12th Japan ITS Promotion Forum

Automated Driving System

Human Factors

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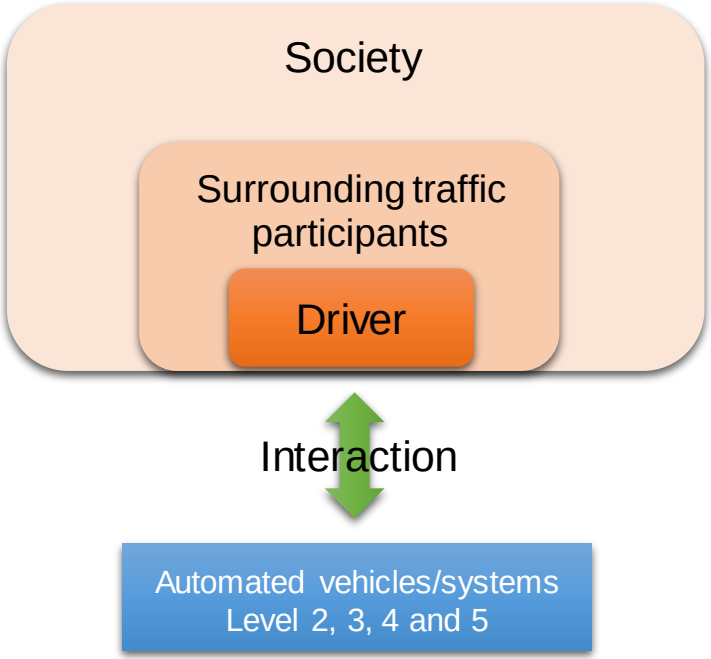
SIP

Cabinet Office

<Translated Version>

Human Factor Tasks in Automated Driving

Framework for extracting tasks used in the HMI Taskforce (FY2015)



Map of Extracted Human Factor Tasks

Interactions between vehicles and humans			Level of Automated Driving				
			Level 1	Level 2	Level 3	Level 4	Level 5
Vehicle <-> Driver	Issues related to system understanding						
	A-1	Understanding system functions	Excessive dependence on system, excessive confidence in system functions, misunderstanding of functions				
	A-2	Understanding system state	Understanding current state and future behavior of system				
	A-3	Understanding system operation	Usability of operation system (meaning of use and operation is unknown)				
	A-4	Understanding system behavior	Anxiety and discomfort in a style of driving that differs from one's own (lane change, speed reduction through curves)				
	Issues related to driver state						
	B-1	Driver state when using automated driving system		Appropriate driver state and maintenance method			
	B-2	Shifting from automated driving system to manual driving		Measures for safe driving handover			
	B-3	User value of automated driving system		Creation of value for overcoming fight with sleepiness	Creation of value for overcoming interruption in relaxation		Creation of value for overcoming standardization of driving
Vehicle <-> Other traffic participants	C-1	Communication between automated vehicle and surrounding drivers		Means of communication at intersections and when merging or changing lanes			
	C-2	Communication between automated vehicle and pedestrians, etc.		Means of communication during pedestrian crossings and in shopping areas and parking lots			
	C-3	Balance between observing traffic rules and making traffic flow smoothly			Concessions to other drivers, mismatch between legal speed limit and traffic speed		
Vehicle <-> Society	D-1	Social value and acceptance of automated vehicles			Functional design appropriate for diffusion rate to increase social acceptance		
	D-2	Responsibility of accidents and traffic violations			Responsibility for accidents and traffic violations while using automated driving systems		
	D-3	Driver's license system			License system for automated vehicles		

Human Factor Tasks with High Priority

Vehicle <-> Driver	A-1	Understanding system functions	Excessive dependence on system, excessive confidence in system functions, misunderstanding of functions				
	A-2	Understanding system state	Understanding current state and future behavior of system				
	A-3	Understanding system operation	Understanding system operation (operation of use and operation in unknown)				
	A-4	Understanding system behavior	Anxiety and discomfort in a style of driving that differs from one's own (lane change, speed reduction through curves)				
	Issues related to driver state						
	B-1	Driver state when using automated driving system		Appropriate driver state and maintenance method			
	B-2	Shifting from automated driving system to manual driving		Measures for safe driving handover			
	B-3	User value of autonomous driving system		Creation of value for overcoming [illegible]	Creation of value for overcoming interruption in relaxation		Creation of value for overcoming standardization of driving
Vehicle <-> Other traffic participants	C-1	Communication between automated vehicle and nearby drivers		Means of communication at intersections and when merging or changing lanes			
	C-2	Communication between automated vehicle and pedestrians, etc.		Means of communication during pedestrian crossings and in shopping areas and parking lots			
	C-3	Balance between observing traffic rules and making traffic flow smoothly		[illegible]	[illegible]		ic speed
Vehicle <-> Society	D-1	Social value and acceptance of automated vehicles			Functional design appropriate for diffusion rate to increase social acceptance		
	D-2	Responsibility of accidents and traffic violations			Responsibility for accidents and traffic violations while using automated driving systems		
	D-3	Driver's license system			License system for automated vehicles		

Task A: Issues related to understanding system functions

Task B: Issues related to driver state

Task C: Issues related to communication between automated vehicles and other surrounding traffic participants

Organization and Responsibilities for R&D

Implementation structure of SIP-adus human factors R&D and large-scale field operational tests

- Overall management: AIST
  - Task A R&D: University of Tsukuba
  - Task B R&D: AIST
  - Task C R&D: Keio University
  - System prototype: Denso Corporation
  - Large-scale field operational tests *Companies participate in public road tests and test course experiments for Tasks A, B and C
    Operated by: Tokyo Business Service Co., Ltd.
    - Companies participating in large-scale field operational tests (OEMs and suppliers)

- FY2016: Project commissioned by Cabinet Office
- FY2017 to FY2018: NEDO project

Introduction of Example of Research Outcomes

Task B

Objective

Clarify the impacts that the driver state during Level 2 and Level 3 automated driving have on the driver's driving transition behavior when switching from automated to manual driving. Extract monitorable metrics of driver state (readiness) that affect transition behavior.

(FY2016 DS test →FY2017 TC test →FY2018 Test on public roads)

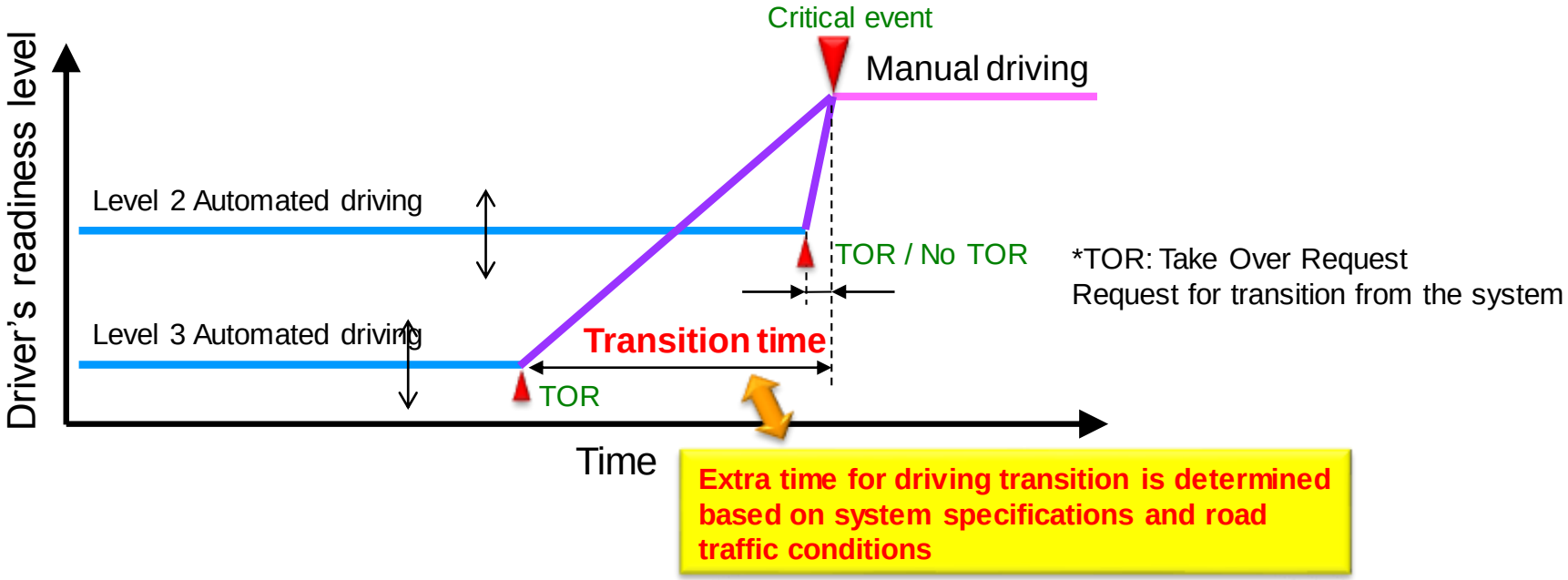
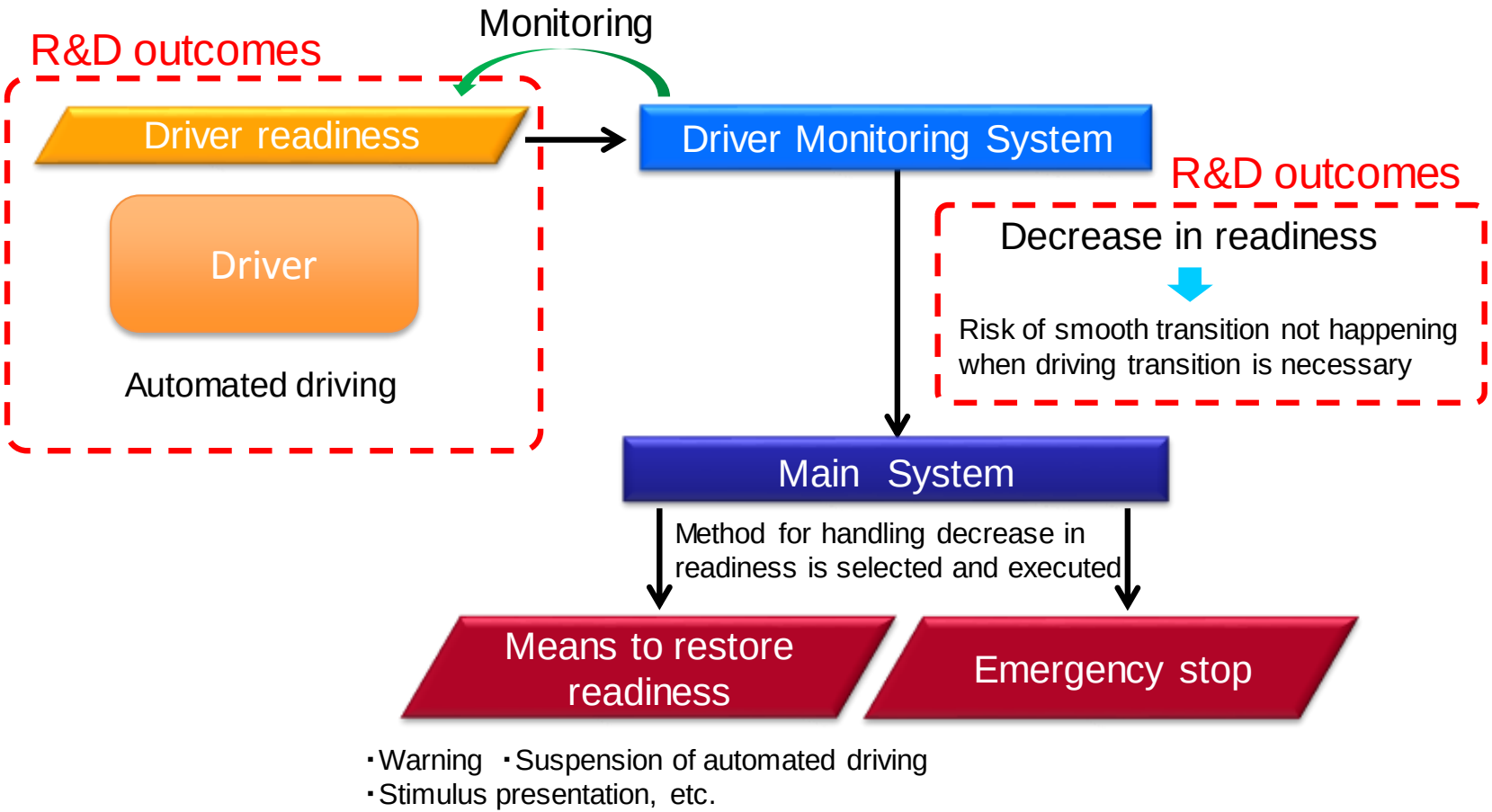


Image of Incorporation of R&D Outcomes into System



Test Method

(1) By adding mental arithmetic tasks and visual/operational tasks to the test subject during automated driving using a driving simulator, conditions of cognitive load (mental distraction) and visual/operational load (taking eyes off the road) are created. Testing of alertness is left up to the natural variations among test subjects. (2) Driver state is measured using various physiological and behavioral metrics. (3) Driving transition and risk avoidance behavior in response to a system request (TOR) set according to the scenario are measured. The correlation among (1), (2) and (3) is measured.

Driver state

- Condition of cognitive load based on metal arithmetic tasks
- Condition of visual/operational load based on secondary tasks using a touch panel
- Decreased alertness (natural variation among test subjects)

Metrics

- Brain waves
- Line of sight
- Eye movement
- Pupil diameter
- Blinking
- Eye closing time
- Heartbeat
- Blood pressure

etc.

Transition behavior

- Driving operation
- Proximity to obstacles
- Vehicle behavior after transition, time required for stabilization

Etc.

Correlation

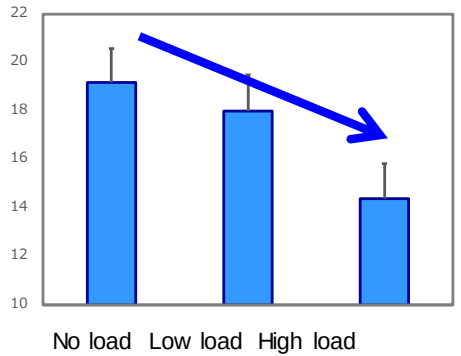
Scenario

Automated driving by following preceding vehicle
→ System generates TOR
→ Preceding vehicle changes lanes
→ Stopped vehicle appears

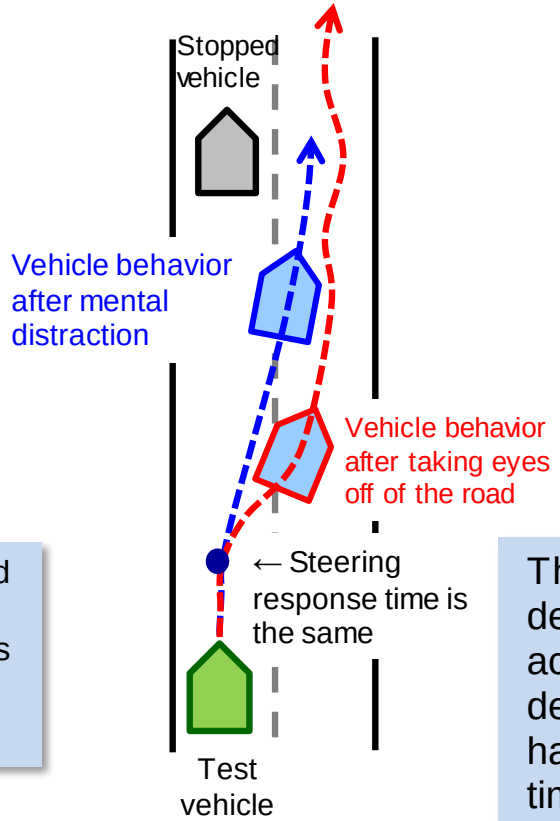
Test Results

■ Impact of driver state on driving handover action

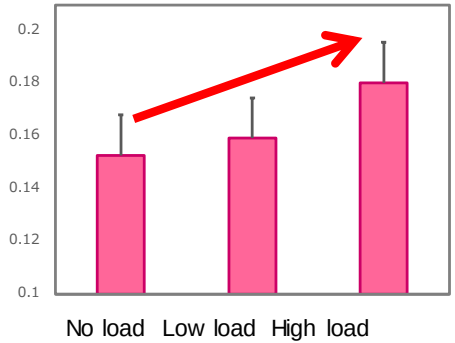
Minimum distance (m) to obstacle during lane change



Cognitive load (mental distraction)



Variation in steering 5 seconds after completion of lane change



Visual/operational load (taking eyes off of the road)

The visual information processing speed decreases due to a cognitive load, and the response time for avoiding obstacles decreases. As a result, the driver is closer to the obstacle.

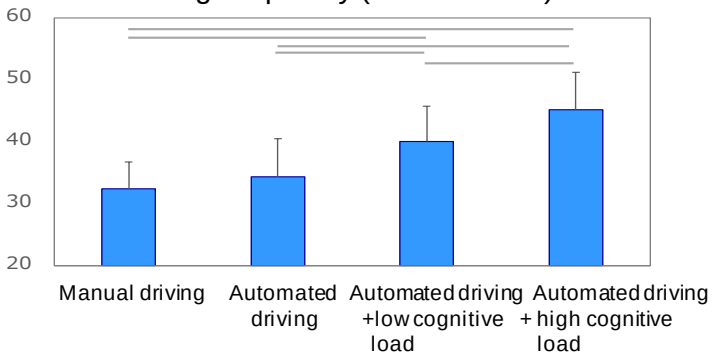
The level of situation awareness declines due to visual loads. As a result, accuracy of behavior to avoid obstacles declines (lane change due to sudden handle movement), and it takes more time for the vehicle to stabilize.

Test Results

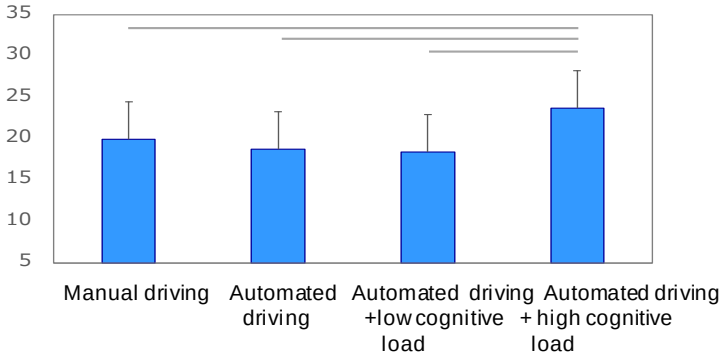
■ Monitorable metrics for driver state (readiness metrics)

State of cognitive load

Blinking frequency (blinks/minute)

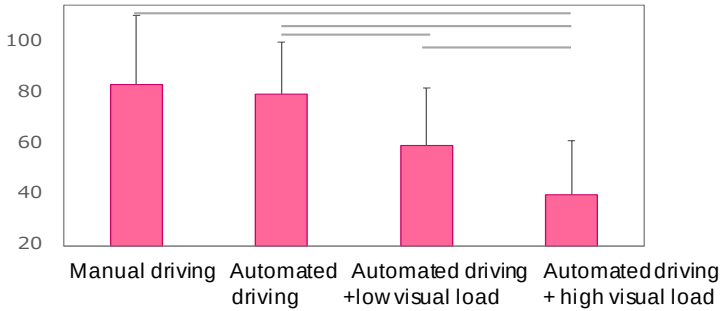


Eye movement (saccade) occurrence frequency (times/minute)

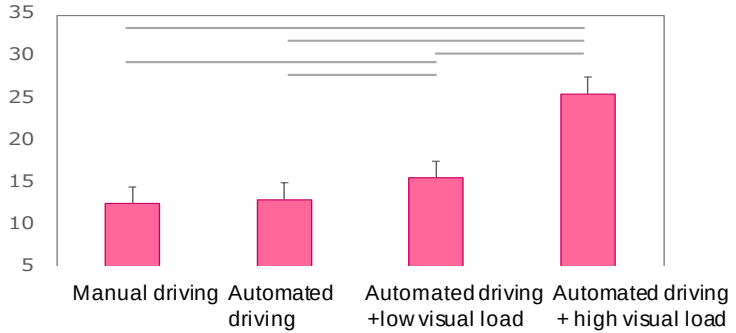


State of visual/operational load

Percentage of frontal visual recognition (%)



Eye movement (saccade) occurrence frequency (times/minute)

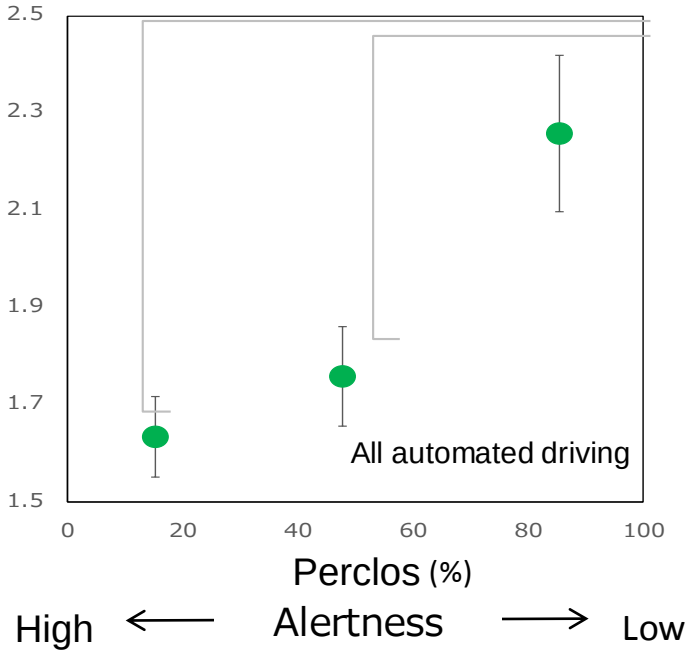


Test Results

- Impacts of decreased alertness on driving transition and monitorable metrics for alertness

Alertness

Correlation between percentage eye closure (perclos) and steering reaction time (s) after TOR is generated.



Summary

- It was found that mental distraction, taking eyes off of the road, and decline in alertness by the driver during automated driving have different adverse effects on transition behavior in situations where a driving transition is necessary.
- As monitoring metrics for driver state (readiness) that affects the abovementioned driving transition, those with high measurability using on-board devices were extracted.
- In the future, the results obtained will be verified on test courses (FY2018) and tests on public roads (FY2018).

Outlets of Outcomes

Program Director

Steering Committee

System Practicalization WG

International Cooperation Working Group

JAMA/JSAE/SIP
HF coordination meeting

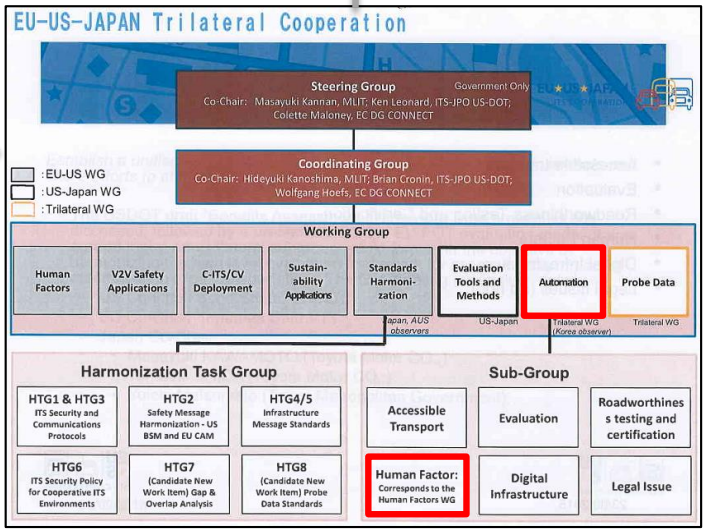
Human Factors & HMI R&D consortium

JSAE

JAMA

International standard
ISO TC22/SC39

International standard
UN-ECE R79



EU-US-Japan trilateral cooperation

International Standardization Plan ISO/TC22/SC34