International Cartographic Association
Association Cartographique Internationale

Research of security compliance technology on high-definition maps multi-source updating

Yongxuan Liu [a], Ming Dong[a,*], Guangjun Jia[a], Yijin Zhen [a], Qingxiang Jiang[a], Zhili Yi[a]

[a] *Beijing Institute of Surveying and Mapping, liuyongxuan123@126.com, onethyme@163.com, 13911755125@139.com, z.z.jennyzz@163.com, jiangqingxiang2019@163.com, yzlwah@163.com*

* Corresponding author

Abstract: As an important infrastructure for the development of intelligent automobile industry, high-definition maps has the characteristics of high precision, high freshness and rich elements. Massive high-definition geographic information data contains not only sub-meter-level location information, but also attribute information such as elevation, slope, and curvature. Once abused, it may involve national security issues. This paper studies the technical route of security compliance on high-definition maps in the process of multi-source updating, by summarizing the status of high-definition maps management in China and other countries of the world, analyzing its potential safety risks , putting forward the technical framework of supervision, and exploring a platform to apply the supervision on high-definition maps multi-source updating. Our research could provide ideas for the security compliance of high-definition maps, and improve healthy and orderly development of intelligent vehicle industry.

Keywords: Intelligent vehicle ; high-definition maps ; multi-source update ; safety Compliance

1. Introduction

High-definition maps, also known as autonomous driving maps, and intelligent vehicle basic maps, accurately depict and express the geographic coordinates, sizes, and feature information of roads and their components. It has the characteristics of high precision, high freshness, and rich elements. It can provide reference for navigation and positioning, perception, path planning, and decision-making of autonomous vehicles. It is one of the important infrastructures for the construction of high-level autonomous driving. Elghazaly et al. (2023). Massive high-definition maps geographic information data contains not only sub-meter-level location information, but also attribute information such as elevation, slope, and curvature. Once abused, it may involve national security issues. Pan and Jingnan (2021). This paper combs the risks and hidden dangers in the application of high-definition maps, puts forward the technical framework of high-definition maps security compliance, and explores the technical route of high-definition maps security compliance, so as to provide ideas for the healthy and orderly development of intelligent automobile industry.

2. Status of high-definition maps management

In terms of policy, many countries have strict map data encryption measures and confidentiality requirements. The United States adopts the map security technology of military and civilian separation. The military map is strictly confidential, and the civil surveying and mapping results are relatively open. The hierarchical method of geographic information elements is adopted, and the electronic map release needs to be reviewed by the government. Russia also clearly stressed that the public map should not be marked with military facilities and sensitive content, and did the corresponding confidential treatment. Armstrong and Ruggles (2005). Japan has strengthened the restrictions on the use of geographic information databases in its geographic information data security policy, and has made relevant provisions on the security elements to be considered when distributing geographic information data.

In terms of laws and regulations, the United States first clarified the management requirements for the production, testing and release of autonomous vehicles in the 2017 " Autonomous Driving Act. Hemphill (2020)" The EU mainly realizes the supervision and management of intelligent vehicle data through the " General Data Protection Regulations " Car Networking Personal Data Protection Guide. Botte et al. (2010). " In 2022, Germany passed the ' Autonomous Driving Law ', which initially established a legal system for the supervision of autonomous driving applications.Park (2023). Japan revised and passed the ' Road Traffic Law ' to realize the ' Level 4 ' operation license system for fully automated driving under certain conditions to ensure data security. Imai(2019).The UK issued the ' Self-driving Cars Act ' to achieve the use of self-driving vehicles on roads and other public places to ensure safety and reliability.Ou(1992).

In China, in terms of policy, the State Council issued the "Opinions on the Pilot Work of Doing Business Environment Innovation, " in 2021, encouraging six pilot cities, including Beijing, Shanghai and Chongqing, to pilot the use of high-definition maps for intelligent connected vehicles under the premise of ensuring safety. From 2022 to 2024, the Ministry of Natural Resources successively issued two national standard mandatory

Advances in Cartography and GIScience of the International Cartographic Association, 5, 18, 2025.
32nd International Cartographic Conference (ICC 2025), 17–22 August 2025, Vancouver, Canada. This contribution underwent double-blind peer review based on the full paper. https://doi.org/10.5194/ica-adv-5-18-2025 | © Author(s) 2025. CC BY 4.0 License

standards drafts : " Notice on Promoting the Development of Intelligent Connected Vehicles and Maintaining the Security of Surveying and Mapping Geographic Information " and " Notice on Strengthening the Management of Surveying and Mapping Geographic Information Security of Intelligent Connected Vehicles " and " Basic Requirements for the Security of Geographic information Data Sensing System of Intelligent Vehicles " and " Basic Requirements for the Security Processing of Geographic information Data of Intelligent Vehicles. " The drafts aim to implement the overall national security concept, promote the development of intelligent vehicles, and maintain the security of surveying and mapping geographic information. Liu et al. (2019).

Beijing explores the whole chain safety supervision in the links of intelligent vehicle map collection, transmission, storage and application, and strives to realize the safety supervision mode of "pre-registration, in-process supervision and post-traceability" and initially establishes a safety supervision platform. Through the co-construction mode of government, map merchants and enterprises, Shenzhen has built a map compliance cloud and carried out joint supervision. The double closed-loop scheme is adopted to realize the closed-loop of automatic driving algorithm training safety and the closed-loop of surveying and mapping geographic information security management and control. Shanghai encourages and guides the combination of map merchants and automobile enterprises to participate in the pilot, verifies the feasibility and applicability of the multi-source technology route, and explores the in-process and post-event supervision paths such as formulating safety management and control plans, carrying out incremental review, and safety risk assessment. Through the coordination of government and enterprises, Hangzhou uses the basic data of natural resources, public security and other departments, as well as the data of vehicles and roadsides, and integrates the high-definition maps data of map makers to carry out multi-source update testing and application verification. Chongqing supports enterprises to update geographic information data by means of crowd-source collection and update after reviewing maps with high-definition maps data. The relevant link of multi-source collection and update technology has been preliminary verified.Guangzhou constructs an intelligent interactive map review technical framework to realize geographic fence matching, geographic feature inspection, attribute compliance inspection, accuracy inspection, sensitive semantic inspection, etc., and supports the rapid review of advanced assisted driving maps below L3 level and high-definition maps above L4 level.

In terms of laws and regulations, in December 2024, Beijing released ' Beijing Autonomous Vehicle Regulation '. The regulation stipulate that if you use autonomous vehicles to carry out surveying and mapping activities, you should have navigation electronic map producing and other surveying and mapping qualifications,or entrusting an enterprise or institution with the qualifications above.

3. The risk points of high-definition maps multi-source updating

High-definition maps are generally collected and produced for the first time by professional mobile mapping vehicles equipped with lidar, positioning and attitude sensors, panoramic cameras and other equipment. After the map data is produced, the map is generally updated in a multi-source manner. The vehicle-side and roadside-side devices use multiple kinds of sensors to collect the road and surrounding data and upload it to the map cloud, and download the updated map from map cloud. The map cloud is released and applied through data fusion, data difference, data update, and map review to form the final map product,Wijaya et al. (2024), The overall production technology route is shown in Figure 1 .

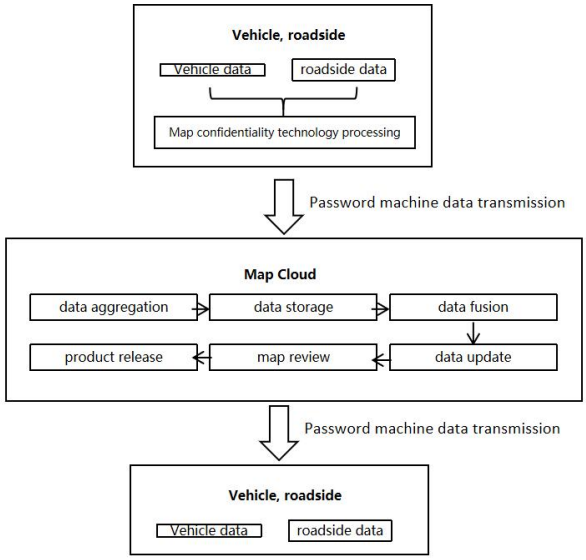

Figure 1. Technical route of high definition map production .

Intelligent vehicles can obtain massive coordinate information in the real world and real-time images around the road through long-time, large-scale and superimposed acquisition. Relevant information can not only be used to extract and analyze important and sensitive regional geographic information, but also to construct large-scale and high-precision vectors and three-dimensional maps. Okamoto et al. (2008), Therefore, there are many risks in all aspects of high-definition maps, which are as follows :

- In the data acquisition stage, there is no relevant surveying and mapping qualification enterprise to carry out illegal surveying and mapping ; the scope of data collection is beyond the pilot area of high-definition maps allowed by the government.
- In the stage of data production and processing, the original geographic information data collected has not been processed by map security technology to decrease the accuracy of the map in some degree, and the data has not been commercially encryption technique protected and safely input and output when transmitted between the vehicle and cloud, the road and

cloud and the vehicle and road, resulting in data being stolen, tampered with and attacked.

- In the stage of data release and application, the failure to perform the map review procedure, the transmission to the illegal platform, and the failure to perform the approval procedure according to law when the data is exported lead to data leakage and property rights disputes, which in turn affects information security and the legitimate rights and interests of enterprises.

In addition, when the high-definition maps is updated by the vehicle-side multi-source, it will collect information such as the vehicle 's own location, driving trajectory, and surrounding pedestrian images. Improper protection will expose public or personal privacy, thus affecting user 's information security.

4. The overall framework of high-definition maps safety supervision

The high-definition maps is mainly derived from the collection and processing of spatial coordinates, images, point clouds and attribute information of roads and surrounding facilities at each end and side, which is a statutory surveying and mapping activity. Therefore, the whole supervision framework is an important guarantee to ensure the accuracy, integrity and security of map data, including the following aspects .

4.1 Supervision subjects and responsibilities

Those who are engaged in the collection, storage, transmission and processing of high-definition maps data are the main body of surveying and mapping activities. The vehicle industry, service providers and intelligent driving software providers should abide by relevant regulations and assume corresponding responsibilities according to law, and should obey the managemant of the department of natural resources on navigation electronic maps. .

4.2 The content and process of supervision

First is about qualification management, Chinese domestic enterprises should have the qualification of navigation electronic maps, and foreign enterprises must cooperate with qualified domestic enterprises to carry out surveying and mapping activities; Second, in the process of multi-source data collecting to update the high-precision maps, the vehicals and map cloud need to process the data by map security technology mentioned above, and commercial encryption technique protection is needed during data uploading and downloading process. Third, before the release of map, a map review procedure should be performed, to ensure the security of the content of the map , .Zhang et al. (2021).

5. Practice ofhigh-definition maps security compliance

5.1 High-definition maps multi-source updating supervision process

We design a process for supervision of high-definition maps multi-source updating by intelligent vehicles, and achieve supervision through the whole processes of the map updating, including pre-registration, in-process monitoring, and post-traceability, as Figure 2.

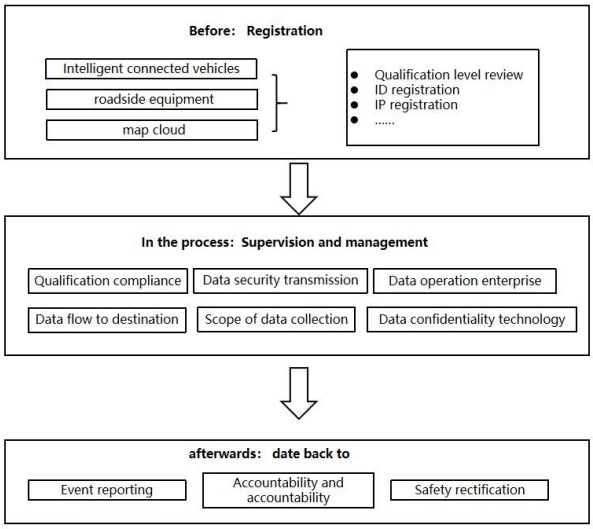

Figure 2.High-definition maps security compliance process.

Pre-registration : For enterprises and institutions engaged in high-definition maps activities, they need to register and register basic information on the regulatory platform (such as vehicles, roadside units, identification of map platforms, IP addresses, surveying and mapping qualification certificates, etc.). After that, the map security technology plug-in and safety supervision plug-in are installed for different end-sides to realize the security technology processing and secure transmission of geographic information data.

In-process supervision : the platform collects, stores, analyzes and processes the activity logs of surveying and mapping activities at each end, such as geographical fence identification, declassification and desensitization judgment, data inflow and outflow direction, activity

trajectory perception prediction, etc., to ensure the safety compliance of high-definition maps application end.

Post-traceability : through the inspection and supervision of the compliance of surveying and mapping activities, generate alarm information and online notification for violations, combined with offline supervision and rectification, and finally realize the closed-loop safety supervision of the whole data process, and realize the manageable, controllable, traceable and preventable intelligent management of high-definition maps.

5.2 High-definition maps multi-source updating supervision platform

We explored a platform for supervision of high-definition maps multi-source updating by intelligent vehicles to apply the supervising procession of high-definition maps multi-source updating,. and to analyze the behavior of supervision log, so as to provide judgment basis for decision makers.

The platform mainly includes six modules : vehicle and road-side management module, map platform management module, compliance inspection module, violation traceability module, visual portal and user management module. The core functions of each module are introduced as follows:.

- Vehicle-side and road-side management module.including the authentication, registration and audit of the vehicle supervision object in the pre-registration stage, as well as the access, storage and query of the basic information of the vehicle behavior log data in the matter.
- Map platform management module. Including the pre-stage of the map platform regulatory object authentication registration and audit, as well as the roadside behavior log data access, storage and log basic information query.
- Compliance inspection management module. In - process supervision stage, the log data accessed by the regulatory object, the connected vehicle, the roadside / edge cloud, and the map platform are checked according to the compliance rules. When there is no compliance, the violation information is generated and entered into the violation traceability module for processing.
- The violation traceability module. In the post-traceability stage, the violation message is pushed to the relevant processing personnel. After the violation processing personnel process it offline, the offline processing results are submitted online on the regulatory platform. All violation information, historical trajectory playback of illegal vehicles, and violation handling details can be viewed here.
- Visual portal. Based on the map engine, combined with vehicle logs, roadside logs, platform logs, alarm information and other data, statistical analysis of different dimensions is carried out, and visual display is carried out, mainly including.statistical analysis of regulatory objects, statistical analysis of reporting logs, statistics and analysis of illegal alarms.
- User management module. For the management of platform users, roles and permissions, the platform roles mainly include : platform administrators, regulatory auditors, compliance inspectors, and violation handlers. Different functional permissions can be assigned to different roles of personnel, and the operation of the platform can be comprehensively guaranteed.

6. Conclusion

As an important embodiment and typical application of new productivity, intelligent vehicles have injected new impetus into the development of the industry. At the same time, high-definition maps, as important basic resources and data elements, are an important part of the automatic driving industry , and have the potential to drive related industries. While a balance between development and security should be kept well. Based on the summarizing the status of high-definition maps management in China and other countries of the world, this paper puts forward the method of safety supervision of high-definition maps multi-source updating, develops a supervision platform, and establishes the whole process supervision mode of pre-registration, in-process supervision and post-traceability stage over the map cloud , vehicle-side and road-side map. In the future, we will research on the hierarchical classification method of high-definition maps data to achieve focused, hierarchical and refined data security compliance management.

7. References

Armstrong, M. P., & Ruggles, A. J. (2005). Geographic information technologies and personal privacy. Cartographica: The International Journal for Geographic Information and Geovisualization, 40(4), 63-73.

Botte, M., Pariota, L., D'Acierno, L., & Bifulco, G. N. (2019). An overview of cooperative driving in the European Union Policies and practices. Electronics, 8(6), 616.

Elghazaly, G., Frank, R., Harvey, S., & Safko, S. (2023). High-definition maps: Comprehensive survey, challenges and future perspectives. IEEE Open Journal of Intelligent Transportation Systems.

Hemphill, T. A. (2020). Autonomous vehicles: US regulatory policy challenges. Technology in Society, 61, 101232.

Imai, T. (2019). Legal regulation of autonomous driving technology: Current conditions and issues in Japan. IATSS research, 43(4), 263-267.

Liu, J., Dong, Y., Zhan, J., & Gao, K. (2019). Thoughts and suggestions on autonomous driving map

policy. Strategic Study of Chinese Academy of Engineering, 21(3), 92-97.

Okamoto, K., Takahashi, N., Iwanami, K., Shige, S., & Kubota, T. (2008). High precision and high resolution global precipitation map from satellite data. 2008 Microwave Radiometry and Remote Sensing of the Environment, 1-4.

Ou, Y. (2024). Driving into the Unknown: An Evaluation of Liability for Accidents Caused by Autonomous Vehicles under UK Law. Manchester Review of Law, crime & Ethics, 12.

Pan, Z., & Jingnan, L. I. U. (2021). A generalized data model of high definition maps. Acta Geodaetica et Cartographica Sinica, 50(11), 1432.

Park, K. S. (2023). A Study for Improving Driving Safety Assurance for Fully Autonomous Vehicles-Focusing on Amendments of the German Road Traffic Act and the Japanese Road Traffic Act. Journal of Auto-vehicle Safety Association, 15(1), 45-54.

Wijaya, B., Jiang, K., Yang, M., Wen, T., Wang, Y., Tang, X., ... & Yang, D. (2024). High Definition Map Mapping and Update: A General Overview and Future Directions. arXiv preprint arXiv:2409.09726.

Zhang, T., Tu, H., & Qiu, W. (2021). Developing High-Precision Maps for Automated Driving in China: Legal Obstacles and the Way to Overcome Them. Journal of Shanghai Jiaotong University (Science), 26(5), 658-669.

Zhu, G., Zhao, F., Song, H., & Liu, Z. (2024). Cost Analysis of Vehicle-Road Cooperative Intelligence Solutions for High-Level Autonomous Driving: A Beijing Case Study. Journal of Advanced Transportation, 2024(1), 6170743.

Advances in Cartography and GIScience of the International Cartographic Association, 5, 18, 2025.
32nd International Cartographic Conference (ICC 2025), 17–22 August 2025, Vancouver, Canada. This contribution underwent double-blind peer review based on the full paper. https://doi.org/10.5194/ica-adv-5-18-2025 | © Author(s) 2025. CC BY 4.0 License