

Efforts toward Realization of Connected Car Society

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Abstract

It is generally said that “Connected Car Society” will come in near future along with the spread of the Internet and the development of IoT technology where almost vehicles are connected to networks and new services and businesses are created.

Also, on the background of Global warming, Aging, Increase of traffic jam and traffic accident etc. by urbanization, Change of consumer needs, Change of society such as development of network society, Semiconductor technology, Mobile communication technology and Drastic evolution of ICT technology such as information processing technology including IoT, Big data, AI and others, a wave of big change such as Autonomous driving, Sharing and EV as well as Connected Car has been rushing to the field of automotive industry.

In this paper, we introduce global trends for these environmental changes and DENSO TEN’s business vision focusing on connected car society. As our efforts to solve implementing issues, we explain the efforts toward advanced communication type drive recorder, on-demand data collection technology and providing of data interoperability.

1. Introduction

The ever-increasing speed and capacity of mobile networks, as well as the development and advancement of the technology of the “Internet of Things” (IoT) have led to the spread and popularization of “connected cars”. Additionally, the automotive industry and surrounding environment has changed greatly due to the increasing progress in the use of big data which has accompanied the spread of the IoT, the evolution of AI by use of deep learning, and similar factors. It is certainly safe to say that the “Connected Car Society” will come in the near future, resulting in nearly all vehicles being connected to networks, and new services and businesses utilizing this connectivity will be created (Fig. 1).

Global Market of Connected Cars (Passenger Vehicles)
(Based on new vehicle sales)

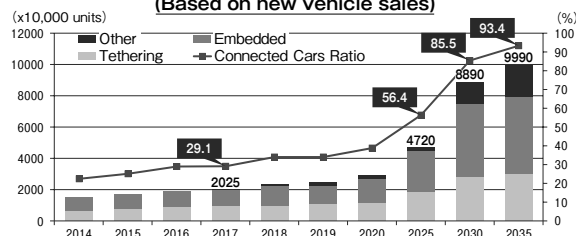


Fig. 1 Global Market of Connected Cars 1)

In the Connected Car Society, all sensors mounted on the car are connected to the network, and it is possible to provide new value by analyzing and utilizing these data.

It also enables autonomous driving by using communication to supplement the high-definition maps and information on locations where sensors cannot reach needed for autonomous driving.

However, network connectivity also creates new security issues. Security countermeasures have become an extremely important issue due to the increased dangers such as illicit remote control

that have arisen with the advance of electronically controlled vehicles.

Currently, against a backdrop of an aging society, environmental and energy problems, increased traffic jams and accidents due to increasing urbanization, social changes such as the development of a network society and sophistication of mobility services, the advancement of semiconductor technology, and the massive evolution of ICT technology including mobile and communication technologies (LTE-5G, etc.), the IoT (with the cloud and similar functions), big data, and information processing technology (AI, etc.), the automotive industry is awash in waves of great global transformations such as the advent of the connected car as well as autonomous driving, sharing, and electric vehicles (EV) (Fig. 2).

In response to such changes in society, DENSO TEN have established "Vehicle-ICT" as our business vision and are promoting our business activities to realize the Connected Car society. In this paper, we present various countries' efforts to address these megatrends, issues to realize a Connected Car Society, and our efforts.

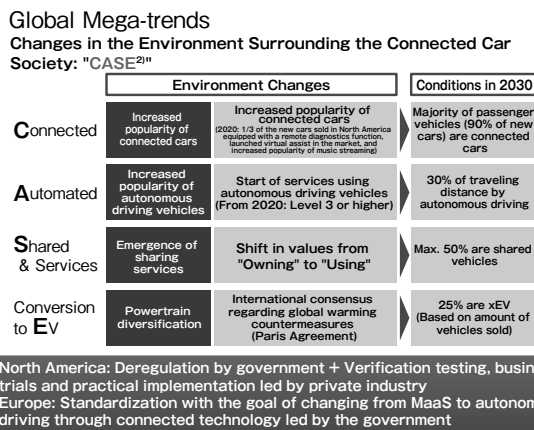


Fig. 2 Changes in the Environment Surrounding the Connected Car Society ³⁾

2. Global R&D Activities

In response to these global megatrends, we carry out R&D activities in three regions in Japan, USA, and Europe, in order to timely grasp the trends of markets, technologies and standardization in each region, by taking advantage of regional characteristics and location.

North America provides opportunities for business trials and practices in all aspects of "CASE"²⁾ through investing and securing inter-industry companies and start-ups aiming at autonomous driving realization and entry into mobility services by automobile manufacturers. For this reason, we have been performing the following activities:

- ① Research and exploration of seeds technology through open innovation activities utilizing universities and startups
- ② Study and creation of new distinctive service ideas, and integration of seeds technology
- ③ Solving issue by Proof of concept (PoC) development and field testing

In Europe, the European Commission with strong leadership aims to enhance the competitiveness of the European automobile industry, and the government supports the development of the EU industry against new threats (Google, etc.). Amid this, the government is promoting the next-generation standardization on Autonomous driving technologies and Connected technologies through government-led projects related to autonomous driving. For this reason, we are working to gather information by strengthening the relationships with local institutions and universities, in order to timely grasp the trends of standardization and assessment in Europe and contribute to business, technology and product strategies. In Japan, while looking at these activities in Europe and the United States, industry, government and academia collaborate, promoting activities to solve problems of Connected Car Society through deregulation and demonstration testing. For this reason, DENSO TEN is performing information gathering activities not just in regards to the government and relevant agencies, but also related to the global movements of Japanese automobile manufacturers.

This information and results obtained from our activities in Japan, the USA, and Europe serve as the base for planning technical and product strategies, and are used for developing and expanding our business operations.

Below, we describe the trends in conditions, technology, and standardization of each market based on these investigations.

2. 1 Technical, Market, and Standardization Trends in the North America

In the North America, a country where the IoT is advanced, the Connected Car Society has been developing mostly focused on IT-related companies.

Tesla, a company that developed out of IT, has been able to achieve onboard software that can be used in the same manner as software of a smartphone, enabling it to be the first company in the automobile industry to introduce Firmware Over The Air (FOTA) for powertrain system ECUs. The ability to use FOTA for applying updates to an ADAS ECU, which includes support of the "AUTOPILOT" autonomous driving function and "Summon" remote parking function, provides a massive lead over other companies.

Furthermore, Nauto, an autonomous driving technology start-up company, has developed a system that uses cameras to record driver's state and surrounding conditions while driving in order to analyze risk using a cloud-based AI (Fig. 3), and the system can also immediately detect dangerous behavior due a driver nodding off while driving.



Fig. 3 Risk Analysis System Developed by Nauto 4)

Google (currently Waymo), a leader in autonomous driving, has been developing software since 2009 that is essential for autonomous driving systems, and has performed test driving over a total distance of more than 700,000 miles. In response to this, automobile manufacturers have been bringing in experienced human resources

based on purchasing of start-ups and research bases to accelerate software development in reaction to the in-house developed hardware of Google (currently Waymo), automobile manufacturers have adopted NVIDIA and Intel platforms for use in developing and verification testing of autonomous driving systems.

In the sharing service, Uber and Lyft, a ride share service utilizing smartphone, are on the rise by users with their "price", "convenience" and "confidence".

In conjunction with the environmental regulations in California (Zero Emission Vehicle : "ZEV" regulation etc.), the models of PHV and EV continue to develop and expand as electric vehicles steadily become more popular.

We expect that the business of Connected Car will evolve in a complex way, with various industries leveraging the cooperation and alliances with car manufacturers, such as the EV and auto-driving of sharing cars in the future.

2. 2 Technical, Market, and Standardization Trends in Europe

As we previously mentioned, research and development for the realization of connected and autonomous driving is being carried out in Europe with a comprehensive policy that unifies environment and transportation policies under government initiatives. The focus for this is not simply to achieve autonomous driving but rather to create discussions regarding the mobility society in terms of how autonomous driving and vehicles can be used in society and transportation (Fig. 4).

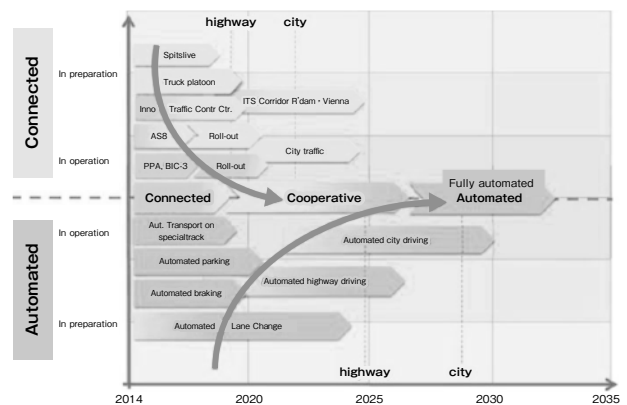


Fig. 4 Plan to Introduce Autonomous Driving in Europe 5)

ERTICO, the main organization for promoting ITS in Europe, consists of the following four activities with each activity consisting of the various projects under it.

- CAD (Connected and Automated Driving)
- Clean Mobility
- Transport & Logistics
- Urban Mobility

Connected and Automated Driving (CAD), responsible for research and development of connected and autonomous driving, promotes standardization of items such as conformity and data sharing among upstream services from an IoT perspective. Standards consist of the following.

SENSORIS: Promotes standardization of data formats for uploading from a vehicle to the cloud.
 ADASIS: Promotes standardization of interfaces so that the ADAS application can access map data.
 AUTOPILOT: Focuses on IoT eco systems from the perspective of automatic parking, car sharing, and public autonomous driving systems.

Especially, the Open AutoDrive Forum (OADF), which is initiated by NDS, ADASIS, SENSORIS, and TISA, promotes activities for standardizing data chains of dynamic road information necessary for autonomous driving (Fig. 5).

OADF: Activities to standardize data chains of dynamic road and traffic information critical for autonomous driving

NDS: Standardization of the data format of high-precision maps

ADASIS: Standardization of map data usage in vehicles

SENSORIS: Standardization of probe data information

TISA: Standardization of road and traffic information

In regards to autonomous driving, three German automakers (VW/Audi, Daimler, and BMW) have taken the lead in technical development by collaborating with US and Israel IT companies as shown by Audi's release of a new model that is first car ever equipped with Level3 autonomous driving functions (limited to driving at 60 km/h or less on congested freeways and similar conditions) in Fall 2017.

On the other hand, they are promoting standardization of the integration between upstream services and data sharing from the IoT point of view through the European project demonstration experiments in community service and automatic valet parking.

In regards to sharing services, the MaaS (Mobility as a Service) is integrated into the realization of a variety of transportation means, and the community car or the like by autonomous driving is put to practical use, and the city experiment is progressing.

Conversion to EV has accelerated suddenly with Norway and Holland indicating that sales of gasoline and diesel vehicles will be prohibited from 2025, while other countries are going forward with similar actions, and with Volvo announcing that all their cars sold from 2019 will be EV or hybrid vehicles. While all car manufacturers are preparing for the shift to EVs, there are still some issues that urgently require resolution such as the recharging infrastructure and driving distance.

These types of regulations, assessments, standardization, and EU projects in Europe are being carried out in an integrated manner in order to realize a MaaS society.

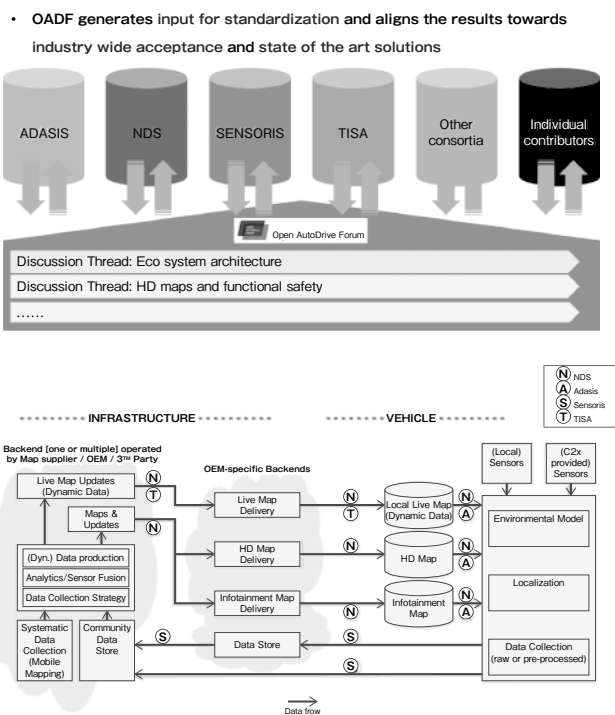


Fig. 5 OADF Structure and Eco System 6)

2.3 Technical, Market, and Standardization Trends in Japan

In Japan, the Public-Private ITS Initiative/Roadmaps, enacted mainly by the Cabinet Office, have served as the basis for creating a promotional system among industry-academia-government in order to promote research and development related to connected and autonomous driving. In preparation of the 2020 Tokyo Olympics, activities are being promoted to create global leading-edge ITS.

In relation to connected technology, research and development, and comprehensive verification testing of 5G is being carried out with the objective of providing safe-driving support, and data utilization, while also promoting the creation of new services by utilizing the distribution and utilization of data using 5G.

Autonomous driving has moved towards practical implementation amid the SIP Autonomous Driving Program implemented by the Cabinet Office, with large-scale verification testing being carried out by use of autonomous driving systems, dynamic maps, and HMI, as well as measures directed at practical implementation. Additionally, the Ministry of Land, Infrastructure, Transport and Tourism, in conjunction with the Ministry of Economy, Trade and Industry, held a “Study Panel on Autonomous Driving Business” in relation to the use of autonomous driving systems for mobile services, and other measures are being taken in order to resolve issues of technical and business natures such as those related to automatic valet parking and truck platoon driving.

In regards to sharing services, car sharing business by rental car and parking lot companies is expanding.

Deregulation and the utilization of IT have enabled fully automated (unmanned) car rental and return, resulting in a rapid expansion of such services.

Measures are being carried out to promote the popularization of EVs and PHEVs as global warming countermeasures and key to economic growth strategies.

As EVs are currently in the initial stage of introduction, there are still issues regarding vehicle cost, improving the recharging infrastructure, and similar items, while various measures are being implemented to promote popularity such as subsidies, and tax incentives for introducing vehicles and facilities.

3. DENSO TEN Business Vision for Realizing a Connected Car Society

Looking towards the arrival of the Connected Car Society as described above, we established Vision 2022, to “contribute to creation of free and comfortable mobility society where people and vehicles, and community and vehicles are connected,” as our business vision in 2012. We are working to realize Vehicle-ICT as the system concept for achieving this vision (Fig. 6).



Fig. 6 DENSO TEN Business Vision: Vision 2022

Vehicle-ICT is a system concept that not only introduces ICT into a car but also fuses cars and ICT. As shown in Fig. 7, this shows that by combining the real world mobility society with various cloud services in cyberspace, it will be the best partner for cars and people.

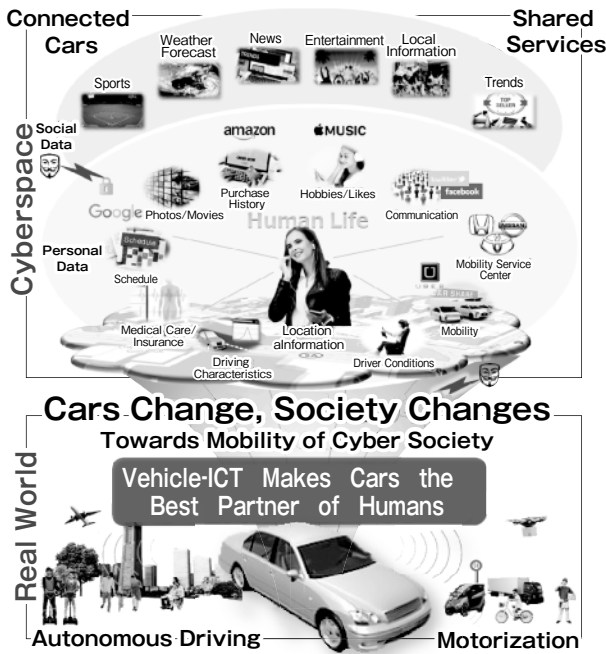


Fig. 7 Vehicle-ICT Concept

4. Issues in Realizing a Connected Car Society

It is thought that, with the advance of the above-described global business changes in regards to “CASE”, the overall system of the Connected Car Society will serve to increase the sophistication of various services in current automobile and non-automobile domains such as open services (streaming transmission and information services), commercial vehicle services (such as shared cars), autonomous driving support services (such as dynamic maps), and OEM services (such as EV maintenance) (Fig. 8).

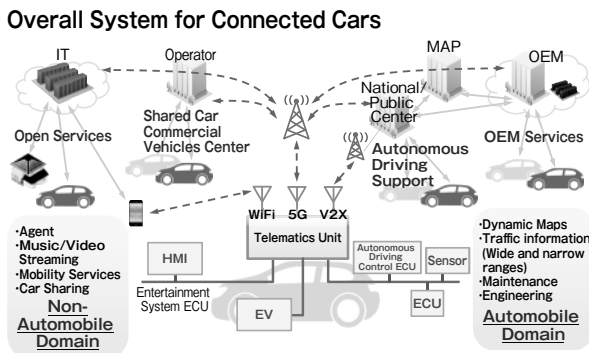


Fig. 8 Overview of Connected Car Society System

With the goal of realizing this type of system, public wireless communication efforts consist of

the practical implementation of 5G, next-generation communication with special characteristics of high speed, large capacity, low delay, and multiple simultaneous connections. In the future, it is thought that V2X and WiFi technologies, which connect the vehicle infrastructure, will be joined together to serve as the network.

With the rapid popularization of connected cars, and the popularization, evolution, and diversification of mobility services, it is thought that the amount of data accumulated and processed by these various systems is increasing at a tremendous rate (Fig. 9).

This massive data increase has not only caused increased communication loads and costs, it has also resulted in a large increase in storage capacity on the cloud side, as well as a massive increase in interactive data processing.

For this reason, reducing the amount of data collected in the cloud is a major issue.

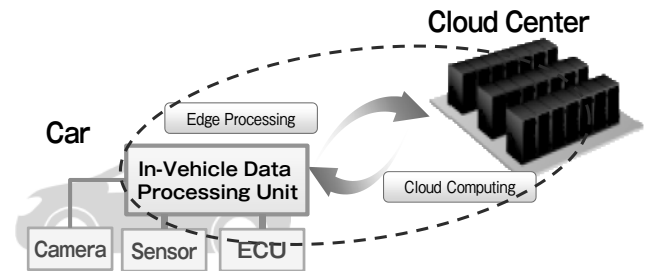


Fig. 9 Diversification of Services and Increased Data

Additionally, in the use of vehicle data in realizing a society with plentiful mobility, it is very important to enhance the functionality of each service, and also to connect and integrate the various services.

As the requirements for data from vehicles needed for each service (such as the frequency, accuracy, and reliability of each data acquisition, and required additional information) vary depending on the purpose of use, a major future issue will be ensuring interoperability among the various types of services.

5. DENSO TEN’s Efforts

In order to increase popularization, diversification, and sophistication of the types of services described above, it is essential to collect vehicle data via networks and to utilize that data.

From the perspective of the IoT system, it is important that data collection consists of event extraction and tagging for structuring, regulating, and also converting to metadata of the various types of data described above on the vehicle side, which functions as a system edge.

The following two items are important from the perspective of data processing:

- ① Deep learning and similar AI processing must be used with large amounts of unstructured data such as that of images and voices of the surrounding environment, driver, passengers, and other elements in order to be aware of the environment and individuals, and structure data so that it can be analyzed.
- ② Structured data such as that of position, time, speed, and fuel consumption must be correlated by use of big data analysis or similar methods to provide a more sophisticated semantic understanding of the data.

From the perspective of the above, the evolution of future services together with the linking of onboard edge processing and cloud computing within the IoT will be the key to any future system (Fig. 10).

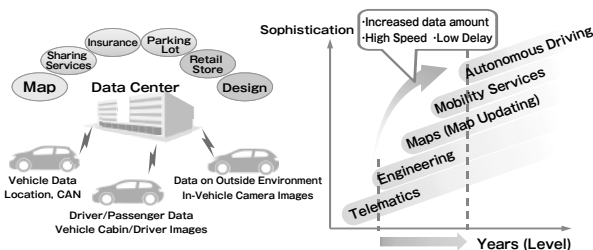


Fig. 10 Linking of Vehicle Edge Processing and the Cloud

For example, AI learning can be performed by using big data collected in the cloud, and the learned model can be equipped to the vehicle by using OTA or similar method so that edge processing can be performed in an advanced manner, thereby serving to evolve the system.

We are working on the advancement of the drive recorder with the communication function for such a system. In this system, it is an urgent problem to respond to the increasing data collection described above.

As shown in Fig. 11, we have been developing technology so that tagging and virtual management

of data enables on-demand acquisition of only data that matches the service’s needs, thereby reducing the amount of data.

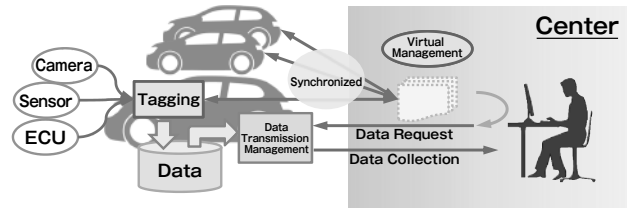
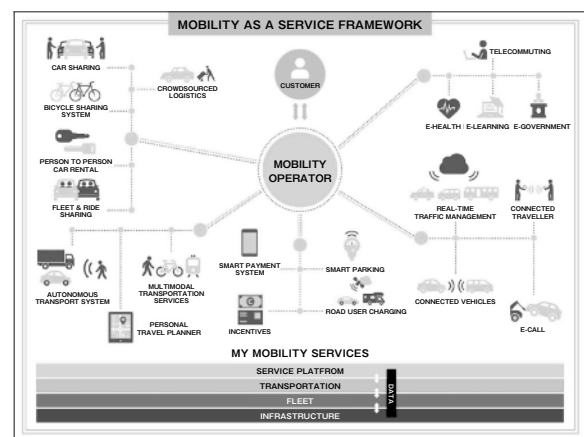


Fig. 11 On-Demand Data Collection System to Reduce Data Amounts

As for the issue of securing interoperability of data between various types of service, efforts towards MaaS, which connect various services and integrate as a service, are progressing mainly in Europe (Fig.12).



Silvia Curbelo Betancort, What is ITS and how it will change the way you move?, 30 April 2015, <http://www.europeanpublicaffairs.eu/what-is-its-and-how-it-will-change-the-way-you-move/>

Fig. 12 Example of MaaS System Concept⁷⁾

Fig. 12 shows an example of a MaaS system concept. Although, in order to realize MaaS, interconnection is needed not just between vehicles but also among the various transportation services, it is also essential to ensure interoperability of the various service data on a time and place basis, such as data related to human, vehicles, transportation/ social infrastructure, and logistics.

From this point of view, we are actively working on standardization activities such as OADF in Europe and elsewhere.

6. Summary

In this paper, we have indicated the global trends in regards to realizing a Connected Car Society and also introduced our corporate vision focusing on the society.

We have also outlined our efforts to resolve issues related to practical implementation in developing an advanced drive recorder with communication function, achieving on-demand data collection, and ensuring interoperability of such data.

7. Conclusion

It is said that the automobile industry undergoes a massive transformation once every 100 years, and it is thought that in a decade from now, the popularization of connected cars together with the mobility industry created through the interactive linking of autonomous driving, shared cars, EVs, and other vehicles will lead to this massive transformation.

Amidst this type of transformation, we aim to “contribute to creation of free and comfortable mobility society where people and vehicles, and community and vehicles are connected” through Vehicle-ICT, which fuses vehicles and ICT.

As a member of the DENSO Group, we will further develop and evolve the Vehicle-ICT with the know-how we have accumulated and continue to provide new value to the future mobility society.

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* Note: FUJITSU TEN LIMITED (renamed to DENSO TEN Limited) became a consolidated company of DENSO CORP. from Fujitsu Limited due to a change in the shareholder capital structure in November 2017.

- Vehicle ICT(Vehicle-ICT) is a registered trademark of FUJITSU CORPORATION.
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- APPLE MUSIC is a registered trademark of Apple Inc.

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