design, so that electromechanical deliverables can be regenerated with one click after the main design parameters are adjusted. At the same time, the platform realizes automatic clash detection and intelligent adjustment among the electromechanical disciplines: through spatial overlap analysis and safety spacing verification, it automatically identifies and flags spatial conflicts of facilities such as fans and fire protection pipes, and supports batch optimization or manual adjustment.The digital collaborative design modules for tunnel electromechanical engineering are shown in Figure 7.

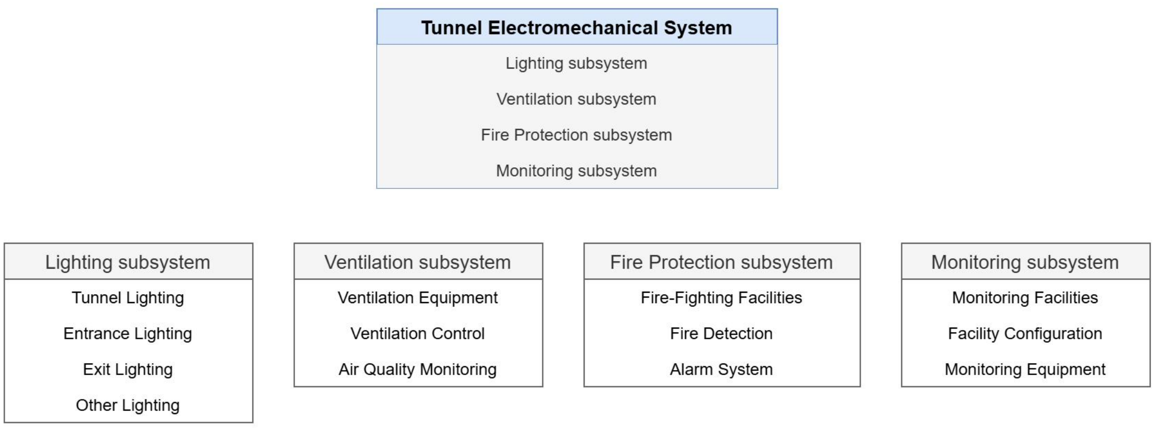



**Figure 7. Digital Collaborative Design Modules for Tunnel Electromechanical Engineering**

The core database is the data hub of the system. It adopts a hybrid storage strategy of “relational database (MySQL) + object storage (MinIO)” and divides the data into four domains—lighting, fire protection, ventilation, and monitoring—by discipline. Each database adopts a unified data model design approach, using the tunnel ID and the business scheme version ID as key association fields, and clarifies the association relationships of entities at each level through an entity-relationship model. Fine-grained management of data access permissions is realized based on the JWT and RBAC models, ensuring data security and consistency.

## 3. System Implementation and Testing

### *3.1 System Development Environment and Tools*

The development of this system is based on the C# programming language and the .NET Framework/.NET Core platforms, leveraging their native advantages in Windows desktop application development and in AutoCAD and Revit secondary development. The desktop client is developed based on the .NET Framework and the AutoCAD API and adopts the MVVM architecture pattern; the web client is based on the Vue.js and Element UI frameworks and adopts an SPA (Single Page Application) design; and the server side is built on .NET Core and the JNPF framework, adopts the RESTful API specification, and uses the SqlSugar ORM for database operations. MySQL is used to store structured data, MinIO object storage manages unstructured files (drawings and models), and Redis is used for cache acceleration. During development, Git is used for version control and Docker container technology is used for application deployment, ensuring the consistency and portability of the system in different environments.

In terms of the hardware platform, the system is deployed on high-performance computing servers equipped with high-speed CPUs, large-capacity RAM, and fast SSD storage to support real-time data processing and analysis. For video image processing requirements, GPU acceleration technology is adopted, which significantly improves processing speed and shortens response time during the BIM model training stage.

### *3.2 System Implementation Process*

The system implementation follows the principle of modular design and proceeds along a progressive path of "requirement decomposition – module development – integration testing – engineering validation". During development, the data acquisition module is implemented first, which is responsible for automatically extracting fundamental data such as portals, structural segments, and cross passages from the main tunnel design deliverables. Next, the data processing and analysis module is developed to realize the design algorithms and quantity calculation algorithms of each discipline. The intelligent decision support module is the core of the system: according to the design parameters and specification requirements, it automatically generates facility arrangement schemes and collaborative validation reports. Finally, the user interaction interface module is developed: the desktop end is integrated into the AutoCAD environment, providing interactive tools such as menus, parameter forms, and drawing previews, while the web end provides collaborative functions such as online browsing, data query, and deliverable management. After all modules were completed, detailed integration testing was carried out to ensure efficient collaboration among the modules and accurate data transmission. The interface design follows the principles of conciseness and intuition: the main interface clearly displays key information such as real-time design parameters, facility lists, and engineering quantities, supports interactive functions such as search, filtering, and sorting, and provides report generation and data export functions.

### *3.3 System Testing and Evaluation*

After the system was developed, comprehensive functional testing and performance evaluation were carried out. The functional testing covered the core functional modules of all subsystems and verified the system's capabilities in collecting, processing, and analyzing design data and in generating accurate design deliverables by simulating the design scenarios of different tunnel types (short, medium, and long tunnels) and different technical grades (expressways, Class I highways, and Class II highways). The performance evaluation focused mainly on the system's processing speed, stability, and scalability, and assessed the system's performance under high load through stress testing and long-duration operation testing.

To verify the applicability and reliability of the system in actual engineering design, the project team selected three actual tunnel electromechanical design projects of different types—a short tunnel (≤1000 m), a medium tunnel (1000 m–3000 m), and a long tunnel (>3000 m)—as validation cases, completing the engineering design application testing of three tunnels in total. The test results show that the lighting discipline automatically completed the bidirectional symmetric arrangement of luminaires and generated plan layouts, cross-section drawings, and luminaire lists; the ventilation discipline automatically completed the CO concentration calculation and the bidirectional symmetric arrangement of fans; the fire protection discipline automatically completed the spacing calculation and arrangement of fire hydrants and fire extinguishers; and the monitoring discipline automatically completed the alignment-adaptive chainage calculation and arrangement of facilities such as cameras and vehicle detectors. Upon manual verification, the accuracy of quantity statistics reached more than 99%, a significant improvement over the traditional manual statistics approach (about 90% accuracy).

Taking a single medium tunnel (approximately 2100 m in length) as an example, the traditional manual design approach requires about 15–20 working days to complete the CAD drawings, BIM modeling, and quantity statistics of the four disciplines, whereas after the application of the system only about 3–4 working days are required, improving design efficiency by about 75%–80%. In the collaborative design verification, the system successfully implemented the civil–electromechanical data linkage mechanism, so that electromechanical deliverables could be regenerated with one click after the main design parameters were adjusted, and successfully identified 3–5 spatial conflicts of facilities, which were eliminated after adjustment.

## 4. Conclusions

This study successfully designed and implemented a BIM-based digital collaborative design system for highway tunnel electromechanical engineering. By integrating four core components—CAD digital design, BIM automatic modeling, a collaborative design platform, and a core database—the system effectively addresses the problems existing in current highway tunnel electromechanical design, such as low efficiency, poor collaboration, difficult BIM modeling, and fragmented deliverable management. Based on the main tunnel design parameters, the system can automatically complete the facility arrangement calculation, CAD drawing generation, BIM model construction, and quantity statistics of the four disciplines of lighting, fire protection, ventilation, and monitoring, and can realize automatic clash detection and intelligent adjustment among disciplines.

The implementation and test results show that the system can shorten the tunnel electromechanical design cycle by more than 60%, reduce BIM modeling time by 80%, and achieve a quantity statistics accuracy exceeding 99%, significantly reducing the time and labor costs of the design stage. The civil–electromechanical data linkage mechanism effectively solves the difficulty of multi-disciplinary collaboration, and the design change response time is reduced from several days to the minute level. The four-in-one technical system of "collaborative platform + CAD + BIM + database" constructed in this study forms a digital design solution for highway tunnel electromechanical engineering that covers all disciplines and the entire workflow. It fills the technical gap in the field of multi-disciplinary, full-process digital collaborative design of tunnel electromechanical engineering in China and is of great significance for promoting the leapfrog transformation of highway tunnel electromechanical design in China from manual operation to intelligent digitalization.

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