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Research on Planning Scheme Evaluation and Scene Module Analysis of Intelligent Networked Automobile Proving Ground

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Abstract: The development of Internet and artificial intelligence technology endows the traditional automobile industry with the color of intelligent and networked industry. The development of intelligent networked vehicles can improve the related transportation efficiency and solve the existing disadvantages such as environmental damage and energy depletion. As a testing ground for evaluating and verifying the quality and performance of vehicles, it will be the focus of its support system development. Therefore, this project has considerable practical application value. Based on the experience of planning and construction at home and abroad, this paper analyzes the comparison method of multi-scheme selection of overall planning, functional layout and road layout, estimates the cost and realizes the scheme evaluation of intelligent networked automobile proving ground. At the same time, the key points of scene design module are studied to provide reasonable design methods for its construction and implementation, and provide technical reference for the design of related fields.

1. Introduction

The development of intelligent networked vehicles needs a complete testing and evaluation system to support its long-term stable development. As an important facility in the evaluation and measurement system, the networked automobile intelligent test site has intelligent research, module development and performance testing, which is also an important part of the development of intelligent connected vehicles. In the long run, comfortable, energy-saving and efficient driving will eventually replace the traditional concept of transportation. Based on this background, it can be seen that the development of intelligent networked automobile proving ground needs a complete planning scheme evaluation and scene module analysis and research.

2. Background Analysis

2.1 Foreign Smart Car Proving Ground

Europe, the United States, Japan and other industrialized countries attach great importance to the testing and evaluation of smart cars and transportation. The United States has established test sites in many places. Such as Mcity proving ground, as shown in figure 1; GoMentumStation proving ground, as shown in Figure 2, etc. The European Union has also formulated a smart car development link, trying to regard intelligent networked cars as one of the most important development directions in the process of industrialization, and has built a number of test facilities and venues, such as AstaZero; WillowRun and so on. Applusidida, a Spanish company, and HoribaMira, a British company, also designed the intelligent networked vehicles in a targeted way, and redesigned the traditional vehicle test site to meet the test requirements of the intelligent networked vehicles. As shown in Table 1 [1].

Figure 1: Mcity proving ground

Figure 2: Go Mentum Station proving ground

Table 1: Comparison of main foreign intelligent networked automobile test sites

name	site	Area/m^2	Completion time	test function
Mcity	United States of America	130 thousand	In 2015	Autopilot and v2x technology
Asta Zero	Sweden	2 million	In 2014	Vehicle dynamics, driver behavior, communication technology
City Circuit	Britain	3.04 million	/	Traditional automobile, intelligent transportation and intelligent networked automobile.
Willow Run	United States of America	1.36 million	the year of 2018	Autopilot and v2x technology

2.2 Intelligent Networked Automobile Domestic Proving Ground

At present, many parts of the country have stepped up efforts to build intelligent test areas for networked vehicles and actively promote the testing and inspection of semi-closed and open roads. For example, the closed test area of Shanghai Demonstration Zone is located in the south of Shanghai F1 Stadium. The total length of the road is 3.6 kilometers. A mobile simulation building is installed at the intersection to simulate the urban environment, a parking lot and a small gas station. Intelligent traffic lights and intelligent communication equipment are installed on the roadside, and a temporary simulation information protection tunnel is built. Chongqing Demonstration Zone has built a leading international demonstration project and public utility product development platform for smart cars and transportation applications. This plot covers more than 90% of the special road conditions in the western region and more than 85% of the road and communication environment in China, and supports research, test verification, testing and certification, as shown in Figure 3.

Figure 3: Chongqing Intelligent Networked Automobile Testing Center

2.3 Summary and Analysis

As can be seen from the above different scenarios, the test field of smart grid is mainly composed of closed test area and semi-closed test area. The use of intelligent infrastructure abroad is mainly concentrated in closed test demonstration areas, such as the representative test sites mentioned above. Compared with foreign countries, domestic intelligent networked vehicles and related experiments started late. However, in recent years, the early stage of intelligent networked vehicles in China also focused on closed core test areas, which have been gradually released in the above-mentioned open road planning areas such as Beijing, Chongqing and Changsha. The layout of the closed test area is basically described as follows. The closed test area mainly includes: 1) expressway (used for expressway modeling, urban expressway, etc.), parallel scene type, maintenance, presence, charging, etc. 2) Urban road network area is mainly used to simulate different types of urban public scenes, such as different intersections (including plane intersections and vertical intersections) and different types of traffic islands; 3) Rural roads are mainly used to simulate various extreme turning radii, longitudinal slopes, shadows, different road shapes and other scenes; 4) Area, space is a more flexible layout area, which can set up different urban scenes and parking scenes, and can also be simulated through the architectural structure of some closed areas, lighting simulation, ice surface and special scenes, such as street topography [2].

3. The Comparison and Cost Estimation of the Overall Planning of the Test Site

3.1 Comparison of Overall Planning of Proving Ground

The construction and operation cost of the test site is high, and the sustainable development faces great challenges. The construction needs many inputs such as land, hardware, software, personnel, etc., especially for the new site. Even if the traditional test site is upgraded, there will be high-cost infrastructure investment in the early stage. Judging from the current site usage, each test demonstration area should conduct in-depth research on the needs of the test subjects, including road needs, scene needs, project needs, etc., and make comparative analysis of multiple versions of the scheme, and at the same time understand the real needs of enterprises testing on the road, estimate the cost, avoid the waste of resources caused by insufficient utilization, and improve the service capacity under the market competition mechanism. Taking the scheme of a proving ground in southwest China as an example, this paper discusses the advantages and disadvantages of the two versions of the proving ground planning scheme, and analyzes the key points of scheme selection, as shown in Figure 4 below.

Scheme I Environmental Planning and Layout of Test Site Scheme II Environmental Planning and Layout of Test Site

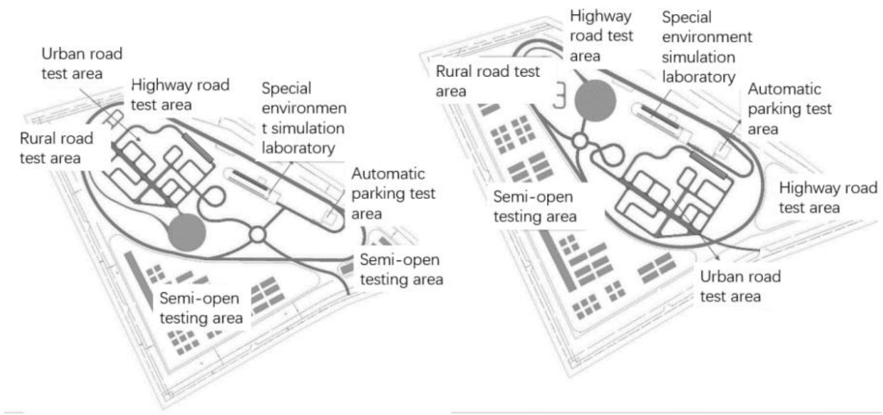

Figure 4: comparison of two versions of proving ground planning

According to the drawing information, the planning of scheme 1 and scheme 2 is compared and analyzed, and the advantages of scheme 2 in planning and layout can be found. 1) In the second scheme, the contact surface between the open area and the municipal road will be increased to facilitate the interface with the urban space. The increase of traffic entrances and exits has reduced the pressure on urban traffic. 2) Arranging buildings along the main roads of the city will have a better effect on the image and style of the city, and can better show the image of the park to the outside world. 3) The proving ground in Scheme 2 is more intensive than that in Scheme 1, which improves the land utilization rate without changing the function of reducing the use. 4) The proving ground in the second scheme is located inside the site, which provides inherent advantages for the test vehicles that need to be kept confidential. 5) The planning and layout of Scheme 2 is more regular and compact, and the open space left on the left side of the closed test area is rectangular, so it is more effective to arrange other buildings as a semi-open test area.

Secondly, in the planning and design of intelligent networked automobile proving ground, the shape, length and location of closed test area expressway, urban road, rural road, special environment simulation laboratory, automatic parking road and semi-open area should be considered, and the optimal design can be completed by comparing multiple versions of the scheme. By analyzing and comparing the length and area of expressway, urban road and rural road in Scheme I and Scheme II, it can be found that the expressway in Scheme II is slightly lower than that in Scheme I, but the length and area of urban road and rural road in Scheme II are both larger than those in Scheme I, and the land utilization rate of site layout is higher. The location and area of the special environment simulation laboratory and automatic parking road in Scheme I and Scheme II are consistent, while the land utilization rate of the test site in Scheme II is higher and the construction area of the innovation center is larger, as shown in Table 2. Through the above comprehensive evaluation, it is determined that scheme 2 is better, so scheme 2 is selected for later deepening construction design.

Table 2: Comparison of main data between Scheme I and Scheme II of the proving ground

	Contrast project	Scheme No.1	Option 2
one	Expressway area	41,625 square meters	37,125 square meters
2	Urban road area	86,058 square meters	117,138 square meters
three	Rural road area	5620 square meters	6900 square meters
four	Coverage area of test site	1200 mu	1000 mu
five	Coverage area of innovation center	610 mu	830 mu
six	land use rate	88%	89%

3.2 Cost Estimation of Proving Ground

After determining the basic layout of Scheme II, optimize the design of Scheme II, focusing on increasing the area of expressway. After design adjustment, it is necessary to estimate the cost of expressway circle area, urban road area, rural road area, continuous detour, dynamic square, special environment simulation road and multi-adhesion coefficient braking road in key areas. Accurate cost calculation is conducive to the smooth construction of the scheme. As shown in Table 3. In the study of multiple projects, it is found that the design of intelligent networked automobile test site needs to comprehensively consider the needs, functions, road integrity, land utilization rate, etc., and the cost factor is not dominant, but the cost still needs to be estimated after the design, so that it should be within a reasonable range and should not be too high, which will make the construction party invest too much.

Table 3: Cost Estimation of Scheme II

	Project	Area of deepening version of Scheme II (m2)	Jian'an project cost (ten thousand yuan)
one	High-speed loop area	42818	5249.19
two	Urban road area	102483	5338.74
three	Rural road area	5167	198.93
four	Winding road	8250	367.13
five	Dynamic square	31400	1975.69
six	Special environment simulation road	34843	1550.51
seven	Multi-adhesion coefficient braking road	64652	3698.09

4. The Design and Evaluation of the Test Site Scene

4.1 Overview

The development and testing of automatic driving system aims at realizing three technical paths: driving intelligence, road cooperation and remote driving. In order to realize the above technical paths, it is necessary to develop different scenarios for closed test sites and road blocks, intelligence, grid equipment configuration and algorithms. The closed proving ground should enrich the variety of scenes. This is mainly manifested in the following aspects: 1. The diversity of road forms; 2. Whether the types of road signs and signs are clear; 3. Wealth of road users: vehicles, non-motorized vehicles, adults, children, animals, etc. 4. Diversity of driving scenes, including driving direction and participants' performance [3].

4.2 Scene Settings

In the planning and design stage, we not only need to understand the normative test scenarios required by intelligent networks, but also need to implement a wider range of social road scenarios in as limited an area as possible. An important part of the closed proving ground is a simulated expressway, which imitates the scenes of expressways and urban expressways, and combines ramps, toll booths and other conventional configurations. Road signs and signal lines of corresponding roads are the main roads for ADAS system testing. Generally speaking, the straight line segment should be longer, and the suitable length needs to be more than 1 km. At the same time, different ADAS requirements and different radius curve requirements are defined at both ends of the road, and the input and output sections of the straight line are defined. It can also be combined with a square, which provides different rotation radius requirements, and the combination of straight lines provides the required rotation length. A fast loop is established in the intelligent network proving ground, and the two ends of the rotation radius are the three radii required by ADAS500250125M system. The length of the radius is determined by the red line of the field. Of course, the ADAS system needs a bending length of at least 350 meters and must comply with the original design intention as much as possible.

On the expressway, multi-layer layout is usually used, and multi-layer scenes are set on the expressway under different traffic conditions. For example, in the ACC test: tracking, reversing, multi-lane steering, prohibiting the target vehicle, constant speed, emergency braking, etc. Tracking: On a straight line, the target vehicle runs at a constant speed of 80km/h, and the test vehicle follows the target vehicle at a speed of 80 km/h.. If the current vehicle slows down, the test vehicle must be able to brake in time to keep a safe distance from the previous vehicle; If the current vehicle accelerates or even disappears, the test vehicle should be able to quickly accelerate to the maximum speed on the road, and keep a suitable safety interval with the previous vehicle after chasing [4-6].

4.3 Intelligent Networked Vehicle Proving Ground Planning and Design Scenario Module

The Ministry of Transport released a report in 2018, and discussed six intelligent networked vehicle test site evaluation indicators, such as general requirements, general requirements for test roads and road type requirements, specific requirements for test roads, environmental requirements for road networks, and maintenance requirements. The evaluation system of networked automobile intelligent test site aims to objectively evaluate the construction and service capacity of the national test site, control the rational planning of the test site, and strengthen the standardized test capability. Coordinate test service standards, promote resource sharing and mutual recognition of intelligent networked vehicle test results, create an environmental environment for the innovative development of intelligent networked vehicle industry, and promote the transformation, upgrading and quality development of automobile industry [7-8].

The scene of the intelligent networked automobile test site is a comprehensive reflection of the environment and driving behavior in a certain time and space. The scene layout is the construction of the automobile test environment, which is a deepening design based on the planning plane. Different scenes can be laid out along the road alignment, and various typical characteristic test environments can be built. In the scene design, each scene should be tested, and the test route loop of the test item and the route interference between multiple test items should be fully considered, so that the automobile test can not only meet the requirements of standards and regulations, but also maximize the test capacity of the test site [9]. The test scenario is a driving condition composed of weather conditions, road traffic facilities, traffic participants and other external conditions, as well as the driving tasks and status of the vehicle. Car companies need to change the development mode and test method to scenario-based development mode and test method, and drive the development iteration with the scenario, and conduct efficient test based on the scenario, as shown in Figure 5. Considering various factors, we can define and construct the scene library of automatic driving function in the design, as shown in Table 4.

Figure 5: Classification of Design Scenes

Table 4: Design Scenario Model

Building a functional scene library						
Driving area	Intersection condition	pavement behavior	Temporary roadblock	light	Traffic flow situation	weather
urban highway	No intersection	street lamp	Lane narrowing	morning	few	sunny day
high-speed	crossroads	isolation belt	Lane widening	high noon	less	cloudy day
countryside	Duolukou	speed bump/hump	Temporary speed limit	afternoon	many	rain
national road	Roundabout	downward slope	reversible lanes	night	more	snow

There is a big gap in the construction level of intelligent networked automobile test sites in China, but they are all built according to these design scenarios. For example, Beijing Haidian Test Base was upgraded from Haidian Driving School, with 4.8 km of urban road and rural road scenes, supporting V2X test; The intelligent system test area in Changsha Xiangjiang New Area is completely newly built, covering urban roads, highway sections with toll stations, rural road tests and off-road tests, supporting V2X tests, and can accommodate more than 20 test vehicles (5 high-speed vehicles, 10 urban vehicles and more than 6 other vehicles) in the same period. Chongqing urban simulation road test evaluation and test demonstration area was rebuilt by China Automobile Research Institute, covering urban road test scenarios. Due to the influence of terrain, straight roads, bends, ramps, bridges and tunnels are complete, supporting V2X test; Changchun Jingyue test site was transformed from FAW traditional test site, covering the urban road test site, which can carry out rain and snow bad weather scene test, support V2X test, and can accommodate 10 test vehicles. [10]

4.4 Evaluation of Planning and Design Scenarios of Intelligent Networked Automobile Proving Ground

Scene testing is still the main means to test smart connected cars, which is limited to the relevant policies and regulations and public road testing in China. At present, many foreign test sites tend to combine real road measurement and virtual simulation test to test the safety of smart grid vehicles before landing. On the one hand, some situations rarely occur under real road conditions and can be repeated from different angles in the simulation environment. On the other hand, when engineers make modifications to automobile driving, they can predict the impact of these modifications through the simulation environment. Therefore, we should make use of foreign experience and advanced technology to focus on building and improving closed test sites and simulation test platforms.

In the design, it is necessary to improve the evaluation criteria of automatic driving scene library including natural driving, standards and regulations, dangerous working conditions, traffic rules and other sources, so as to improve the safety of automatic driving system in the system design stage. In the research and development stage of the system, the integrated simulation test of in-the-loop simulation is carried out by establishing the scene to improve the reliability of the automatic driving function. In the later stage, the scene design is designed and adjusted according to the test requirements and situation feedback of the intelligent networked vehicle, as shown in Figure 6.

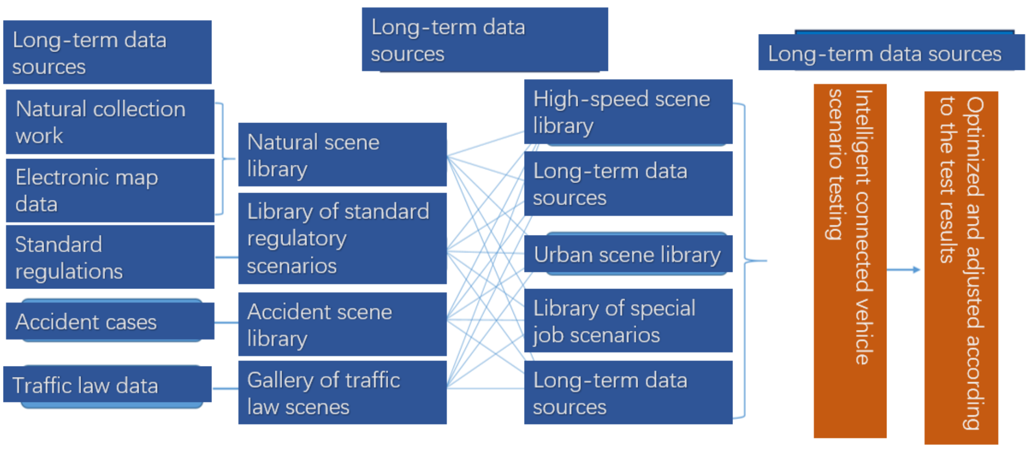

Figure 6: Perfect design scene library

Generally speaking, smart grid vehicles in China show a strong development trend, but most of the test sites are located in developed areas such as Beijing, Zhejiang and Chongqing, which are suitable for the typical characteristic environment of China, such as plateau, desert and Gobi. Therefore, the next step for national and local governments should be to build and deploy a number of intelligent test sites with typical terrain and climate characteristics of China in the northwest and southwest of China, within the framework of implementing the "the belt and road initiative" initiative. The construction of the test site should be combined with the overall development of other sites, so as to realize different treatment, realize complementary functions and avoid overlapping functions and waste of resources.

5. Suggestions on the Construction of Domestic Intelligent Networked Automobile Test Site

Although the development of intelligent networked vehicles in China started late, some progress has been made in recent years. At present, Shanghai, Chongqing, Shenzhen, Changsha and other places plan to build a suitable testing ground. Since the R&D level of intelligent networked vehicles in China is still focused on the automatic driving of SAE3 and below, the construction of special test platform must follow the principle of "two steps" in terms of speed and practicality. According to the mature experience of establishing an intelligent test site for interconnected vehicles abroad, from the perspective of test environment and test facilities, the following suggestions are put forward for building an intelligent test site for interconnected vehicles in China [11].

5.1 Road Environment

Most of the existing overseas test sites combine pavement with pavement, and some only provide pavement due to the limitation of site area. According to the test requirements of automatic driving system of SAE3 and below and ADAS, the construction of Chinese test site can only be temporarily arranged in the first phase of asphalt and urban road construction to meet the test requirements of driver assistance system. If the terrain and conditions permit, the construction should be combined with asphalt and uneven roads, and the influence of complex and changeable road performance on the driving process of intelligent vehicles should be evaluated according to the diversity of road shapes.

5.2 Infrastructure Support

In order to reduce the renovation cost, improve the utilization rate and maintenance cycle of the factory, the construction of China proving ground must be based on the flexible concept, provide some support for the early construction of infrastructure, and reserve space for rich scenarios in the future [12].

5.3 Auxiliary Test Equipment

In addition to importing road users such as mannequins, bicycles and balloons, China Experimental Zone can also develop suitable simulation test equipment such as electric bicycles according to the unique road conditions in China. Evaluate the adaptability of intelligent networked vehicles to road conditions in China. Weather is also an important factor affecting the performance of intelligent networked vehicles[13]10. In view of the high cost of construction, operation and maintenance of meteorological simulators, such facilities can be added to the test site in the second stage, and relevant interfaces and spaces can be reserved in the early stage, but they cannot be used as main functional buildings[14]. Once the construction site operates well and has sufficient resources, relevant facilities can be gradually added during the renovation and expansion[15].

6. Conclusion

Intelligent networked vehicles are the inevitable trend of the transformation and upgrading of the automobile industry. With the development of intelligent connected vehicles, the proving ground of intelligent connected vehicles has become one of the main fields of industry research. Foreign related design is still at the forefront. Therefore, China should make full use of the advanced experience of foreign proving ground construction, combine with the specific national conditions of China, and integrate advanced design concepts, scene characteristics and testing methods to improve the planning, design and evaluation level of domestic proving ground, make rational planning and scientific layout, and better promote the development of smart connected automobile industry in China.

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