Development Strategy of Internet Plus Intelligent Transportation

Gao Kefu [1], Sun Hongbin [2], Wang Nan [3], Guo Chi [1]

1. Global Navigation Satellite Systems Research Center, Wuhan University, Wuhan 430079, China
2. Center for Strategic Research on Frontier and Interdisciplinary Engineering Science and Technology, Beijing 100081, China
3. Wuhan Second Ship Design and Research Institute, Wuhan 430064, China

Abstract: Internet Plus Intelligent Transportation can promote data and information sharing among traffic facilities during traffic operation. It can also optimize the operation modes of transportation organizations, increase economic and social values, and comprehensively satisfy people's mobility needs. To actively meet these new development needs, this study clarifies the current state of development and problems facing the Internet Plus Intelligent Transportation model, summarizes its integration trend with other industries and fields, and expounds on the architecture of Internet Plus Intelligent Transportation. It is proposed that a travel chain should be created that is ubiquitous, flexible, seamless, trusted, and intelligent, based on the intelligent Transportation as a Service concept (iTaaS) and new critical infrastructures in China that are internationally competitive such as the BeiDou satellite navigation system and 5G technology. Moreover, it is also necessary to strengthen the independent innovation and integration of key technologies, establish an Internet of Vehicles with intelligent and precise control while developing intelligent connected vehicles, cultivate an industrial ecology for the Internet of Vehicles, and strengthen policy guarantees.

Keywords: Internet Plus; intelligent transportation; new infrastructure; Internet of Vehicles; BeiDou satellite navigation system

1 Introduction

As transportation technology in China has developed, the focus has changed from merely pursuing speed and scale to quality and efficiency, which is necessary for the further development and modernization of transportation. The pattern will change from relatively independent development of various transportation modes to coordinated development and from relying on traditional elements to pursuing innovation, with the ultimate goal of building a safe, convenient, efficient, green, economic, and intelligent modern comprehensive transportation system. Internet Plus Intelligent Transportation refers to the collaborative innovation of the Internet, Internet of Things, fifth-generation mobile communication networks (5G), big data, cloud computing, BeiDou satellite navigation systems, and artificial intelligence (AI), to promote the deep integration of cutting-edge technological achievements and applications in transportation, automobiles, navigation, and other fields. Internet Plus Intelligent Transportation can promote data and information sharing among traffic facilities during traffic operation. It can also optimize the operation modes of transportation organizations and increase economic and social values.

Shared, green and intelligent travel will be the future features of travel, to satisfy personalized public mobility needs. The "sense of gain" of transportation is safety, convenience, and comfort for personal travel, and harmony, smoothness, and sustainability for public travel. The essence of these technologies is to improve the quality of

transportation service. The intelligent Transportation as a Service concept (iTaaS) should be considered as a guide for improving overall operating efficiency and service supply quality for the comprehensive transportation system in China. Structural reform of the transportation supply side and the construction of new transportation infrastructure should be promoted. The enthusiasm and creativity of traditional transportation companies and Internet companies should be utilized, and a new transportation industry with Internet innovation as the key element should be developed. Coordination among government departments should be increased, through active and flexible system designs, to accommodate, encourage, and cultivate new business forms and models.

The era of intelligent, data-driven industrial transformation has arrived. The most typical smart product produced over the last decade is the smartphone, but the car will become a new mobile intelligent terminal in the next decade. [1] At present, the development of intelligent networked vehicles is in full swing. After experiencing shifts from perception to control, components to vehicles, single applications to integration, and one-way communication to interaction, cars are entering a new era of "comprehensive perception + reliable communication + intelligent driving." Therefore, it is necessary to research the deep integration and innovation of Internet Plus and intelligent transportation; the electrification, intellectualization, networking, and sharing of the intelligent transportation industry; and the development route of intelligent transportation systems from the perspective of development strategy, so as to provide theoretical support for the development of a new mode, technology, and format of Internet Plus Intelligent Transportation in China. Based on the analysis of Internet Plus Intelligent Transportation needs, this study clarifies the current challenges and developmental trends, demonstrates the technical architecture, and provides countermeasures and suggestions for future development.

2 The analysis of Internet Plus Intelligent Transportation needs

During the evolution from auxiliary to driverless driving, network connections will develop from single-vehicle to multi-vehicle network connections and finally, to traffic system network connections. Vehicle perception, analysis, decision-making, and execution will be updated rapidly to gradually replace the driver's role in analysis, judgment, and decision-making. Ultimately, the system will perform highly automatic driving and fully automatic driving. As the key and essential segment of future transportation, intelligent high-precision maps provide real-time perceptions of traffic resources and form the basis for controlling traffic operations. Since this is a new map form, it is necessary to analyze and discuss the key features and main attack directions, so as to promote research and applications utilizing intelligent high-precision maps.

The interconnection perception and collaborative control of people, vehicles, and roadways are the essential characteristics of the Internet of Vehicles. It is necessary to study the relationship between the Internet connection and intelligent control and establish the overall architecture of intelligent transportation and the Internet of Vehicles technology system with international influence relying on independent core key infrastructures and technologies. "Two networks, two centers, and two full sensing control" is the overall technical idea used to meet the above requirements. "Two networks" refers to the driver and vehicle condition sensing network and the road condition and environment sensing network. The "two centers" consist of computer and cloud platform centers inside the car. "Two full sensing control" refers to the full-time spatial sensing control of the road and the whole process control of vehicle operation.

The industrial ecosystem and collaborative innovation mechanism of intelligent transportation application services are urgently needed. At present, most domestic vehicle networking technology still exists only in relatively closed environments, such as laboratories, scientific research institutes, and vehicle factories. Technology research and development is scattered, and the technical standards and data interfaces are difficult to unify, which restricts the participation of third party software service developers. China should study and formulate corresponding policy provisions, strengthen effective docking with the international industrial chain, encourage opening of the traditionally closed automobile industry, and promote the comprehensive development of the Internet of Vehicle industry chain spanning the fields of automobile manufacturing, maintenance, communication, information service, and public service, as well as promote innovation and entrepreneurship related to Internet Plus Intelligent Transportation.

3 The development trends of Internet Plus Intelligent Transportation

3.1 The development status of Internet Plus Intelligent Transportation

Internet Plus plays an increasingly important role in supporting the basic platform of intelligent transportation.

China's Internet Plus Intelligent Transportation has achieved synchronous development with similar foreign products in many subfields. 1）In the direction of vehicle road collaborative intelligent transportation, vehicle active and passive safety, intelligent connected vehicles, and one-stop transportation information services, domestic institutions and enterprises are carrying out research and developing applications that are synchronized with those in the international research community. 2）In traffic congestion charge collection, shared electric vehicles/cars/bicycles, online car-hailing/ hitch ride, bus rapid transit, shared transportation and payment modes, domestic institutions have partially led the development of these technologies. 3）Examples of large-scale application management services that are rarely seen in other countries include on-street parking network charging at the city level, national highway network monitoring and emergency services, electronic non-stop toll collection (ETC) national network charging, national highway passenger network ticketing, national public transportation card networking, Internet traffic safety integrated service management platforms, and electronic registration identification of motor vehicles.

It should also be recognized that with economic development, the external environment has become more complex and severe, and there is still a lack of independent innovation capabilities in some industries in China. Therefore, the development of the intelligent transportation industry also faces many challenges.

(1) Fundamental research into intelligent transportation is relatively limited in China. For example, there is little research on intelligent standards and schemes for road network infrastructures. Environmental and weather perception is weak. The Internet of Vehicles architecture, vehicle-road coordination (V2X), and vehicle-vehicle coordination (V2V) standards are missing. 5G network delays cannot meet the safety requirements of automatic driving. There is not sufficient competitiveness in the automatic driving industry.

(2) The traffic facilities' level is varied. The development of China's transportation network construction subsystems is discordant with low interoperability. The standards of roadside facilities are not uniform, and coordinated development is weak. The infrastructure level of the transportation network is high (high-speed railway and highway mileage is the best in the world), but insufficient attention has been paid to the construction of intelligent integrated hubs and one-stop network operation platforms.

(3) The system and regulation guarantee of traffic innovation and development is lagging. Research and development of the new infrastructure, mode, and format of Internet Plus Intelligent Transportation put forward new requirements for the traffic management system and governance capacity. For example, for supervision of the automatic driving map [2], it is urgent for relevant systems, regulations, and policy systems to update with the times, adapt and lead the development of the application.

3.2 The development trends of Internet Plus Intelligent Transportation

In April 2020, the National Development and Reform Commission defined the scope of "new infrastructure." As one of the important fields where emerging technologies integrate and innovate traditional infrastructure, intelligent transportation infrastructure is classified as integrated infrastructure. To have ubiquitous and seamless travel serviceability, intelligent transportation infrastructure needs to fully perceive the relevant location data of roads, vehicles, people, and the environment (to achieve the comprehensive interconnection of "people, vehicles, and roads"), implement full-time and spatial traffic control on each road, and perform full-scale traffic control on each vehicle.

The core construction of intelligent transportation infrastructure is the Internet of Vehicles, which allows intelligent and precise control of intelligent connected vehicles. The Internet of Vehicles is a cyber-physical system network with precise time-space location service, and remote time-space location precision control is necessary.

At present, the trend of integrating Internet Plus Intelligent Transportation with many industries tends to be clear and is mainly reflected in the following aspects.

(1) Technology integration. In combination with new economic and social development needs and technological innovation trends, especially in the intelligent era, there have been integrated applications of new technologies in the field of intelligent transportation, such as the terrestrial-satellite communication network, Narrow Band Internet of Things, BeiDou satellite navigation and its enhanced system, new-generation mobile communication, AI, intelligent manufacturing, new materials, and new energy [3].

(2) Data integration. A cloud platform containing large amounts of traffic data should be built based on Internet Plus technologies, which integrates the public collection of traffic data (such as road conditions, parking, vehicle flow, and public transport), traffic control, congestion, police situations, and accident data provided by the public transport management department, to realize the automatic map presentation. This provides a scientific basis for eliminating congestion and provides a "crowdsourcing update" solution to solve the timeliness problem of high-

precision maps required for automatic driving.

(3) Field integration. The transportation reform characterized by the "four modernizations" of automobiles is emerging. The integrated development of automobile manufacturing, automobile services, energy networks, transportation operation services, mobile Internet, information services, and intelligent transportation will be the general trend.

(4) Infrastructure integration. In 2019, the *Outline for Building China's Strength in Transportation* proposed that the goal of research and development of intelligent connected vehicles should be to form an independent, controllable, and relatively complete industrial chain. The ubiquitous and controllable traffic information infrastructure represented by BeiDou satellite navigation and 5G will support the integration and innovation of intelligent transportation suitable for China's conditions.

(5) Travel service mode integration. The "sense of gain" of Internet Plus Intelligent Transportation for the public is iTaaS, which has been listed in the *Outline for Building China's Strength in Transportation*. The integrated development of transportation services will provide the critical foundation and core support for service innovation and upgrading of new formats and modes.

4 The architecture of Internet Plus Intelligent Transportation

The essence of the Internet Plus Intelligent Transportation system is an ecological system integrating the network supporting technologies such as cloud, network, and terminal technologies. Various intelligent vehicle control terminals, intelligent vehicle safety protection terminals, road health perception devices, road condition perception devices, and road climate environment sensing equipment constitute the perception/access/communication technology system of Internet Plus Intelligent Transportation. Network technologies provide a channel for information transmission and involve a new generation of wireless communication network represented by 5G, location service networks that are integrated, seamless, high real-time, reliable, and precise both indoors and outdoors represented by BeiDou satellite navigation, and the intelligent Internet of Vehicles represented by intelligent connected vehicles. The cloud includes a new generation of road network information infrastructure, a transportation big data intelligent analysis platform, and a transportation industry information resource commercialization platform. It adopts Internet platform integration to provide comprehensive shared transportation and traffic resources for roads, railways, waterways, and aviation.

From the perspective of the platform structure, the construction of the Internet Plus Intelligent Transportation technology system also needs an "application layer, intelligent control layer, and physical implementation layer" system framework utilized in the industrial and consumer Internet. On the whole, it is necessary to strengthen the supporting role of new transportation infrastructure such as intelligent transportation information systems, management systems, public transport systems, intelligent vehicle control systems, and emergency rescue system. In addition, implementation of the standardization and systematization of key technologies such as multi-source collaborative perception, indoor and outdoor integrated navigation and positioning, multi-source data fusion, human–computer interaction, intelligent computing platforms, and high-precision mapping is also necessary. Specifically, considering the macro demand of Intelligent Plus and the trend of technology integration, the architecture focuses on the edge computing ability of the terminals, add an edge processing platform layer, uses intelligent transportation as the main carrier of the edge computing layer, and develops the edge virtualization/service technology led by the new generation of AI technology. In the cloud service platform layer of the new intelligent system, the collaborative intelligent service application of new technologies in intelligent transportation is emphasized. The "traffic brain" is used for management and control to provide an intelligent security guarantee for the transportation system, with a focus on developing key technologies such as AI engines, system simulations, and human-computer interactions. In the application layer of the new intelligent system cloud service, the iTaaS concept is highlighted, focusing on the sharing of new traffic format services, research, and breakthroughs in intelligent transportation platform technology, and reshaping the industrial ecology through technological innovation.

In addition, to participate and become a leader in the new economy and breakthrough the traditional mode of inertia thinking to respond to the new production model, business model, and strategic needs, a loose and orderly development environment should be created, and technical exploration and demonstration of intelligent transportation applications should be accelerated to promote a massive change in the transportation sharing mode. Furthermore, the development environment should be able to adapt to diversified transportation needs by improving service levels and allow "steady growth" by ensuring investment.

5 Countermeasures and suggestions

Facing the problems of traffic congestion and environmental pollution in the process of China's urbanization, combined with the development of the new normal in the Chinese economy, it is necessary to promote the construction of new infrastructure and the development and institutional guarantee of Internet Plus Intelligent Transportation. In the industry, it is necessary to establish technical, safety, service integration and application standards for Internet Plus Intelligent Transportation and build an industrial ecosystem in which the government, market, and society all participate. Internet Plus Intelligent Transportation policies and regulations in key areas should be established quickly.

5.1 Strengthen the innovation and integration of independent key technologies

Deep integration of BeiDou satellite navigation, 5G, big data, Internet of Things, supercomputing, blockchain, and AI with the traditional transportation industry and infrastructure should be achieved, aiming at the next-generation information technology, intelligent manufacturing, new materials, and new energy. Strengthening forward-looking and disruptive technology research promotes the transformation of the transportation industry. There should be a focus on the following aspects of technology research and development: intelligent management and control of transportation road network infrastructure, intelligent coordination of transportation tools and facility environment, intelligent coordinated transportation management of transportation systems, seamless coordination of large-scale transportation hubs and one-stop service, multi-modal transportation and integrated transportation integration, regional transportation service security and standard systems, and information security and privacy protection. Aiming at the goal of data resources enabling transportation development, the integrated development of transportation infrastructure, transportation service, energy, and information networks should be accelerated to build a ubiquitous and intelligent new transportation infrastructure.

New technologies such as BeiDou satellite navigation, 5G, and AI should be used to build collaborative intelligent service capabilities in intelligent transportation and form a new generation of integrated transportation and transportation technology systems. 1) By using the high-precision navigation enhancement capability of the BeiDou satellite navigation system, the mobile communication network and the Internet can be enabled to locate the instantaneous position of mobile information on the Internet, clarify the direction of the information and the instantaneous flow rate, and make the mobile Internet have seamless and integrated indoor and outdoor positioning functions [4] to meet the "new infrastructure" requirements of full time-domain/full airspace positioning. 2) Based on 5G network technology and BeiDou satellite navigation and its enhanced system, all-weather, continuous, full-range intelligent transportation infrastructure should be constructed to support information collection, processing, and transmission, as well as the interaction of people, vehicles, roads, and the environment in the vehicle transportation process. This could provide road perception, lane-level precise navigation, and remote control services to form a hierarchical traffic control network with high reliability, high safety, and low delay [5].

5.2 Cultivate an industrial ecology for the Internet of Vehicles

The overall standard, service integration system, and industrial ecological chain of Internet Plus Intelligent Transportation should be built, technology enterprises in intelligent transportation should be cultivated through marketization, the cross-border integration of intelligent transportation related industries should be guided, and an intelligent transportation ecosystem should be formed with the participation of the government, market, and society.

The integration of shared transportation and the Internet should be encouraged, a passenger transport information service system should be constructed, and the development of new models such as Internet shared vehicles, parking lots, charging piles, and gas-filling stations should be guided and standardized. The integration of public transport and the Internet should be encouraged to improve on a system for its intelligent application. The intelligence level of intercity transportation should be improved, and active innovation should be applied to the road passenger information service to improve the residents' travel experience. With the goal of personalization, comfort, informatization, and intelligence of vehicles, an intelligent transportation service system can be established with the support of the transportation cloud platform, and a resource-saving and environment-friendly comprehensive transportation system for planning, operation, and management can be formed.

It is necessary to create shared transportation applications in urban areas with high informatization levels and orderly open transportation applications of big data. In addition, it is important to encourage technological enterprises and financial institutions to participate in the construction of shared transportation networks and operation

applications, integrated collaborative transportation service applications of the integrated transportation system, precise location-based service applications of Internet rental cars, and information interconnection and interworking applications of logistics resources based on Internet use.

Aiming at the commercial application of automobile insurance and the consumer market of the Internet of Vehicles, solutions should be found for the application problems of BeiDou high-precision positioning and vehicle intelligent location services in vehicle insurance fields. The development of high-precision, low-cost, and robust BeiDou vehicle driving records and auxiliary driving terminals should be promoted, and a new and practical police-insurance service platform should be established to create an application ecosystem for the intelligent connected vehicles industry.

5.3 Implement policy guidance and guarantees

The government should take the lead to speed up research on methods of opening and sharing of transportation big data. The reorganization and integration of relevant data can break the current fragmented data application state, remove the constraints of information interconnection and sharing, and better support intelligent travel.

In response to traffic congestion and pollution, a reward and punishment mechanism should be established as an important weight factor to encourage shared travel, and it should be promoted to be the main body of city transportation services. The sharing and exchange of transportation information among governments, enterprises, and individuals should be promoted, and industries should be encouraged to form chain alliances and create a shared transportation cloud service system with the participation of government, market, and individuals. Tolerance of technological innovation in intelligent transportation is recommended. Furthermore, it is necessary to allow trial and error appropriately, change from prior prohibition to post supervision, and encourage innovative development of shared transportation.

It is crucial to ensure that the market and product access mechanism of automatic vehicles are researched, focusing on new solutions to liability and insurance issues and solving related privacy and data protection issues. A series of national and industrial standards should be researched and formulated, such as automatic driving high-precision map production and data specifications, multi-source heterogeneous transportation big data interconnection standards, and intelligent transportation security standards. The development of software and hardware technology related to automatic driving should be accelerated, and top-level application design should be planned to ensure the international market competitiveness while adapting to national conditions.

References

[1] Paden B, Cap M, Sze Z Y, et al. A survey of motion planning and control techniques for self-driving urban vehicles [J]. IEEE Transactions on Intelligent Vehicles, 2016, 1(1): 33–55.

[2] Liu J N, Dong Y, Zhan J, et al. Thoughts and suggestions on autonomous driving map policies [J]. Strategic Study of CAE, 2019,21(3): 92–97. Chinese.

[3] Liu J N, Guo W F, Guo C, et al. Rethinking ubiquitous mapping in the intelligent age [J]. Acta Geodaetica et Cartographica Sinica,2020, 49(4): 403–414. Chinese.

[4] Liu J N, Gao K F. Challenges and opportunities for mapping and surveying and location based service in the age of intelligence [J]. Geomatics and Information Science of Wuhan University, 2017,42(11): 1506–1517. Chinese.

[5] Xinhua Net. Liu Jingnan: Role, path, and vision of "5G+BDS/GNSS" [EB/OL]. (2019-12-11) [2020-05-15]. http://www.xinhuanet.com/info/2019/12/11/c_138622969.htm. Chinese.