Issues related to human factors in international regulation activity of automated driving technologies

Michiaki Sekine

National Traffic Safety and Environment Laboratory

Discussion on automated driving technology in United Nations

- World Forum for Harmonization of Vehicle Regulations (WP.29) established a meeting called ITS/AD-Informal group in 2014 and had discussed the basic concept of automated driving technology.

- ITS/AD had terminated after transferring the agenda to the newly established GRVA in September 2018

- Main outcomes of ITS/AD are as follows:
  - Proposals for harmonized definition of automated driving to establish the vehicle regulations
  - To identify the main horizontal issues and legal obstacles to be consistent with the Road Traffic conventions
  - The general guidelines on cybersecurity and data protection

Role sharing between driver and system

SAE Level	Name	Vehicle motion control	Object and Event Detection and Response	Fallback	Operational Design Domain
0	No Automation	Driver	Driver	Driver	n/a
1	Driver Assistance	Driver & System	Driver	Driver	Limited
2	Partial Automation	System	Driver	Driver	Limited
3	Conditional Automation	System	System	Driver	Limited
4	High Automation	System	System	System	Limited
5	Full Automation	System	System	System	Unlimited

A proposal for the Definitions of Automated Driving under WP.29 (Outline) (Partial excerpt from ITS/AD-14-04-Rev1)

	Object and Event Detection and Response (OEDR) by the driver The driver may not perform secondary activities			**Object and Event Detection and Response (OEDR) by the system The driver may perform secondary activities**		
SAE Level	1	2a	2b	3	4	5
Vehicle Tasks	Longitudinal/ lateral control	Both Longitudinal/ lateral control		Deactivated at the driver's request	Shall monitor the driving environment for any decisions	Monitor the driving environment
Driver Tasks	Longitudinal/lateral driving	Monitoring environment and necessary response		Remains vigilant for the transition demand	Does not need to execute any driving tasks in the ODD.	Does not need to execute any driving tasks in whole trip.
Consideration points on regulation	Same as current principle	System is deactivated by driver request.		Detection of driver's availability	To ensure driver is in the position to take over	minimal risk condition outside of lane.
Examples of the necessary system performance requirements						
Override function	Necessary in general			Necessary in general	Delay deactivation in compromise safety.	Unnecessary
Driver monitoring function	Hands-off detection	Hands-off detection	Plus eye movement detection	Detection of driver's availability	Necessary at the end of ODD.	Unnecessary

A proposal for the Definitions of Automated Driving under WP.29 (Outline)
(Partial excerpt from ITS/AD-14-04-Rev1)

	Object and Event Detection and Response (OEDR) by the driver The driver may not perform secondary activities			**Object and Event Detection and Response (OEDR) by the system The driver may perform secondary activities**		
SAE Level	1	2a	2b	3	4	5
Vehicle Tasks	Longitudinal/ lateral control	Both Longitudinal/ lateral control		Deactivated at the driver's request	Shall monitor the driving environment for any decisions	Monitor the driving environment
Driver Tasks	Longitudinal/l ateral driving	Monitoring environment and		Remains vigilant for the transition demand	Does not need to execute any driving tasks in the ODD.	Does not need to execute any driving tasks in whole trip.
Consideration points on regulation	Same as current principle	System is deactivated by driver request.		Detection of driver's availability	To ensure driver is in the position to take over	minimal risk condition outside of lane.
Examples of the necessary system performance requirements						
Override function	Necessary in general			Necessary in general	Delay deactivation in compromise safety.	Unnecessary
Driver monitoring function	Hands-off detection	Hands-off detection	Plus eye movement detection	Detection of driver's availability	Necessary at the end of ODD.	Unnecessary

Vehicle Task, Driver task, and Consideration points on development of regulation

Examples of the necessary system performance requirements

A proposal for the Definitions of Automated Driving under WP.29 (Outline)
(Partial excerpt from ITS/AD-14-04-Rev1)

	Object and Event Detection and Response (OEDR) by the driver The driver may not perform secondary activities			**Object and Event Detection and Response (OEDR) by the system The driver may perform secondary activities**		
SAE Level	1	2a	2b	3	4	5
Vehicle Tasks	Longitudinal/ lateral control	Both Longitudinal/ lateral control		Deactivated at the driver's request	Shall monitor the driving environment for any decisions	Monitor the driving environment
Driver Tasks	Longitudinal/lateral driving	Monitoring environment and necessary response		Remains vigilant for the transition demand	Does not need to execute any driving tasks in the ODD.	Does not need to execute any driving tasks in whole trip.
Consideration points on regulation	Same as current principle	System is deactivated by driver request.		Detection of driver's availability	To ensure driver is in the position to take over.	minimal risk maneuver outside of lane.
	Examples of the necessary system performance requirements					
Override function	Necessary in general			Necessary in general	Delay deactivation in compromise safety.	Unnecessary
Driver monitoring function	Hands-off detection	Hands-off detection	Plus eye movement detection	Detection of driver's availability	Necessary at the end of ODD.	Unnecessary

Secondary activity is not permitted

Secondary activity may be permitted

Important concept in SAE definition

- Operational Design Domain：ODD
  - Assumed design environment for using automated driving
  - Automated driving technology should be used under proper ODD conditions such as a motorway or a parking lot
  - However, the setting method of ODD has not been concretely decided yet
  - Anyway the driver must return to manual operation before the ODD is finished
  - An appropriate HMI is required to inform the driver of the state of the ODD

Acceptability of secondary activity

- How can we accept secondary activities during automated driving?

- Prohibited items of Japan's Road Traffic Act
  - Gazing at car navigation display
  - Using a mobile phone in the hand during driving
  - ➢ Secondary activities are practically prohibited in Japan.

- Systems with level 3 or higher may allow secondary activity
  - ➢ Can the driver take over promptly in response to the system's request?
  - ➢ What is necessary technology to ensure safety?

- Our lab examines the technical requirements necessary for ensuring safety based on the evaluation result of the influence of the secondary activity on the transfer of driving authority.

Transition Demand Study

1. Two aspects were observed in automated driving in level 3 on a motorway by our driving simulator.

   (1) Required time from a transition demand is issued until the driver resumes manual operation

   (2) Driver's behavior when encountering difficult traffic situation immediately after resuming operation

2. Three types of the transition situations were examined.

   (1) Exit of the motorway (Planned transition)

   (2) A system malfunction, another vehicle cutting in and decelerating (Unplanned transition)

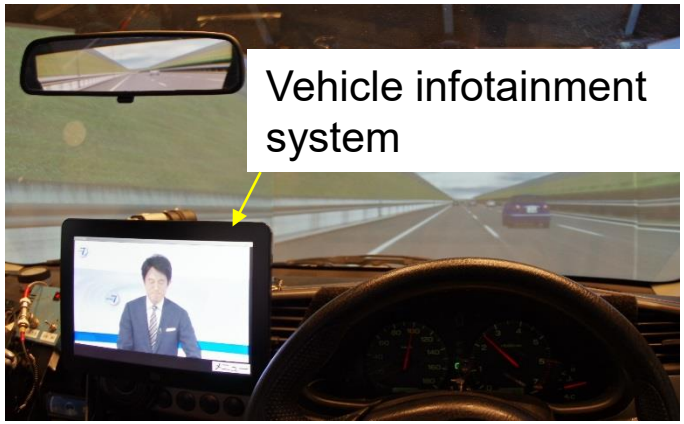
   (3) Lane decrease due to a road construction (Unplanned)

Example of Secondary Activities

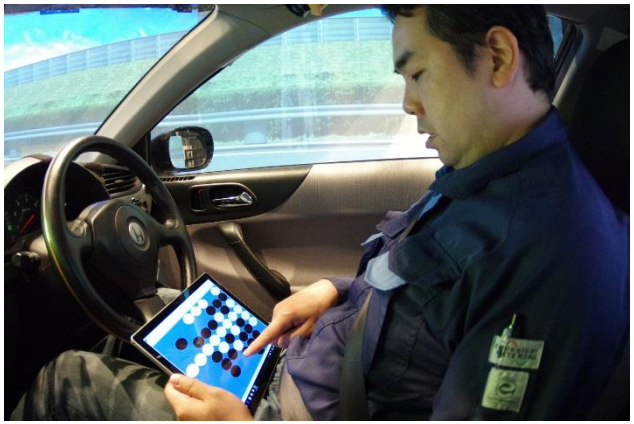
Two types of secondary activities that may be executed during automated driving were examined.

type 1 : Watching videos through the display of the vehicle infotainment system

type 2 : Playing a game with a touch pad which is not linked to the vehicle infotainment system in his/her hands (Reversi game).



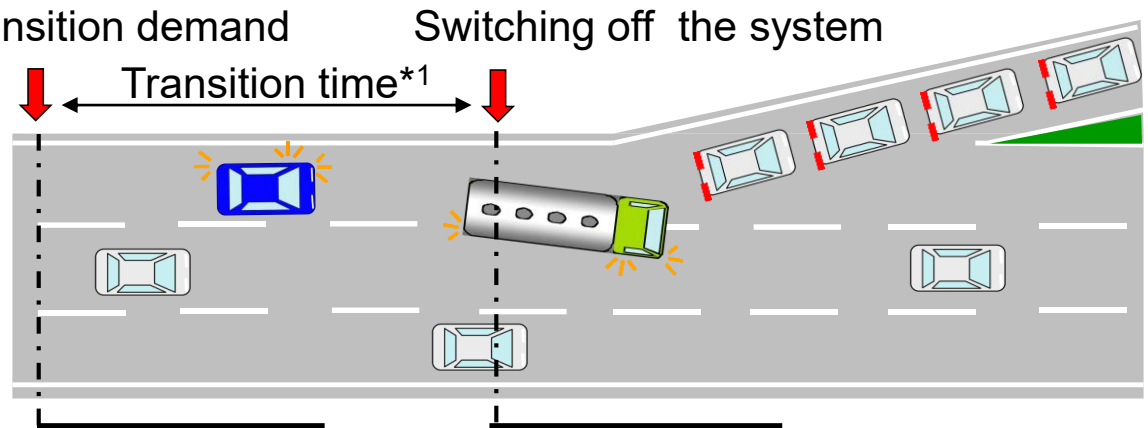
type 1



type 2

Experimental traffic scenes and transition demand

Scene A : Exit of the motorway (an example of planned transition)



Exit of the motorway is congested, and the frontal vehicles are stopping.

Visual HMI

*1 Transition time : 15sec. (fixed value)

Audible HMI

(Ping-pong! Exit of the motorway, the automated driving will be switched off soon.)

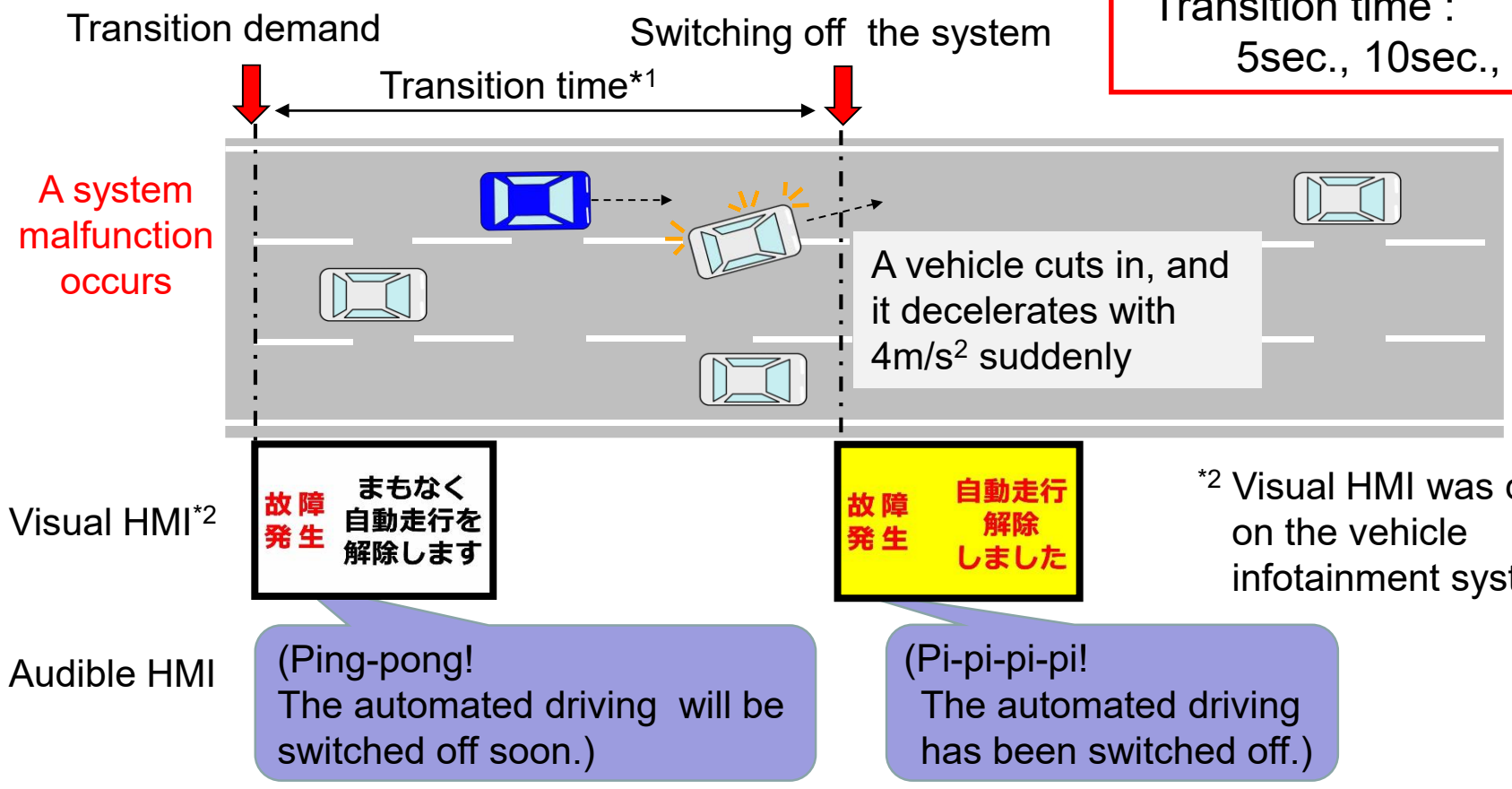
(Pi-pi-pi-pi! Exit of the motorway, the automated driving has been switched off.)

Most young drivers could slow down the vehicle speed in this situation.
Many older drivers avoid collisions with steering operation rather than brakes.

Experimental traffic scenes and transition demand

Scene B : A system malfunction, another vehicle cutting in and decelerating (an example of unplanned transition)

***1 Experimental variable**
Transition time :
5sec., 10sec., 15sec.



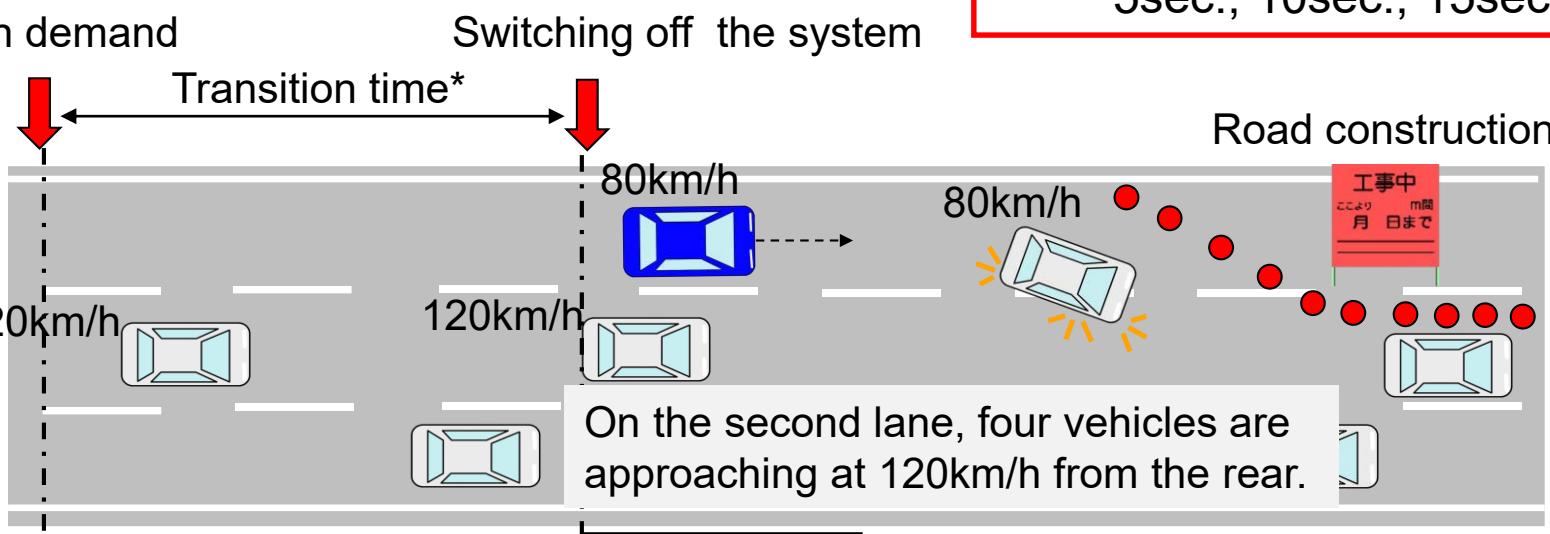
*2 Visual HMI was displayed on the vehicle infotainment system

As the transition time becomes longer, the time from issuing transition demand to holding the steering control increases.

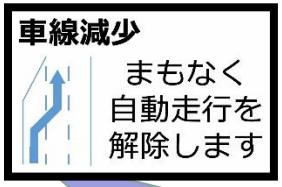
Experimental traffic scenes and transition demand

Scene C : Lane reduction due to a road construction
(an example of unplanned transition)

***Experimental variable**
Transition time :
5sec., 10sec., 15sec.



Visual HMI*2



*2 Visual HMI was displayed on the vehicle infotainment system

Audible HMI

(Ping-pong!
The automated driving will be switched off soon.)

(Pi-pi-pi-pi!
The automated driving has been switched off.)

As the transition time becomes longer, the time from issuing transition demand to the start of operating the steering control to move to the lane increases.

Results Summary

- Many of the drivers can hold the steering control within around 5 sec. after the transition demand is issued. On the other hand, if we consider the time margin for the drivers in order to manage their vehicle more safely just after the transition, to keep around 10 sec. as the transition time is considered suitable.

- Many of drivers tend to respond more slowly in case of the longer transition time. In this experiments, the longer transition time was not always used effectively for the safer transition. Therefore, some requirements of HMI during the transition time to make the driver start manual operation more quickly will be necessary (for example, to inform the driver imminent situation by the audible HMI, etc.).

- It is considered that the system should manage the vehicle behavior during the transition time to reduce the risk after the transition time in both cases of planned and unplanned transition (for example, to reduce the vehicle speed, etc.).

- As the secondary activity, in case of watching videos on the vehicle infotainment system, no special concern was observed. On the other hand, in case of operating a touch pad which is not related to vehicle infotainment system, a concern was observed that a part of the drivers could not recognize transition demand.

What is the next?

- Requirements for vehicle design based on human factor
  - HMI for reliably bringing back the driver to manual operation
  - If the HMI can not ensure safety sufficiently, safety measures by vehicle control will be necessary (such as decelerating the vehicle after the transition demand)

- Evaluation method of secondary activity in level 4
  - The type of secondary activity may be more diverse than level 3
  - The relationship between the magnitude of physical and cognitive load and the time to resume manual operation after transition demand at the end of ODD should be evaluated
  - What is the standard task to evaluate this? (Do N-Back and SuRT satisfy this requirement?)
  - It is necessary to decide what kind of secondary activity is finally acceptable

- Thank you for your attention

You can access following documents from UN official web site

- Definition of Automated Driving under WP.29: ITS/AD-14-04-Rev1
- Results of the Study on Transition for level 3 Automated Driving system: ACSF-17-07