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Thoughts and Suggestions on Autonomous Driving Map Policies

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Abstract: The autonomous driving map is a key element of autonomous driving, and is crucial to the commercial development of the autonomous driving field. However, the industrialization of autonomous driving maps in China is currently impeded by laws and regulations related to ground mapping, map application, and supervision. This study analyzes the main policy and regulatory issues faced in the development, application, and management of autonomous driving maps in China, specifically those relating to encryption of autonomous driving maps, limitations on geographic information expression, qualifications for geographic information collection and the map review process, accident liability and insurance issues, and autonomous driving map-related test specifications and test scenario issues. Considering the domestic and international development trends of the autonomous driving fields, this study advances four suggestions for accelerating the development and commercialization of autonomous driving vehicles in China: formulating an autonomous driving map management mode, permitting pilot application and systematic opening of autonomous driving maps, lifting restrictions on corporate authorization and optimizing the review process, and establishing a national autonomous driving map platform.
Keywords: autonomous driving map; autonomous driving regulation; autonomous driving policy

1 Introduction

Globally, transportation reform, characterized by electrification, intellectualization, networking, and sharing of vehicles, is emerging. The reform aims to reduce the consumption of traditional energy, achieve zero emission and congestion, improve road traffic efficiency, increase traffic safety, and to ensure zero casualties. The development and commercial application of autonomous driving vehicles based on the electric platform (hereinafter referred to as Level 3 and above) has become the focus of international competition. The autonomous driving vehicle industry, as a product of the integration of various advanced technologies such as artificial intelligence (AI), network communication, and automation control, is of considerable significance in promoting national economic, social, technological and safety development, and driving the transformation and upgradation of the manufacturing industry and industrial development [1].

The major automotive industry countries, such as the United States, Germany, and Japan, are actively promoting the development of autonomous driving. Multinational motorcar auto corporations have released their commercialization schedules for autonomous driving vehicles. The development of autonomous driving vehicles in China has entered an important development phase, and China is gaining ground due to its policy support, industrial investment, and scale of innovation and application in this stage of traffic reform.

The autonomous driving map conveys real-time perception of traffic resources in the entire space-time range, and

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is the basis for the operation and control of the entire operation process of the vehicles. It offers higher precision (usually up to centimeter-level), and more static and dynamic road information, assisting vehicles in perception, positioning, and in planning control, compared with traditional navigation electronic maps [2,3]. The map compensates for the insufficiency of sensor detection range, the performance limitation of the terminal, and the lack of prior information by interacting with the sensor information to achieve accurate perception and real-time modeling of the vehicle in the surrounding environment to ensure driving safety [4].

However, the commercialization and industrialization of autonomous driving vehicles are impeded by China's laws and regulations on map development, application, and supervision. If this situation is not swiftly remedied, not only will the core aims of transportation be difficult to achieve, China's comparative advantage will be weakened.

2 Main problems

Because of certain aspects of China's laws and regulations, five challenges mitigate against the development, application, and management of the autonomous driving map. They are discussed in the following subsections.

2.1 The issue of autonomous driving map encryption

According to the *Notice on Strengthening Autonomous Driving Map Production Test and Application Management*, China's autonomous driving map shall be managed by referring to the laws and regulations applicable to the navigation electronic map. Furthermore, according to the *Navigable Electronic Map−Basic Requirements of Security Processing Technology* [5], navigation electronic maps must be encrypted before they can be approved. Over the past decade, the encryption of traditional navigation electronic maps has not only ensured the national geographic information security, but has also promoted the sound development of related industries utilizing the navigation electronic map. However, the development of autonomous driving has engendered new map requirements, thereby further complicating the encryption challenge.

Autonomous driving vehicles require centimeter-level navigation accuracy to ensure the safety and accuracy of driving [6-8]. However, because of the random jitters generated by map encryption deflection, the consistency of the position accuracy of autonomous driving vehicles in different regions within the permissible range cannot be guaranteed, which may lead to misjudgment, and increase the risk of accidents.

The real-time position sensor data of autonomous driving vehicles need to be deflected by encryption plug-ins before it matches the navigation map. However, this process will prolong the calculation time of the "decision-making link" of autonomous driving, resulting in a delay in the operation and control of autonomous driving vehicles, and increased risks.

It is necessary to keep the map attribute information, which has no relationship with driving safety, strictly confidential. The contents of the autonomous driving map above L3, as interpreted by machines, can be excluded from the map after attribute identification.

Encryption plug-ins, as a safety-related component of autonomous driving vehicles in terms of system development, should meet the requirements of *Road Vehicles—Functional Safety—Part 2: Management of Functional Safety* [9] on functional security, software process improvement, capability and testing, and data security. In the future, the functional safety level will be considered a necessary condition for the commercialization of the autonomous driving system. At present, the capability of the encryption plug-ins used in the navigation electronic map to satisfy relevant requirements has not been ascertained. It is necessary to investigate and demonstrate the extent to which the encryption plug-ins can satisfy relevant requirements following improvements.

In summary, special standards relating to the encryption of autonomous driving map should be established, rather than merely following the standards of navigation electronic map.

2.2 Restricted expression of some geographical information in autonomous driving map

According to the requirements of the *Provisions on the Scope of State Secrets in Surveying and Mapping Administration, Notice of Relevant Provisions on Management of Navigation Electronic Map, Supplementary Provisions on Disclosure of Map Contents (Trial),* and *Provisions on the Disclosure of Basic Geographic Information (Trial),* products that need to access map data are not permitted to express attribute information such as the maximum longitudinal slope, minimum curvature radius and elevation of the road, the slope of important bridges, and the height and width of important tunnels. The absence of the above geographic information in the autonomous driving map will affect the safety of operating the autonomous driving system. Specifically, the absence of radius of curvature value can make the corner velocity or direction of the system inaccurate; the absence of information on

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road elevation will render vehicles unable to judge their actual position in real-time when they drive on multi-layer overpasses.

2.3 Qualification requirements of geographic information collection and map review process of autonomous driving map

In accordance with the *Surveying and Mapping Law of the People's Republic of China*, the surveying and mapping activities involved in basic map production and map update require surveying and mapping qualifications. Therefore, enterprises without surveying and mapping qualifications cannot collect the most basic geographic location information and road signs. According to the *Notice on Strengthening Autonomous Driving Map Production Test and Application Management*, autonomous driving maps should be drawn only by the units with the qualifications required to survey and map navigation electronic maps. It is worth noting that the autonomous driving vehicle is a high-performance mobile surveying and mapping instrument; it can record the track, capture images, and acquire point cloud data through various sensors during the driving process, and update the map content by interacting with the data of the autonomous driving map. However, the autonomous driving map has high requirements in terms of the accuracy of the geographical location (centimeter-level) and the timeliness of expressing the changes in the road (second-level). Therefore, acquiring and updating real-time road data is a critical challenge currently affecting the implementation of the autonomous driving map. It is not possible to satisfy the requirements of the autonomous driving map by depending solely on the efforts of qualified professional organizations.

In terms of map review, maps are still reviewed manually, in accordance with the traditional navigation electronic map mode; this leads to a relatively long map review period, and makes it impossible to satisfy the timeliness requirements of the autonomous driving map.

2.4 Insurance of autonomous driving map and determining accident liability

The development of autonomous driving vehicles will complicate the liability cognizance following accidents. When a driver switches to the autonomous driving mode, responsibility is shifted from the human driver to the car factory, the sensor manufacturer, the algorithm provider, the autonomous driving map service provider among others [10]. Generally, liability and responsibility assignment following traffic accidents are clearly defined by laws and regulations. At present, it is difficult to determine liability after traffic accidents involving autonomous driving vehicles in terms of relevant laws and regulations in China. For example, according to the *Regulation on the Implementation of the Road Traffic Safety Law of the People's Republic of China*, the traffic safety law and regulations on its implementation are human-centered, and not applicable to autonomous driving. According to the *Intelligent Connected Vehicle Road Test Management Regulation (Trial)*, human drivers are responsible for traffic violations during the testing stage. However, it does not involve situations when the driver is not at fault, or is not in the car. The *Product Quality Law of the People's Republic of China* is mainly applicable to situations due to non-compliance with relevant standards, a product has defects, and causes damage. However, the autonomous intelligence of the autonomous driving vehicles makes the predictability of the intelligent decision-making algorithm vague; it is also difficult to define whether there is a necessary connection between the algorithm and an accident, leading to a dilemma in liability cognizance [11].

Furthermore, the high intelligence of autonomous driving vehicles will significantly reduce the rate of traffic accidents, with effects on the traditional automotive insurance market. The traditional insurance system based on driving behavior analysis [12] will no longer be fully applicable, as the risk rating for future autonomous driving vehicles will be related to the technical level of the vehicle safety system and the map quality of the autonomous driving map.

In addition, the timeliness of autonomous driving map updates will also have a significant impact on insurance coverage. The *Intelligent Connected Vehicle Road Test Management Regulation (Trial)* clarifies the requirements for liability cognizance, insurance, and compensation during the testing stage. However, the application scope of management regulation is limited, and is not applicable to more practical application scenarios.

2.5 Test specifications and test scenarios related to autonomous driving map

The application scenarios mentioned in the *Intelligent Connected Vehicle Road Test Management Regulation (Trial)* are minimal. The regulation offers little guidance to the complex real environment. Besides, in accordance with the *Regulation on the Implementation of the Road Traffic Safety Law of the People's Republic of China*, a motor vehicle shall not be used to conduct test runs, or for driving lessons on the expressway.

The expressway, as one of the pioneering commercial application scenarios of the autonomous driving vehicle in the future, will be an important scene for the production and application of the autonomous driving map. Restricting testing of vehicles on the expressway is not conducive to the future development of autopilot-related industries.

Meanwhile, the top-level framework for road tests is established in the *Intelligent Connected Vehicle Autonomous Driving Function Test Regulation (Trial)*; however, enterprises in different cities need to reapply for authorization in new cities according to the varying requirements, which is rather time-consuming. Moreover, it is challenging to meet the testing requirements of autonomous driving vehicles and the autonomous driving map as the number of closed testing sites is limited.

3 Suggestions

The contradiction between the current relevant laws and regulations and the development needs of the autonomous driving map will increase the complexities of developing and applying autonomous driving vehicles in China. In contrast, the auto industry powers such as Germany, Japan, and the United States have a competitive edge in the innovation and entrepreneurship of autonomous driving vehicles, because they have fewer policy restrictions on surveying and mapping. Therefore, China is actively exploring legislative rules in the field of automatic driving. For example, according to the *Notice of the State Council on Printing and Distributing a New Generation of Artificial Intelligence Development Plan*, it is necessary to formulate laws, regulations, and theoretical norms that promote the development of AI. The National Development and Reform Commission's *Intelligent Vehicles Innovation Development Strategy (Draft for Comment)* also clearly states that it is necessary to eliminate legal obstacles affecting the development of intelligent vehicles.

To accelerate the development and commercialization of autonomous driving vehicles in China, the following four recommendations are made.

3.1 Developing the autonomous driving map management mode

The autonomous driving map, as a new form of map, has its distinctive features in terms of technical indicators and application requirements, compared with traditional navigation electronic maps. Globally, the autonomous driving map standard, as a guide for map production, mainly draws on European standards, such as some standards of the European Telecommunications Standards Institute (ETSI) and Navigation Data Standard (NDS). In contrast, although domestic institutions have begun to work on standards development, the pace is slow. Unified national standards and industry standards have not been formed, and the product design in this industry is mainly a reflection of foreign demands and standards.

In addition, the development of autonomous driving in China is also dependent on the reconstruction and adjustment of the existing human-centered traffic accident liability and insurance claims systems to tackle liability cognizance and insurance claim successfully following an accident. The United Kingdom and Japan already have corresponding bills. For example, the *Automated and Electric Vehicles Bill* of the United Kingdom clearly defines the accident liability cognizance and insurance issues, and clarifies the conditions under which the insurance company must accept the claims and the no-claims conditions [13]. Japan's *Self-Driving Relevant System Outlines* also clarifies the issue of liability. However, China has no such laws and regulations. It is of utmost importance that the necessary laws and regulations be created.

In summary, it is recommended that a new mode of management different from the traditional navigation electronic map management mode should be adopted to solve the limitation of existing systems and standards. It is also necessary that product technical standards, liability cognizance, and claims standards be clearly defined for the implementation of the autonomous driving map.

3.1.1 Establishing the technical standard system of autonomous driving map

On the one hand, it is recommended that the Ministry of Natural Resources take the lead in promoting the timely development of relevant technical standards, including research basis, general specifications, product and technology applications, and related standards to ensure driving safety and geographic information security in the implementation of autonomous driving maps. Therefore, a unified standard for the industry, specifically for guiding the development and application of autonomous driving map-related industries is necessary. On the other hand, cooperation with foreign standards organizations should be strengthened to ensure the consistency and compatibility of the development of China's national standards with relevant foreign standards.

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3.1.2 Developing supporting regulations of autonomous driving map

The autonomous driving map and traditional navigation electronic map fundamentally differ in their mode of expression, means of operation, and maintenance. The autonomous driving map is distinct because of its machine-based image recognition. It is recommended that the Ministry of Natural Resources take the lead in revising laws and regulations related to autonomous driving map to meet the objective development needs of the autonomous driving map (such as precision requirements and some security requirements of sensitive geographic information), clarifying the liability cognizance, and further standardizing and guaranteeing the orderly and high-quality development of China's autonomous driving vehicle industry.

3.1.3 Establishing appropriate insurance claims system

The risk rating for autonomous driving is related to vehicle safety systems and the autonomous driving map. The transfer of the liability subject of following accidents involving autonomous driving vehicles requires an innovative liability insurance model. It is recommended that a compulsory insurance system be adopted. The insurance company should be required to provide compensation within the limits of compulsory insurance liability. The responsible entities, such as system developers, map providers, and car owners, should assume corresponding responsibilities according to their respective faults [14].

3.2 Pilot application and orderly popularization of autonomous driving maps

The increased variety and complexity of the autonomous driving application scenario places higher demands on the real-time perception of autonomous driving vehicles, and the accuracy, real-time performance, and intelligence of the autonomous driving map. It is important to test the suitability of the autonomous driving map in test areas that are very similar to real scenes to verify the quality and explore the effective application scenarios of the autonomous driving map. Therefore, it is suggested that the testing of the autonomous driving map should be conducted in an orderly fashion. Pilot testing can be conducted in small areas to investigate the practicability and existing problems of the autonomous driving map, and explore the feasibility of realizing the scale and commercialization of the autonomous driving map. Gradually, the autonomous driving map can be popularized.

3.2.1 Pilot application of autonomous driving map in specific areas

It is recommended that the Ministries of Transport, Public Security, and Industry and Information Technology conduct pilot projects in the defined demonstration zones for intelligent network testing in all provinces and municipalities on the premise of ensuring national geographic information security. Auto-driving vehicles/enterprises should be permitted to collect location information, information on real-time road conditions, and road information in pilot areas to meet the development needs of the autonomous driving map. More practical suggestions are as follows. It is necessary to expand the test area to cover more application scenarios. The test review time of test application should be shortened to improve the test efficiency. Finally, unified national test requirements should be established to avoid repeated application and evaluation of trans-regional tests.

3.2.2 Opening up the necessary roads in the production and application of autonomous driving map to achieve full coverage of public roads across China

It is recommended that The Ministry of Natural Resources, together with the Ministry of Transport, create a road map for the production and application of the autonomous driving map. First, the production and application of the autonomous driving map in the intelligent network-testing demonstration area, covering the entire process of data collection, such as data processing, map production, map publishing, and map update, should be completed. Then, a feasible commercialization plan of the autonomous driving map should be designed based on the various challenges identified in the test. Finally, the production and application of the autonomous driving map on roads, highways, and other public roads in the relatively closed administrative area will be gradually popularized.

3.3 Granting enterprise permissions and optimizing the review process

On the one hand, relying solely on qualified professional organizations cannot meet the real-time update needs of the autonomous driving map. Crowdsourcing, a new type of task allocation and execution mechanism, can maximize group intelligence to realize low-cost and mass real-time updates. Crowdsourcing is acknowledged as the future of the autonomous driving map in the industry. However, it requires qualifications, because it is also a surveying and mapping act, in accordance with the *Surveying and Mapping Law of the People's Republic of China*. Besides, crowdsourcing data also needs to comply with China's map production-related policies when it is used for map

production and update. The collection and use of crowdsourced data are drastically limited by these problems.

On the other hand, the future wide-scale connection of autonomous driving vehicles is dependent on the crowdsourcing update mode of the autonomous driving map. Each vehicle will be the information node of the intelligent transportation system, and the real-time map update will be realized through interaction with external data. The massive data generated will include not only basic information, such as vehicle position and speed, but also private data such as driving trajectory, drop-off location, and driving behavior [15]. Therefore, the storage, use, and privacy of these data shall be taken seriously.

Consequently, it is recommended that with the Ministry of Natural Resources at the forefront, the following measures be taken, to encourage the innovation and commercial development of the autonomous driving map through the entire process of collecting, processing, and updating information while ensuring the safety of national geographic information.

(1) Relaxing laws on mapping and the requisite qualifications for designing the autonomous driving map to simplify the process for Chinese enterprises involved in autonomous driving. Promoting the opening up of road information resources to the public in an orderly fashion, making it accessible to more enterprises, and forming a benign competitive industrial ecology.

(2) Promoting the construction of relevant technical regulations for crowdsourcing. Technically, a unified fusion theory framework and effective data fusion algorithm should be built to verify the validity of the crowdsourced data and filter it, determine the priority of data interaction and its delay rule, and grade the data update frequency. In terms of industry, the specific implementation mechanism and future development model of the crowdsourcing model should be clarified. It is recommended that the crowdsourcing data be processed under the supervision of the state, which, led by data-commissioned companies, should solve problems such as unclear ownership and insufficient security of crowdsourcing data, and protect data privacy and security.

(3) Accelerating the technical studies on automation and the intelligent administrative review process for the autonomous driving map, replacing the traditional manual review process with a network-based and intelligent automatic review process, thus shortening the review and information disclosure cycle to satisfy the timeliness requirements of autonomous driving maps.

3.4 Establishing a national autonomous driving map platform

The ideal purpose of the autonomous driving map is to achieve space-time and real-time coverage of traffic resources through the interchanging and sharing of resources among users. However, the various data required for mapping in China is scattered among agencies such as map service providers and automobile companies. All parties are afraid of sharing data; the result is wastage of resources and limited map coverage expansion.

Therefore, a powerful third party is required to coordinate the various parties, and connect all kinds of data interfaces required for the autonomous driving map. Corresponding industry alliances have been established in foreign countries. For example, a “dynamic map platform” spearheaded by the government, and jointly funded by several automotive and surveying and mapping companies was established in Japan in 2016; the aim is to develop and maintain autonomous driving map data covering all roads in Japan. Compared with foreign countries, China’s top-down regulatory system can significantly simplify the complex regulatory rules and procedures of the federal systems. Therefore, China will gain an international competitive edge in the construction of a national autonomous driving map platform by combining the advantages of its national system and relying on the top-level design. In this regard, the specific recommendations are as follows.

(1) A national framework for the development and supervision of the autonomous driving map should be established. This framework will effectively coordinate relevant departments such as the Ministries of Transport, Public Security, and Natural Resources to formulate clear regulatory policies, and guide the healthy development and competition of the autonomous driving map market.

(2) It is suggested that the construction of a national public service cloud platform based on the basic data of the autonomous driving map should be promoted, and a central autonomous driving map network should be formed by integrating all the available resources. Prior to that, a rapid update mechanism using crowdsourcing to update and maintain data for maps should be established. Besides, a crowdsourcing update ecosystem should be built to ensure the sustainability and effectiveness of data updates, thus accelerating the commercialization of autonomous driving maps.

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4 Conclusions

The autonomous driving system is the focus of the new phase of international competition, and will be a major determining factor if China is to emerge at the forefront of the AI field by 2030. It will drive the transformation and upgrading of the manufacturing industry and industrial development. However, the autonomous driving map, an essential part of the autonomous driving, is currently constrained by aspects of China's laws and regulations, impeding its industrialization process. It is important to promote the development of China's autonomous driving technology by revising national policies, including relevant state laws and regulations, and formulating specialized management models to support the development and application of the autonomous driving map.

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