Scholar Publishing Group
International Journal of Engineering Technology and Construction
https://doi.org/10.38007/IJETC.2025.060101
ISSN 2789-7176 Vol. 6, Issue 1: 1-9

Construction and Practical Exploration of Intelligent Transportation Management Platform

Wanbao Gao[1,a,*], Bo Yang[1,b], Bo Zhang[1,c], Chao Zhang[1,d], Feiyang Zhao[2,e], Aoyang Fu[2,f], Weiling Cai[3,g]

[1]*Ningbo Juema Information Technology Co., Ltd, Ningbo, China*
[2]*Ningbo University of Finance & Economics, Ningbo, China*
[3]*Donghua University, Shanghai, China*
[a]*714883940@qq.com*, [b]*ybseu2013@126.com*, [c]*252007505@qq.com*, [d]*1776555345@qq.com*, [e]*625977607@qq.com*, [f]*1121389996@qq.com*, [g]*1835511648@qq.com*
[*]*corresponding author*

Keywords: Intelligent transportation; Management platform; Construction practice

Abstract: The urbanization process shows a rapid development trend, the urban population continues to grow, the number of motor vehicles has risen sharply, resulting in traffic congestion, frequent accidents and low efficiency of resource use and other problems become more serious, has become an important bottleneck restricting the sustainable development of cities. In this context, the construction of intelligent traffic management platform came into being and became the key and effective way to solve these intractable traffic problems. Through in-depth research on the construction cases of intelligent traffic management platform in several regions in China, this paper analyzes its current situation and common problems, and elaborates the key elements of platform construction, including infrastructure digitization, data brain construction, new infrastructure promotion and safety operation and maintenance guarantee. Taking the smart traffic management platform in Shifang City and Suide County as examples, the effectiveness and operation mechanism of the platform in practical application were discussed, and successful experiences were summarized, such as the deep integration of technology and business, multi-department cooperation and so on. Finally, the future development direction of the intelligent traffic management platform is prospected, aiming to provide theoretical and practical reference for promoting the continuous optimization and wide application of the intelligent traffic management platform, and help urban traffic management to move forward to intelligent and efficient.

1. Introduction

With the acceleration of urbanization and the improvement of living standards, urban transportation is facing numerous severe challenges, including increasingly severe traffic

congestion, frequent traffic accidents, and worsening environmental pollution. Traditional traffic management methods can no longer meet the demands of the rapid development of modern transportation. These methods often struggle to cope with complex and dynamic traffic conditions, resulting in low management efficiency and limited-service levels.

The advent of smart traffic management platforms provides an effective solution to these problems. These platforms leverage advanced information technologies such as the Internet of Things (IoT), cloud computing, big data, and artificial intelligence (AI) to achieve comprehensive, real-time perception, analysis, and control of traffic systems. For instance, by deploying various sensors, cameras, and vehicle-mounted positioning devices on roads, precise data on traffic flow, speed, vehicle location, and other parameters can be collected, enabling dynamic monitoring of traffic conditions and offering comprehensive and accurate data support for management departments.

On this foundation, smart traffic management platforms utilize big data analytics to uncover hidden patterns and problems within the data, assisting management departments in making scientifically sound decisions, such as optimizing traffic light timing and planning more rational traffic routes. These measures effectively alleviate traffic congestion and improve the efficiency of traffic management. Additionally, the platform can disseminate real-time traffic updates and travel suggestions to participants through intelligent information distribution systems. This enhances the travel experience of citizens, guides them toward more suitable travel options, helps reduce vehicle emissions, and improves urban environmental quality.

From a broader perspective, the construction of smart traffic management platforms is a key component in promoting smart city development. It plays a vital role in enhancing the overall competitiveness and sustainable development capacity of cities. Further improvements to these platforms provide valuable references for enhancing traffic management levels and service quality, contributing to the development of modern transportation toward greater intelligence, efficiency, and environmental sustainability.

2. Overview of typical regional construction cases in China

In recent years, various regions in China have actively promoted the construction of smart traffic management platforms, achieving significant results. The following is an overview of the construction efforts in Shandan County and Fushan District, Yantai City.

The Transportation Bureau of Fushan District, Yantai City, following the development strategy of “enhancing service quality and improving regulatory efficiency,” adopted a “government investment + social financing” approach to build and pilot a comprehensive and practical smart traffic management platform. This platform is closely aligned with relevant plans and guidelines from the Shandong Provincial Department of Transportation, drawing upon the experiences of advanced regions nationwide. It encompasses nine modules, including the safety standardization management of transportation enterprises, remote driver education and training, public travel management, and law enforcement management. The “smart regulation” application scenario (as shown in Figure 1) integrates the regulation of passenger and hazardous goods transport, freight, public buses, and taxis into a unified platform. It consolidates various administrative law enforcement and service functions of the transportation system, integrating 47,000 pieces of basic data on “people, vehicles, enterprises, and roads” into the platform. This data is fully shared and utilizes the provincial and municipal dynamic information public service platforms for key operational vehicles. It also connects with the Shandong Province Transport Administration 3.0 System, forming dynamic analysis, intelligent regulation, and targeted credit supervision applications without imposing additional economic burdens on industry-related transport enterprises

or vehicle owners. The system can automatically identify issues and complete the process of reporting, rectifying, handling, and providing feedback, establishing a closed-loop mechanism. It has achieved a closed-loop mode for safety production rectification in enterprise management, addressing shortcomings of traditional regulatory methods, such as inadequate coverage due to manpower shortages, and low efficiency in transportation services.

Based on the construction practices in these regions, it is evident that local governments have tailored smart traffic management platforms to meet their unique traffic needs and development goals. These platforms have played an active role in improving traffic conditions and enhancing management efficiency, providing practical references for further exploration of the key factors in building smart traffic management platforms.

Figure 1. Scenario application of "smart supervision"

3 Common problems existing at this stage

3.1 Data collection and processing

Firstly, the comprehensiveness and accuracy of traffic data collection remain insufficient in some regions. Due to the diversity of data sources, such as various sensors and monitoring devices from different manufacturers, the lack of unified standards and protocols leads to inconsistencies in interfaces and data formats, hindering data integration and sharing. For instance, traffic flow monitoring sensors installed on different road sections in some cities may vary in terms of data collection frequency and precision, making it challenging to aggregate and analyze the data. This, in turn, makes it difficult to accurately reflect the overall traffic situation.

Secondly, ensuring the real-time nature and validity of the data poses challenges. Traffic conditions are highly dynamic and require real-time updates; however, due to constraints in network transmission, device performance, and other factors, issues such as data transmission delays and losses frequently occur. Moreover, within the vast amounts of traffic data, there exist erroneous or

invalid data points. Current data cleaning and quality assurance mechanisms are inadequate, resulting in inefficiencies in identifying and eliminating these issues. Consequently, this affects the accuracy of decision-making and analysis based on the data.

Lastly, the depth of data mining and application is insufficient. Despite the accumulation of vast amounts of traffic data, many regions remain at a basic level of data analysis, focusing only on simple statistical summaries. They lack the use of advanced data analysis techniques, such as big data analytics and artificial intelligence algorithms, to uncover hidden traffic patterns, travel trends, and potential issues. As a result, the value of the data has not been fully realized.

3.2 System integration and collaboration

On the one hand, integrating information systems across different departments poses significant challenges. Traffic management involves multiple departments, such as traffic police, transportation bureaus, and road administration. Each department has developed relatively independent information systems based on their respective business needs. However, these systems often lack effective interconnectivity mechanisms, creating "information silos" that hinder data sharing and make collaborative management difficult to achieve. For example, if traffic accident data managed by the traffic police department cannot be timely integrated with road construction information held by the transportation bureau, it may reduce the efficiency of traffic diversion and emergency response.

On the other hand, there is insufficient coordination among smart transportation management platforms across regions. As inter-city connections grow closer and cross-regional traffic flows become more frequent, the smart transportation management platforms of different cities or regions often operate independently without unified coordination or interfacing mechanisms. This lack of integration limits the ability to allocate transportation resources across regions, optimize collaborative traffic planning, and improve the overall efficiency of regional traffic operations.

3.3 Capital investment and operation and maintenance

In terms of funding, the construction of smart transportation management platforms requires substantial upfront investment, including the procurement of large quantities of hardware equipment and the development of software systems. These initial costs are significant, and further funds are required for continuous technological upgrades and functionality expansion. In regions with limited fiscal budgets, meeting the demands of construction and development becomes difficult. Meanwhile, introducing private capital often encounters challenges such as determining collaboration models and profit-sharing mechanisms, leading to significant funding gaps that hinder project progress.

In terms of operations and maintenance, there is a shortage of specialized personnel who possess both traffic management expertise and information technology skills. This lack of multidisciplinary professionals makes it difficult to ensure the platform's stable operation and timely repair of faults. Additionally, the costs of updating and maintaining aging or damaged equipment remain high. Some regions lack a comprehensive maintenance management system and effective contingency plans. Consequently, unforeseen incidents can result in partial platform failures, disrupting its normal functionality.

In summary, these common issues highlight the need for targeted strategies to address the challenges in the construction and operation of smart transportation management platforms. By resolving these issues, the platforms can better realize their potential and contribute to the improvement of traffic management systems.

4 Key elements of platform construction

4.1 Digitalization of infrastructure

The digital enhancement of transportation infrastructure is a crucial foundation for the construction of a smart transportation management platform. By utilizing digital means, it can significantly enhance the data perception and collection capabilities of transportation infrastructure, laying a solid foundation for the efficient operation of the entire platform.

The large-scale deployment of cameras also plays a vital role. High-definition cameras installed at urban road intersections, main roads, and key sections of highways can not only capture real-time traffic scenes and accurately capture traffic violations but also utilize video analysis technology to dynamically monitor and analyze traffic parameters such as traffic flow, queue length, and lane occupancy.

In the process of building a comprehensive transportation "data brain," advanced technologies such as big data and cloud computing play a key role. Firstly, big data technology can aggregate and integrate traffic-related data scattered across various business systems and devices, including maintenance, law enforcement, operations, and safety supervision. These data, originally complex in terms of permissions, sources, and collection channels, are unified through a data platform built with big data technology, breaking down data barriers and achieving comprehensive data collection.

After data integration and aggregation, the more critical step is data sharing and intelligent application, forming an integrated platform for smart highways as shown in Figure 2. The "data brain" can deeply mine and analyze the integrated data, uncovering valuable information hidden behind the data, such as traffic patterns, travel trends, and potential issues, thereby providing a scientific basis for traffic management decisions and dispatch commands.

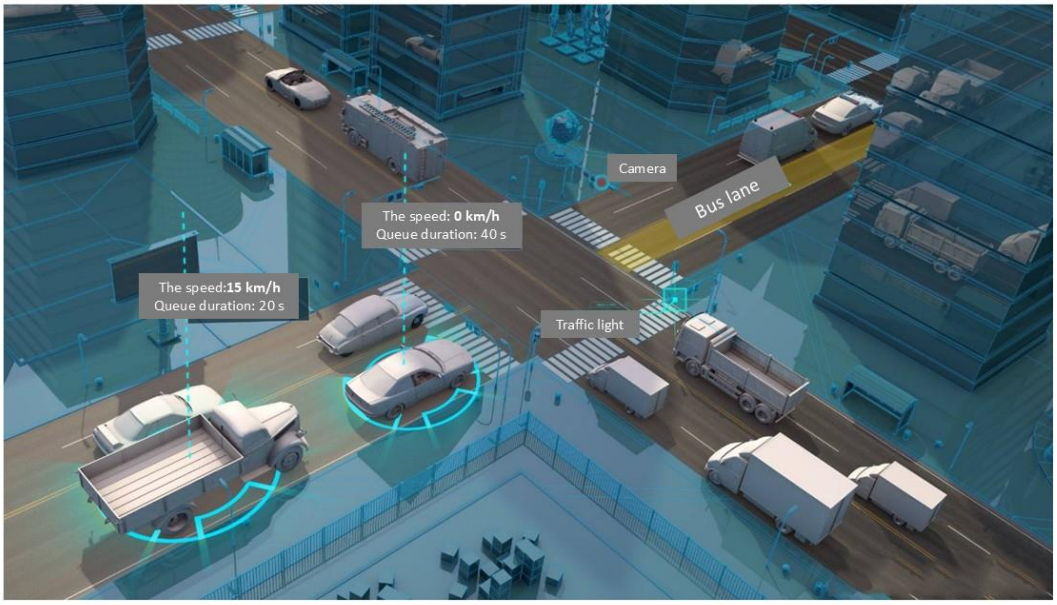

Figure 2. Smart Highway and Integration Platform

4.2 Promoting new infrastructure for smart transportation

The new infrastructure of smart transportation covers multiple aspects and plays an important role in the construction of the smart transportation management platform, among which the layout

of intelligent traffic signal systems and intelligent parking systems is particularly crucial.

As shown in Figure 3, the electronic toll collection system (ETC) is also an important component of the new infrastructure of smart transportation. It is widely used in highway toll stations and some urban expressways, allowing vehicles to automatically complete payment without stopping, greatly improving the efficiency of toll stations and reducing traffic congestion and exhaust emissions caused by parking payments. There is also the intelligent bus system, which installs positioning devices and intelligent dispatch terminals on buses to achieve real-time positioning, operation status monitoring, and intelligent scheduling of buses, enabling passengers to accurately grasp the arrival time of buses and arrange their travel plans reasonably, while also helping to improve the operational efficiency of public transport and enhance its appeal.

Various projects of smart transportation new infrastructure have optimized different links of traffic operation from different angles, directly enhancing the intelligence level and service quality of transportation, laying a solid foundation for creating an efficient, convenient, and green smart transportation system.

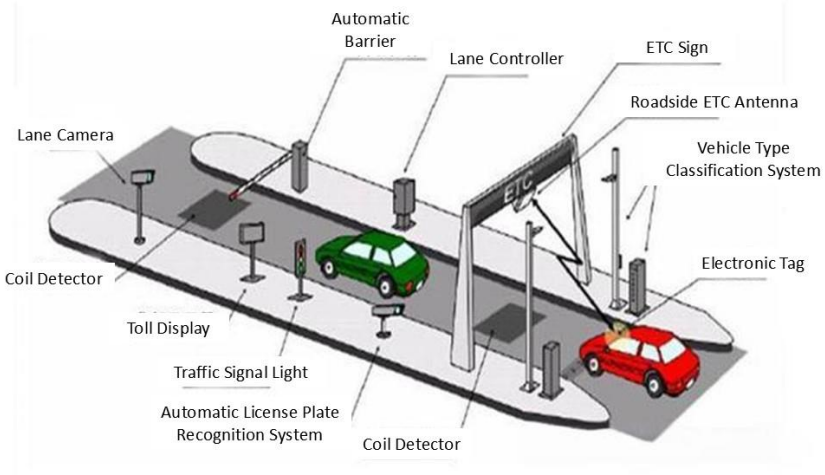

Figure 3. Electronic Non-stop Toll Collection (ETC)

4.3 Security and operation and maintenance strategy

In the construction process of the smart transportation management platform, safety and operational maintenance are crucial components that determine whether the platform can function continuously, stably, and securely.

Ensuring data security is one of the core issues. The transportation field involves massive amounts of data, including sensitive content such as personal travel information, traffic flow monitoring data, and road infrastructure conditions. To prevent data breaches, a strict data access permission management mechanism must be established. Data access levels should be assigned to staff based on their job functions and business needs.

Effective subsequent operational and maintenance management is a strong support for the long-term operation of the platform. Operational and maintenance work involves various aspects and requires a professional team equipped with a combination of transportation management knowledge and information technology skills. Team members should be familiar with traffic business processes, understand the meaning and purpose of various data types, and also master

technical means such as server maintenance, software upgrades, and network troubleshooting to efficiently handle various emergency situations.

In summary, only by building a secure and reliable operating environment and implementing effective operational and maintenance strategies can the smart transportation management platform continue to function, avoid risks such as data leaks and system failures, and truly assist the transportation management industry in moving towards a more intelligent and efficient direction.

5 Project Implementation Process

During the implementation of the project, the Smart Transportation Management Platform of Shifang City fully utilized various advanced technological methods to construct the platform and collect and analyze data.

Firstly, Digital Twin Technology was employed to create a 3D reconstruction of Beijing Avenue in Shifang City, forming a comprehensive 3D digital base for transportation. This digital base provides an intuitive and accurate virtual environment for subsequent traffic simulation, analysis, and management decision-making, reflecting the actual situation of roads and surrounding facilities.

Secondly, in terms of hardware equipment deployment, rational layouts of medium-high video stations and fixed overload control stations were implemented to monitor traffic conditions comprehensively. Medium-high video stations cover larger areas of road regions, capturing real-time traffic scenes and obtaining vehicle trajectories and flow information.

Lastly, in the aspect of software system development, a powerful software system was designed and developed to achieve real-time collection, processing, and analysis of traffic data. Raw data collected by sensors and video devices undergo preprocessing, cleaning, and analysis through the software system, extracting valuable information such as traffic flow trend changes and congestion node identification, providing strong support for scientific decision-making by traffic management departments.

5.1 Application effectiveness analysis

After the launch of the Smart Traffic Management Platform in Shifang City, significant application achievements have been made in several aspects.

Firstly, a unified management platform has been established, integrating business systems such as road administration law enforcement and road maintenance, thus overcoming the previous fragmentation and isolation of information across different systems. Now, managers only need to log into this platform to centrally view and manage all types of business information, greatly improving management efficiency and preventing repeated work or management loopholes caused by poor communication.

Secondly, data visualization has been achieved. With the aid of three-dimensional digital technology and big data, traffic data is presented in the form of “one map”. Managers can intuitively understand the traffic conditions at various intersections, including the volume of vehicles, speed, congestion status, etc., and these data can be updated in real time, providing intuitive and accurate references for traffic command, signal control, and other decision-making processes, helping to promptly identify traffic issues and take responsive actions.

Thirdly, remarkable results have been achieved in resource optimization. Through in-depth analysis of the massive amount of traffic data collected, the platform can accurately grasp the traffic flow patterns on different sections and during different periods, thereby enabling reasonable allocation of traffic resources.

5.2 Platform operation mechanism

The Suide County Intelligent Traffic Management Platform operates effectively by employing various methods to achieve intelligent traffic management. In terms of road condition presentation, a large number of sensors, high-definition cameras, and data sharing with relevant departments are used to collect real-time information about vehicle flow, speed, road occupancy, and so on. Then, cloud computing and big data technologies are applied to analyze and process this information, presenting an accurate overview of the entire jurisdiction's road conditions on a 'single map' displayed at the command center, making it easy for managers to understand the situation at a glance.

In terms of duty management, the platform uses AR video or roadside video to monitor the working status of traffic police officers in real-time. Points-based management is implemented to address situations where officers are absent from their posts, not performing their duties properly while on duty, or not fulfilling their responsibilities. Additionally, a responsibility area policing model is adopted in urban areas, implementing a road captain and police captain accountability system to clarify the scope of responsibilities for each traffic officer, making traffic management more refined and orderly.

Regarding risk and hazard assessment, the platform leverages the advantages of big data fusion analysis technology to integrate multi-source data for multidimensional analysis. A road transport enterprise traffic safety supervision system is constructed to monitor various potential risks in real-time during road transport. Particular attention is paid to factors like continuous driving duration of heavy-duty trucks and operating times and speeds of passenger and hazardous goods vehicles. Early warnings are issued for violations such as speeding and fatigue driving, allowing traffic police officers to intervene proactively, effectively preventing traffic accidents, and ensuring road safety.

6 Conclusions

As science and technology continue to advance and societal demand for transportation grows, the smart transportation management platform will evolve toward greater intelligence, synergy, and service orientation in the future. The following outlines its anticipated development directions in terms of integrating new technologies, cross-regional collaboration, and service expansion.

In the future, the smart transportation management platform will integrate more cutting-edge technologies to enhance the intelligence of transportation management. For instance, artificial intelligence will be more widely applied, using machine learning and deep learning algorithms to analyze vast amounts of traffic data in real time. This not only allows for more accurate predictions of traffic flow changes and accident probabilities but also enables adaptive control of traffic signals, automatically adjusting signal timings based on actual traffic conditions to minimize congestion.

Furthermore, the proliferation of 5G communication technology will provide the smart transportation management platform with high-speed, low-latency data transmission capabilities, facilitating real-time and stable communication between vehicles (Vehicle-to-Vehicle, V2V), and between vehicles and infrastructure (Vehicle-to-Infrastructure, V2I). This will greatly aid the large-scale deployment of autonomous driving technologies, enabling highly coordinated vehicle movements, improving road utilization rates, and enhancing traffic safety.

In summary, the future prospects for the smart transportation management platform are promising. Continuous optimization and upgrades in the integration of new technologies, cross-regional collaboration, and service expansion will lay a solid foundation for building a more efficient, convenient, green, and safe transportation system. It points out the path forward for industry practitioners and researchers alike, and it is hoped that collective efforts will propel the

smart transportation sector to new heights.

Acknowledgements

This work was supported by the financial support from the District Key Project in High-Tech district of Ningbo [grant number 2024CX050004], projects of scientific and technological research of colleges student's of China(202313022036, 202413001008).

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