Document FRAV-07-10
7th FRAV session
17 November 2020

Competent and Careful human driver performance model

Nov 17, 2020

Transmitted by experts of Japan

Agenda

- Background
- Basis for each parameter
    1. Risk perceive situation

        What is 0.375m?

    2. Human delay

        What are 0.72m and 0.75sec

    3. Max Decerebration G and

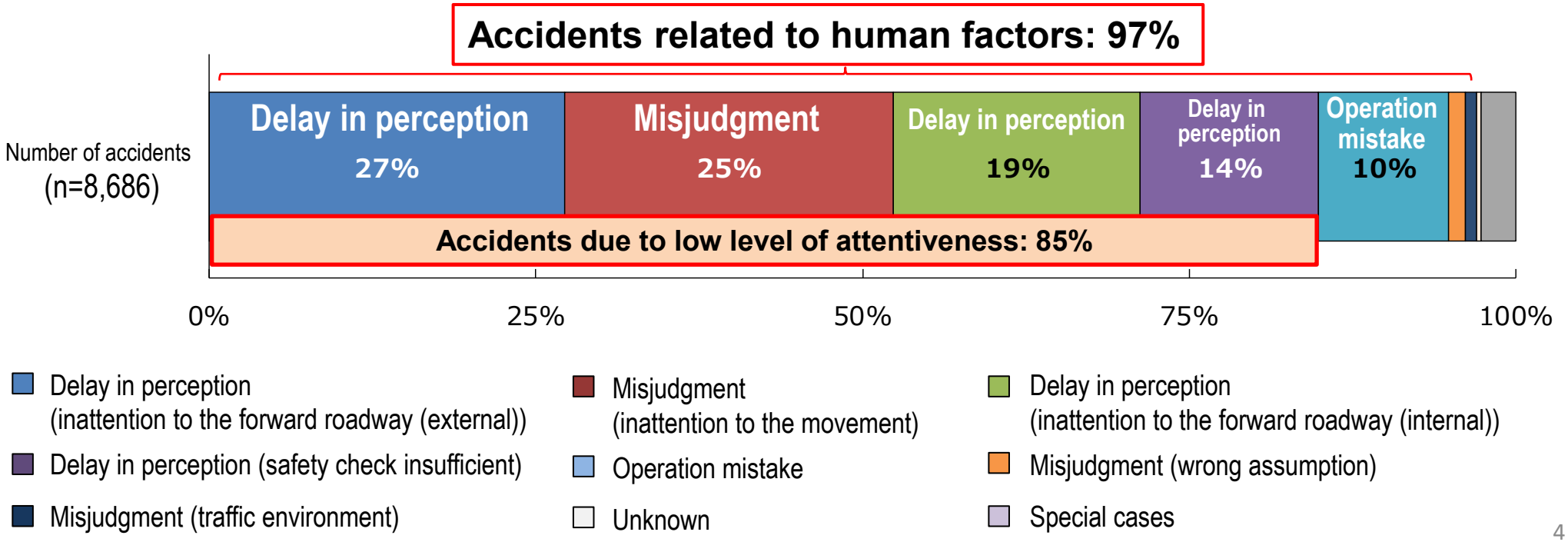
        What is 0.774G/0.6sec w/ AEB

BACKGROUND

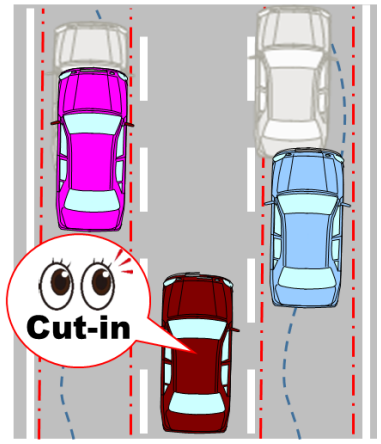
Accident Rate Caused by Human Factors of Driver (Highway)

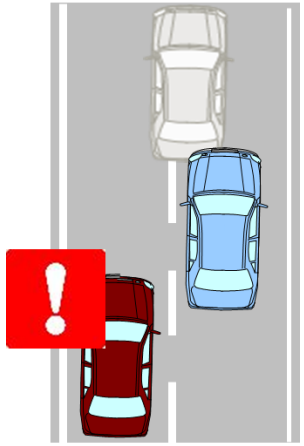
- 97% of the accidents were related to the human factors of driver. **(of which 60 % was due to delay in perception caused by caused by lack of attentiveness)**
- Most of the accidents can be prevented **if the driver's level of attentiveness is high.**

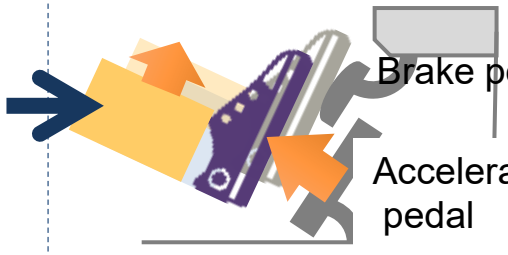
■ Data collection criteria:
Accidents occurred on highways in Japan in which the primary responsible party was a vehicle (automobile/motorcycle) (2017)

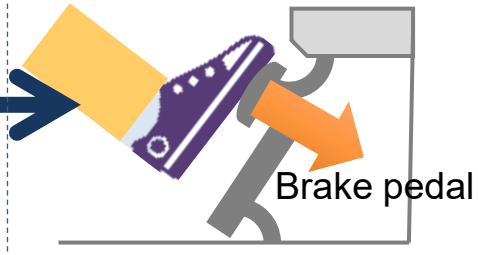


Driver Model Structure









Delay in releasing accelerator pedal

Delay in pressing brake pedal

Risk Perceive Situation

Human reaction delay

Risk Perceived delay

Braking delay

Deceleration degree and Max. G-force

Definition of a situation that is perceived as a risk that requires evasive action in response to the behavior of surrounding vehicles.

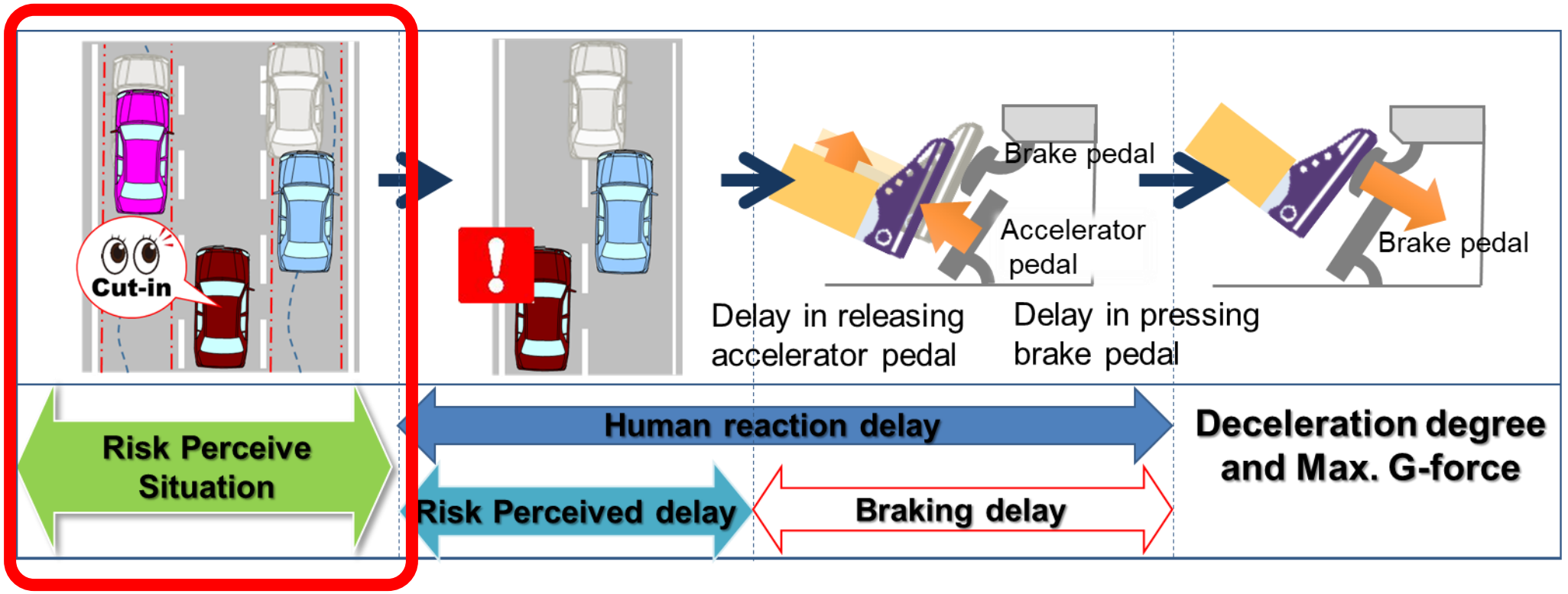
The time it takes to perceive the behavior of surrounding vehicles as dangerous

The time between recognizing the risk, determining avoidance action, and changing from the accelerator pedal to the brake pedal.

Definition of time and maximum G until deceleration rises to a given G
＋AEB assist

BASIS FOR EACH PARAMETER

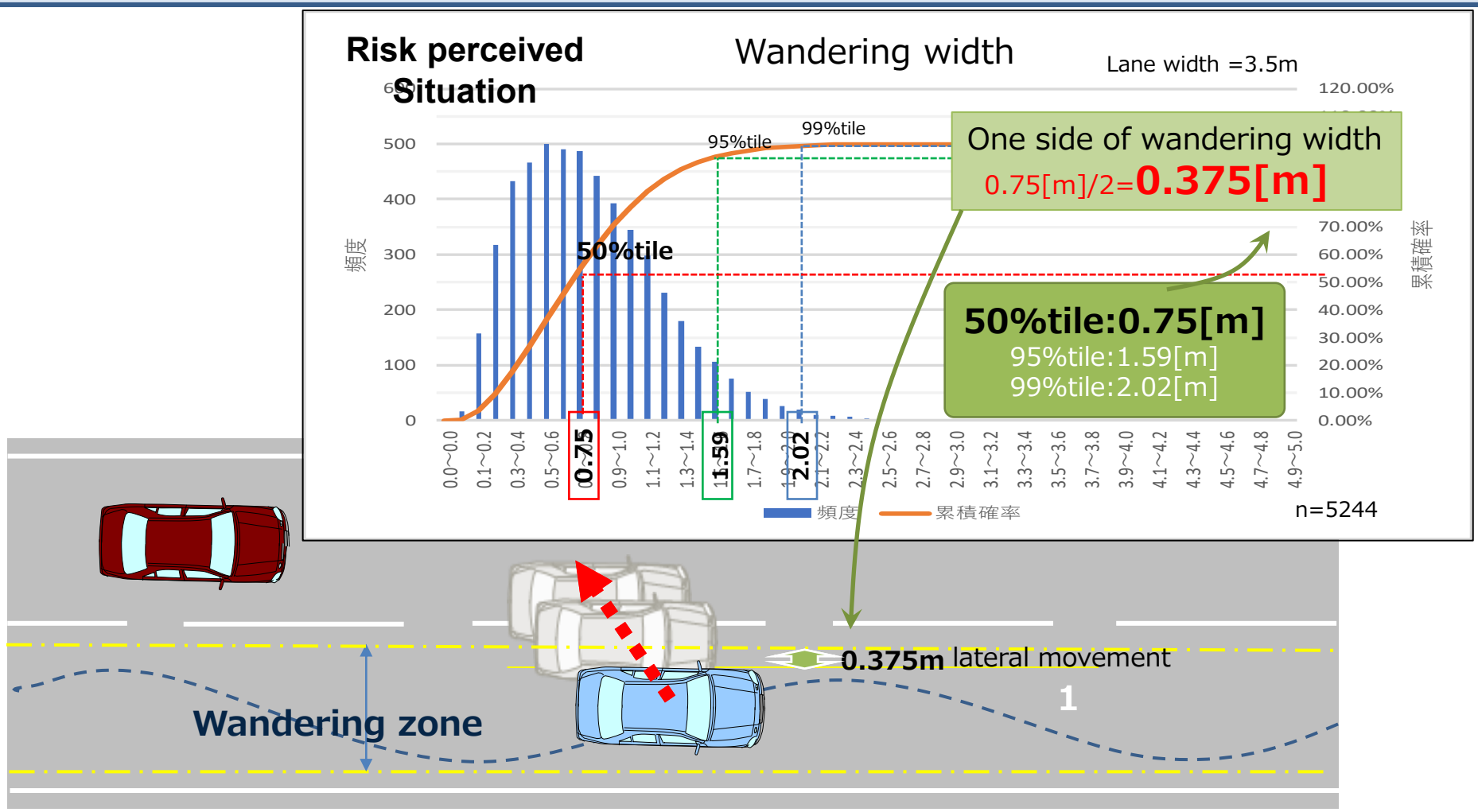
1. Risk perceive Situation



Risk Perceived Boundary by Lateral Movement

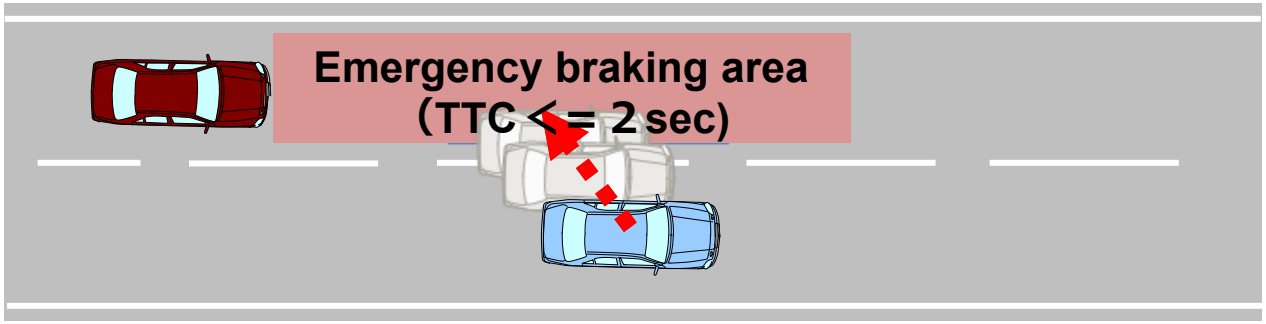
When the other vehicle is wandering within its own lane, it is unlikely that the ego-vehicle perceives the possibility of cut-in

Define the cut-in perceived boundary based on the lateral movement range of other vehicle wandering within its own lane



Risk Perceived Boundary by Longitudinal Distance

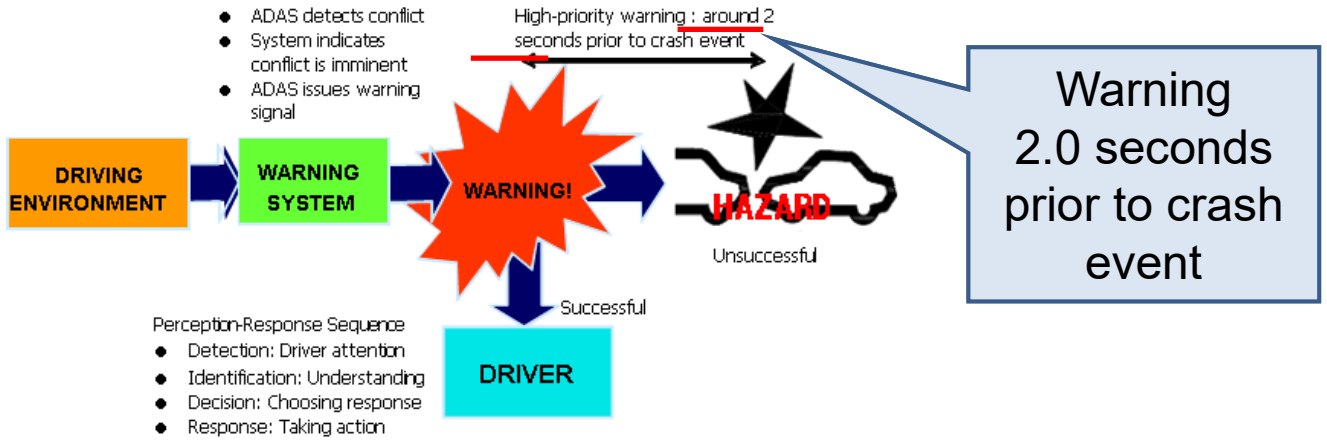
Based on the UNR guidelines on warning signals, define
Time To Collision (TTC) of 2.0 seconds as the boundary of emergency braking area



(a) Low-level: driver prepares action or decision within 10 seconds to 2 minutes; may escalate to a higher level if not acted upon;

(b) Mid-level: requires action or decision within around 2 to 10 seconds; may escalate to high-level warning if not acted upon;

(c) **High-level: warning** requires the driver to take immediate action or decision (0 to around **2 seconds**) to avoid a potential crash that could result in serious injuries or fatalities.



Warning
2.0 seconds
prior to crash
event


United Nations
Economic and Social Council
ECE/TRANS/WP.29/1091/Add.1
Distr.: General
26 July 2011
English
Original: English, French and Russian

Economic Commission for Europe
Inland Transport Committee
World Forum for Harmonization of Vehicle Regulations
154th session
Geneva, 21–24 June 2011

Reports of the

World Forum for Harmonization of Vehicle Regulations on its 154th session

Administrative Committee of the 1958 Agreement on its forty-eighth session

Executive Committee of the 1998 Agreement on its thirty-second session

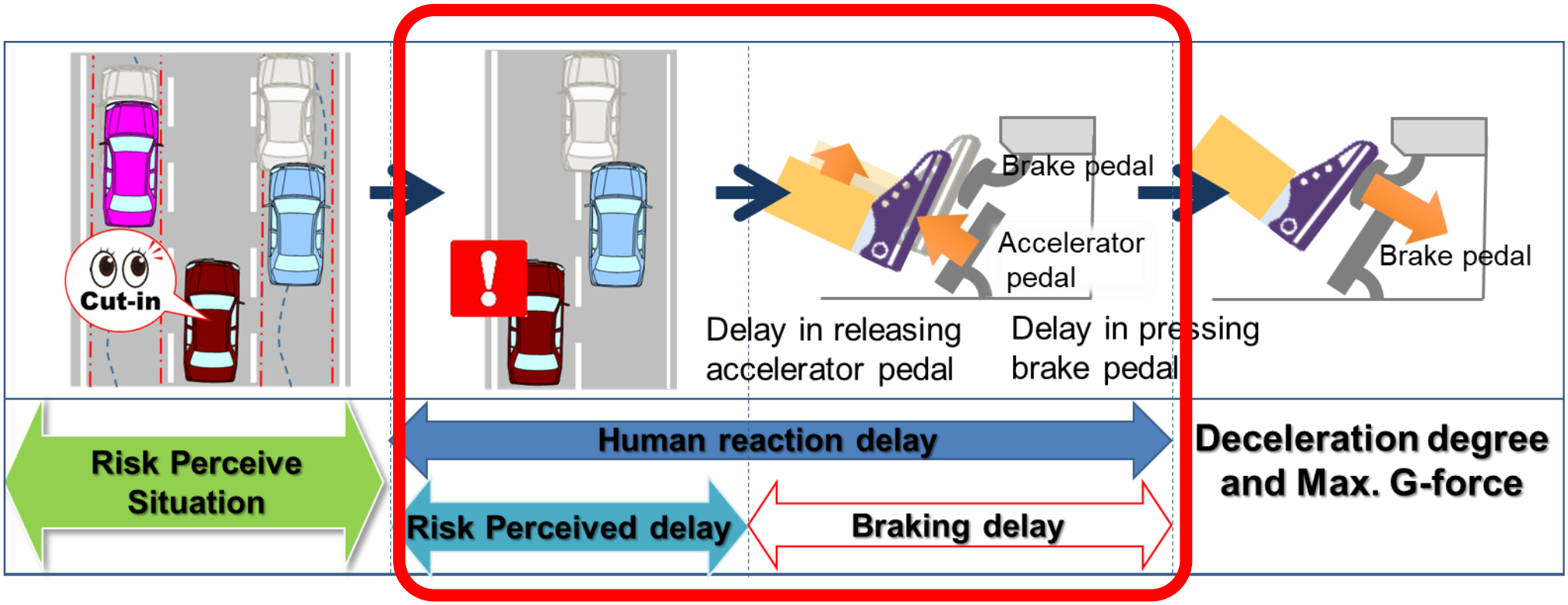
Administrative Committee of the 1997 Agreement on its eighth session

Addendum

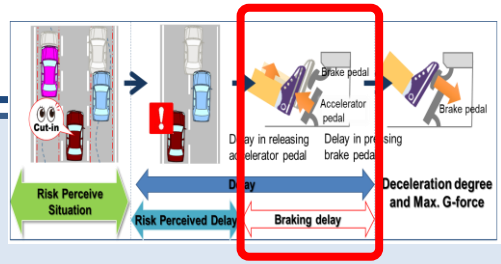
At its 154th session, the World Forum for Harmonization of Vehicle Regulations (WP.29) adopted guideline on establishing requirements for high-priority warning signals (ECE/TRANS/WP.29/2011/90). The guidelines were transmitted by the Informal Group on ITS. The guidelines contain Statement of Principles on the Design of High-Priority Warning Signals for Advanced Driver Assistance Systems (ADAS). The World Forum requested the secretariat to circulate the adopted version of the guidelines as an addendum to the report (ECE/TRANS/WP.29/1091, para.20).

「ECE/TRANS/WP.29/1091/Add.1
Annex III Guidelines on establishing requirements for high-priority warning signals」

2. Human reaction Delay

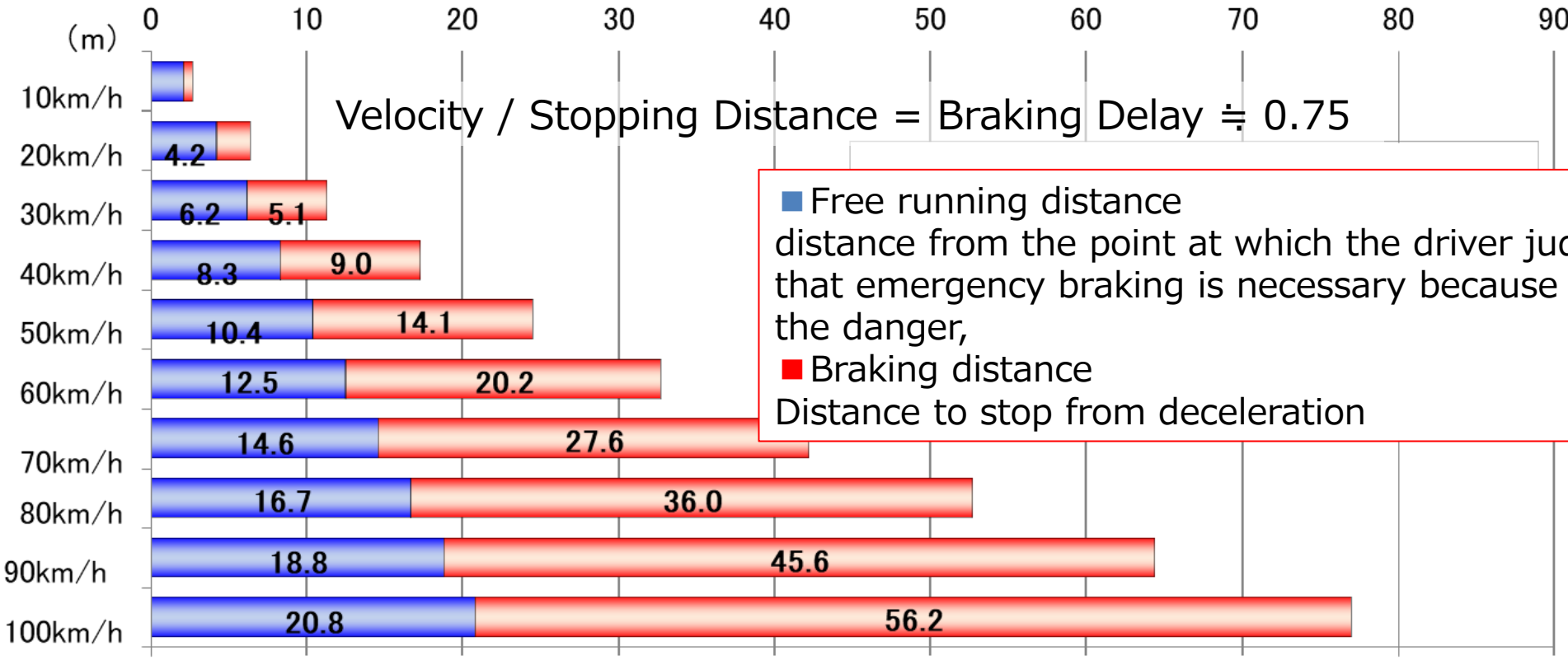


Braking Delay



Braking delay 0.75sec is the value commonly used to calculate the stopping distance among the police and the courts in Japan.

Stopping Distance against velocity



Velocity / Stopping Distance = Braking Delay ≒ 0.75

■Free running distance
distance from the point at which the driver judges that emergency braking is necessary because of the danger,
■Braking distance
Distance to stop from deceleration

Reference: https://www.pref.niigata.lg.jp/uploaded/attachment/226116.pdf

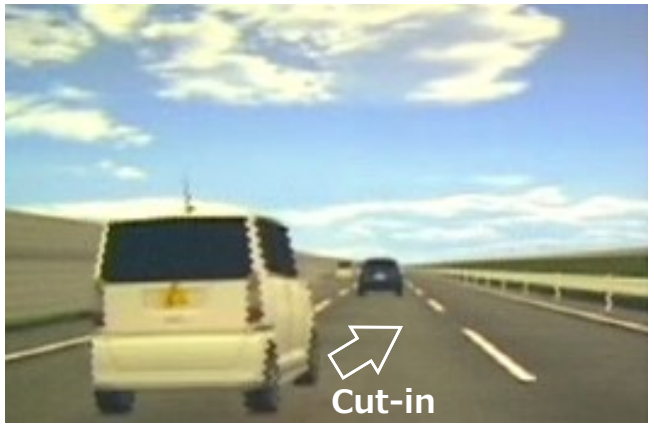
※This value has been in use since about 1967.

Analysis of Risk Perception Time by DS Test

Analyze DS test data of driver reaction time against cut-in by other vehicle

■ Measure risk perception time (time to react and avoid) of drivers against cut-in by other vehicle with 11 test participants

DS test summary



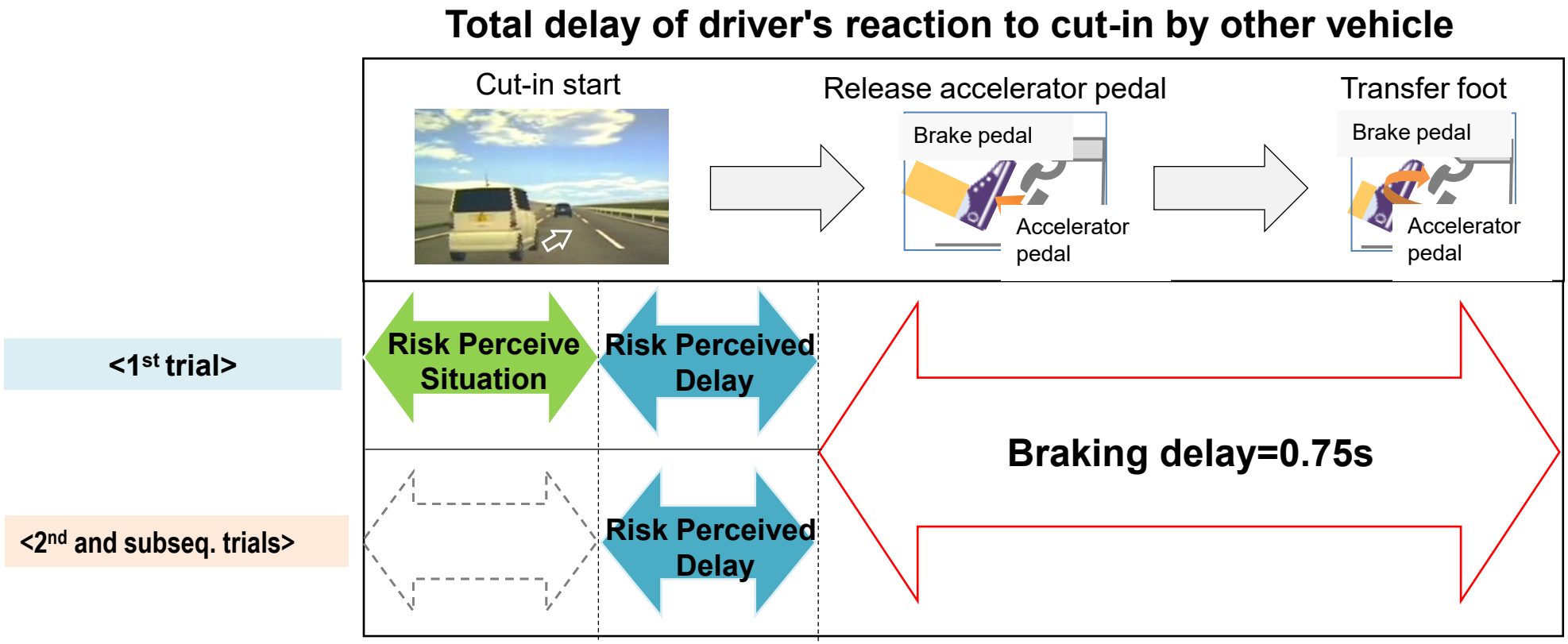
Parameter	Value
Lane width	3.5 m
Ego-vehicle target velocity V_e	100 km/h
Platoon velocity traveling in parallel forward V_o	70 km/h
Max. lateral velocity of cut-in vehicle V_{oL}	1.8 m/s
TTC at cut-in start	3.0 s

Test group details

No. of participants	Description	Composition of participants
11	Having 5 years or more driving experience on regular basis, drives on highway at least once a month	- 6 Males, 5 Females - Avg. age: 38.7

Risk Perception Time Against Cut-in by Other Vehicle

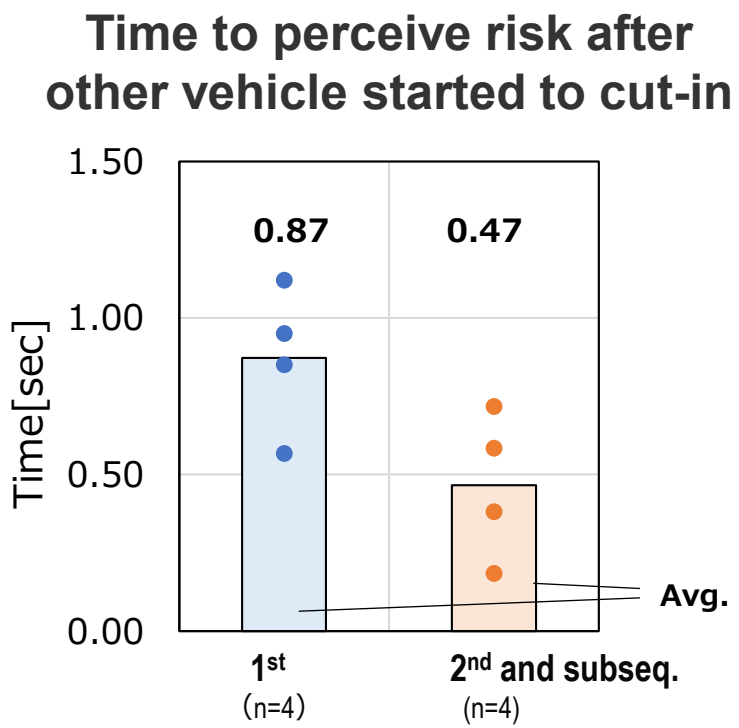
Average time of risk perception was 0.8 sec in the first trial, and 0.4 sec in the second and subsequent trials



Risk Perception Time Against Cut-in by Other Vehicle

Average time of risk perception was 0.8 sec in the first trial, and 0.4 sec in the second and subsequent trials

Trial			Accelerator release time (1)	Foot transfer time (2)	Time from risk perception to maneuver initiation	Subtract 0.75 sec
1st	1-1	1	1.40	0.47	0.75	1.12
	1-2	1	1.18	0.42		0.85
	1-3	1	1.12	0.20		0.57
	1-4	1	1.53	0.17		0.95
2nd and subseq.	2-1	2	1.15	0.32	0.75	0.72
	2-2	2	1.13	0.20		0.58
	2-3	2	0.77	0.17		0.18
	2-4	2	0.90	0.23		0.38
1st		Avg.	1.27	0.29		0.87
2nd and subseq.		Avg.	0.96	0.26		0.47
		Ratio	0.75	0.92		0.53



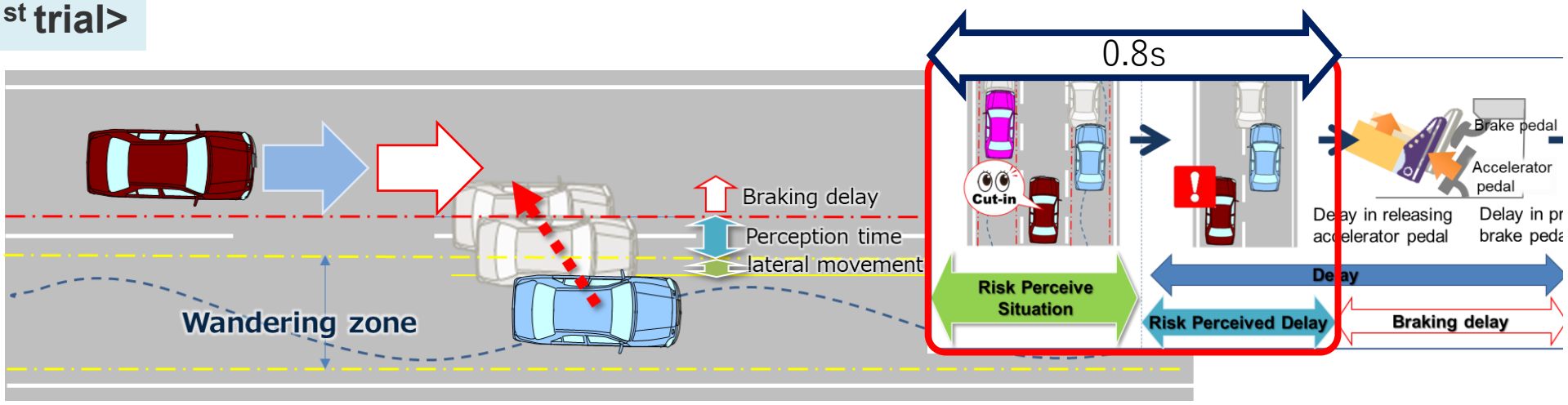
- 1st trial: Approx. 0.9 sec.
- 2nd and subseq. trials: Approx. 0.5 sec.

※The collected data are results of same TTC and brake avoidance with the same cut-in timing.

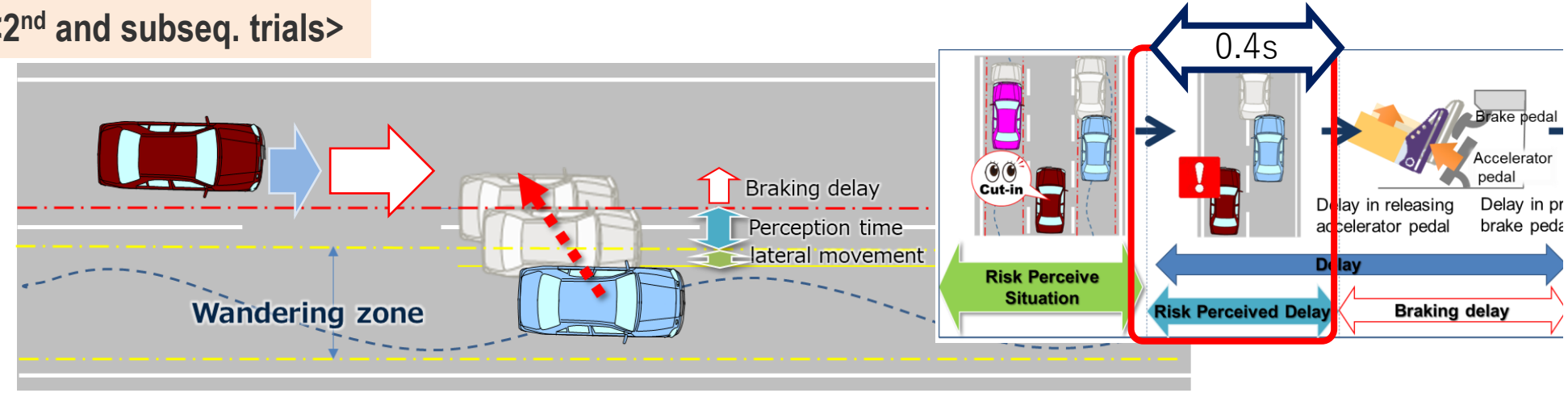
Driver Reaction Time Against Cut-in

In 2nd trial driver has learned the protocol in 1st trial and will expect the cut in just after starting the lateral movement of the vehicle in adjacent lane.

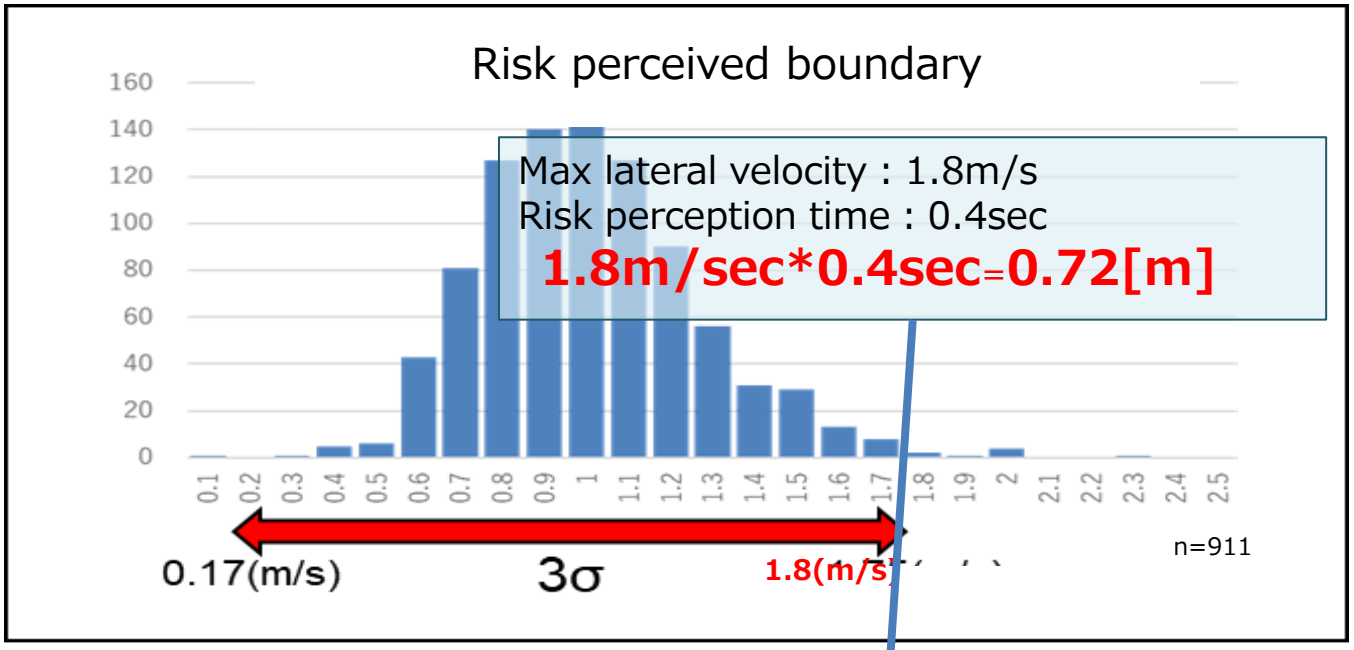
<1st trial>



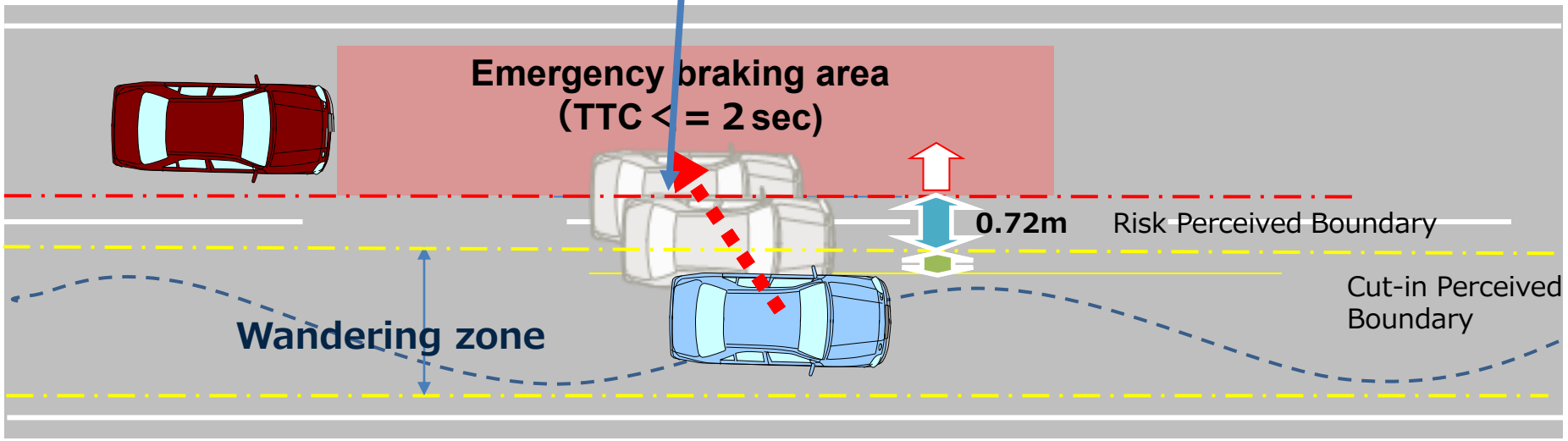
<2nd and subseq. trials>



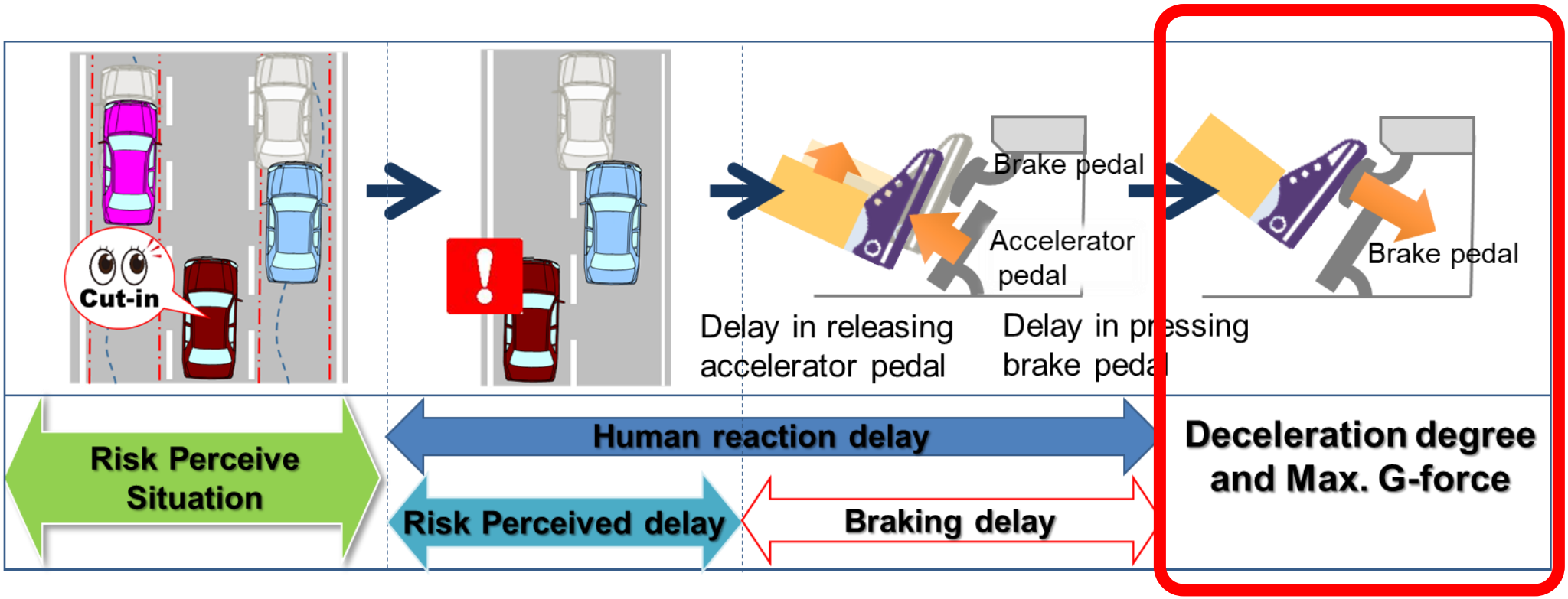
Risk Perceived Boundary



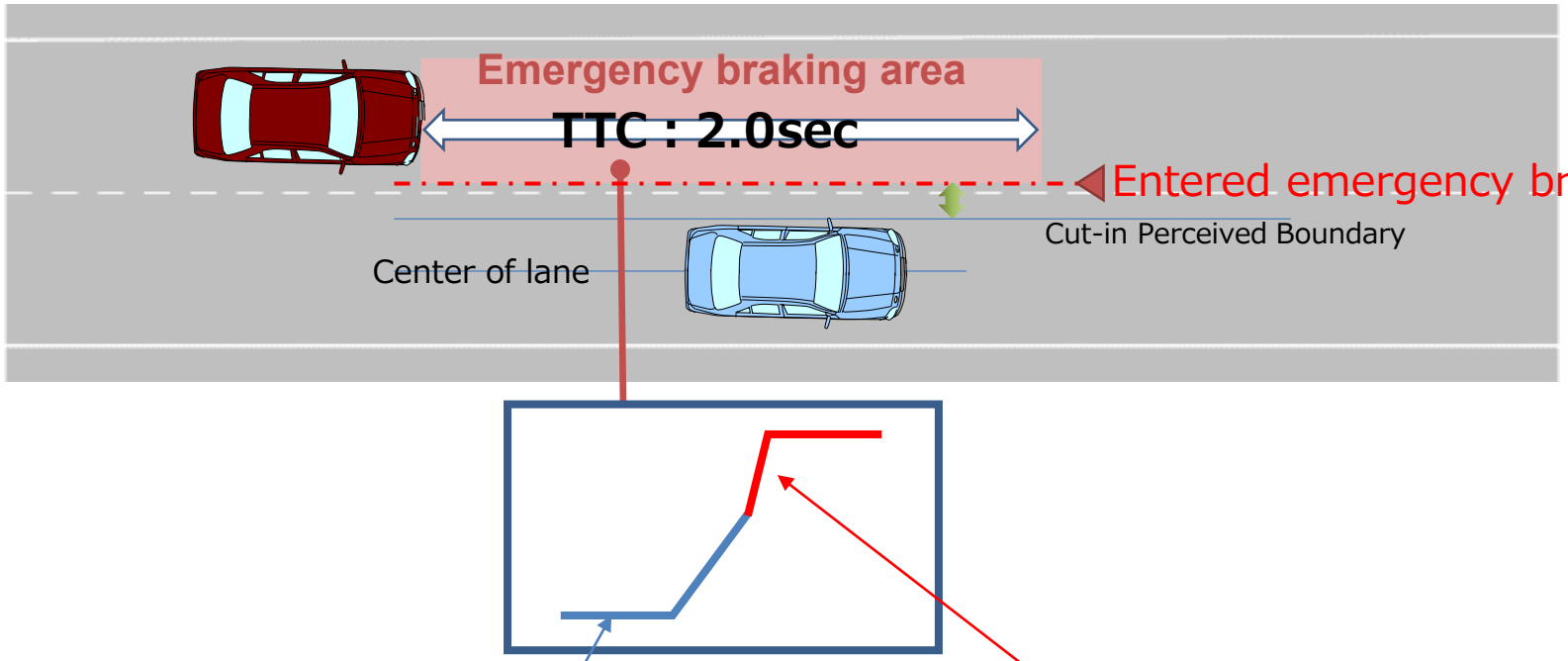
When the lateral velocity is slower then the risk perception time become longer.
So the quicker risk perception time, which is more demanding to AD, is adapted as assumption.



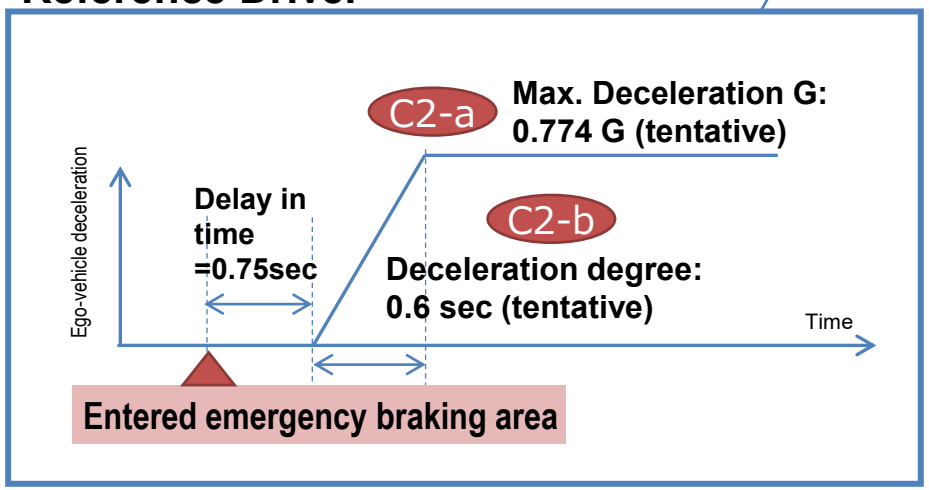
3. Deceleration degree and Max. G-force



Deceleration Degree and Max. G-force



Reference Driver



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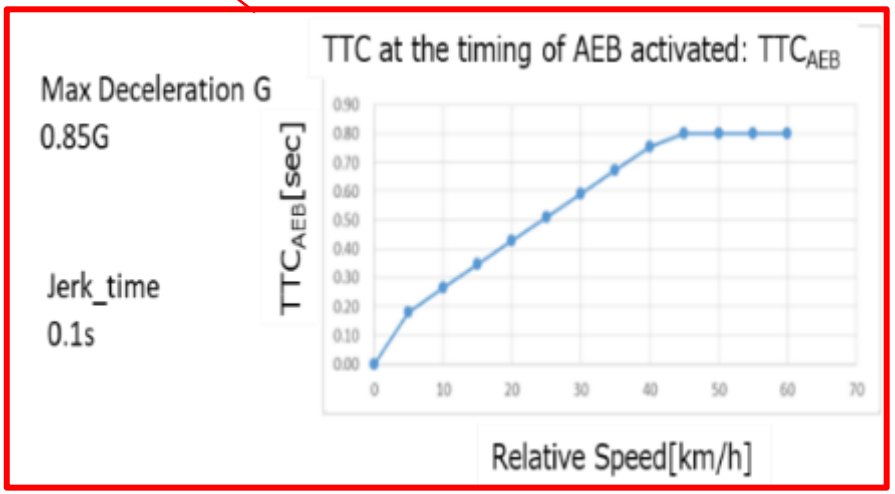
AEB



Max. deceleration G-force

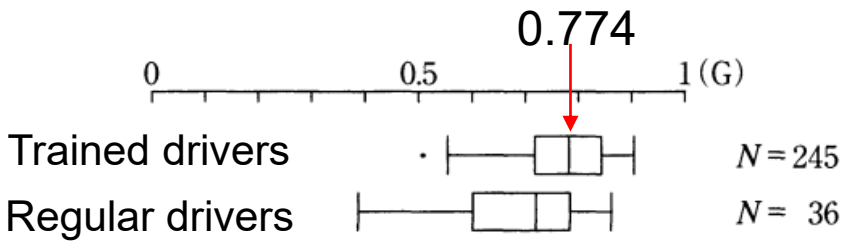
Trained drivers' **Max. deceleration G-force: 0.774G**

=> Define the driver model with **skilled drivers who have driving skills superior** to regular drivers

【JP】

A study example of emergency braking characteristics of driving trainees in Japan
- Regular drivers : 0.689 G
- Trained drivers* : 0.774 G

*Trained drivers: Trainees of Japan Safe Driving Center (JSDC) Central Training Academy for Safe Driving



(Makisita et al., 2001)

*Dry road surface

【US】

Near-Crash median (0.74 G)
Incident median (0.5 G)

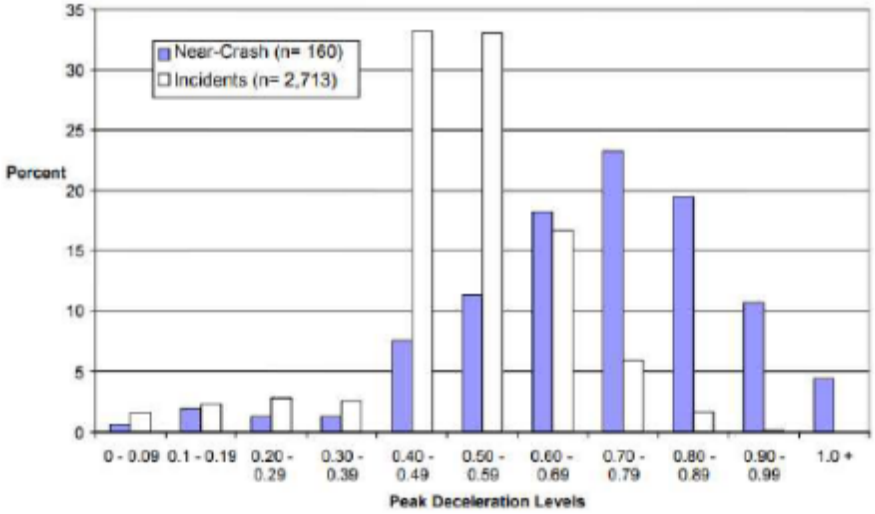


Figure 4. Peak deceleration categories, conflicts with a decelerating lead vehicle (near-crashes & incidents). (NHTSA, 2007)

・183 Trained drivers, (JP, 21～65years old)

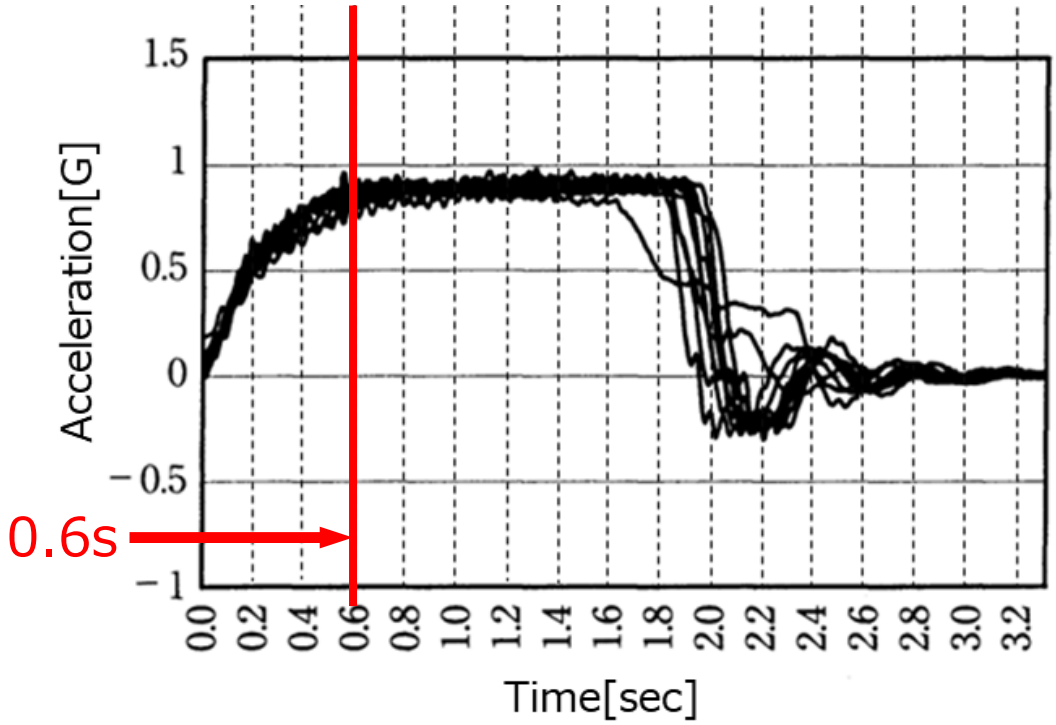
・100-car naturalistic driving study
・Age group: 18-20(15%), 21-24(20%), 25-34(17%), 35-44(18%), 45-54(18%), 55+(12%)

C2-b Achieving Time to max G

Trained drivers' **time to reach Max. deceleration: 0.6 second**

■ Acceleration waveforms of trained drivers

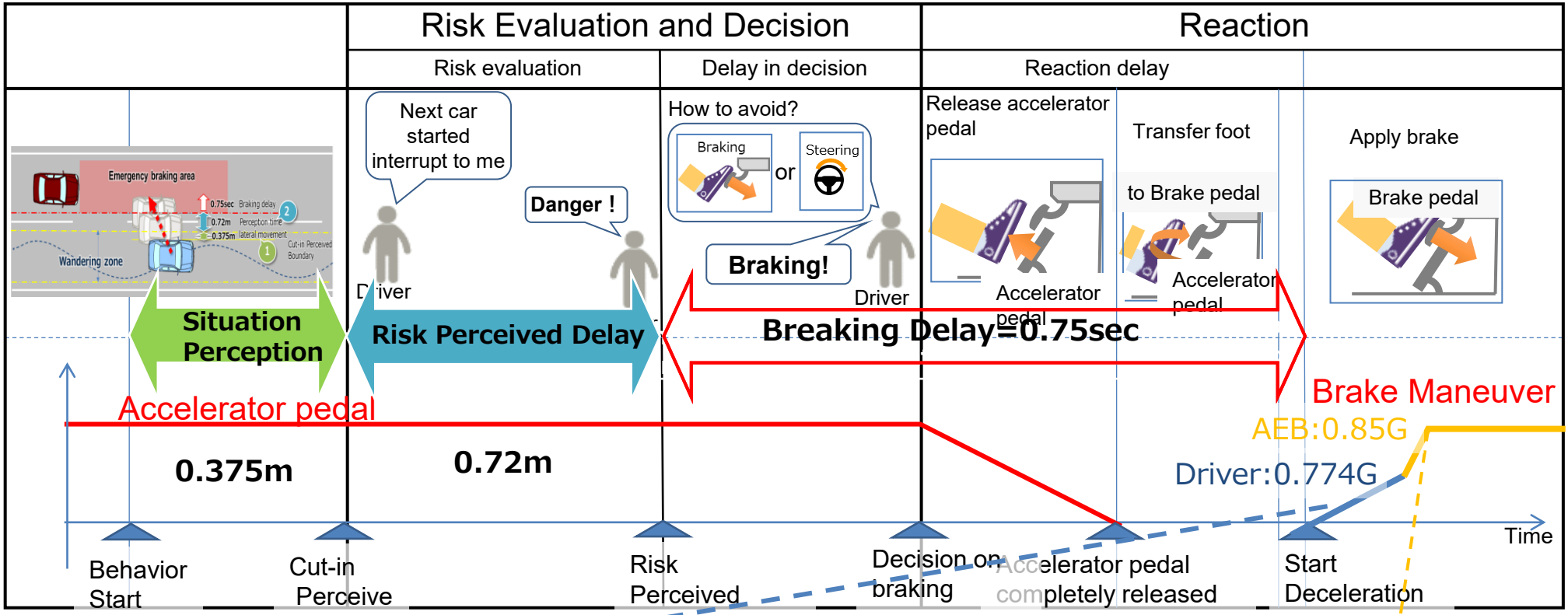
・**183 Trained drivers, (JP, 21～65years old)**

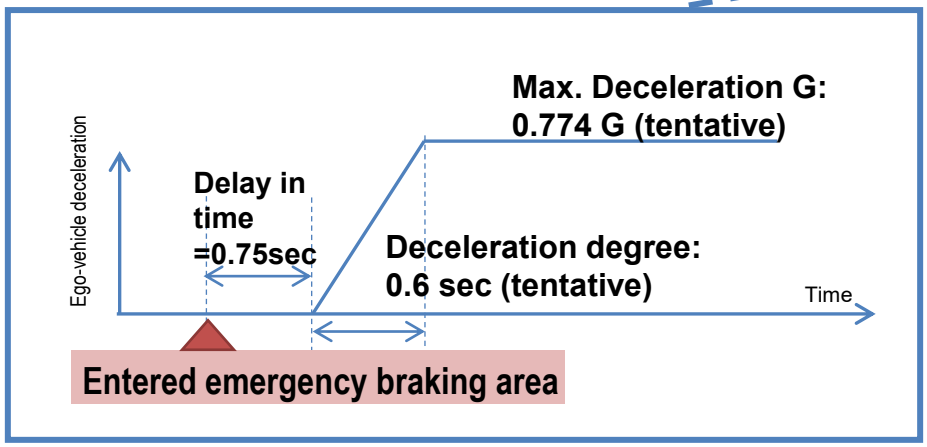


Achieved steady deceleration state of 0.9 G within 0.6 second (Based on the graph)

(Makisita et al. , 2001)

Competent and Careful human driver performance model





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