Research Report on the Integration of C-V2X with Smart Logistics for Sino-German IoV (ICV)

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Copyright Statement

Foreword

In adherence to the "Joint Statement of Intent on Cooperation in the Field of Automated and Connected Driving" signed collectively by China's Ministry of Industry and Information Technology, Germany's Federal Ministry for Economic Affairs and Climate Action, and Germany's Federal Ministry of Digital and Transport, a bolstering of Sino-German cooperation in the R&D and industrial application of C-V2X (ICV) technology is underway. After the release of the "Research Report on C-V2X Mass Production and Application for Sino-German IoV (ICV)" by enterprises and industry organizations from both nations, wherein the commercial feasibility pathways of C-V2X applications were analyzed and studied, further explorations and validations were conducted to determine the value of Cellular Vehicle-to-Everything (C-V2X) technology in empowering the smart logistics industry.

This report, contextualized by the real transportation needs of the Volkswagen Anhui plant, designs a unified framework for C-V2X and smart logistics, conducts testing, and evaluates the concrete advantages of integrating C-V2X technology into smart logistics across four dimensions: efficiency, safety, carbon reduction, and the ripple effect. Overall, the findings highlight the transformative potential of C-V2X in elevating transport logistics, augmenting urban traffic safety, and championing environmentally-friendly initiatives.

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I. Project Background Overview

In March 2021, China unveiled its "Outline of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Long-Range Objectives Through the Year 2035", highlighting its ambition to actively and prudently develop intelligent connected vehicles, expedite transformation of traditional transportation infrastructure, create 5G-based application scenarios and industrial ecosystems, and undertake pilot demonstrations in key areas such as intelligent transportation and smart logistics. In December 2021, China's Ministry of Industry and Information Technology and Ministry of Housing and Urban-Rural Development jointly issued a "Notice on the Second Batch of Pilot Cities for the Coordinated Development of Smart City Infrastructure and Intelligent Connected Vehicles," noting that the pilot should aim to strengthen the construction of smart city infrastructure and achieve demonstration applications of intelligent connected vehicles of different levels in specific scenarios, adhering to principles of demand-driven, market-oriented, orderly construction, and vehicle-road collaboration, continuously enhancing the intelligence level of urban infrastructure and accelerating the development of the intelligent connected vehicles industry.

Against this backdrop, companies and industry organizations from China and Germany are collaborating on the Volkswagen Anhui Smart Logistics project ("this Project"). Their objective is to create a logistics transport environment that integrates C-V2X with smart logistics. They aim to validate the benefits of C-V2X in improving smart logistics transport efficiency, reducing accident rates, and conserving energy and reducing emissions. They're also exploring replicable and scalable practices to combine smart logistics with the construction and operation of smart cities, providing a quantitative model reference for subsequent business model development and gathering precious insights for the coordinated advancement of smart city infrastructure and intelligent connected vehicles.

II. Selection and Verification of Applications of C-V2X and Smart Logistics Integration

(I) Application Selection

Smart logistics is an emerging field which integrates advanced info-tech and communication tools like ICV, AI, and cloud services with contemporary logistics. It addresses challenges like subpar transportation efficiency, high costs, and frequent driving mishaps. This is achieved by embedding automation, digital capabilities, and intelligence across the logistics landscape. C-V2X, as a new generation of information and communication technology that achieves comprehensive connections and efficient information interaction among “people-vehicles-roads-clouds.” It amplifies logistics vehicles' capabilities, minimizing accident risks, bolstering transportation safety, optimizing route planning, steering clear of traffic congestions, and improving transportation efficiency. It does this by fostering communication among smart logistics vehicles (“logistics vehicles”) and other entities, be it vehicles, roadside infrastructures, or digital platforms, while also providing real-time traffic insights and transportation data.

Using insights from the “Research Report on C-V2X Mass Production and Application for Sino-German IoV (ICV),” as well as the outcomes from value scenario selections, mass production strategies, and other research, and in line with Volkswagen’s logistical needs in Anhui Province, the project timeline, technological direction, among other critical factors, the project has pinpointed C-V2X tools such as green wave speed direction, warnings for potential red-light breaches, warnings for at-risk road users, speed limit notifications, and alerts for potential intersection collisions to serve as overarching features for the real transportation journey of vehicles. By establishing benchmarks for the integrated application of C-V2X and smart logistics, and by initiating real-world integration of C-V2X with smart logistics, our goal is to gauge the tangible benefits of C-V2X in advancing logistics transportation.

(II) Verification Plan

1. System Architecture

The project establishes a collaborative environment for logistics transportation involving vehicles, roads, and cloud systems in the transport segment between the Volkswagen platform factory and the Volkswagen Hefei facility in Anhui Province. It tests and validates the integrated application of C-V2X and smart logistics. The main components of the testing and validation framework include a connected electric truck, roadside facilities, and multiple platforms, as shown in Figure 1.

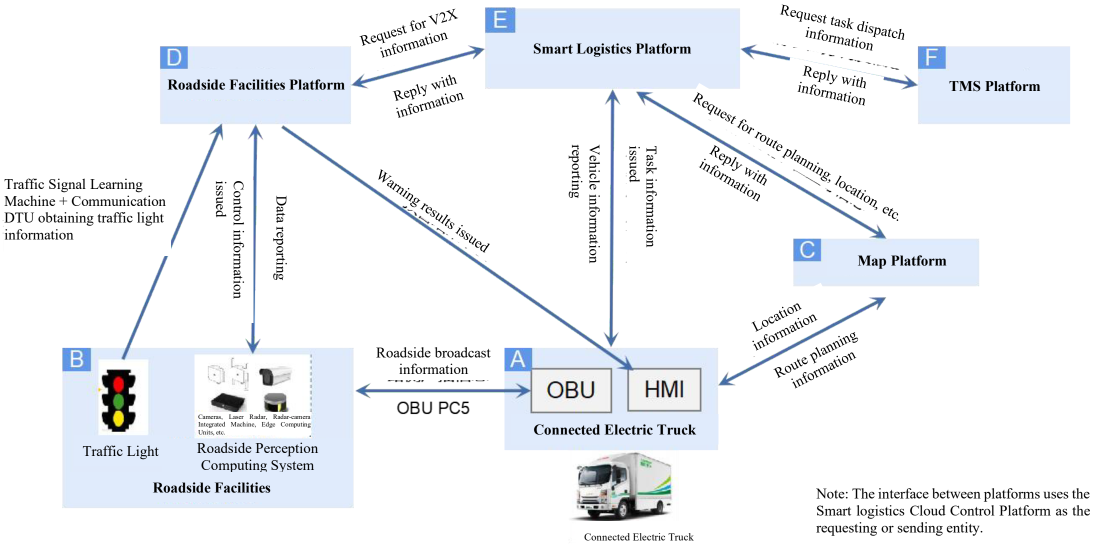


Figure 1 Smart Logistics Testing & Verification System Architecture

(1) Connected electric trucks are fitted with onboard units (OBUs), a Human-Machine Interface (HMI), and other essential modules to gather data like positioning, vehicle control, V2X, etc. Devices for visual information assistance are also present. These offer drivers route direction and vocal prompts for safe driving, all with the intention of improving transport efficiency and road safety.

(2) Roadside designs are categorized into two types: perception-enabled intersections and those without perception capabilities. Perception-enabled intersections are equipped with roadside units (RSU), cameras, millimeter-wave radar (MWR), lidar, traffic lights, and other roadside facilities. These RSUs have the capability to directly interface with OBUs in vehicles for V2X interactions. On the other hand, intersections without perception capabilities lack this advanced system; instead, traffic signal learning machines are installed on the signal lights, and through Data Transfer Unit (DTU), traffic signal information is uploaded to the roadside facilities platform. By synthesizing feedback from vehicles with the traffic signal information, the platform determines traffic light timings, warnings for potential red-light breaches, green wave vehicle speed direction, and more. This information is then transmitted to the in-vehicle HMI systems via 4G/5G connections.

(3) The platform side consists of a Smart Logistics Cloud Control Platform, a Roadside Facilities Platform, a Transport Management System (TMS), and a Map Platform. The Smart Logistics Cloud Control Platform, acting as the system's core platform, enables data interaction interfaces with the Roadside Facilities Platform, Map Platform, and vehicle-mounted devices,

realizing vehicle management, C-V2X information management, dynamic dispatching, route planning, and other management functions, as well as report analysis, CA certification, and other service capabilities. The Roadside Facilities Platform acquires perception data, traffic signal data, and real-time traffic status information and can upload it to the cloud control platform or dispatch it to the vehicle side. The TMS platform, being the transportation management system for vehicles, is responsible for sending the truck's starting and ending point information to the Smart Logistics Cloud Control Platform. The Map Platform obtains the transport task information dispatched by the Smart Logistics Cloud Control Platform, plans the optimal driving route for the vehicle side, displays it on the in-vehicle HMI, and uploads it to the Smart Logistics Cloud Control Platform for data analysis and management.

2. Scenario Storyline

The smart logistics scenario storyline describes the information interaction process of the main links from the TMS platform dispatching orders, through en-route transportation, to finally arriving at the destination, as shown in Figure 2.

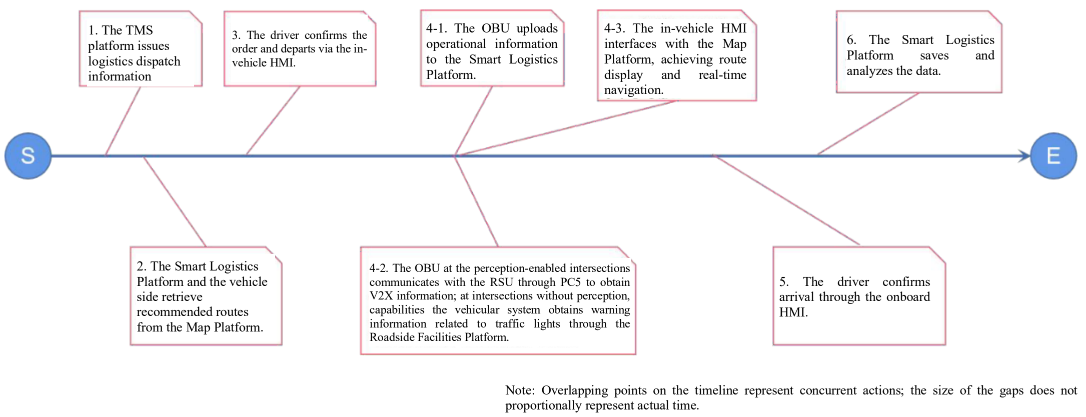


Figure 2 Logistics Scenario Storyline

(1) The TMS platform dispatches the starting point information of the logistics delivery to the Smart Logistics Platform.

(2) The Smart Logistics Platform sends the starting point, time, scheduling, and other connected truck dispatch information to the vehicle side and synchronizes it with the Map Platform to obtain recommended driving routes. Simultaneously, the Map Platform synchronizes the route planning results to the vehicle side and achieves route synchronization between the vehicle and cloud through ID.

(3) The driver departs after obtaining transport task information and optimal route information from the in-vehicle HMI.

(4-1) The onboard OBU communicates with the Smart Logistics Platform via 4G/5G networks. The OBU reports real-time vehicle location, real-time vehicle information, generated V2X information, and V2X events to the cloud. The cloud processes the relevant information compliantly and develops business applications.

(4-2) If the vehicle passes through a perception-enabled intersection, the onboard OBU communicates with the RSU via PC5, obtaining V2X information such as information reminders and safety warnings, and provides information prompts and warnings through HMI. If the vehicle passes through an intersection without perception capabilities, the onboard HMI obtains traffic signal type warning results sent by the Roadside Facilities Platform via 4G/5G networks and provides information prompts, such as traffic light information and green wave vehicle speeds.

(4-3) The onboard HMI interfaces with the Map Platform, achieving path display and real-time navigation.

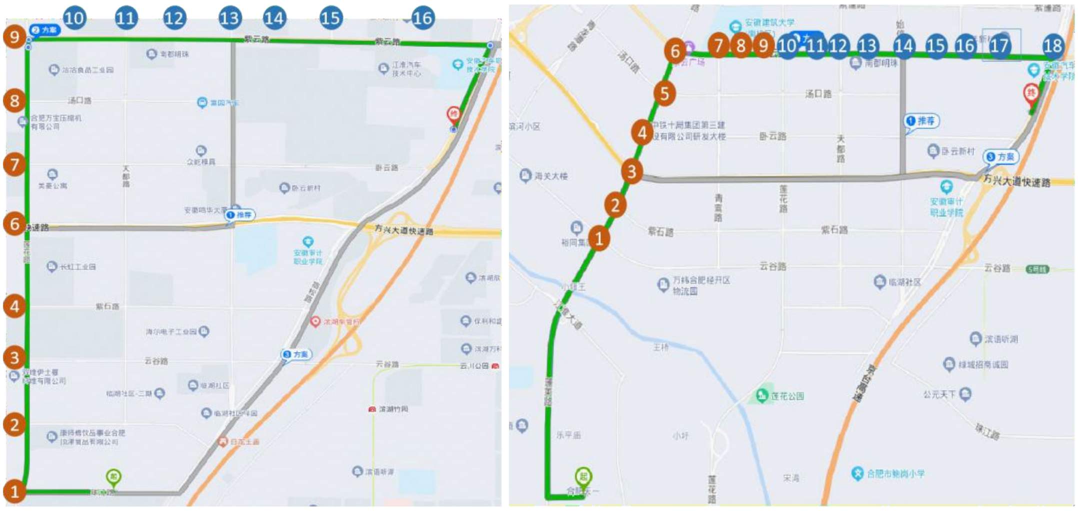
(5) The driver reaches the destination, confirms arrival through the in-vehicle HMI, and sends the message to the Smart Logistics Platform.

(6) The Smart Logistics Platform saves the vehicle data of this transport, such as V2X information, time, real-time routes, traffic planning, and scheduling information, and further analyzes the benefit improvement of C-V2X scenarios on logistics transportation.

3. Test Plan

Testing is divided into two control groups: one group consists of intelligent connected electric vehicles with C-V2X functions such as green wave speed direction, warnings for potential red-light breaches, at-risk road user warning, speed limit warning, and intersection collision warning light; the other group comprises non-connected electric vehicles without C-V2X functions. Both groups have route planning capabilities.

During the test, the two groups of vehicles separately obtain transport task information with close scheduling times and the same starting points dispatched by the Smart Logistics Platform. Based on the transport task and actual road conditions, the Map Platform sends the same route recommendations (Route 1 or Route 2) to the two groups of vehicles with close schedules. Route 1, as shown in Figure 3(a), passes through approximately 9 km of intelligent roads (16 perception-enabled intersections), while Route 2, as shown in Figure 3(b), passes through approximately 9 km of intelligent roads (9 perception-enabled intersections and 9 intersections without perception capabilities). The blue-marked locations on the two routes are overlapping routes.



(a) Route 1 (b) Route 2

Figure 3 Test Verification Route Map

III. Method for Evaluation of the Integrated Application of C-V2X and Smart Logistics

(I) Definition of Evaluation Metrics

To address the real-world needs of businesses in streamlining logistics and ensuring efficient transport, safe driving, eco-friendliness, and seamless factory operations, this project has developed four key assessment metrics: efficiency, safety, carbon emission, and ripple effect. These metrics will provide a holistic quantitative assessment of the benefits derived from the synergistic use of C-V2X and smart logistics.

1. Efficiency

The purpose of the efficiency metric is to gauge the enhancements made in actual logistics operations via smart logistics innovations. The efficiency assessment comprises two second-tier metrics: transit duration and passive green wave passage rate, detailed in Table 1. Specifically:

(1) The green wave passage evaluates the boost in logistics efficiency achieved through the passive green wave speed system. It is further divided into two third-tier metrics: successful green wave speed passage rate and green wave speed direction accuracy rate.

(2) The transit duration metric gauges factors like velocity and time spent on the route. This is further split into two third-tier metrics: mean transit time and punctuation rate.

Table 1 Specific Settings for Efficiency Metrics

Primary metric	Second-tier metric	Third-tier metric	Metric description
Efficiency	Green wave speed	Green wave speed passage rate	The number of times of effective passage through green wave intersections
		Green wave direction accuracy rate	Total number of intersections passed according to the recommended speed/Total number of intersections with traffic lights passed. Here, passing an intersection according to the recommended speed refers to the vehicle traveling at a speed within the recommended range for green wave passage upon reaching the “stop line at the entrance of the intersection”
	Transportation duration	Average transportation duration	Total transportation duration/Total number of vehicle transportation occurrences
		Punctuality rate	Number of punctual arrival/Total number of vehicle operations

2. Safety

The safety metric aims to evaluate how smart logistics technology improves transportation safety compared to conventional logistics methods. This metric comprises two submetrics: vehicular safety and human safety, as detailed in Table 2. Specifically:

(1) Vehicle safety metric focuses on assessing potential risks to the vehicle during its operations. It is further divided into four third-tier metrics: the count of vehicle accidents, the extent of damage from driving incidents, the tally of static warnings, and the number of dynamic warnings. The static warning situations include scenarios like speed limit notifications and traffic light information broadcasts. On the other hand, dynamic warning situations encompass alerts for potential red-light breaches, warnings for

at-risk road users, and intersection collision alerts.

(2) Human safety metric evaluates the potential risks posed by the vehicle to its driver and pedestrians during its journey. This category is further divided into a third-tier metric: number of vehicle accidents causing injuries and fatalities.

Table 2 Specific Settings for Safety Metric

Primary metric	Second-tier metric	Third-tier metric	Metric description
Safety	Vehicle safety	Vehicle accident count	Number of vehicle accidents
		Driving accident loss	Sum of financial loss from driving accidents
		Static warning count	Number of alerts in static warning scenarios
		Dynamic warning count	Number of alerts in dynamic warning scenarios
	Human safety	Number of vehicle accidents causing injuries and fatalities	Number of vechicle accidents causing injuries and fatalities

3. Carbon Emission

The carbon emission metric is designed to evaluate the energy conservation and reduced emissions achieved by using connected electric trucks in this project, in contrast to their non-connected counterparts, especially with the integration of C-V2X technologies like green wave speed direction. As illustrated in Table 3, this metric encompasses a second-metric: power consumption, which pertains to the carbon emissions produced by the energy needs during vehicle operation. Specifically, the overall carbon emissions due to power consumption is calculated as = electricity consumed × grid emission coefficient, where the grid emission coefficient is defined as 0.5703t CO_2/MWh, based on the stipulated value for electric power in the "Guidelines for Corporate Greenhouse Gas Emission Calculation Methods and Reporting for Power Production Facilities".

Table 3 Specific Settings for Carbon Emission Metric

Primary Metric	Second-tier metric	Metric description
Carbon emission	EPower Consumption	Electric consumed × grid emission factor

4. Ripple Effect

The ripple effect metric aims to evaluate the value of corporate social responsibility that can be realized by relying on smart logistics projects. It includes three secondary indicators: Environmental Score, Social Value Score, and Corporate Governance Score, as illustrated in Table 4. The ripple effect metric is designed to measure values like corporate social responsibility attainable through the smart logistics project. This metric comprises three submetrics: environmental score, social value score, and corporate governance score, as detailed in Table 4. Specifically:

Table 4 Specific Settings for Ripple Effect Metric

Primary metric	Second-tier metric	Metric description
Ripple effect	Environmental score	Advancing carbon neutrality goals, reducing energy consumption, and achieving sustainable development objectives
	Social value score	Ensuring safe driving and transportation, contributing to the realization of smart city development concepts, and stimulating the positive development of all relevant enterprises
	Corporate governance score	Facilitating technological innovation, enhancing transportation efficiency, and improving work efficiency

(II) Evaluation Metric Collection Method

The project mainly utilizes smart logistics management platform data statistics, questionnaire surveys, and manual calculation, etc., for data collection. The data collection methods for each metric are as follows.

1. Efficiency

The efficiency-related third-tier metrics are collected through the smart logistics management platform. Among them, the average transport duration and punctuality rate are obtained from the smart logistics management platform by collecting vehicle entrance and exit time, which is then used to calculate the transport duration. The number of effective green wave passages and the green wave direction accuracy rate are determined by collecting the recommended green wave crossing speed and the actual operating speed of vehicles as they cross the "stop line at the entrance of the intersection" through the smart logistics management platform, followed by manual calculations.

2. Safety

Safety-related third-tier metrics are collected using a combination of data from the smart logistics management platform and manual statistics. Among them, metrics like the number of vehicle accidents, damage caused by driving accidents, and the number of casualties are collected through manual counting or obtained from third-party entities. The number of static warnings and dynamic warnings are gathered using the warning count data from the smart logistics management platform.

3. Carbon Emission

The third-tier metrics of carbon emission are collected by the smart logistics management platform, which gathers data on carbon emissions indirectly caused by energy consumption in vehicle operation.

4. Ripple effect

The ripple effect is gathered and analyzed through survey questionnaires, collecting and compiling scores from project-related personnel on the contributions of the smart logistics concept in the areas of environment, society, and corporate governance.

IV. Analysis of the Benefits of Integrating C-V2X with Smart Logistics

The project was carried out over a period of 2 months, with a total test verification of more than 6500 kilometers of valid mileage. Based on the test data analysis results, connected electric trucks compared to non-connected electric trucks showed positive benefits in terms of logistics transportation efficiency, safety, carbon emissions, and the ripple effect.

1. Enhanced Transportation Efficiency

Through statistical analysis, the average number of valid green wave passages per trip (the number of times successfully navigating intersections) and green wave direction accuracy rate (total number of intersections passed based on the recommended speed divided by the total number of intersections with traffic lights) for the connected electric trucks in this project were 3.65 and 35%, respectively. Based on the aforementioned green wave passage effects, the benefits of improving logistics transportation efficiency are analyzed as follows:

(1) Average Transport Duration

The average transport duration metric reflects the average time a vehicle takes for each transportation process. Statistical analysis showed that the average transport duration for non-connected electric trucks and connected electric trucks were 2051.36 seconds and 2022.69 seconds, respectively. Thus, with the application of the C-V2X technology, the average single-trip transport duration improved by 1.42% compared to traditional transportation scenarios. Therefore, C-V2X technology helps improve transportation efficiency, making logistics transportation smoother, more in line with production and operational rhythms, and maximizing logistics transportation efficiency.

(2) Punctuality Rate

The punctuality rate metric reflects the proportion of on-time vehicle arrivals relative to the total number of trips. Statistical analysis showed that the average single-trip punctuality rate for non-connected electric trucks and connected electric trucks were 82% and 91%, respectively. With the support of C-V2X technology, the on-time rate of vehicle operations improved by 9%, enhancing the responsiveness and efficiency of logistics transportation to a certain extent.

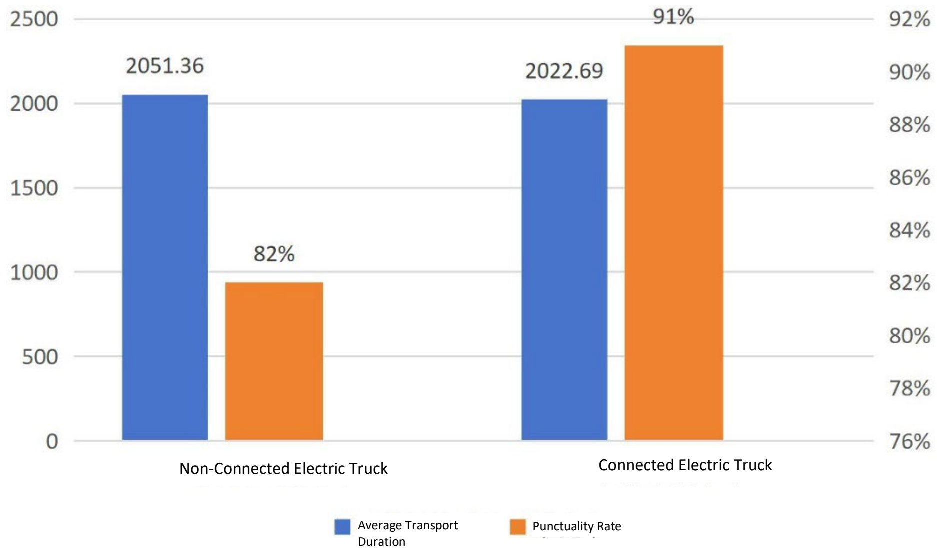


Figure 4 Comparison of Average Transport Duration and Punctuality Rate Metrics

2. Enhanced Driving Safety

Both groups of electric trucks did not experience any vehicle accidents, driving accidents, or casualties. In terms of other metrics, connected electric trucks had an average of 0.76 static warnings and 13.95 dynamic warnings per trip, effectively assisting the connected electric trucks in reducing the accident rate, thereby further ensuring the safety of logistics transportation.

3. Reduced Carbon Emissions

Non-networked electric trucks and networked electric trucks have average single-trip carbon emissions of 6.23 and 6.22 kilograms respectively. That is, electric trucks bolstered by C-V2X selection application technology tend to reduce carbon emissions and can help enterprises achieve their green and low-carbon development goals.

Table 5 Summary of Evaluation Metrics (Single-trip Average)

Primary metri	Second-tier metric	Third-tier metric	Connected vehicles	Non-connected vehicles
Efficiency	Green wave passage	Total number of green waves	3.65	N/A
		Green wave success rate	35%	N/A
	Transport duration	Average transport duration (second)	2022.69	2051.36
		Punctuaion rate	91%	82%
Safety	Vehicle safety	Number of static warnings	0.76	N/A
		Number of dynamic warnings	13.95	N/A
Carbon emission	Carbon emission from power consumption (kg)		6.22	6.23

4. Generating Ripple effect

A total of 1248 valid questionnaires were collected for the project. According to the survey results, over 80% of participants believe that the integrated application of C-V2X and smart logistics enhances value in environmental protection, social value, and corporate governance. This is manifested in various ways, such as: assisting in achieving carbon neutrality targets, reducing energy consumption and realizing sustainable development goals; ensuring safety in driving and transportation, contributing to the realization of smart city development concepts, and promoting the development of all relevant enterprises; facilitating technological innovation and enhancing transportation efficiency and work productivity.

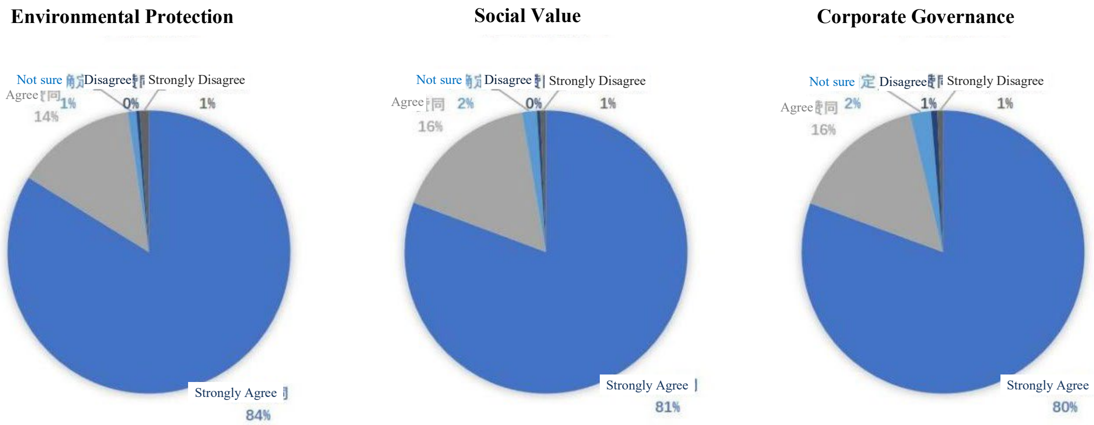


Figure 5 Ripple effect Questionnaire Results

V. Conclusion and Outlook

(I) Conclusion

In light of the aforementioned analysis results, the integrated application of C-V2X and smart logistics has immense developmental potential and prospects, contributing to enhancing the intelligence, efficiency, safety, and energy-saving levels of logistics transportation. On one hand, C-V2X technology provides more accurate information about road conditions and traffic congestion for logistics vehicles, offering a more precise data basis for the route planning and scheduling of logistics vehicles, thereby achieving efficient and green low-carbon transportation to a certain extent. On the other hand, C-V2X technology reduces the likelihood of logistical transportation accidents by providing safety warning applications for logistics vehicles. Moreover, C-V2X technology, when combined with a logistics information system, realizes real-time monitoring and tracking of logistics vehicles, providing more accurate logistics transportation information, and improving logistics service quality.

However, during the project validation process, due to the limited sample size of test data and interference from other factors like driving habits, drivers' unfamiliarity with C-V2X applications such as green wave passage, and battery wear, some analysis results are not precise. For example, the success rate of green wave calculations is relatively low, and the low-carbon benefits brought by networking are not apparent. Moreover, from the analysis of Vehicle speed consistency ratio[1], the C-V2X application has impacted the smoothness of driving speeds to some extent, indirectly leading to an increase in carbon emissions. Additionally, because the public roads tested were not fully retrofitted for road intelligence, and some intersections were in debugging mode during the verification phase, the test environment affected the quality of C-V2X application triggering. Also, due to the limitations in data sharing between the smart logistics platform and cross-industry platforms, this test did not verify the benefits of logistics and urban traffic efficiency in scenarios where logistics transportation vehicles actively apply for green wave passage.

(II) Outlook

Based on the construction results and experiences of the project, this report proposes the following development suggestions from the perspective of promoting the industrialization of C-V2X and smart logistics integration:

1. Continuous promotion of scaled application pilots and multi-dimensional testing & verification: Considering the current validation results, due to limited test sample sizes, insufficient intelligent infrastructure modification of the driving routes, and the presence of interference factors, the efficiency, safety, and carbon emission application evaluation metrics, although improved, are not significantly apparent. Therefore, there is still a need for larger-scale and more diverse application pilots, along with deeper data accumulation and analysis, to further explore the value of C-V2X and smart logistics integrated applications under long-term, large-scale operations. Furthermore, focusing on commercial value, the construction and operational costs of integrating vehicles, roadside facilities, platforms, and other application environments, as well as the indirect profits brought about by improvements in transportation efficiency and production automation, are crucial dimensions for evaluating application benefits.

[1] Coefficient of Variance of Speed: [(x1-x)^2+(x2-x)^2+......+(xn-x)^2]/n, x is the average speed of a single vehicle for a single delivery order; xn is the real-time speed recorded every 10s during the delivery process. Vehicle speed consistency ratio: [(x1-x)^2 + (x2-x)^2 + ... + (xn-x)^2]/n, where x is the average speed of an individual vehicle for a single trip; xn represents the real-time vehicle speed recorded every 10 seconds during the trip.

These need to be further explored through scaled application verifications.

2. Strengthening research on technical compatibility and standardization: The application of C-V2X technology needs to be compatible with the requirements and technical features of existing smart logistics systems, such as achieving data exchange, protocol conversion, and interface calls between logistics systems and logistics vehicles, transportation facilities, third-party platforms through C-V2X. Therefore, it's recommended to establish standards and specifications suitable for the logistics industry's C-V2X applications, guiding the connectivity and data flow process among different systems and devices, and promoting the commercial replication and expansion of the integrated system of C-V2X and smart logistics.

3. Promotion of cross-industry data sharing: C-V2X technology can collect and analyze vast amounts of traffic and logistics data. By sharing data with other industries (e.g., traffic management, transportation, urban planning), there's an opportunity to holistically analyze and optimize the entire logistics transportation process and jointly address issues like traffic congestion and safety accidents. It's suggested that relevant management departments and enterprises promote cross-industry data sharing mechanisms and develop corresponding incentive policies, promoting the logistics industry's use of more comprehensive, accurate data to improve the effectiveness of the entire logistics transportation system.

4. Developing customized integrated application products: Current integrations of smart logistics and C-V2X mainly focus on safety, efficiency, and information service scenarios. However, there are no applications aimed at smart logistics' low-carbon transportation requirements that utilize networking for energy savings. It's recommended to deeply research vehicle energy-saving driving modes tailored for different road traffic environments, and combined with C-V2X technology, develop energy-saving driving applications for those environments, such as optimal driving speed, best acceleration and deceleration curves, and other energy-saving driving suggestion applications. Feedback applications that encourage drivers to adopt more energy-efficient driving behaviors, and applications providing suggestions for energy-saving gear shifting and power switches, should also be developed.

Appendix 1: Abbreviations

Abbreviation	Full Name in Chinese	Full Name in English
C-V2X	基于蜂窝移动通信技术的车联网	Cellular Vehicle to Everything
DTU	无线终端设备	Data Transfer Unit
HMI	人机接口	Human Machine Interface
OBU	车载单元	On-Board Unit
TMS	运输管理系统	Transportation Management System
V2X	车载单元与其他设备通讯	Vehicle to Everything

Notes to Compilation

Lead Compilers:

German Association of Automotive Industry

China Academy of Information and Communications Technology

Volkswagen (China) Investment Co., Ltd.

Participating Compilers:

Volkswagen Anhui Co., Ltd.

China Information Communication Technologies Group Corporation

Jianghuai Automobile Group

Hefei Economic and Technological Development Zone Administration Committee

Hefei Haiheng International Logistics Co., Ltd.

CAICT ICV Innovation Center (Chengdu) Co., Ltd.

Zhejiang Deqing Mogan Mountain Intelligent Connected Future Technology Co., Ltd.

Zebra Network Technology Co., Ltd.

(Note: The order of the participating compilers does not imply rank and is organized according to the initial stroke order of their first characters in Chinese.)