同济大学交通运输工程学院
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Facilitating the Deployment of Highly and Fully Automated Vehicles in Road Traffic along the Asian Highway Network

Country Report for China

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ONE
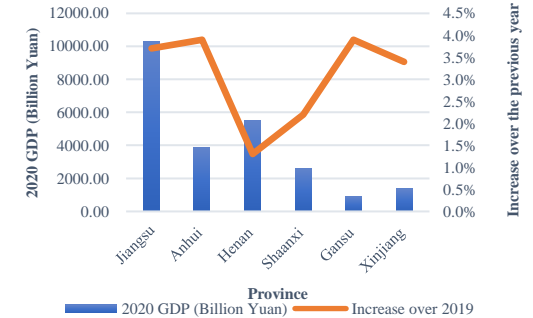
INTRODUCTION

INTRODUCTION / Background

Economy in China

- Continuous increase of GDP.
- Stable employment rate
- Stable consumer price index
- Growth rate of freight volume: 2%.
- Growth rate of postal express business: 6.3%.

GDP of the provinces along AH9 in China, 2020

Legend: 2020 GDP (Billion Yuan) — Increase over 2019

Transportation in China

- Formalization of transport infrastructure network
- Improvement of comprehensive transportation system
- Technology innovation
- Enhancement of transportation related facilities and equipment

China's GDP and its growth rate, 2016-2020

Legend: GDP (Billion Yuan) — Growth rate
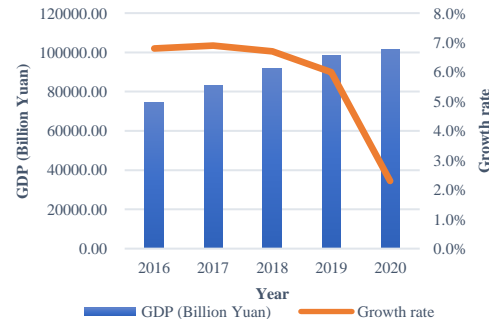
The provinces along AH9 in China

- GDP in provinces steadily increased
- Increase of number of civilian vehicles
- The total highway mileage expanded
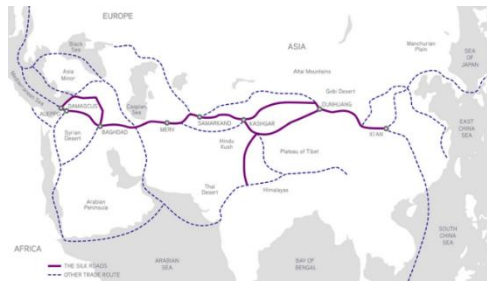- Imbalance of development

- Total length: 4,395 km (2,731 mi)
- The longest contiguous expressway in China with a single numeric designation (G30)
  - ◆ Part of AH34 (Lianyungang to Xi'an)
  - ◆ Part of AH5 (Xi'an to Khorgas)
  - ◆ Part of AH4 (Urumqi to Toksun)
- It passes through the historically significant Hexi Corridor in Gansu and Xinjiang

Expressway Network | Silk Road Economic Belt

(i) Basic Data of AH9 in China

Section	Indicator	Value
Jiangsu	Length	238km
	Lanes	Two-way four-lane
	Speed limit	120km/h
Anhui	Length	52km
	Lanes	Two-way four-lane
	Speed limit	120km/h
Henan	Length	611km
	Lanes	Zhengzhou to Luoyang/Lankao: Two-way Eight-lane Else: Two-way four-lane
	Speed limit	100km/h
Shaanxi	Length	379km
	Lanes	Tongguan to Baoji: Two-way Eight-lane Else: Two-way four-lane
	Speed limit	120km/h
Gansu	Length	1691km
	Lanes	Two-way four-lane
	Speed limit	120km/h
Xinjiang	Length	1476km
	Lanes	Two-way four-lane
	Speed limit	120km/h (Wulumuqi:70-80km/h)

TWO

ITS PLANS FOR SMART HIGHWAY

Internet
A vast network that connects computers all over the world

Big data
Processing a large volume of data with high computing velocity

Artificial Intelligence
The simulation of human intelligence in machines that are programmed to think like humans and mimic their actions.

Block-chain
A blockchain is a growing list of records, called blocks, that are linked together using cryptography.

Supercomputing
A computer with a high level of performance as compared to a general-purpose computer.

Beidou Satellite Navigation System
A Chinese satellite navigation system.

The Transport Network in China should be **Convenient, Cost-effective, Green, Intelligent,** and **Safe**.

Jiangsu
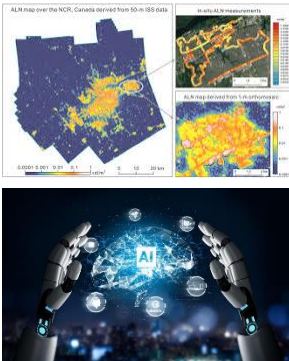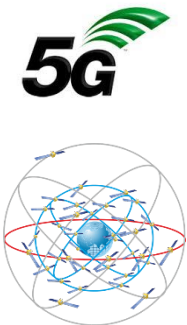
Principles

- ➤ Systematic
- ➤ Practical
- ➤ Safe
- ➤ Advanced
- ➤ Economic
- ➤ Scalable

Pilot project:

- ➤ S342 highway in Wuxi

Anhui

安徽省地图
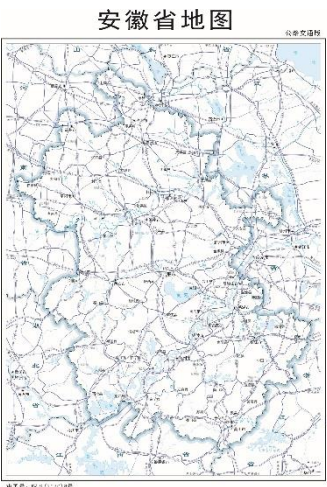
Deployed Facilities

- ➤ Highway Full-process Monitoring and Management System
- ➤ Highway Severe Weather Condition Monitoring and Warning System
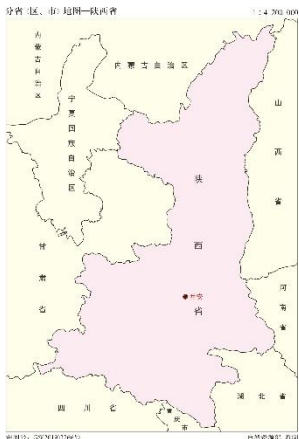- ➤ Electronic Toll Collection
- ➤ Mobile payment

Henan

Deployed Facilities

- AI Analysis Cameras
- Millimeter-wave Radars
- Edge Computing Servers
- Electronic Toll Collection
- Mobile Payment

Shanxi

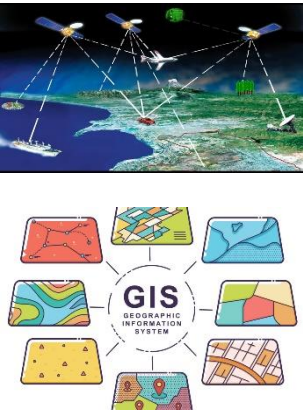### Facilities

- Internet of Things +5G
- High-Speed Operation Management
- Public Travel Information Service

Gansu

Complete by 2035

➢ Smart highway pilot projects

➢ effective vehicle-road coordination

➢ meteorological service information system
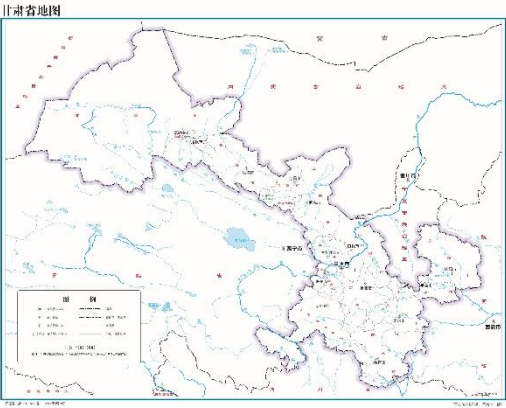
A new live broadcast system for highway condition monitoring
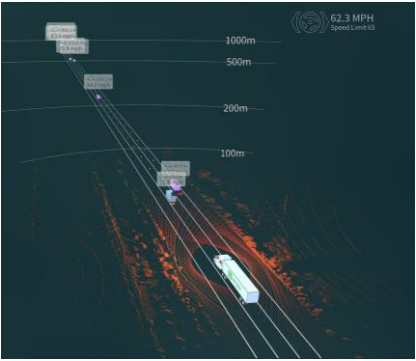
Xinjiang

Planning

Relevant policies are still being explored.

THREE

REPRESENTATIVE SMART HIGHWAY PILOT PROJECTS

The S342 highway is an important intercity highway in southern Jiangsu Province
The pilot project is completed by 2020 in Wuxi, Jiangsu

- **5G technology**
  60% of the demonstration highway sections have covered by 5G signals (as of 2020).

- **Roadside sensor equipment**
  The highway uses cameras and radar to detect abnormal traffic conditions such as car accidents, congestion, etc. It can automatically alarm and capture real-time pictures for emergency handling.

- **Service scenarios**
  10 service scenarios can be provided through the mobile phone app, such as vehicle speed guidance, vehicle confluence, pedestrian avoidance, abnormal road conditions, and road congestion.

5G technology

Roadside sensor equipment

The Donghai Bridge is a cross-sea bridge connecting Shanghai, and Zhejiang Province in China. It is one of the key supporting projects of the Yangshan Port.

- **Cooperative Adaptive Cruise Control (CACC) technology**
  TuSimple completed the high-speed CACC system, which can achieve a stable distance of 12 meters between more than 3 trucks at a speed of 70 to 80 km/h.

- **Test area for intelligent connected vehicles (CV)**
  The construction of the test has been completed (by 2019), includes several functional areas such as straight roads, tunnels, and rainfall simulation.

- **V2X vehicle-road collaboration system**
  The construction of the data center V2X vehicle-road collaboration system has been completed with real-time vehicle status monitoring. At present, the automated self-driving trucks can run with other human-driven vehicles with a speed limit of 80 km/h on the Donghai Bridge.

Donghai Bridge

Automated truck platooning

FOUR

TECHNICAL ADEQUACY FOR AUTOMATED TRUCKS

Real-time traffic information collection system

The real-time traffic information collection system collects real-time traffic information mainly by roadside equipment, mobile phones, and vehicle on-board units. The system collects the following information:

- **Traffic status**
  Traffic volume, instantaneous speed, average speed, lane occupancy, headway time, speed information, travel distance, etc.

- **Traffic emergencies**
  Incidents, road maintenance, user report information, traffic incident handling information, etc.

- **Traffic meteorological environment**
  Meteorological data provided by meteorological stations and by third-party information service platforms.

- **New-generation vehicle-side information**
  Vehicle trajectory, abnormal status, real-time positioning, operating status, etc.
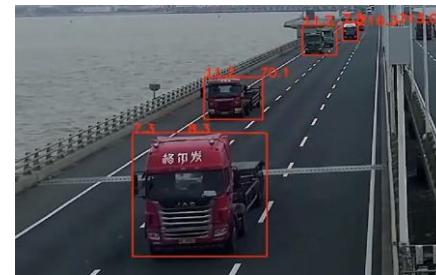
Roadside senser detection

vehicle on-board sensor

Infrastructure performance information collection system

The infrastructure performance information system collects information about pavement health status to ensure the safety of autonomous driving on different road sections.

- **Pavement performance**
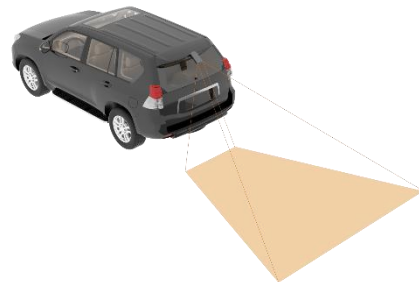 Roughness, pavement distress, skid resistance, and other information to measure the quality of the pavement.

- **Roadside facilities performance**
  The completeness of highway signs, marking facilities, and equipment.

- **Other facility performance**
  The information of tunnel and bridge facilities.

In-vehicle information collection equipment

Analysis pavement health status

Cooperative Vehicle Infrastructure System (CVIS)

The CVIS system coordinates the intelligent highway roadside system with vehicles, using 5G or dedicated short-range communication technologies to provide extremely low-latency broadband wireless communication to ensure the safety of automatic driving.

- **Multi-network integration technology**
  The system integrates transportation network, information network, with energy network, realizing coordinated decision-making and control with the aim of global optimization.

- **Vehicle to Infrastructure (V2I) communication system**
  The system can be classified as the application system, the cloud system, the edge-side system, and the terminals. V2I system can provide high-concurrency, real-time, and high-speed data communication services.

- **Lane-level traffic control technology**
  This technology reduces the speed difference in the lane to improve the highway capacity and ensure driving safety.

V2I communication system

Lane-level traffic control

Transportation is one of the main areas to implement the BeiDou Navigation Satellite System. By the end of 2020, there were about 7 million business vehicles in China have been equipped with BeiDou devices.

- **Dynamic positioning**
  Integrating the BeiDou system with the real-time kinematic positioning (RTK) technology, the precision of static positioning can reach millimeter level, and that of the dynamic positioning can reach centimeter level.

- **Differential calculation and data management services**
  Based on high-definition maps, It can offer useful services such as map browsing, routing planning, data management, location information, etc.
  The high-precision positioning technology with high-precision positioning and lane-level route planning can provide digital maps for intelligent connected vehicles for more stable and reliable positioning services.

BeiDou Navigation Satellite System

High-definition maps

As of the end of September 2020, more than 690,000 5G base stations have been built and opened in China, which is more than 70% of the global total. The 5G-based intelligent transportation infrastructure includes but not limited to the following systems:

- **High-definition positioning platform**
  Including a series of modules such as high-definition integrated positioning module, data calculation module, etc. to improve the positioning accuracy and reliability.

- **New-generation communication infrastructure**
  Which can leverage the advantages of 5G and high-definition positioning resources. It can promote the integration of new technologies such as 5G, artificial intelligence, cloud computing, big data, and edge computing in transportation constructions.

Through the full usage of 5G, edge computing, and V2X, the CVIS network can integrate the essential in the transportation systems and implement a series of smart highway services

FIVE

AUTONOMOUS VEHICLES IN CHINA

The autonomous driving development plan in China

Policy

◆ **14TH FIVE-YEAR PLAN**

- A standardized policy environment should be created to regulate autonomous vehicles and intelligent logistics
- The related laws, regulations, and ethical review rules should also be improved

◆ **OUTLINE FOR THE CONSTRUCTION OF NATION WITH A STRONG TRANSPORTATION SYSTEM**

- Strengthening the study and development of intelligent connected vehicles (autonomous driving, vehicle-infrastructure cooperation, etc.) to form an independent and controllable industrial chain.
- Promoting new equipment and facilities such as intelligent roads, digital pipe networks, intelligent warehousing , etc.

SMART HIGHWAY
_Non-Accident_Non-Stop_Non-Fault_

◆ **GUIDES OF PROMOTING THE DEVELOPMENT AND APPLICATION OF AUTONOMOUS DRIVING**

Clarified the goals by 2025:
- positive progress on basic theory;
- important breakthroughs in key technologies and products;
- a series of basic and key standards for autonomous driving;
- several national-level testbeds and industrialization.

Baidu Apollo & Tesla Autopilot

◆ Tesla Autopilot

- Tesla is one of the pioneer companies making self-driving vehicles.
- Tesla Autopilot, amounts to the Level 2 vehicle automation.
- containing a suite of features such as lane centering control, traffic-aware cruise control, etc.
- Purely relying on cameras and radars, the autonomous driving performance may not be as good as Xpeng equipped with high-definition maps.

◆ Baidu Apollo

- Proposing a series of standardized interfaces for driverless systems;
- Authorizing automakers to connect their systems;
- Apollo with Level-4 vehicle automation commenced mass production in 2017;
- It can predict the movements of pedestrians and vehicles in its vicinity.

Unicorns: Xpeng, NIO & Li Auto

XPeng P7 OTA Upgrade

◆ NIO and Li Auto

Level-2

- The NIO Pilot has two important functions—the Navigate on Pilot (NOP) and the Self-Automatic Parking Assist with Fusion (S-APA with Fusion).

- The Li Auto also incorporated automated driver-assistance system with its Mobileye EyeQ4 visual recognition chips, millimeter-wave radar, etc.

◆ XPeng

- Supporting Level-3 vehicle automation;
- Incorporating high-definition maps covering most highways and some urban expressways in China;
- With the high-definition maps, more suitable to the complex traffic environment in China, comparing with Tesla that entirely relies on computer visions;
- With Adaptive Cruise Control (ACC), Adaptive Turning Cruise (ATC), etc.

SIX

SOCIAL ACCEPTANCE, LAWS, AND REGULATIONS

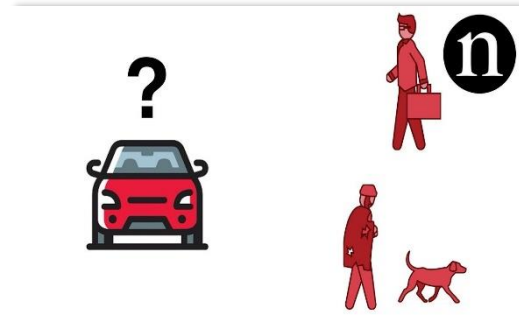# Social acceptance of autonomous vehicles

◆ Attitude

- The majority of the public has a positive attitude towards autonomous vehicles;
- The high acceptance is largely due to the rapid development of the digital economy.

◆ Trust

- 10% and 68% of Chinese consumers, respectively, fully trust and may trust;
- Only 4% of consumers completely distrust the fully autonomous driving.

◆ Focuses

- Concerning about the ability to deal with accidents, legal liability, and privacy.
- Among these concerns, the safety issue places the first.

Who's Ready for Self-Driving? China. When asked about their next vehicle purchase, more Chinese drivers would consider buying a fully autonomous vehicle that still allowed drivers to take control.

83% CHINA
Drivers who want automated highway driving:
84% China 59% Germany 40% USA
48% GERMANY
43% USA
Drivers who want automated lane changing:
77% China 50% Germany 40% USA

Source: BCG 2017 Self-Driving Car Survey · APTIV ·

AUTONOMOUS DRIVE START

A high overall degree of acceptance of autonomous vehicles in China

Laws and regulations for autonomous vehicles

◆ Legislative work

- Mid-term and Long-term Development Plan for the Automobile Industry;

- Guideline for Developing National Internet of Vehicles Industry Standard System.

◆ Current shortcomings

- The related legislation in China is very cautious, mainly involving road test;

- Current level of laws is relatively low. Only some regulatory documents and national standards have been initiated.

◆ Future paths

- The laws will be introduced around 2025 according to "Strategies for Development of Intelligent Vehicles";

- By 2025, related technologies, laws and standards, etc. will be further regulated.

The laws and regulations related to autonomous vehicles in China has developed rapidly in recent years, but have not yet been systematically established.

Legislative and regulatory barriers

◆ Clarify the concept

- The accurate definition of the legal concept is an important prerequisite;

- Clarifying the difference between autonomous vehicles and traditional ones and legal scope of "autonomous vehicles" is significant.

◆ Clear liability

- Requiring all vehicles to be equipped with data recorders to clarify details when in need;

- The automakers should bear the corresponding responsibility when accident caused by automatic driving;

◆ Demonstrate legislation

- Some demonstration areas have been built in Shanghai, Beijing , etc. for road test.

- The operating conditions in the demonstration areas can be studied for the determination of relevant laws and regulations.

Regarding the current laws and regulations in China, the revision of current road traffic safety laws is suggested to be considered from the following aspects.

SEVEN

SUMMARY

◆ The development of smart highway and autonomous vehicles has become the national strategy for transportation development in China

◆ However, the current development of smart highway supporting autonomous driving in the provinces along the AH9 in China largely varies:

- ☐ In Jiangsu Province, the government paid great attention to the construction of the smart highway and the development speed is fast. Comprehensive and systematic planning for the smart highway has been formed, and several achievements related to the smart highway constructions and operations have been obtained.

- ☐ In the provinces of Anhui, Henan, and Gansu, the local governments have also issued their development planning and have obtained series of exploratory achievements in recent years.

- ☐ Shaanxi Province has initiated several intelligent projects with the construction of current highways.

- ☐ However, Xinjiang is still at the initial stage of smart highway development and planning. The government has not yet issued systematic development guidance for smart highways.