Collaboration among stakeholders of C-ITS and Automated Driving

ITU Workshop on "The Turing Test for Autonomous Driving –A Global Performance Standard for AI on our Roads"

Budapest, Hungary

2019.9.10

Dr. Hironao Kawashima

- Emeritus Professor, Keio University
  Mobility Culture Research Center
- Chairman of Management Committee, ITS Info-Communications Forum, ARIB
- Member of working group on Connected Car, TTC
- Expert of WG18 (Cooperative ITS), ISO/TC204 (ITS)

1. Introduction

CASE (Connected, Autonomous, Shared & Services, Electric) is the keyword of automobile industry.

All the four components of **CASE** is related to communication and information processing. Here “Connected” and “Autonomous” are focused and impacts and influences to traffic flow will be pointed out and further, the role of communication systems will be discussed.

Purpose of this presentation

- The key words, “Connected” and “Autonomous” have linguistically opposite meanings but here we show that

  “Connected” + “Autonomous”

  approach is required for the realization of automated driving system.
- In order to link the opposite meanings, the concept of ODD management can be the key to integrate various requirements from road vehicle and road traffic management.

Collaboration for ODD management

- Furthermore, this presentation show that the actual communication links to conduct ODD management will be composed of two types of communication systems, wide area communication systems and narrow area communication systems.
- This is the reason why road authorities, automobile industry and communication industry have to start the collaboration for ODD management.

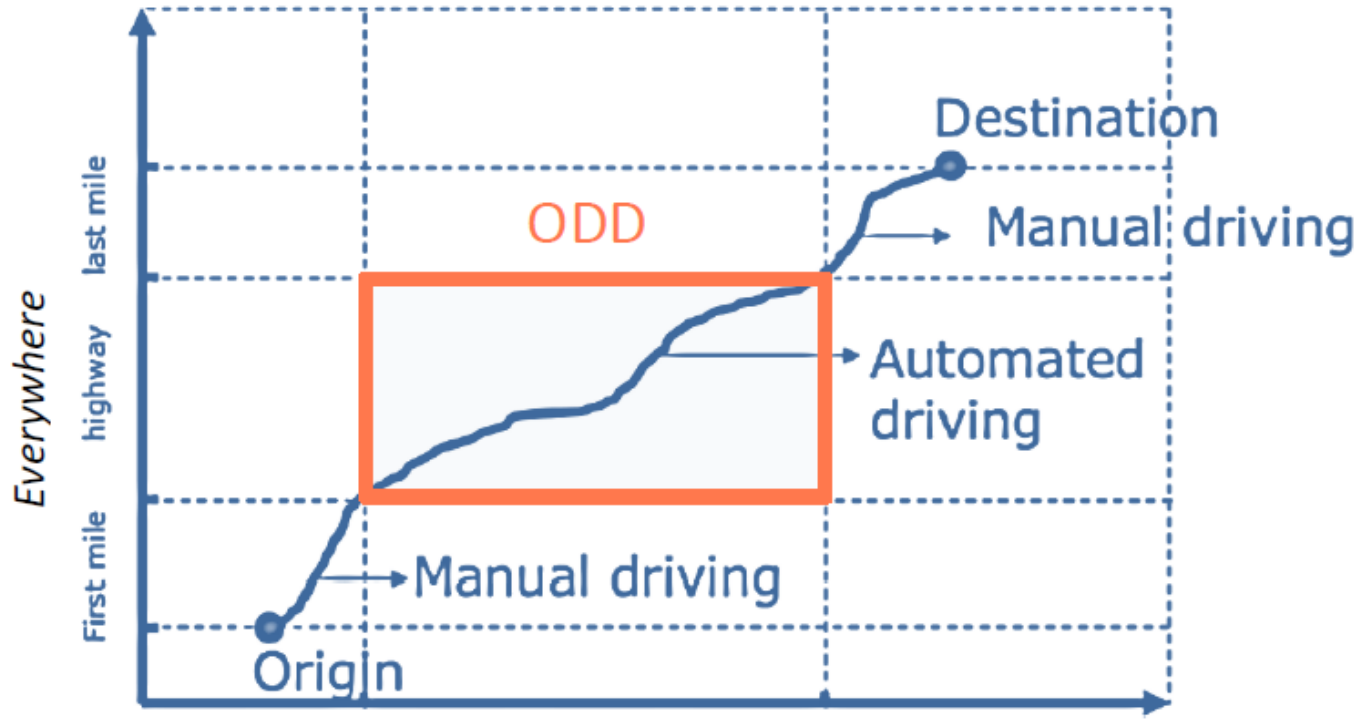
2. ODD (Operational Design Domain) and traffic flow

- The Netherland might be first country to announce that their traffic management will be based on ODD for automated driving by changing ODD according to the road and traffic environment.
- ODD was first announced by SAE and the definition of ODD related to road administration is not clear and many discussions are emerging.

Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Sustained lateral and longitudinal vehicle motion control	OEDR		
Driver* performs part or all of the *DDT						
0	**No Driving Automation**	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	*Driver*	*Driver*	*Driver*	n/a
1	**Driver Assistance**	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	*Driver* and *System*	*Driver*	*Driver*	Limited
2	**Partial Driving Automation**	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	***System***	*Driver*	*Driver*	Limited
***ADS* ("*System*") performs the entire *DDT* (while engaged)**			*System*	***System***	*Fallback-ready user (becomes the driver during fallback)*	Limited
3	**Conditional Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.				
4	**High Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	***System***	Limited
5	**Full Driving Automation**	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	**Unlimited**

SAE levels and ODD are too general
For detailed discussions
about requirements, functional
description is needed.

Operational Design Domain (ODD)



Vehicle capabilities

x

Geographical domain

x

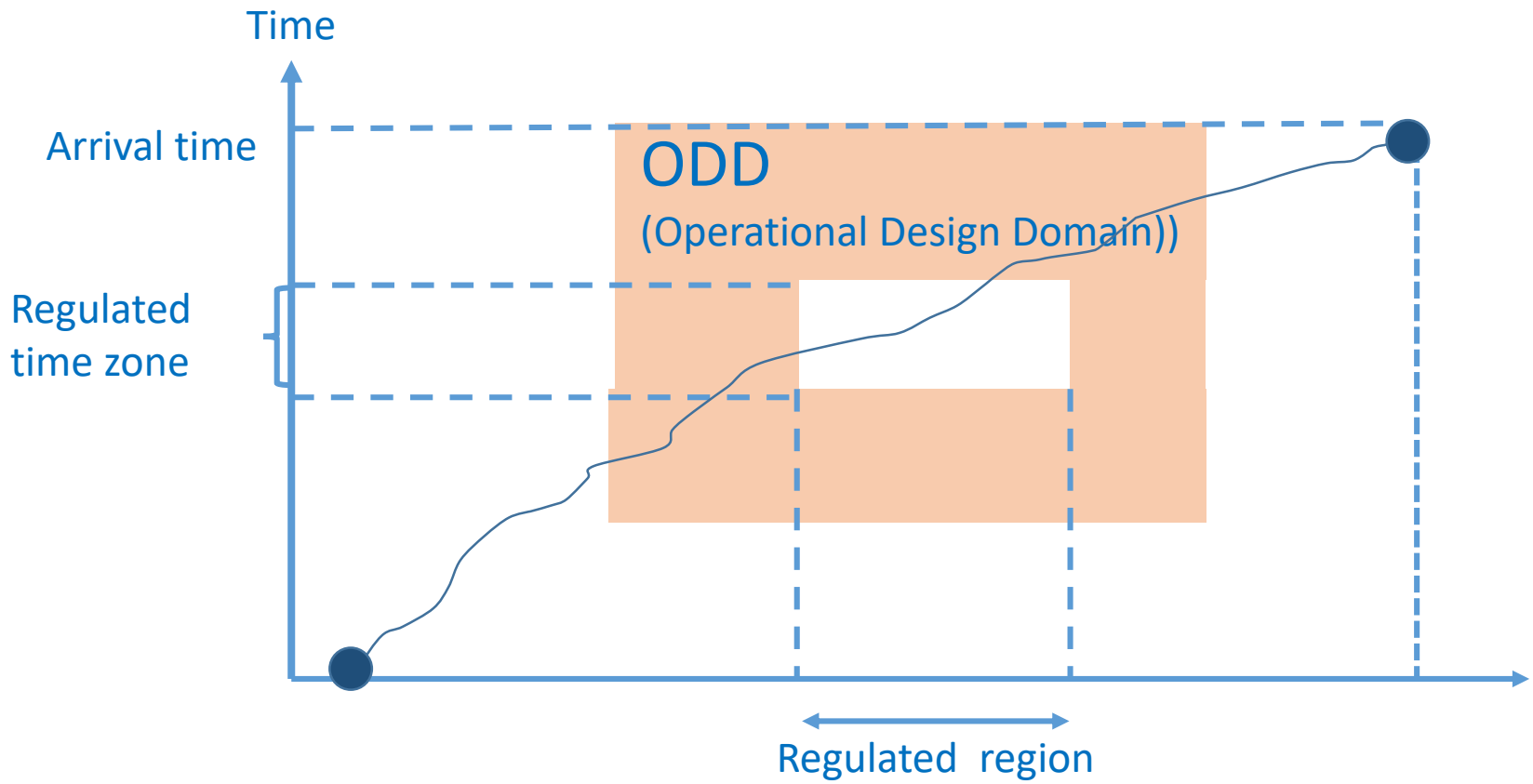
Traffic & situational environment

=

ODD

Tom Alkim, Rijkswaterstaat, 2017

An example of ODD in Japan



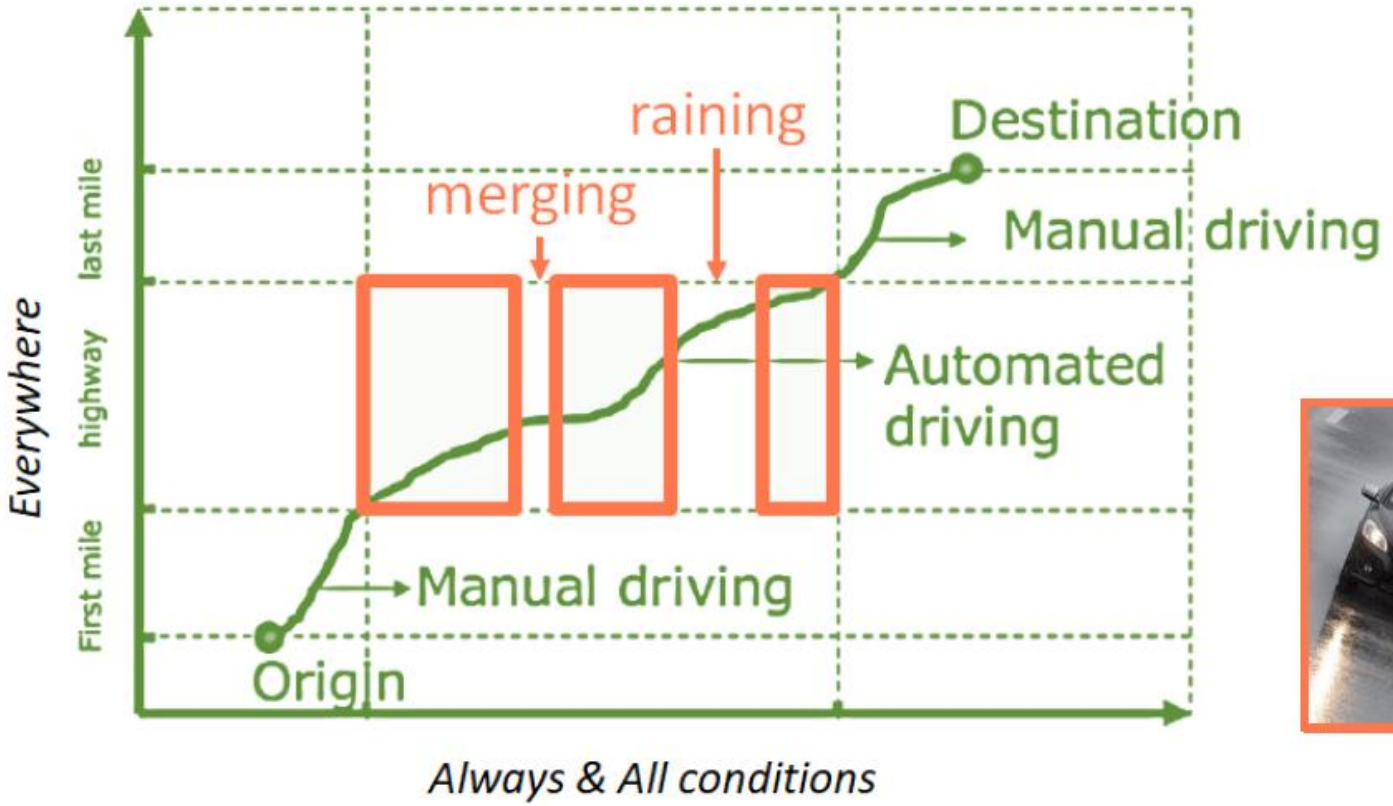
Source; Keio University, Mobility Culture Research Center, 2018

INTERRUPTIONS = TRANSITIONS

25TH ITS WORLD CONGRESS COPENHAGEN 17 – 21 SEPTEMBER 2018
Quality of life

TransAID MAVEN

Funded by H2020 GA No. 690727 and 723390



Tom Alkim, Rijkswaterstaat, 2017

Operational Design Domain : Definition (R. Kulmela et al.)

- ODD is a description of the specific operating conditions in which the automated driving system is designed to properly operate, including but not limited to road types, speed range, environment conditions (weather, day time/ night time etc.), prevailing traffic law and regulations, and other domain conditions.
- The ODDs are in crucial position, determining the parts of the road and street network, and the times, when vehicles can be used in the automated mode.

Operational Design Domain : Definition (R. Kulmela et al.)

- The ODDs are dependent on the capabilities of automated vehicles, and especially on the sensors and artificial intelligence (AI) utilized. Thus automated driving may need specific ODD management systems to be developed, deployed and operated.
- The objective of ODD management is to provide equal services to all vehicles and user on roads, including both automated vehicles, non-automated vehicles and vulnerable road users.

Ref: “The impact fo automated transport on the role, operations and costs of road operations and authorities in Finland”, Risro Kulmela, et al.
Tranficom Research Reports 6/2019

Source Information	Typical Substance	Category of communication systems to transmit substance
Traffic flow	Congestion ahead, location of accident	Narrow area /Wide area
Road repairs	Location of road work section and under construction section	Narrow area
Road maintenance and improvement	Location of sections which have not completed the maintenance of signs and white lines, etc.	Narrow area
Traffic regulation	Speed range and traffic signs	Narrow area
Traffic control	Events and VIP transit	Wide area/ Narrow area
Obstacles ahead	Obstacles outside of vehicle sensor's capability at curves, etc.	Narrow area
Reginal circumstances	Disaster, city planning construction area	Wide area/ Narrow area
Weather condition	Rain, snow, fog at the curve, exit of the tunnel, etc. and the location and the size of rain puddles	Narrow area
Communication failure	Facility obstacle, power supply hindrance and traffic communication disorder	Wide area
Radio wave failure	Jamming, Electromagnetic Interference (EMI), radio interference by the solar flare	Wide area

Examples of dynamic source information for determining ODD (Prototype)

(Source: Keio University, Mobility Culture Research Center 2019)

3. Combination of communication systems to realize ODD management

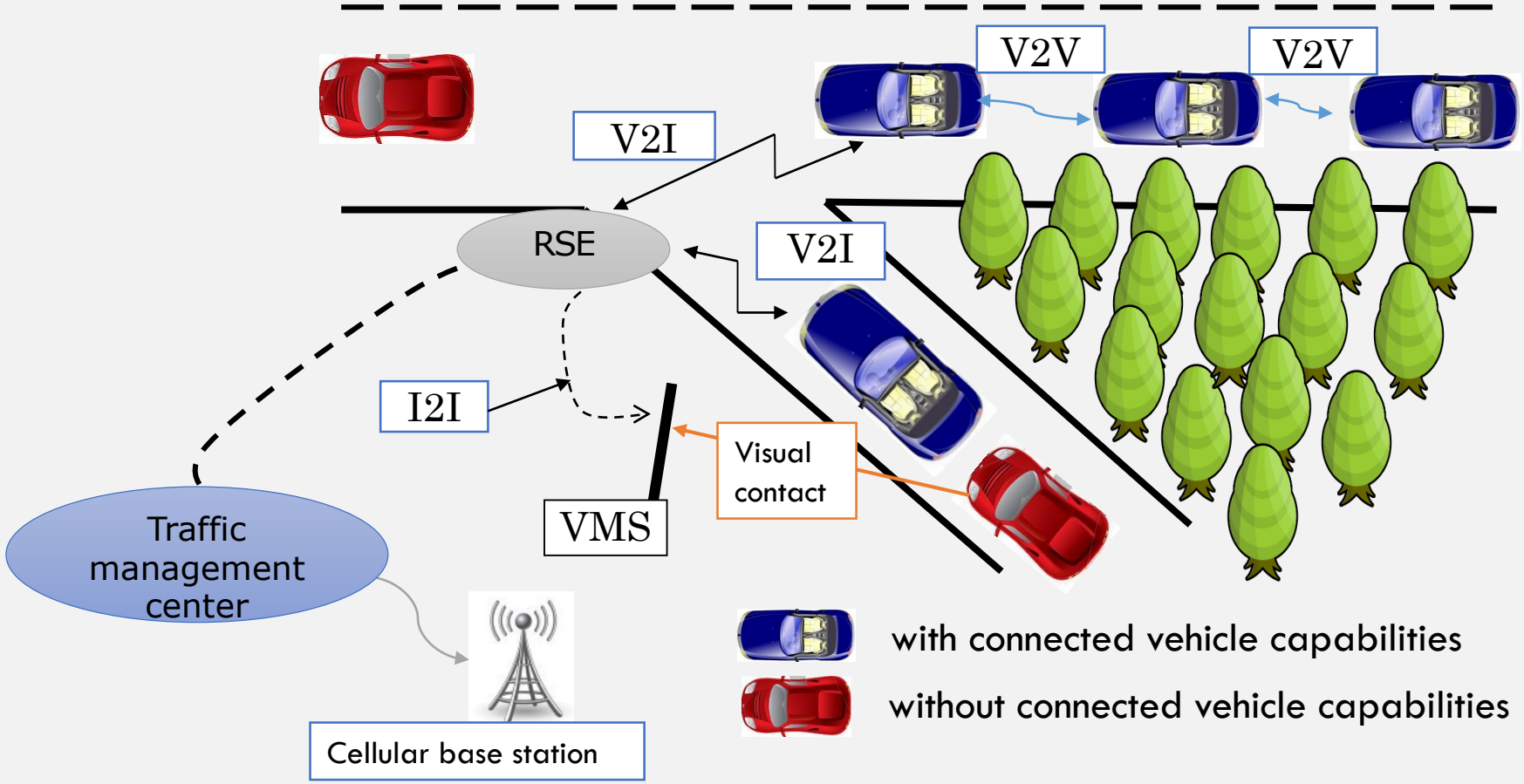
3.1 Merging section

- At current stage, merging sections in expressways for example, might be excluded from ODD in some cases. However, these sections are the places where drivers need help.
- Some kind of orchestration of related vehicles at the merging section is needed but the problem is who and how can we orchestrate the movement of vehicles to keep smooth traffic flow.

ODD management at merging sections

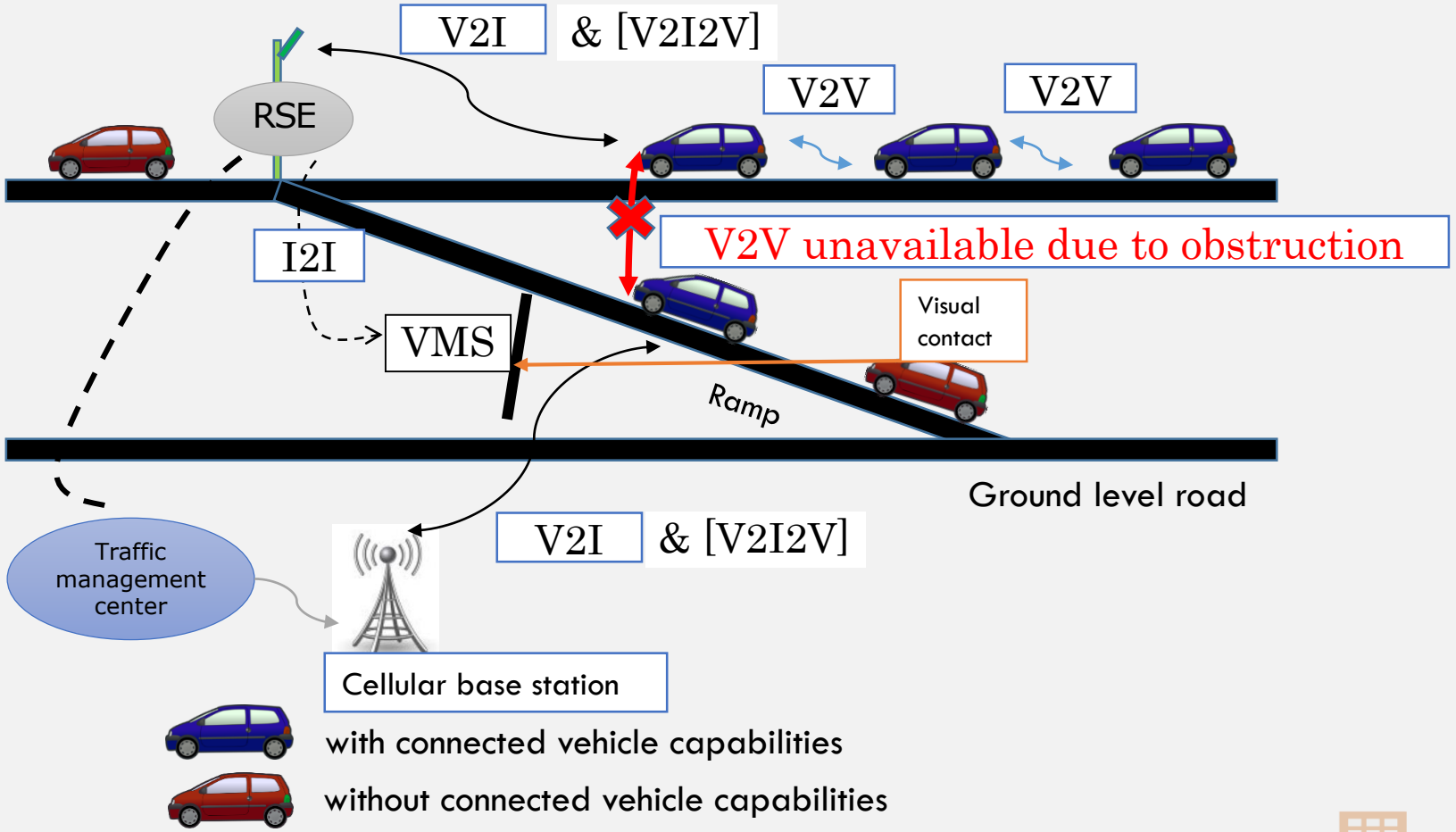
- In order to realize ODD management at merging sections, precise location tracking of related vehicles is necessary. Although the orchestration will be operated at very limited section of the network, the location data generated by automated vehicles will need to comply with data protection rules as far as personal data processing is concerned.
- Since wide area and narrow area communication systems are needed to combine, the resolution of security issues and data protection problems for ODD management becomes very complicated.

Combination of communication systems for ODD management at flat lane rampway



(Source: Keio University, Co-Mobility Society Research Center 2015)

Combination of communication systems for ODD Management at a rampway with elevated lane

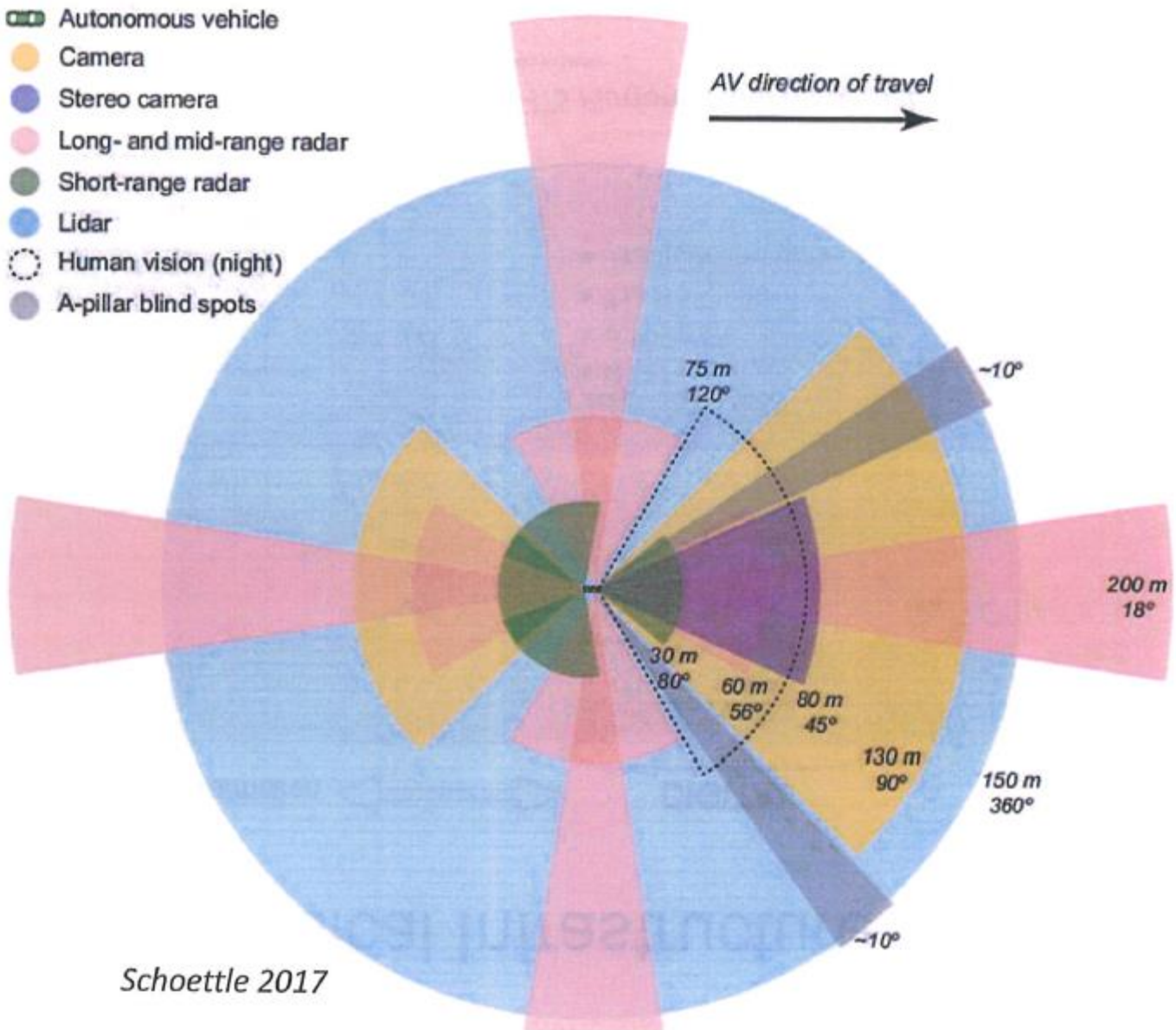


(Source: Keio University, Co-Mobility Society Research Center 2015)

3.2 Extending ODD management by utilizing future I2V

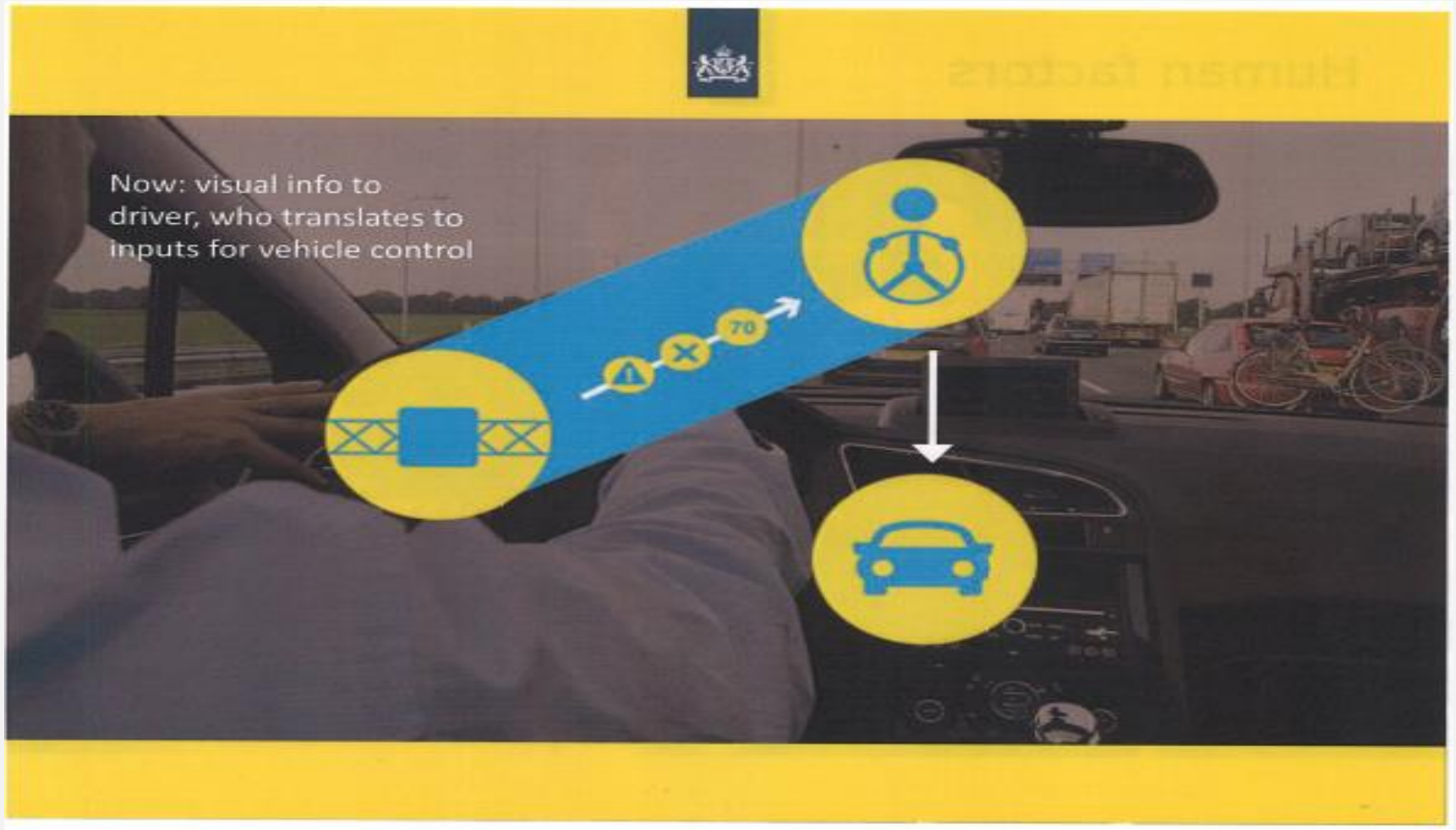
- Vehicle sensors detect very limited area and when weather condition is bad the sensing area will become limited.
- I2V is necessary at long curves and bad visibility sections of the roadway.
- Future I2V will become M2M communication and can be utilized for ODD management, but road authorities are not ready to prepare for this innovation.

Need for electronic horizon & digital infra: Sensor ”sight” distances



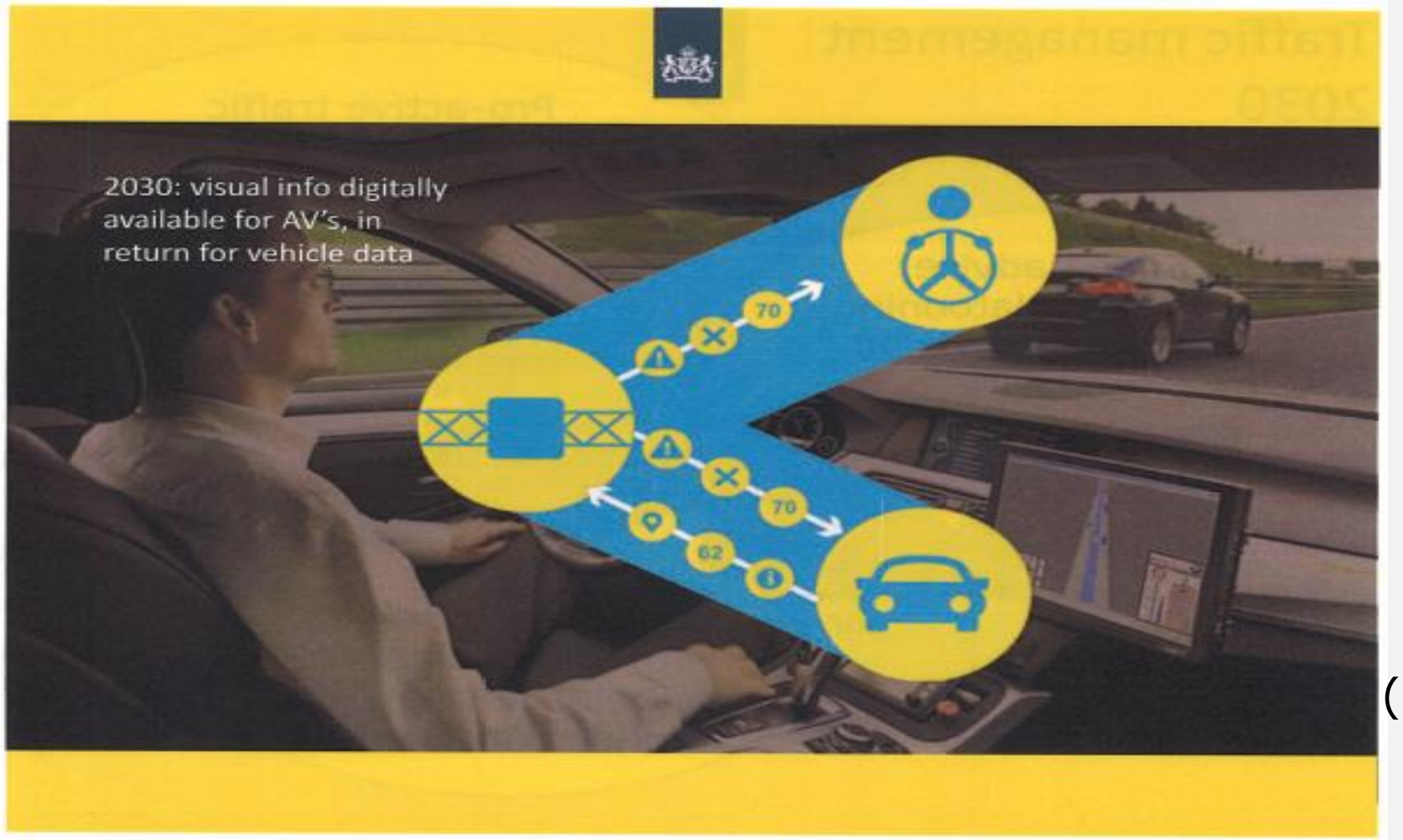
Schoettle 2017

Current I2V



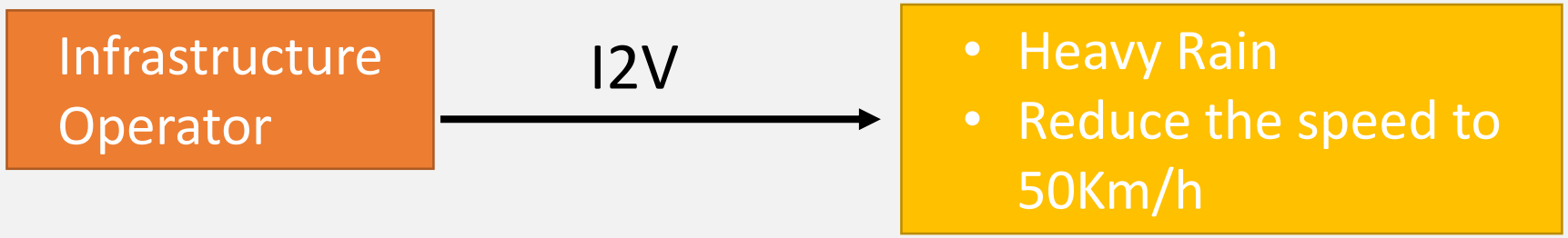
(Source; Rijkswaterstaat)

Future I2V & V2I



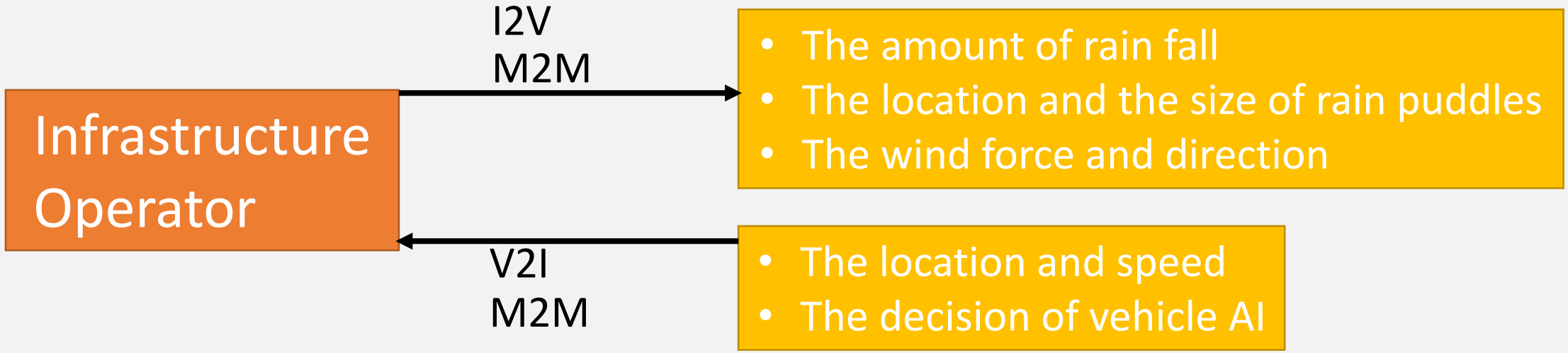
(Source; Rijkswaterstaat)

Examples of current I2V



Basic assumption is that the driver will see the messages by navigation system or smart phone etc., and then driver decides the next action

Future I2V & V2I with M2M capability



(Data for future ODD management)

The operator can send location data of the rain puddles etc., but the driver can not use these data for their action. On the other hand, Infrastructure Operator can receive the actual reaction of vehicle by V2I such as the decision parameter of the vehicle at certain rain puddle, for example.

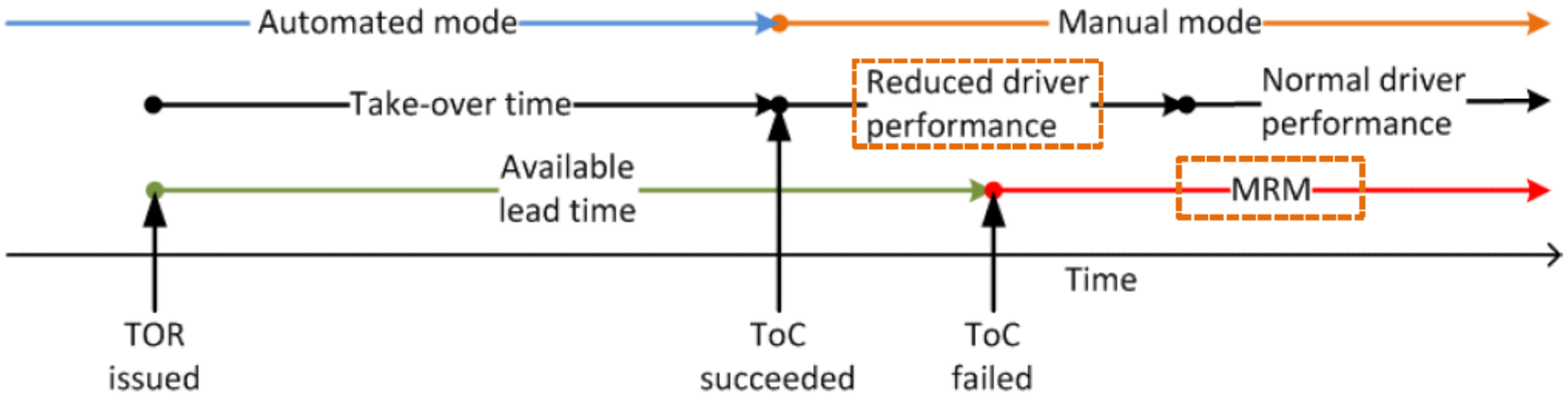
Database for I2V

- MLIT is preparing the National Transportation Data Platform which contains the Road Foundation Map Information such as the road construction data. These data can help automated vehicles to drive smoothly and as a result, it improves the comfortability of the ride.
- These kind of data exchanges between vehicles and infrastructure operators will become very important and the area for future collaboration.

3.3 Relationship among HMI, Vehicle Control and ODD management at the transition stage

- When automated mode changes to manual mode, the vehicle system driven by AI and the driver should recognize the conditions and take suitable action. At this transition stage, it is easy to imagine that complex problems must be solved in very short time.
- The issue which is shown here is that the terminology and the definitions are different among stakeholders. The followings are two examples.

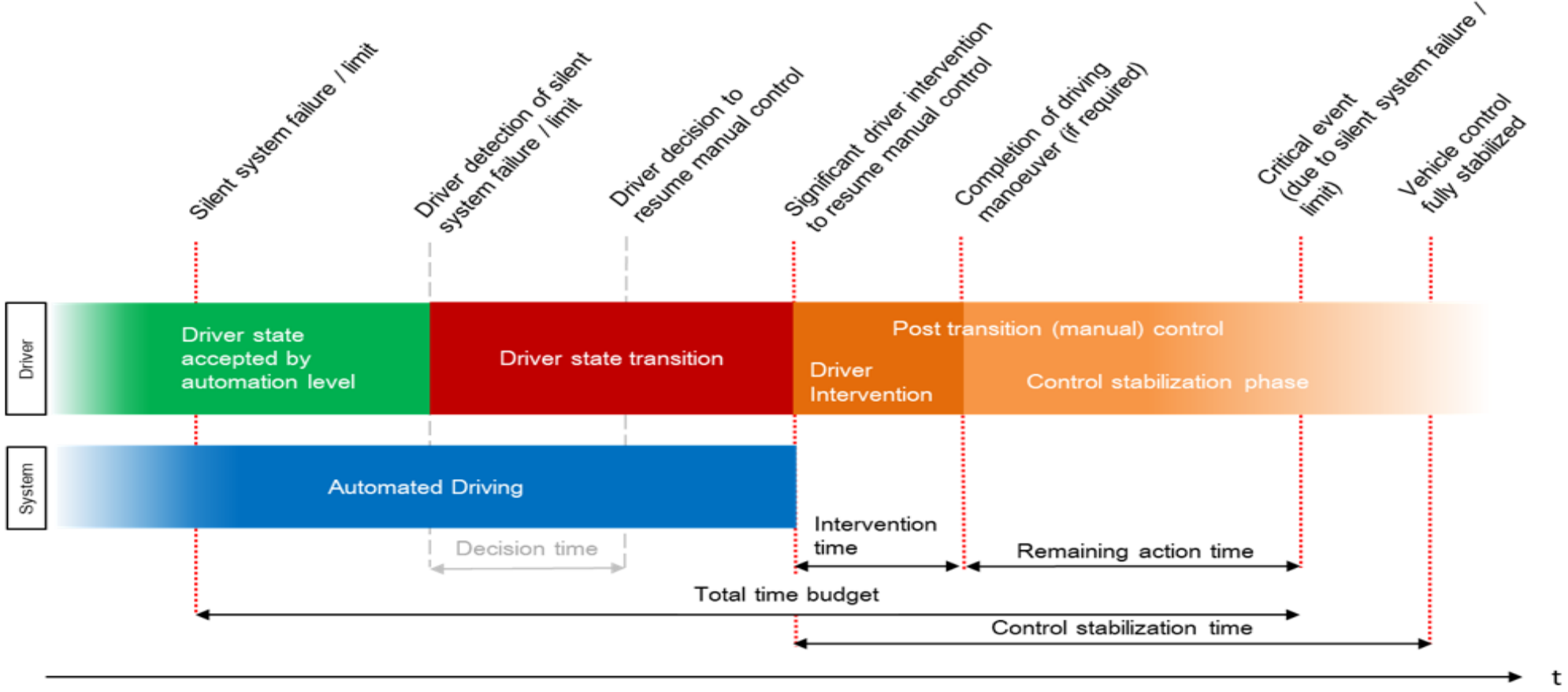
ToC and MRM process (deactivations)



MRM minimum risk condition = stop or park safely

Remark: Driver's reaction is not considered

(Source; J. Vreeswijk, SIP-adus, 2018)



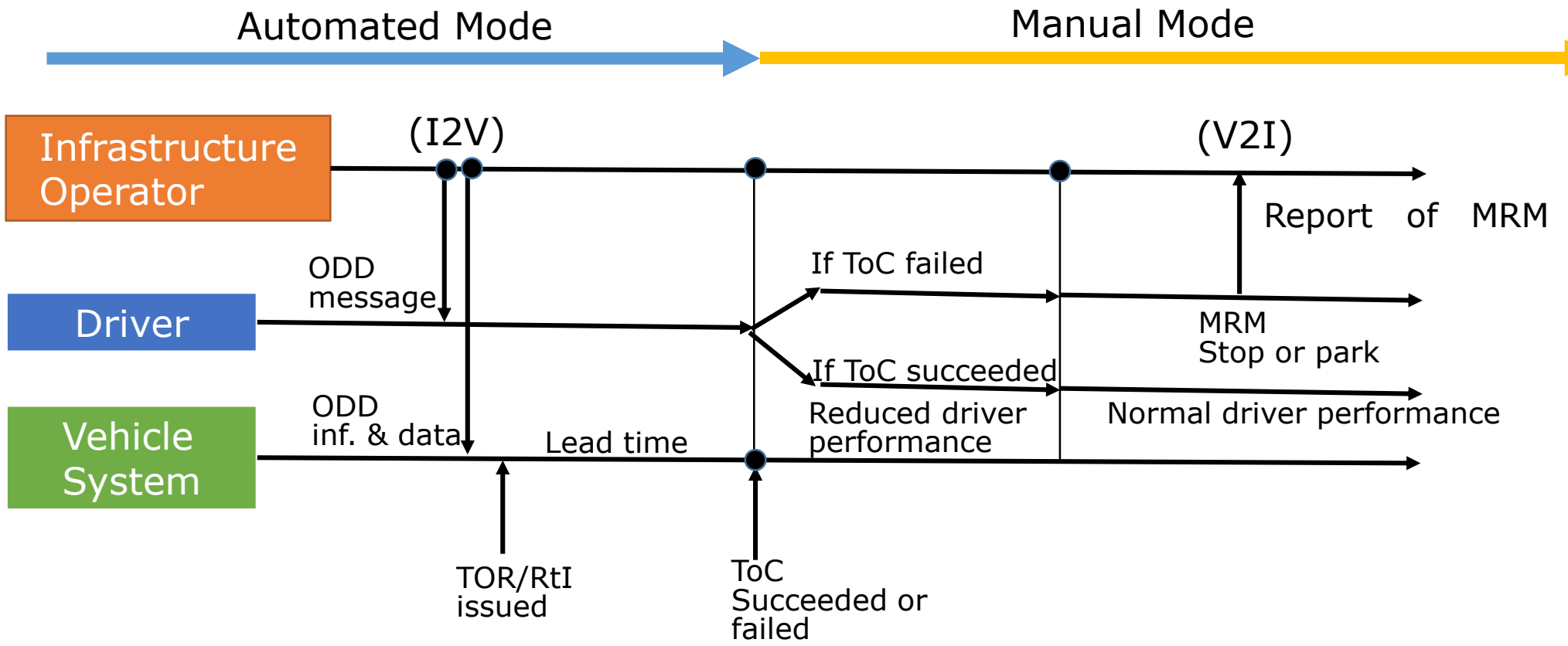
Human-initiated transition from automated to manual driving due to detection of system performance limits

Remark: Linkage with ODD management is not considered.

(Source; ISO/TR21959, ISO/TC22/SC29/WG8, Road vehicles; Human Performance and State in the Context of Automated Driving: Part1 –Common underlying concepts)

Prototype diagram to describe the transition stage

- Next figure shows a prototype idea for describing the transition stage by including driver's view through HMI perspectives, in addition to necessary information for the infrastructure operators and vehicle control system.
- ODD management is important for drivers because drivers want to know why automated mode will change to manual mode. This kind of understanding will influence the driver performance after the control is transferred to the driver and direct message from infrastructure operators is indispensable to explain various road traffic environmental changes.



Infrastructure Operator; Operator who has digital infrastructure, road traffic management capability

Driver; Has a driving experience of the vehicle

Vehicle System; Equipped unit with sensors, digital map, positioning system, communication systems and AI

ODD message; Messages to explain the driver why ODD will be changed

ODD inf. & data; Necessary information and technical data for the vehicle system to decide ToC

TOR; Take Over Request RtI; Request to Intervene MRM; Minimum Risk Manoeuvre ToC; Transition of Control

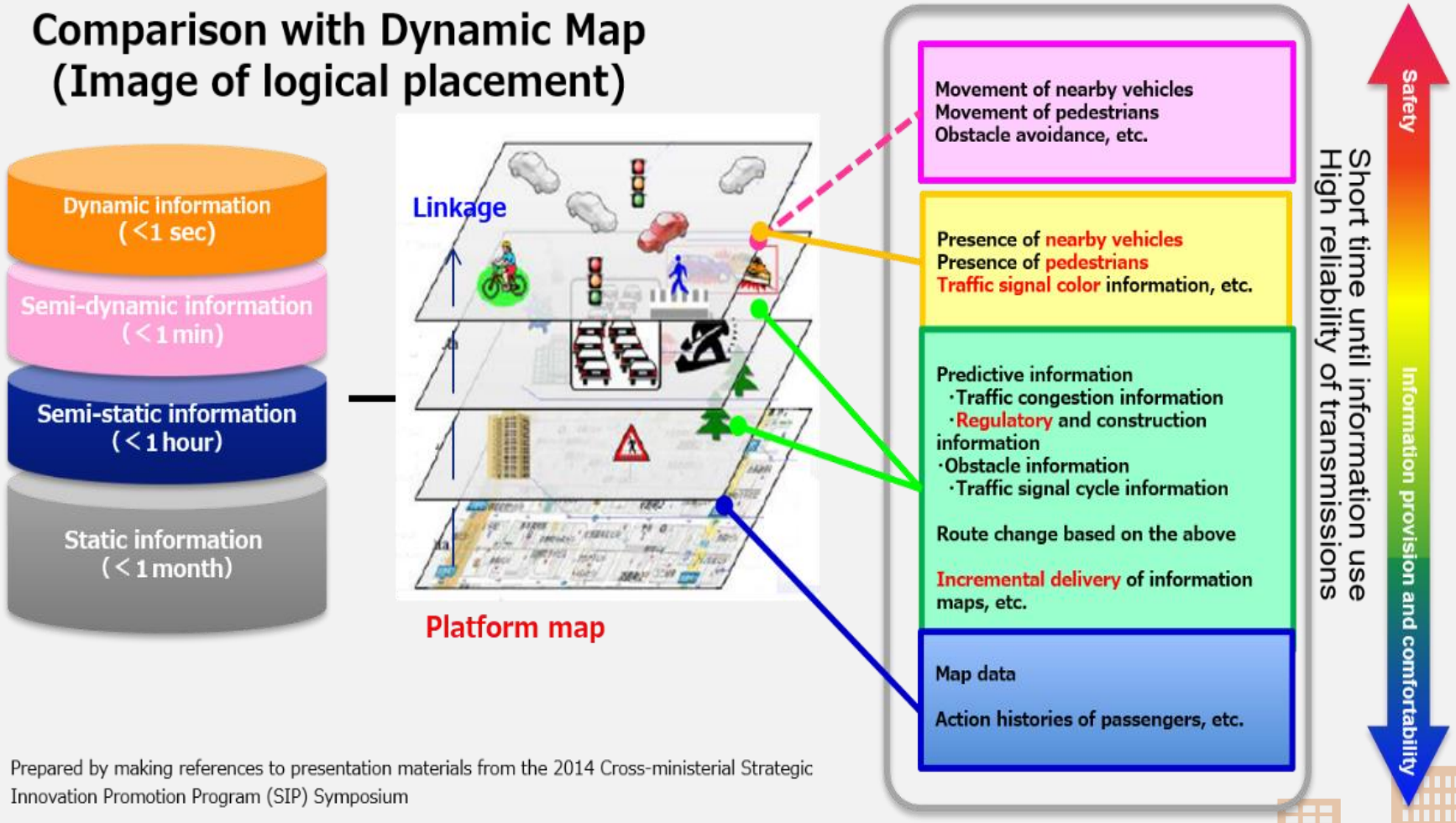
Transition of Control Process actuated by ODD (Prototype)

(Source: Keio University, Mobility Culture Research Center 2019)

4. Concluding remarks

- There are already various proposal about wide area and narrow area communication systems including the combination of these two.
- The next diagram is an image of prototype design of wide area and narrow area communication systems for expressway ODD management.
- The important thing is that for everyday operation of traffic management the personal data is not needed. Only aggregated (mean value, maximum, minimum etc.) data for certain time period at certain section are needed.
- OD (Origin and Destination) data is used for determining road planning and fare policy of toll roads and private sectors are interested for their marketing. But this sould be considered by additional mechanisms.

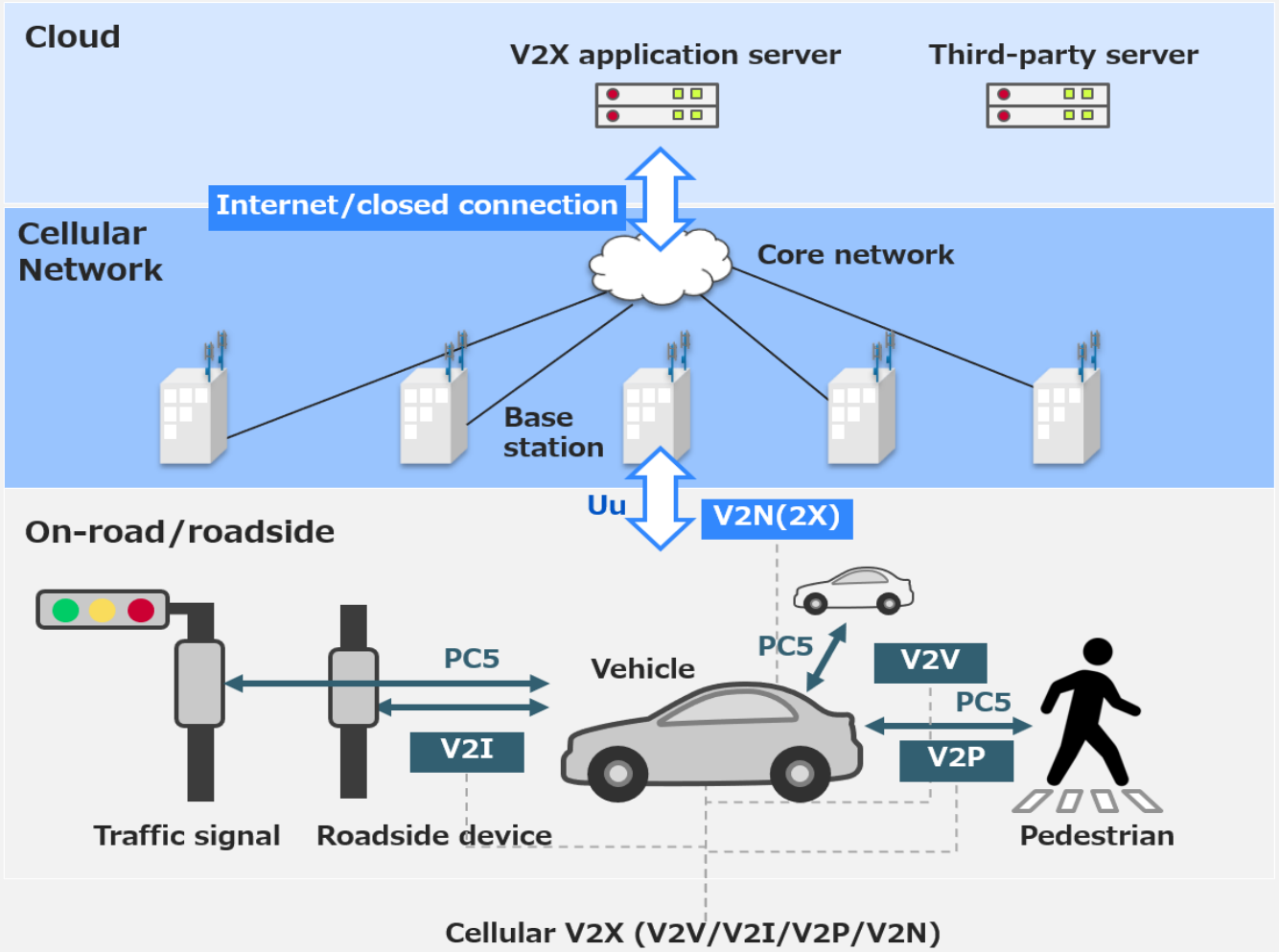
Image of Comparison of Handled Data and Dynamic Map



Prepared by making references to presentation materials from the 2014 Cross-ministerial Strategic Innovation Promotion Program (SIP) Symposium

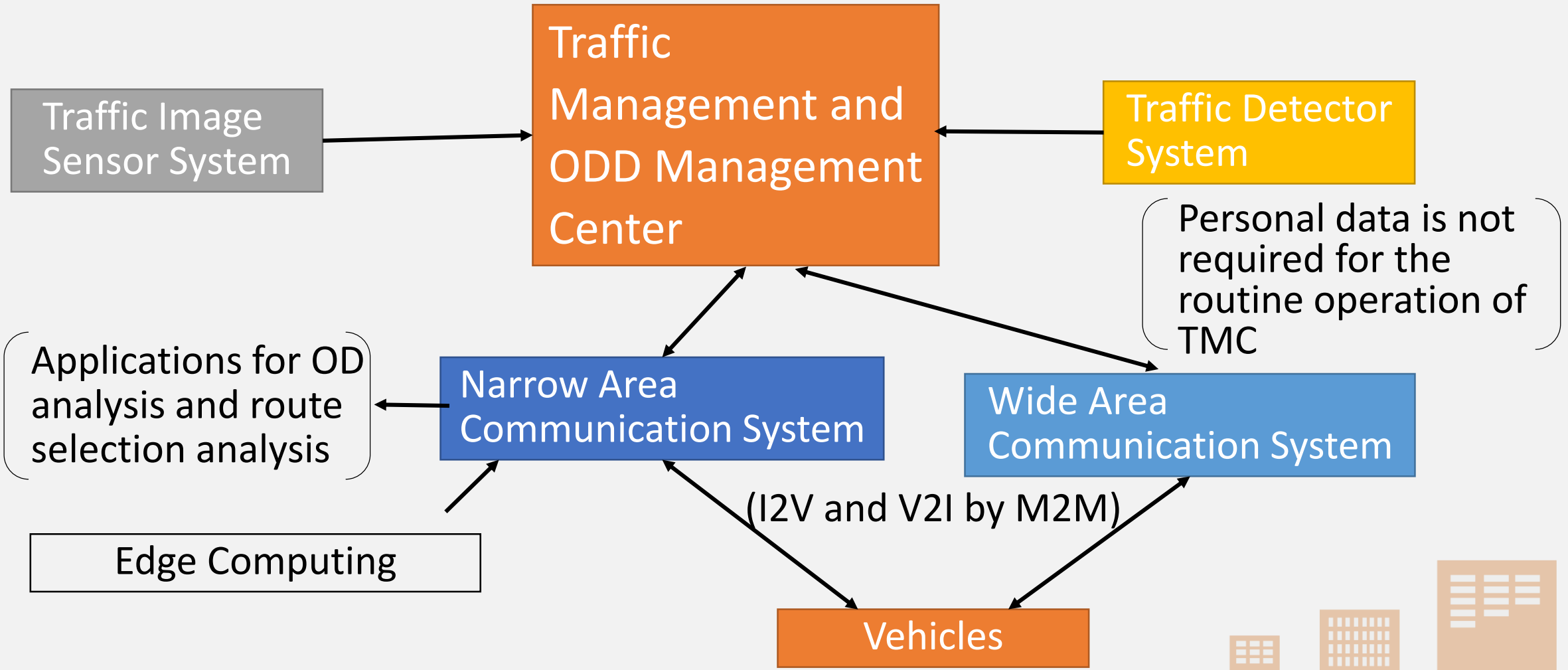
(Source; ITS Info-Communication Forum, Issues Survey Report, June 2019)

Overall Structure of Cellular V2X



(Source; ITS Info-Communication Forum, Issues Survey Report, June 2019)

Wide and Narrow area communication systems for the Expressway ODD Management



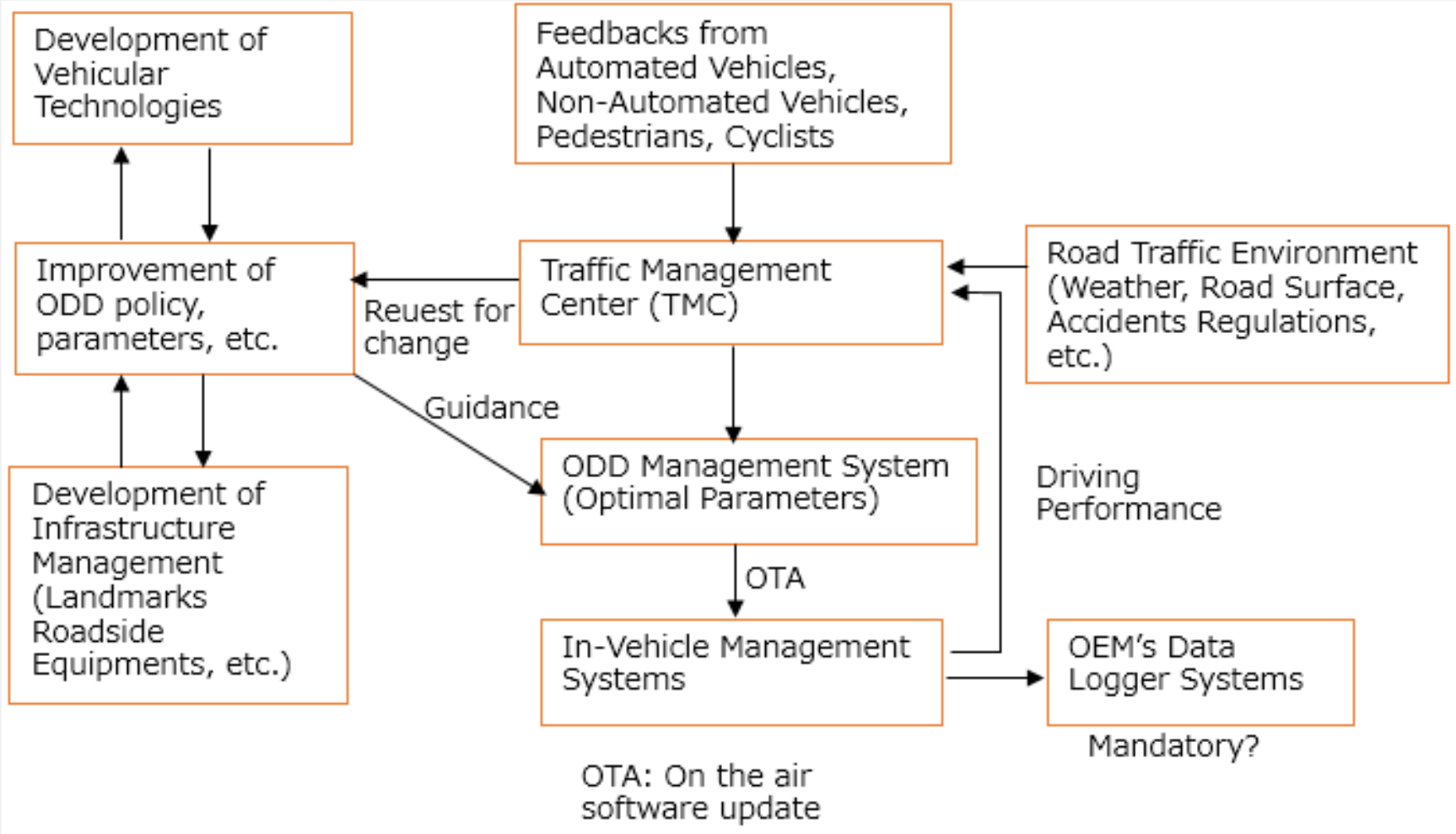
Future activities and related topics

- Road authorities, automobile manufacturers and telecommunication companies do not know each other. For example, road authorities do not know the requirements of automobile manufacturers because they do not have standardize requirements to road authorities. Therefore, road authorities do not know their potential data to help automated vehicles and how the related data base should be developed by future investments.
- ITU seems to have good position to start discussion with automobile manufacturers and road authorities. This is because there will be multiple realization of back born communication systems for ITS and automated vehicles but in any case, it will be the combination of wide area and narrow area communication which is the home ground of ITU.

Future activities and related topics

- Obviously automated driving systems are needed in our future society but it takes time to realize in our society.
- Now, most of the people can use ICT equipment which allows to provide feedbacks from drivers who experienced automated driving. Moreover, non-user of automated driving may have lots to say to the stakeholders the inconvenience which they experienced with automated vehicles.
  The following chart is an architecture to improve our society to introduce automated vehicles more easily. The existence of ICT technology, that is the CASE age, is what is different from the time when automobile was introduced more than 100 years ago.

Basic Architecture of ODD Management Systems



(Source: Keio University, Mobility Culture Research Center 2018. See also R. Kulmela et al. 2019)

ODD management in the mixed traffic conditions

- As is mentioned by Risto Kulmela et al. that ODD management focusses on the improvement of traffic management under mixed conditions . Furthermore, mobility management is needed to be consider since the details of ODD management will change according to the penetration rate of automated vehicles and the innovative developments of related technologies.
- Therefore, the concept of ODD management should be established and shared by many players involved in the mixed traffic conditions.

- As for the international collaboration on the communication integration, Dr. Moon of KOTI and Keio University will have a workshop at the Plenary Meeting of ISO/TC204 in Singapore, October 14.

- The volunteers who have great interest about ODD management will organize a workshop in parallel to ITS WC 2019, on October 22, 14:30~ at the place of walking distance from ITS WC. Please join the workshop.