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Smart transportation in China and the United States

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INTRODUCTION

It is no surprise that countries are suffering traffic problems as their rural and suburban populations move to cities and population density increases around urban areas. As cities grow in density, we have seen vehicular congestion, poor urban planning, and insufficient highway designs. The unfortunate downsides of these trends are the loss of lives due to accidents, time and money spent commuting, and lost productivity and economic growth for the system as a whole. All these developments are problematic because transportation accounts for six to 12 percent of Gross Domestic Product in many developed countries.[1] The cost of traffic congestion alone is estimated to be greater than $200 billion in four Western countries: France, Germany, the United Kingdom, and the United States.[2]

But the good news is that recent advancements in computing, network speed, and communications sensors make it possible to improve transportation infrastructure, traffic management, and vehicular operations. Through better infrastructure, ubiquitous connectivity, 5G (fifth generation) networks, dynamic traffic signals, remote sensors, vehicle-sharing services, and autonomous vehicles, it is possible to increase automotive safety, efficiency, and operations. Connected vehicles are moving beyond crash notification and lane changing guidance to offer a variety of services related to maintenance, operations, and entertainment. 5G networks will enable a shift in cellular technology from supporting fixed services to communication and data exchange that is machine-based. According to ABI Research, improved capabilities are poised to make the automotive sector one of the leading examples of digital innovation.[3]

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New transportation capabilities are popular with a significant portion of the general population. In China, a recent survey found that 74 percent favored “the rapid introduction of automated driving in their country.” However, in other countries, public responses are more cautious. For example, only 33 percent of Germans and 31 percent of Americans supported the rapid expansion of autonomous vehicles in their nations.[4] Residents in the latter countries are more attached to their cars and therefore less eager to embrace automated driving.

In this paper, we look at several developments with the potential to turn current systems into smart transportation networks. These include intelligent infrastructure, traffic management improvements, human-machine interactive systems, vehicle safety, and security advancements. We review these innovations, examine the policy, legal, and regulatory issues associated with them, and close by making recommendations regarding ways to improve smart traffic operations. We argue that taking action on infrastructure investment, network construction, regulations and standards, privacy protection, cybersecurity, navigational systems, cloud and big data solutions, and international cooperation will yield tremendous benefits for the transportation sector.

CURRENT TRANSPORTATION CHALLENGES

There are a number of problematic transportation issues.[5] These include outmoded and congested highways, poor air quality due to trucks and automobiles, and highway accident fatalities. Below, we outline the scope of the difficulties and why they are challenging for urban and transportation planners.

Outmoded and congested highways

Many highways are not equipped for the number of vehicles or the speeds at which the vehicles travel today. Outmoded designs pose safety challenges and make it difficult to deal with the high volume of traffic. A number of U.S. highways are in substandard condition. According to the Infrastructure Report Card, "one out of every five miles of highway pavement is in poor condition and our roads have a significant and increasing backlog of rehabilitation needs."[6] Research using U.S. Department of Transportation data found that "urban highways and roads are in worse condition than rural highways and roads."[7]

Overall, travel delays waste more than three billion gallons of fuel, and nearly seven billion hours of citizens' time.[8] As of 2015, it is estimated that Americans spend about 75 billion hours in traffic and that vehicular automation could save $507 billion in productivity, $488 billion in accident reduction, and $138 billion in productivity savings via reduced congestion.[9]

Research by UCLA Urban Planning Professor Donald Shoup has found that up to 30 percent of the traffic in U.S. metropolitan areas is due to drivers circling business districts in order to find a near-by parking space.[10] It is estimated that anywhere from 23 to 45 percent of metropolitan traffic congestion occurs around traffic intersections.[11] Parking and intersections represent a major source of traffic congestion, air pollution, and environmental degradation.

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For Moscow, Istanbul, Beijing, Mexico City, or Rio de Janeiro, the wasted time is even higher. There, drivers can spend "more than 100 hours a year in congested traffic."[12] In addition, "35 cities in China have more than one million cars on the road; 10 cities have more than two million. In the country's busiest urban areas, about 75 percent of all roads suffer rush-hour congestion."

This trend has a dramatic impact on economic productivity. Last year, 35,000 people in the United States and 260,000 individuals in China died from auto accidents. Many of these fatalities involved alcohol usage or human error. In America alone, travel delays linked to congestion wasted more than three billion billons of fuel and nearly $160 billion.[13]

The number of private vehicles in China as a whole has risen to 126 million, which is up 15 percent over the preceding year.[14] The city of Beijing alone has 5.6 million vehicles in operation.[15] Experts estimate that "the average speed of vehicles during rush hour was 22.6 km per hour in Beijing" (or about 14 miles per hour). This report also identified "crumbling roads and damaged streets" as well as "the lack of maintenance" as major transportation problems.[16]

In another study using online traffic data for 23 large Chinese cities, where traffic congestion is considered a major problem, the authors compiled data every 15 minutes from March to April in 2014, and found that "Beijing has a very lasting and extensive congestion, with low travel efficiency."[17] Other Chinese cities faced similar traffic issues in terms of morning and evening congestion.

Poor air quality

Automobiles and trucks are major contributors to poor quality air in urban areas. Vehicles are thought to be responsible for "approximately 30 percent of the carbon dioxide (CO2) emissions behind climate change."[18] Automotive vehicles emit dangerous gases that pollute the skies and contribute to urban smog due to the internal combustion engines they use to operate, There are two reasons for the increase in vehicle exhaust pollution: first is the increase in the total amount of motor vehicles, the second is blocked or excessive emission exhausts.

Yet metropolitan landscapes do not have to suffer poor air quality. According to a RAND study, "AV [autonomous vehicle] technology can improve fuel economy, improving it by four to 10 percent by accelerating and decelerating more smoothly than a human driver."[19] Since smog in industrial areas is linked to the number of vehicles, increasing the amount of autonomous vehicles on the road is likely to reduce air pollution. A 2016 research study estimated that "pollution levels inside cars at red lights or in traffic jams are up to 40 percent higher than when traffic is moving."[20]

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If nothing is done, the Organization for Economic Cooperation and Development estimates that air pollution-related health costs will rise from $21 billion in 2015 to $176 billion in 2060 around the world The number of lost working days will increase from 1.2 to 3.7 billion globally.[21] Researchers have found that emission control systems "will significantly reduce the contribution of transportation to degraded air quality".[22]

A shared autonomous vehicle system offers benefits in terms of emissions and energy. Researchers at the University of Texas at Austin examined pollutants such as sulfur dioxide, carbon monoxide, oxides of nitrogen, volatile organic compounds, greenhouse gas, and particulate matter with small diameters. Their findings show "beneficial energy use and emissions outcomes for all emissions species when shifting to a system of SAVs".[23]

The ride-sharing firm Uber has found that 50 percent of its trips in San Francisco and 30 percent in Los Angeles are pooled rides with multiple passengers. Globally, that number is 20 percent.[24] Vehicle-pooling offers great benefits for the environment and traffic congestion. Moving away from the model of one person per vehicle would be a big benefit for air quality.

Highway accidents and fatalities

Worldwide, according to the World Health Organization, 1.24 million people die annually due to highway accidents.[25] It is estimated that traffic fatalities cost $260 billion each year and that accident injuries account for another $365 billion. This represents a total of $625 billion annually from highway fatalities and injuries.[26]

According to a RAND study, “39 percent of the crash fatalities in 2011 involved alcohol use by one of the drivers.”[27] This is an area where autonomous vehicles almost certainly will save lives and reduce transportation-related injuries.

In China, about 60 percent of accidents are related to cyclists, pedestrians, or motorbikes hitting or being hit by cars and trucks.[28] Around 94 percent of U.S. vehicular accidents involve human error, and therefore are potentially avoidable.[29]

A study by the U.S.-based Insurance Institute for Highway Safety found that a full deployment of autonomous safety features would lead to a 31 percent reduction in highway fatalities, or over 11,000 American lives a year.[30] That included features such as forward collision warnings, collision braking, lane departure warnings, and blind spot detection.

An analysis published by Iain Gillott of IGR Research documented the high costs of highway accidents. He looked at economic costs such as medical, emergency medical services, insurance administration, legal costs, (lost) market productivity, property damage, (lost) household productivity and roadway congestion as well as comprehensive costs regarding the total societal harm resulting from traffic crashes such as injuries and loss of life. Overall, he found $835.8 billion in total costs and $242 billion in economic costs.[31] If there were a reduction in accidents through the adoption of autonomous vehicles, there likely would be a substantial drop in the economic and social impact of accidents.

Table 1: Economic and comprehensive cost estimates in billions

Type of Crashes	Economic Cost	Comprehensive Cost
Total	$242.00	$835.80
Alcohol-Impaired	$44.00	$201.10
Speeding	$52.00	$203.20
Motorcycle Crashes	$12.90	$65.70
Helmet Nonuse	$1.20	$7.60
Seat Belt Nonuse	$10.40	$68.60
Pedestrian Crashes	$11.50	$65.00
Bicyclist and Other Cyclist Crashes	$4.40	$21.70

Source: Iain Gillott, “The Economic and Societal Impact of Motor Vehicle Crashes”, IGR Research, forthcoming, 2018.

Traffic congestion impairs the quality of life and the efficiency of travel, and results in unnecessary waste of time and economic losses. Traffic congestion is not only related to the rapid growth of vehicle ownership, but also to the level of development of road infrastructure. Road carrying capacity has been far from enough to meet the need of urban development, and resulted in serious congestion.

The development of smart transportation can improve the efficiency and convenience of people-transporting services and freight services, conserve energy, and reduce harmful emissions and road traffic accidents drastically. From a higher, longer, and broader perspective, smart transportation will facilitate the formation of a new modern transportation service system. The strategic importance for socio-economic development is also significant because smart transportation can change vehicle ownership and use modes and can upgrade and reshape business models in the transportation system in an all-round way. Carpooling, hitchhiking, and other travel services are linked to vehicles by the mobile internet, and use big data technology to integrate various elements of transportation. According to statistics, car-pooling in the Beijing area in daily morning and evening traffic peaks can reduce congestion by about 23 million vehicle/kilometers.[32]

TRANSPORTATION OPPORTUNITIES THROUGH NEW TECHNOLOGIES

Advances in telecommunications networks and sensing technologies make possible new capabilities that increase the safety benefits for transportation systems. Often referred to as "smart transportation," intelligent vehicle systems range from in-road reflectors and devices that are embedded in the road to vehicle-sensing systems that avoid collisions and magnetic signature detection technologies that improve the spacing of vehicles operating in congested areas. Through 5G networks and the internet of things, there are many creative options for improving safety and operations. The new-generation ICTs represent a powerful tool to improve access to information regarding traffic flow, detect abnormal road traffic, more accurately determine the operation of vehicles and infrastructure, and more efficiently provide the traffic information for drivers.

Ubiquitous connectivity

A large-scale transformation is underway in transportation made possible by cellular vehicle to everything (V2X) communications. The automotive sector is shifting into a new era of connected and automated vehicles through V2X communications, remote sensors, and autonomous vehicles. Metro optical networks and high-speed wireless access technologies create the basic conditions for ubiquitous smart transportation. At present, relying on sophisticated wireless broadband networks, smart transportation services strive to provide travelers and logistics with timely and credible traffic information regardless of location, time and device.

In the near future, wireless communication technologies for connected vehicles, such as V2X and 5G, will organically link "people, vehicles, roads, clouds" and other traffic factors. This supports access to more information than single vehicle perception and stimulates the innovation and application of automatic driving technology. A transportation system that embraces new modes and formats of automobile and transportation services will improve traffic efficiency, conserve resources, mitigate pollution, reduce accident rates, and optimize traffic management.

> Self-driving vehicles will process 1GB of data every second and use that material to improve the driving experience.

In the new era, connected vehicles will have advanced collision avoidance systems that help drivers avoid accidents. There also will be systems that let drivers and vehicles know about upcoming congestion, potholes, highway construction, or other possible traffic impediments. Vehicles will have computer systems that learn from the experience of other vehicles on the road. Their advanced algorithms are designed to incorporate past experience in current operations. Dashboards will present information in real-time and provide visual displays that allow the driver to make sense of traffic and vehicular conditions.

In general, it is anticipated that through 5G networks and digital connections, information will flow 10 to 100 times faster than today, and that improved data speeds will allow vehicles to increase their response times and operational capabilities. These kinds of 5G networks will have the ability to analyze and synthesize massive amounts of data. Self-driving vehicles will process 1GB of data every second and use that material to improve the driving experience.

Dynamic traffic signals and remote sensors

The keys to smart transportation are intelligent infrastructure, the deployment of advanced sensors, and the adoption of dynamic traffic lights in urban centers. In large part, according to Prakash Kartha of Intel, "autonomous technology is sensor-based. It is a question of how you take cameras and lidar-based information to create learning models for cars and trucks."[33]

Intelligent infrastructure means having fast digital networks, roads with clearly-marked lanes, embedded sensors in highways that warn vehicles when they cross into another lane, and traffic signals that are dynamic in nature. Rather than have static traffic lights that are pre-programmed for set intervals regardless of traffic flows, it is important to have dynamic signals that shift based on the volume of cars and trucks. When traffic is heavier in one direction, the lights will remain green for faster traffic, whereas when traffic slows, it will stay red for longer intervals.

Sensors embedded in roads also help signals determine the frequency of light shifts so that traffic moves in the most efficient manner. Traffic lights can have cameras attached to them, which can help with congestion and highway accidents. It is possible to run artificial intelligence algorithms on this information and use data analytics to improve traffic flow.

Research in China has found that smart transportation improves traffic by 9.25 percent. Using a study of Guangzhou, China, engineers found that adding more dynamic features and deploying modern highway designs, city officials were able to reduce traffic congestions and increase vehicle moving speeds.[34]

Another project focused on Shenzhen, a city in Southern China with the country's highest population density. It used geographical information systems to analyze passenger flows and traffic management. The database tracked accidents, traffic congestion, vehicle flow, traffic speeds, and passenger transfers, and urban planners used "virtualization, distributed computation and cloud technology to guarantee safe and stable operation of the system."[35] Officials found that this GIS platform improved traffic and provided useful analytics for the city as a whole.

In many nations, transportation planners have deployed dynamic message signs (DMS) along highways to warn drivers about traffic congestion, construction, or accidents. A number of studies around the world have found that "the majority of drivers worldwide notice the existence of DMSs, identify that DMSs are providing very useful information, and act accordingly."[36] The only documented drawback has been the many drivers slow down to read the messages and this can contribute to traffic congestion. Road designers have responded by using short and simple messages to ease communications with drivers.

Intelligent processing and big data analysis

Artificial intelligence (AI) that goes beyond traditional rule-based algorithms illustrates the new features of deep learning, man-machine collaboration, and autonomous control. Combined with advanced machine learning, new systems are giving rise to a series of innovative smart devices with advanced processing capability. Based on big data and cloud computing technologies, a multi-dimensional platform for traffic information will help to establish urban traffic risks and warning and emergency response systems, and thereby avoid calamitous accidents. As examples, Alibaba's city brain software, Didi Taxi's smart transportation platform, and other big data products are helping to deal with traffic, improve road operations, and provide decision support for urban managers.

THE SITUATION IN CHINA

Transportation is at the forefront of new applications regarding highway safety and smart city applications in China. According to Asha Keddy of Intel, "the scale of the deployment is mind-boggling. A single city in China is similar in size to the whole country in other parts of the world."[37] The Chinese government has actively introduced new policies to create a favorable environment for the development of smart transportation. The government, industry, and enterprises have jointly developed new initiatives, actively promoted the development of smart transportation, and launched a series of demonstration projects to speed up the deployment of smart transportation.

Proactive government policies to create a smart transportation environment

The Chinese government unveiled the "Made in China 2025" and "Internet Plus" strategies in 2015. "Made in China 2025" highlights the in-depth integration of the new-generation ICT in the manufacturing industry and suggests the development of intelligent vehicles and other intelligent products to continue to expand the manufacturing industry.[38] It sets down five major projects, including accelerating the development of intelligent manufacturing equipment and products and advancing the research, development and industrialization of intelligent means of transportation through overall arrangement. The "Guiding Opinions of the State Council on Actively Promoting the Internet Plus Action Plan" proposes to: improve the intelligent logistical delivery and distribution system; accelerate the connection of freight vehicles to the internet and the interconnection of logistics parks, warehousing facilities, and distribution networks; and promote intelligent technology applications, such as the internet of vessels and the connected vehicles, to improve the transportation system.[39]

In August 2016, the National Development and Reform Commission (NDRC) and Ministry of Transportation (MOT) jointly issued the "Implementation Plan to Promote Smart Transportation by Carrying Forward Internet Plus Convenient Transportation," which makes it clear to accelerate the construction of the internet of vessels and the connected vehicles, develop vehicle networking and automatic driving technologies, build a national wireless technology verification platform for connected vehicles, in a bid to build the next-generation basic transportation information network.[40]

That month, the NDRC also issued the "Internet Plus efficient logistics implementation opinions," which proposed to build a logistics information sharing system, enhance the level of intelligent distribution, develop efficient and convenient logistics new model, and create an open and win-win logistics development surroundings.[41] In February 2017, the State Council released the "13th Five-Year Plan for Modern Comprehensive Transportation System."[42] It calls for a faster move to develop smart transportation, and calls for information technology in support of a comprehensive transportation system. By 2020, a safe, convenient, efficient, green, and modern integrated transportation system will take shape, and modernize transportation in a number of ways.

In April 2017, NDRC and the Ministry of Industry and Information Technology (MIIT) and Ministry of Science and Technology (MOST) jointly announced the "Medium- and Long-term Development Plan for Automobile Industry" which leverages new energy vehicles and intelligent connected vehicles to upgrade the automobile industry.[43] In terms of intelligent connected vehicles, by 2020, over 50 percent of new vehicles will be provided with DA (Driver Assistance), PA (Partially Automation) or CA (Conditional Automation) systems and over 10 percent provided with connected ADAS (Advanced Driver Assistance System). By 2025, over 80 percent of new vehicles will be provided with DA, PA or CA systems, and 25 percent of new vehicles will be provided with PA or CA.

To better address cross-sectorial coordination for the development of connected vehicles, smart transportation, and automatic driving industries, a special committee for the connected vehicles has been set up to build an important platform to boost related industries.[44] The special committee convened the first plenary meeting on September 7, 2017, and put forward: (1) providing better top-level design and overarching planning and carrying out active inter-ministerial coordination and consultation to effectively promote industrial development; (2) using the Group of Experts to fully listen to the views of industry, establishing a comprehensive standard system that covers automobiles information and communications, roads and other facilities, accelerating the formulation of key technology standards, and promoting collaborative innovation in many fields; (3) increasing the research and development efforts regarding key products, improving the public service platforms for testing and validation, technology assessment, and quality certification, advancing the deployment and application of LTE-V2X wireless communications technologies, and promoting the integration of 5G with the connected vehicles; (4) strengthening security management, optimizing security mechanism, and enhancing defense capability to ensure information and network security of key links; and (5) actively carrying out international exchanges, absorbing advanced technologies and innovation resources, and encouraging industrial cooperation between industries at home and abroad.

Industry and enterprise progress on standardization, research, and development

During the 12th Five-Year Plan (FYP) period (2011-2015), China accomplished its planned targets and tasks by rapidly developing the various modes of transport and continuously improving the integrated transportation system in order to meet the overall needs of economic and social development. The investment in transportation infrastructure totaled 13.4 trillion yuan, and the capability of emergency response and transportation safety assurance has been further enhanced.

In terms of standards, in 2017, the MIIT in conjunction with Standardization Administration of China (SAC), has formulated the "Guidelines for the Construction of the National Internet of Vehicles Industry Standard System" involved in the connected vehicles initiative and published them as planned after soliciting public comments, including the General Requirements, intelligent connected vehicles, information and communications, and electronic products and services.[45] The National Intelligent Transportation System Standardization Technical Committee has issued more than 90 smart transportation standards, covering terminology definitions, short-range communications, electronic tolls, traffic information services, traffic and emergency events management, integrated transportation and transport management, vehicle-assisted driving and automatic highway and other contents to provide a strong support for the intelligent transportation system demonstration and application.

At the same time, the standards committee has launched automatic driving classification grading, automatic emergency braking, reversing safety warning, lane change decision aid, curve speed warning, vehicle-road interaction information set, high precision electronic map and other standards development work. Under the actively guidance of MIIT and MOT and with the close cooperation of research institutes, businesses and industry organizations, the

LTE-V2X wireless communication technology series of standards for traffic safety alert and efficiency improvement will be finalized at the end of 2017. They include industry standards adopted by China Communications Standards Association, namely LTE-based wireless communication Technologies for connected vehicles: general requirements, LTE-based wireless communication technologies for connected vehicles: air interface technology, and LTE-based wireless communication technologies for connected vehicles: safety technology, and national standards technical specifications for network layer and application layer of short-range communication dedicated to cooperative intelligent transportation systems.

In terms of research and development, enterprises are active in technical reserves and show the trend of integrated development. First, the electronic toll collection (ETC) system has been networked nationwide. Second, the pre-load rate and use rate of the Baidu satellite navigation system has significantly improved. Positioning accuracy has significantly improved, and the coverage area has rapidly expanded. Third, the traditional auto companies, parts manufacturers and research institutions have begun the mass production of DA devices and active research and development of more advanced automatic driving technologies and products. Fourth, communications companies like Huawei and Datang Telecom are conducting active research on LTE-V2X communication technologies and plan to release LTE-V2X test chips, laying the foundation for the environment for wireless communication among people, vehicles, roads and clouds. Fifth, internet companies, such as Baidu, UISEE and I-driverplus, actively are carrying out studies of precision mapping and automatic driving technologies, and joining hands with the traditional vehicle manufacturers to develop automatic driving systems. In addition, information service providers, such as Didi and Alibaba are contributing to the formation of new intelligent transportation ecosystem based on their advantages in operating system, big data, and cloud computing platform. As the travel-sharing service users have exceeded 400 million in China by now, Alibaba and Shanghai Automotive Industry Corporation (SAIC) have jointly launched the "Internet Vehicle" program.

At the same time, many cross-industry joint organizations, alliances and associations have sprung up to better strengthen the communication and collaboration of enterprises across industries. Under the IMT-2020 (5G) Promotion Group, the C-V2X Task Force was set up to carry out technical research, testing and validation, application and promotion related to LTE-V2X, as well as studies on 5G-V2X business needs and key technologies.[46] China ITS Industry Alliance aims to further advance the industrialization, standardization, testing services and applications of smart transportation systems. China Industry Innovation Alliance for Intelligent Connected Vehicles intends to speed up the research, development, and commercialization of common technologies through a full range of technical, business, and personnel cooperation across industries, and thereby promotes the healthy and orderly industry development of intelligent connected vehicles in the country.

Application demonstration to hasten technological maturity and industrial development

By approving testing bands and organizing testing demonstration, the Chinese Government has actively encouraged the technological research, development, and industrialization in industries related to smart transportation. First, in November 2016, MIIT approved the use of bands 5.905-5.925GHz (bandwidth 20MHz) by the IMT- 2020 (5G) Promotion Group and the Telematics Industry Application Alliance to test LTE-V2X communication technologies, more specifically, communication performance and interoperability. Second, MIIT signed the "Framework Agreement on Cooperation in the Application of Smart Vehicles and Smart Transportation Systems Based on Mobile Broadband Internet" with the governments of Beijing, Baoding, Chongqing, Zhejiang, Jilin, and Hubei, and the Cooperation Agreement on Jointly Building Integrated Testing Bases for Smart Transportation Systems with MPS and Jiangsu Provincial People's Government, and supported Shanghai to establish the intelligent connected driving demonstration zone through pilot projects. These efforts are intended to facilitate technological innovation and standard formulation for smart transportation, connected vehicles, and intelligent and automatic driving in order to promote industrial integration and innovation, and nurture new formats.

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In addition, relying on the road comprehensive test field, MIIT has constructed intelligent driving test base, designed the simulation of urban roads, and developed V2X communications infrastructure, traffic signal facilities, roadside intelligent equipment, weather and tunnel simulation equipment, and automatic driving and vehicle-road coordination test. In August 2017, the Ministry of Transport launched a new generation of control network and intelligent road demonstration applications. It plans to select seven demonstration provinces and cities during the "13th Five-Year Plan" to carry out a new generation of intelligent traffic application demonstration. Finally, demonstration are taking place through the cooperation of enterprises across industries. China Mobile, SAIC, and Huawei are carrying out the demonstration of LTE-V2X active safety system in Yunxi (Hangzhou) and Jiading (Shanghai). CAERI, Datang Telecom, and Changan Automobile launched LTE-V2X technology testing and demonstration in Chongqing (more specifically in the Intelligent Vehicle Integrated Systems Test Area or i-VISTA), covering V2V safety system, road construction warning system, and intersection pedestrian detection system. TMRI, China Mobile, Huawei and FAW collaborated on the demonstration of traffic light induced travel system and intersection traffic conflict warning system in Wuxi. RIOH and Huawei presented the demonstration of LTE-V2X active safety system and automatic driving system in Tongzhou testing ground, Beijing; Didi Taxi and the traffic management departments of Jinan, Wuhan, Chengdu, Suzhou, Guiyang and other cities have cooperated together to optimize the "smart signal" and "tidal lane and smart bus" on the basis of floating vehicle track data.[47]

THE SITUATION IN THE UNITED STATES

To implement a smart transportation system, U.S. auto manufacturers, technology firms, and wireless carriers are working together on 5G network standards and V2X communications. They are striving to overcome a fragmented regulatory environment and cooperate with government officials to devise policies that facilitate road testing, software development, and consumer protection.

The fragmented nature of regulation

The U.S. transportation system is complicated because of the federal government system. The Federal Highway Administration operates interstate highways, while state and local governments have authority over other roads. The shared system of operations sometimes creates complications in terms of financing, investment, and innovation. It is not always clear which level of government is responsible to authorize, manage, and pay for changes.

Much of the transportation innovation that has taken place in the United States has occurred at the local level. The city of Los Angeles synchronized its 4,500 traffic signals in an effort to improve highway efficiency. It has seven million daily commuters contributing to its traffic congestion. In an effort to boost performance, its planners have deployed “magnetic sensors in the road that measure the flow of traffic, hundreds of cameras and a centralized computer system that makes constant adjustments to keep vehicles moving as smoothly as possible.”[48] Data collected by the sensors is sent in real-time to a city network, and its algorithms make immediate adjustments in stop light timing based on the traffic flow. This implementation has achieved positive results. According to city officials, “the average speed of traffic across the city is 16 percent faster under the systems, with delays at major intersections down 12 percent.” In addition, “the average speed on the city’s streets is now 17.3 miles per hour, up from 15 m.p.h. without synchronized lights.”[49]

Other localities are adding intelligent traffic signals that are dynamic in nature. Rather than be programmed for pre-determined intervals, they rely upon sensors that adjust the timing of traffic lights depending on the traffic. St. Petersburg, Florida is in the early stages of deploying such a system. Currently, it relies on a traffic coordinator who monitors video feeds and uses wireless signals to change the traffic lights. If he sees traffic backed up on major thoroughfares or receives complaints from drivers, he can adjust the signal timing. But starting in 2018, the city will move to smart transportation systems that make these shifts automatically using information from remote sensors measuring traffic flows. Tyler, Texas introduced this type of system and found that “it reduced traffic delays by 22 percent.”[50] Pittsburgh has piloted these devices in 50 different intersections around the city and says “it reduced travel time by 25 percent and idling time by over 40 percent.”[51]

Road testing

Many of the country’s leading automakers and technology firms have pioneering technologies to power vehicle operations, navigation, and entertainment. They already have introduced navigational tools such as lane-changing alerts, collision avoidance, and rear-end cameras to improve driver visibility. With the advent of remote sensors, artificial intelligence, and high-definition mapping, companies are paving the way for the commercialization of semi-autonomous and fully autonomous vehicles in coming years. They are deploying tools such as big data analytics and deep learning to bring the notion of connected vehicles to reality.

Within the United States, Ford, Tesla, Waymo (a subsidiary of Alphabet), General Motors, and Chrysler/Daimler have piloted road tests. Intel and Ford are collaborating on Mobile Interior Imaging to explore how imaging cameras can be integrated with remote sensor technology. European auto manufacturers such as Audi, BMW, Volkswagen, Daimler, Mercedes-Benz, and Volvo are working to create a more personalized experience for drivers and passengers. Through road tests, these companies have gained valuable insight into how to improve their software and on-the-road operations. Waymo has tested its vehicles over three million miles of road tests, and compiled a strong safety record.[52]

U.S. Department of Transportation policy guidance

Industry officials have to deal with 50 sets of state rules that can differ dramatically. According to Chris Urmson, formerly of Google, since 2015, “23 states have introduced 53 pieces of legislation that affect self-driving cars—all of which include different approaches and concepts. Five states have passed such legislation, and—although all were intended to assist the development of the technology in the state – none of those laws feature common definitions, licensing structures or sets of expectations for what manufacturers should be doing.”[53]

All of this complicates the task of vehicle developers who need a more unified approach. It is not practical to design a vehicle for Texas that will not be able to operate in Illinois, Florida, or New York. California, in particular, has passed legislation that is overly restrictive. It sets back fully autonomous vehicles by requiring a driver in the front seat, and prevents companies from removing human-operated steering wheels and brakes. That potentially negates some of the benefits of driverless vehicles while also creating a barrier to innovation in the automotive industry.

In an effort to simply the regulatory system, the National Highway Traffic Safety Administration has developed rules designed to promote innovation while protecting consumer safety. Among the features are proving guidelines for uniform regulations in the states, providing exemptions to outmoded safety regulations, operational guidance for new features, and new tools for encouraging autonomous vehicles.[54]

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But in a setback for manufacturers, the national government is insisting that fully autonomous vehicles retain a steering wheel and brakes, and that there be a licensed driver in the vehicle. Some designers argue that having those override features opens the door to drunk drivers and creates a sense of complacency with passengers that can be dangerous.

One idea, suggested by David Hoffman of Intel, to solve this problem is to take advantage of separated roads such as high-occupancy vehicle lanes. "HOV lanes can be turned into autonomous vehicle lanes with no human drivers allowed," he pointed out.[55] That would allow computer-controlled vehicles to function without risk of human mistakes.

American regulations are likely to mandate rules such as "many years—at least five—of demonstrated safety and economic benefits" when phasing to autonomous driving, which would be consistent with the introduction of front airbags and other automotive features in the past. Manufacturers generally are given five to 10 years to meet new safety standards.[56]

MOVING FORWARD

With the progress that has been made on smart transportation systems, it is important to address the policy, legal, and regulatory issues involved with that area. Progress toward smart transportation requires a number of different steps, such as investing in infrastructure, regulations and standards, privacy protection, cybersecurity, navigational systems, cloud and big data solutions, and international cooperation.

Infrastructure investment

It is important to invest in infrastructure in order to design and construct smart transportation systems. The construction of road infrastructure is the basis for realizing smart transportation, and it is urgent to increase investment to construct or update road infrastructure. We need enhancements in traffic signs and markings; traffic cameras and traffic radars that are connected to the internet; and roads, bridges, and tunnels equipped with sensors, all of which are integrated into transportation databases. Public data about road transportation infrastructure covering traffic lights, speed limit indicators, traffic radars, and traffic cameras. All of which will help the real-time monitoring of traffic flow, traffic congestion and weather and improve the capability of smart driving vehicles to perceive the road traffic environment.

Network construction

It is important to make full use of the existing ETC system and LTE networks, step-by-step constructing smart transportation wireless communication network basing LTE-V2X and other access technologies, and to explore higher performance wireless communication networks to provide ultra-reliable, high-bandwidth wireless communication with ultra-low latency in key areas and sections. In addition, supporting the construction of an integrated, intelligent road transportation system that links facilities, vehicles, travelers, and service providers, and covers major urban roads and national and provincial trunk routes and highways is vital for future development.

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Navigational systems

Centimeter-level precision positioning technology and crowd-sourced precision mapping technology based on low-cost sensors will strengthen the basic support for automatic driving and connected vehicles provided by all-weather and all-day precision positioning, navigation, and timing services. Car manufacturers should install high-definition mapping products in an effort to improve navigational devices and smart phones, and broaden the application of navigation and maps in vehicle supervision so as to better serve travel, modern logistics, and tourism.

Gaining consumer trust

A key component in expanding public acceptance of autonomous vehicles is gaining passenger trust. Any move toward semi- or fully-autonomous vehicles requires passengers to trust the hardware and software powering those vehicles. In countries such as the United States, with a long tradition of driver control, it could be difficult to turn vehicle operations over to computerized devices. It requires considerable confidence that systems will operate as advertised for people to make that leap.

According to Jack Weast, Intel's director for self-driving solutions, "what we are finding is the more you can embody those kinds of human trust interactions into a human-machine experience, the human perception of the safety and security of that machine changes dramatically." [57] A study by behavioral scientists Nicholas Epley, Joy Heafner, and Adam Waytz found that passengers were more likely to trust a vehicle when they gave it a human and female voice. Inventing a software character for the autonomous vehicle they called Iris, they "found that riders were roughly four times as comfortable with Iris than the other vehicle." Epley noted that "the presence of a voice is really critical for inferring the presence of a mind. When you hear what somebody has to say, people are judged to be more mindful, more thoughtful, more rational."

Cloud computing and big data technology applications

It is crucial to strengthen transportation big data collection, analysis, and application, and promote the comprehensive development and utilization of data resources in all fields of transportation and the sharing and use across sectors, so as to achieve smart transportation control and overall operational coordination and command. Then, travel plans and real-time travel information will be available for travelers anytime and anywhere. A variety of smart transportation applications needs to be introduced, such as vehicle-road coordination, platooning, and support the development of multimodal transportation and vehicle sharing, which will contribute to the construction and development of smart cities.

Network capacity is a challenge today for service providers and will continue to be so as the industry experiences an exponential increase in data traffic. At the same time, verticals such as smart transportation will bring more and more devices with both data and capacity demands to the network. As 5G is being standardized, work on the virtualization of the network is already underway to ensure future networks are designed to provide new services through the application of distributed clouds with edge computing capabilities. A distributed computing network means that several localized networks will be able to accommodate the connectivity of vehicles in their respective areas of coverage.

This emerging software-defined network will take advantage of research and development of advanced sensors, chips, and control and execution units, develop on-board operating system, middleware and key software for applications, study the algorithms for multi-source information fusion, path planning, intelligent decision-making and man-computer interaction, and press ahead with the research and development of high-grade automatic driving vehicles. These cloud-based services will make possible a range of capabilities from driver assistance, van queue, connected vehicles maintenance, and high resolution map generation.

Regulations and standards

It is important to address the legal issues that restrict the development of smart transportation systems, carry out forward-looking legal reserve research in view of the current issue of lacking supervision, and study and form a rule base of administrative policies and judicial regulations in the fields related to intelligent transportation systems.

Currently, the United States and European Union do not have detailed regulatory plans. In contrast, China has a more systematic approach, which gives its manufacturers an edge in terms of building innovative transportation systems.

There needs to be an integrated regulatory system to solve the issues arising from future large-scale industrial application of smart transportation systems and to safeguard the healthy and orderly development of related industries and the sustainable evolution of social ecology. Currently, the United States and European Union do not have detailed regulatory plans. In contrast, China has a more systematic approach, which gives its manufacturers an edge in terms of building innovative transportation systems.

Privacy protection

Protecting the confidentiality of drivers and vehicular operations is important with autonomous vehicles. As more and more of our lives move into the digital realm, privacy protection becomes even more important. It is important to strictly implement protection management for sensitive data of users and ensure the security and control of that data.

There are two types of information that require protection. One is data from a vehicle's sensors and cameras as it moves along the road. This includes geo-location information, vehicle speeds, vehicle operations, road conditions, and images of the surrounding area. Another is personal information from things drivers and passengers do while in the vehicle, such as the websites they browse over wireless networks, text messages they send, the music they listen to, phone calls they make, the highways they traverse, retail stores they frequent, and whether they violate traffic laws.

Cybersecurity

Cybersecurity mainly refers to the protection of vehicular operations. To deal with cybersecurity threats, it is best to take a risk management approach. Having a transportation network trust system that realizes security control of important information systems and key infrastructure will enhance survivability and disaster recovery capacity. It will improve the capabilities of monitoring, early warning and emergency response to attack, and leakage and theft in the big data environment.

International cooperation and exchanges

It is vital to have international cooperation and communication for key issues related to laws, regulations, standards, and ethics. To facilitate smart transportation, we need to develop international projects on technological development and strengthen communication and cooperation with organizations actively involved in the formulation of international standards.

CONCLUSION: THE SOCIAL AND ECONOMIC BENEFITS OF SMART TRANSPORTATION

The wide application of new technology faces many problems. The road infrastructure needs to be improved, as most roads are not equipped with the features of network connection and intellectualization, road critical nodes cannot communicate with vehicles, the construction of high-precision maps is still in its infancy. Technology maturity needs to be developed, especially for key technologies, such as ultra-reliable and low-latency functionality in high-speed scenarios, and V2V and V2X control. The regulatory system needs to advance as new technologies such as V2I (vehicle to infrastructure) will reshape road traffic patterns, existing regulations cannot fully adapt to the new mode of travel and may restrict the application of new technologies.

But there are new opportunities to save money and lives via digital technologies. Among ubiquitous connectivity, dynamic traffic signals, remote sensors, and vehicular communications, there are new applications that offer significant social and economic benefits. There are safety gains arising from smart transportation. Experts argue that autonomous vehicles can save 585,000 lives between 2035 and 2045 and free up over 250 million hours of commuting time per year globally.[58] One of the strongest arguments in favor of autonomous vehicles is the potential to improve highway safety. Machine-directed vehicles are not apt to get distracted—and avoiding accidents caused by distraction is likely to save lives.

Research by leading firms finds the economic benefits of smart transportation are likely to be substantial. For example, a Strategy Analytics report estimates that autonomous vehicle technology will add $7 trillion to the economy by 2050, when autonomous cars and trucks constitute half of the new vehicles sold. Author Roger Lanctot concludes that "[autonomous vehicles] will drive change across a range of industries, displacing vehicle ownership with Mobility-as-a-Service, and defining a new landscape of concierge and ride-hailing services, as well as pilotless vehicle options for businesses in industries like package delivery and long-haul transportation."[59] In addition, an IHS research report, "Vehicle Sales Forecast," expects 21 million sales globally in the year 2035 and nearly 76 million sold globally through 2035. Their forecast reflects a decade of substantial growth with a 43 percent CAGR between 2025 and 2035 adopted in major global automotive markets.[60]

A McKinsey report estimates $2.5 trillion in potential economic impact will come from continued adoption of mobility services and that, by 2025, a focus on technologies and models will influence transportation and logistics, automotive development, and smart cities and infrastructure.[61] In these areas, data will broaden the demand for transportation, as individually owned vehicles are currently idle 85 to 95 percent of the time. Existing platforms such as Uber, Lyft, and Chinese ride-sharing giant Didi Chuxing have demonstrated the ability to monetize these assets and turn them into high-margin services.

New industries will arise that change the traditional modes of travel, transport, and traffic management. When fully implemented, these advances will bring about profound changes within the transportation industry and economies worldwide.

Smart transportation furthermore has the ability to transform mobility. It can offer mobility to groups such as the elderly and disabled who currently lack good transportation options. According to Caroline Chan of Intel, "it democratizes driving for people. Some individuals can't drive as they age, and autonomous vehicles gives them access to transportation."[62] One of the most important things is to keep people integrated in society and active in their local communities. Autonomous vehicles create a new means for this to happen with vulnerable populations.

With the progress the world is seeing in new-generation ICT and 5G automotive systems, there will be broad economic and social benefits. New industries will arise that change the traditional modes of travel, transport, and traffic management. When fully implemented, these advances will bring about profound changes within the transportation industry and economies worldwide.

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