



Transmitted by Expert from Japan

GRRF Informal Group on Automatic Emergency
Braking and Lane Departure Warning Systems

25-26 June 2009

Items 6.3 to 6.5 of the agenda

Automatic Emergency Braking Systems (AEBS)

Explanation of the draft



AGENDA



1. Scope

- Vehicle Category -
- Detection of the Obstacles -
- Definition of AEBS -

2. Specification

- Speed Range -
- Timing of Braking Control -
- Requirement of Braking Deceleration -
- Enhancement of Damage Reducing Effect -
- Emergency Event Preparation and Collision Warning -
- Prevention of Excessive Dependence to System -
- Off Switch -
- Other Principal Requirements -

3. Test procedures

- Test Procedures for Stationary Obstacle -
- Criteria for Stationary Obstacle -
- Verification Test of deactivation of Braking Control to Obstacle Outside the Test Lane -
- Curved Road -
- Functioning Test of the Malfunction Warning Device of AEBS -





1. Scope - Vehicle Category -

This regulation applies to type approval of the vehicles of categories [M2,M3,N2,N3] * with regard to the Automatic Emergency Braking Systems defined in paragraph 2.3.

*: This vehicle of categories shows the proposal of EC. This issue will be discussed in future in the informal meeting and GRRF .

At the time of application of this Regulation, Contracting Parties shall declare that they intend to mandate the installation of AEBS specified in this regulation in their territory for which category of vehicles.

Japan plans to mandate the AEBS installation for the vehicles of categories 1. and 2. as mentioned below.

1. Vehicles used for the carriage of goods (excluding tractors and trailers) and having a gross vehicle mass exceeding 20 tons.
2. Tractors used for the carriage of goods having a gross vehicle mass exceeding 13 tons.

For solving this issue, Japan has the idea that the mandated category in this ECE Regulation can be selected by the Contracting Party according to their demand from the traffic accident point of view.

Draft : Para. 1





1. Scope - Detection of Obstacles -



Concerning the detecting obstacles, the detection of a stationary vehicle is also mandated in addition to the moving vehicle detection in this draft.

But at the last brainstorming meeting in December 2008, there was the comment that the requirement of detection obstacles should be limited to the moving vehicle.



Therefore, there is an idea of scope in the ECE draft as following.

- A) The detection of moving vehicle shall be mandated**
- B) The detection of stationary vehicle shall be optional, but Contracting Party can mandate a stationary vehicle in its territory.**

These issues mentioned above will be discussed in future in the informal meeting and GRRF .





1. Scope - Definition of AEBS -



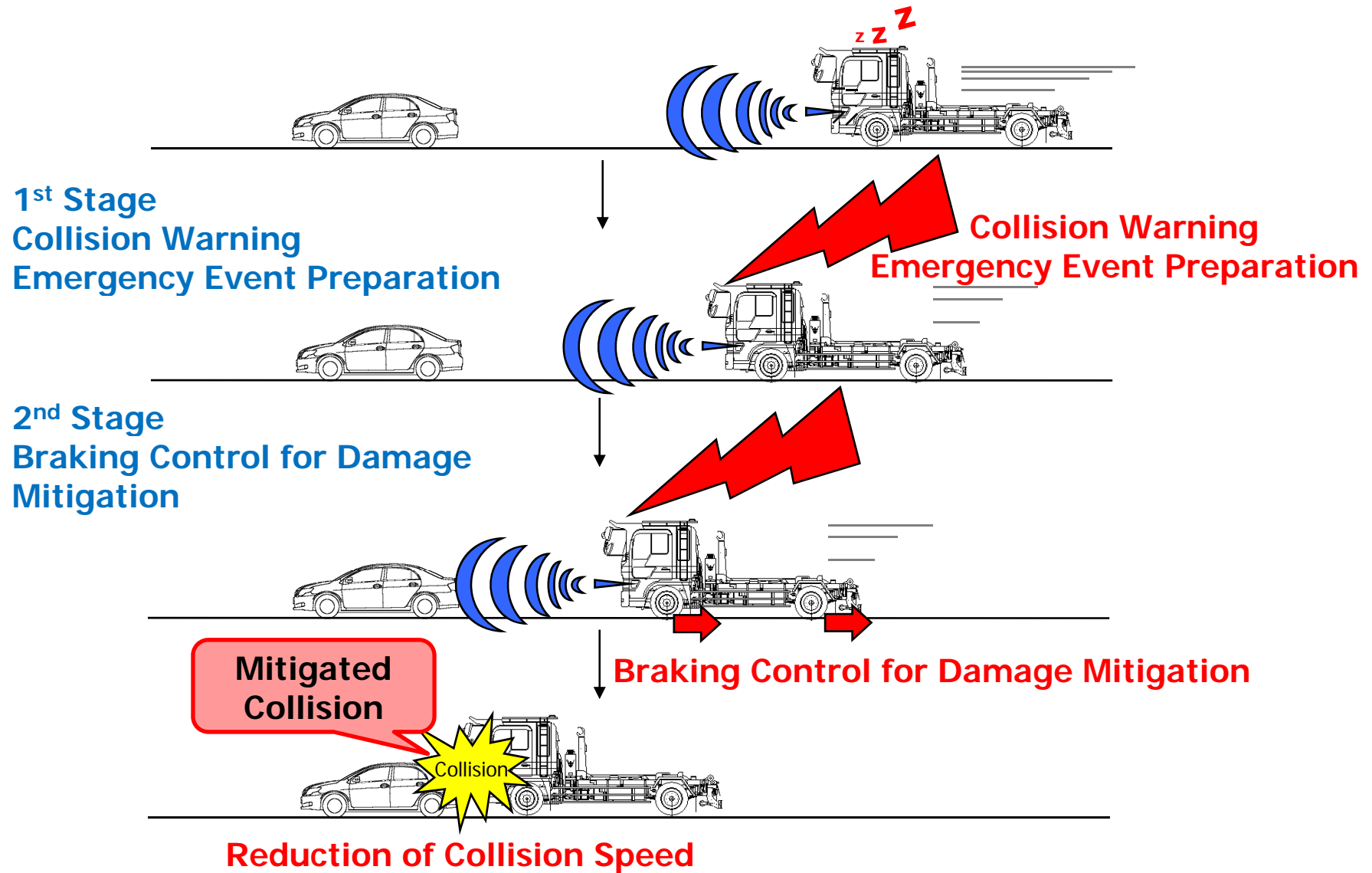
Definition of Automatic Emergency Braking Systems

"Automatic Emergency Braking Systems (hereafter AEBS)"

- A) AEBS has functions of the **collision warning** and the **emergency event preparation** to the driver in case of occurrence of a danger of collision with a forward obstacle.
- B) AEBS has a function of the **braking control for mitigating** the damage of vehicle collision with a forward obstacle in case of that collision is judged imminent or unavoidable.



1. Scope - Definition of AEBS -





2. Specification - Speed Range -



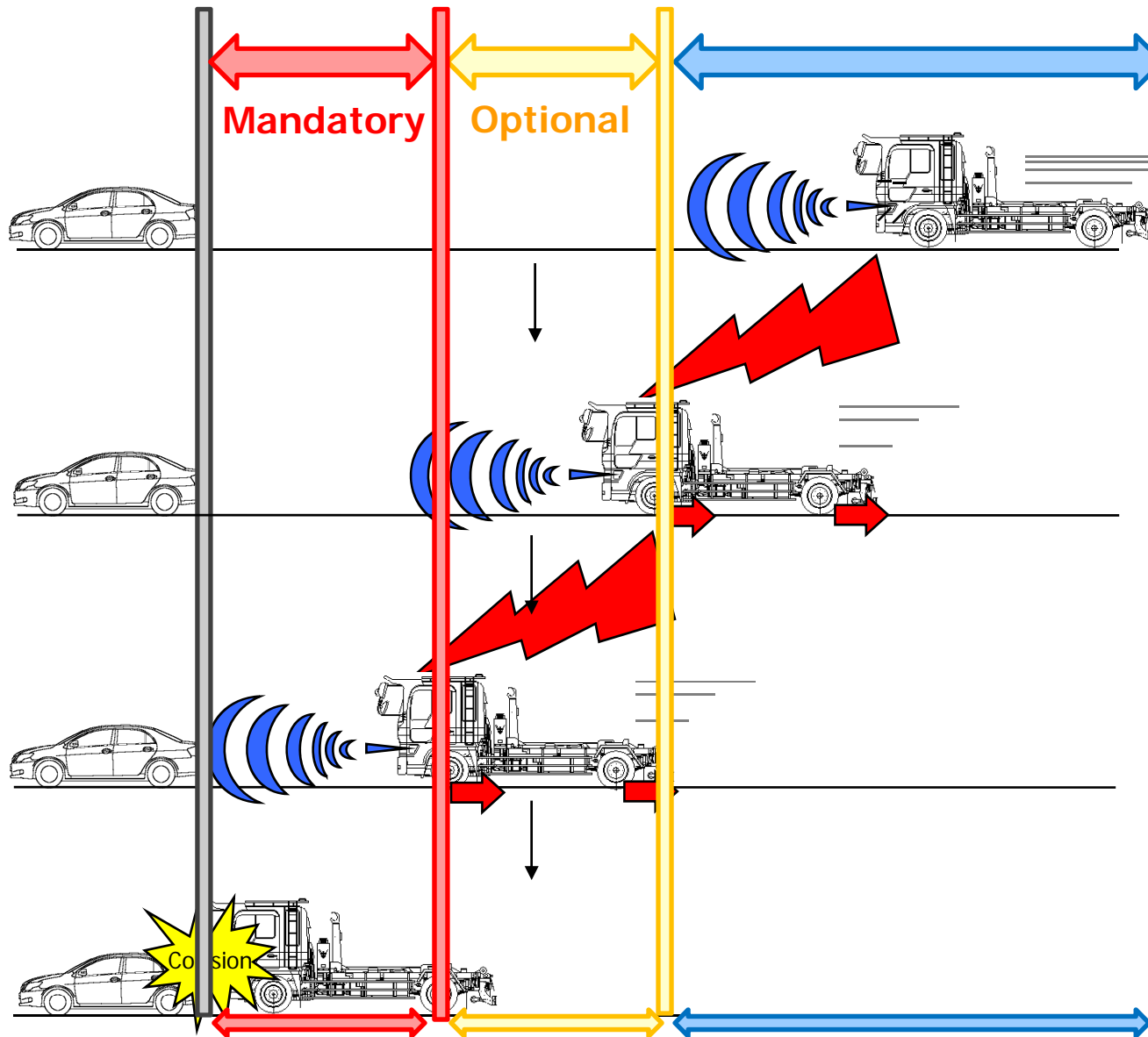
Speed Range

The system need not to start the braking control in the following speed ranges.

- (a) The vehicle speed is exceeding a maximum speed.
- (b) The absolute speed of the vehicle is equal to or less than 15 km/h.
- (c) The relative speed of the vehicle is equal to or less than 15 km/h.
- (d) In case of vehicle malfunctions.



2. Specification - Timing of Braking Control -



The most of driver operates the braking or the steering in the normal driving.

The most of driver has already operated the braking or the steering in the emergency situation.

A driver can't avoid the collision, even if a driver operates the braking or the steering with the maximum vehicle dynamic performance.

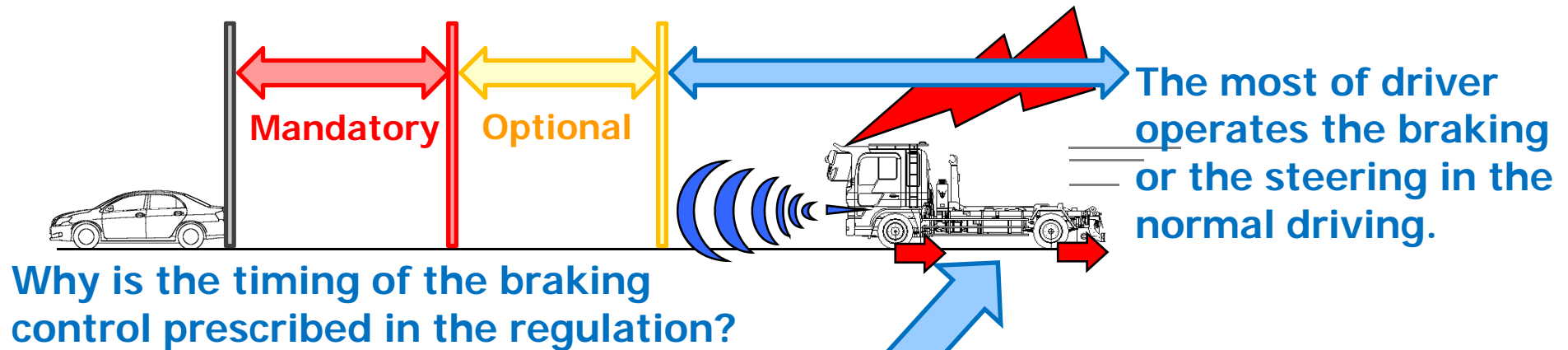
The braking control shall be activated.

The braking control may be used.

The braking control shall not be activated.



2. Specification - Timing of Braking Control -



Why is the timing of the braking control prescribed in the regulation?

DRIVER ACCEPTANCE

If AEBS activates in the normal driving condition, a driver has nuisance feeling.

- A driver may use off-control.
- A driver may have distrust to AEBS.

And then, AEBS might not activate efficiently in the emergency situation.

Draft :
Para. 5.4

Consideration of driver acceptance is important for the effect of AEBS. Therefore, the timing of the braking control is prescribed in this draft.





2. Specification - Timing of Braking Control - Operational Range Based on Physical Avoidance Limit

Operational range based on physical avoidance limit

The timing of the braking control is called **collision judgment line** in this draft.

Collision judgment means a state of a judgment that a collision cannot be avoided physically by operating either the braking or the steering.

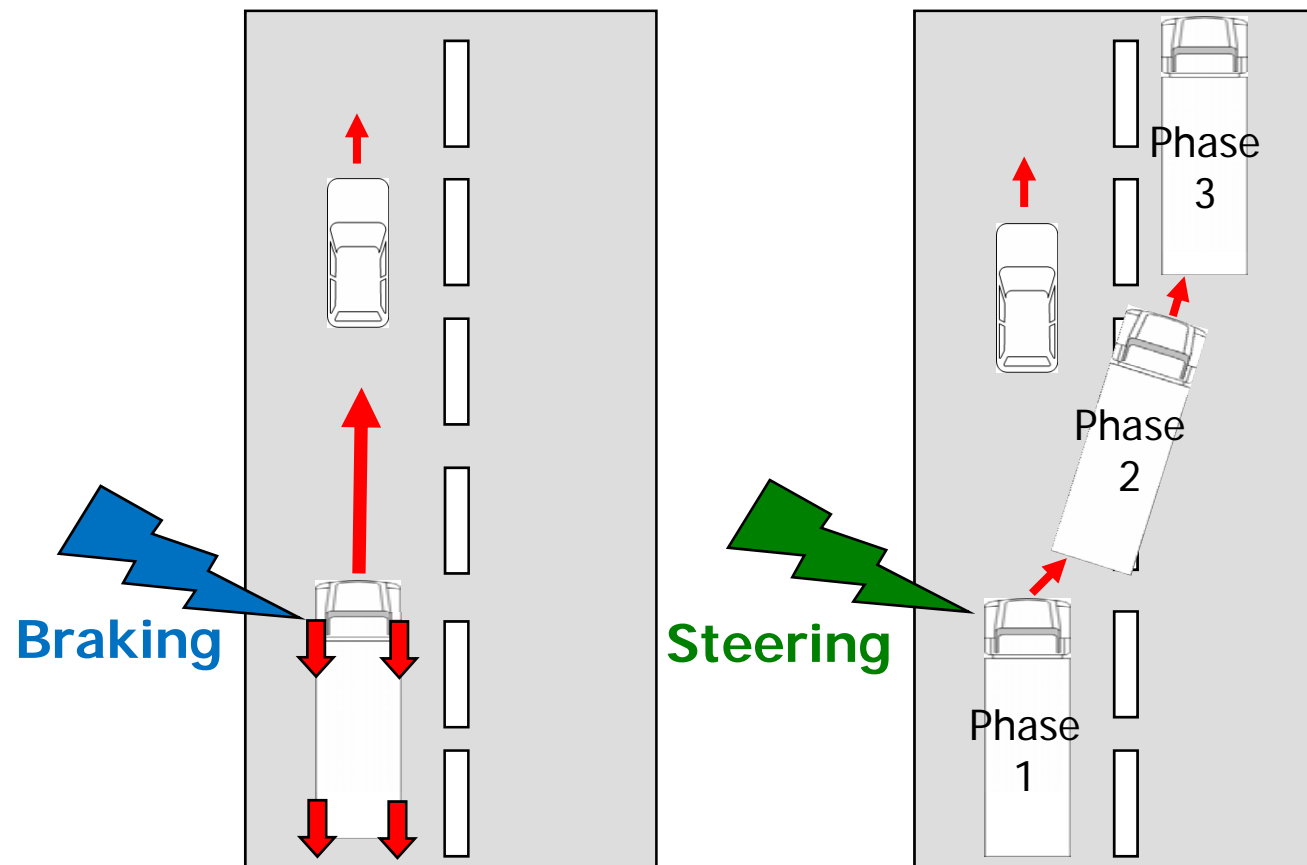
The braking control shall be activated. Draft : Para. 2.10, 5.4.1



2. Specification - Timing of Braking Control -



Driver operates either the braking or the steering for the purpose of avoiding the collision.

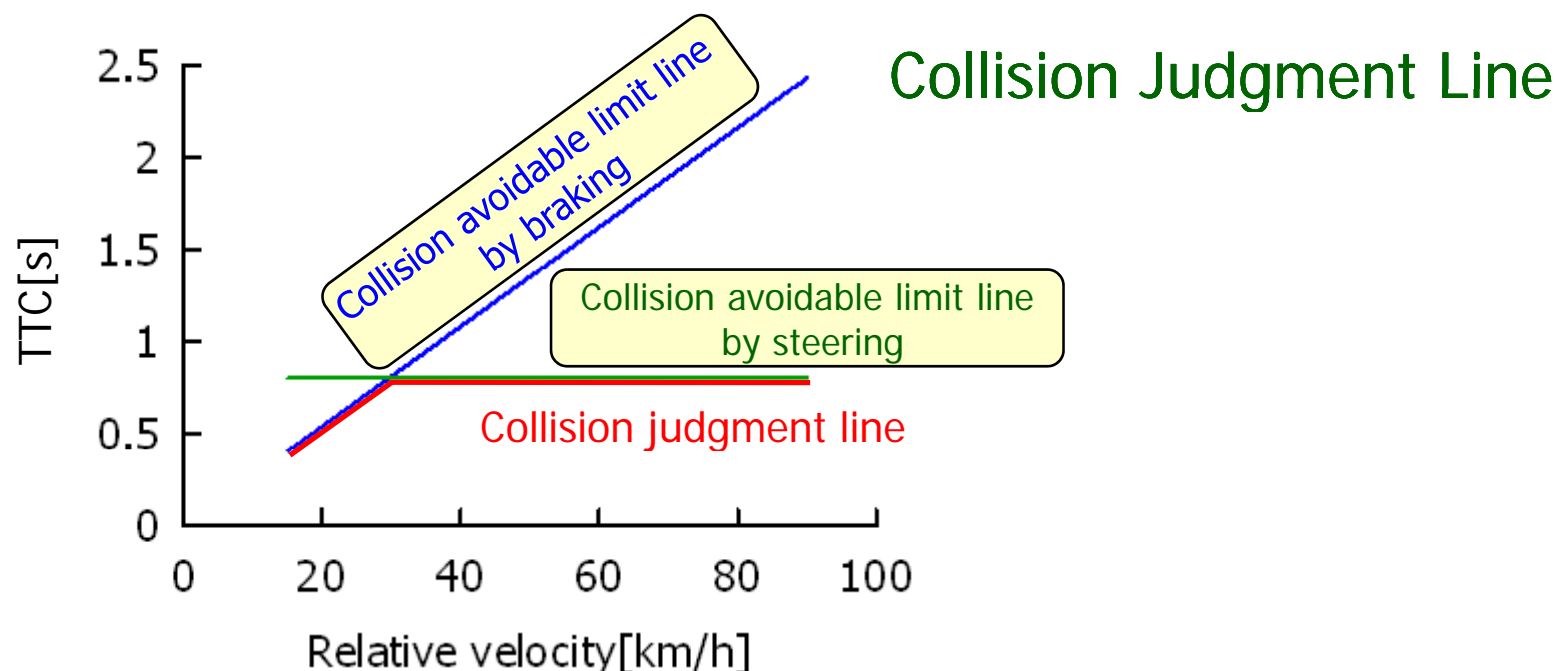


The timing of braking control is prescribed in this draft based on considering the operation of both the braking and the steering.





2. Specification – Timing of Braking Control -



Collision avoidable limit line by braking

Collision avoidable limit line by braking is TTC which is calculated by minimum stopping distance with the braking test.

Collision avoidable limit line by steering

Collision avoidable limit line by steering is TTC which is calculated by minimum lateral displacement with the steering test.

Braking: Braking performance of each vehicle is different.
Therefore, this line is changed by each vehicle.
Steering: TTC = 0.8 (s) fixed value is used for all large trucks.



2. Specification - Requirement of Braking Deceleration -



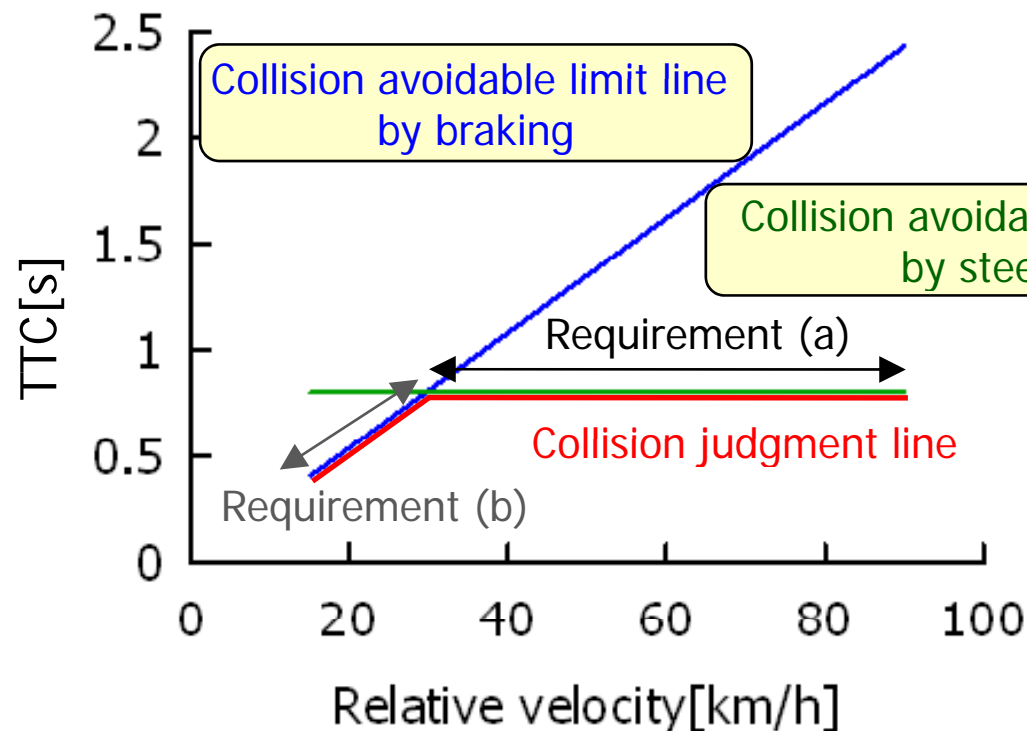
From collision judgment line :

(a) If the collision avoidable limit by steering is lower than the collision avoidable limit by braking.

Braking control shall be activated with average deceleration of 3.3 m/s² or more.

(b) If the collision avoidable limit by braking is lower than the collision avoidable limit by steering.

Braking control shall be activated. (The value of deceleration isn't prescribed in this draft, because of short time for braking control.)



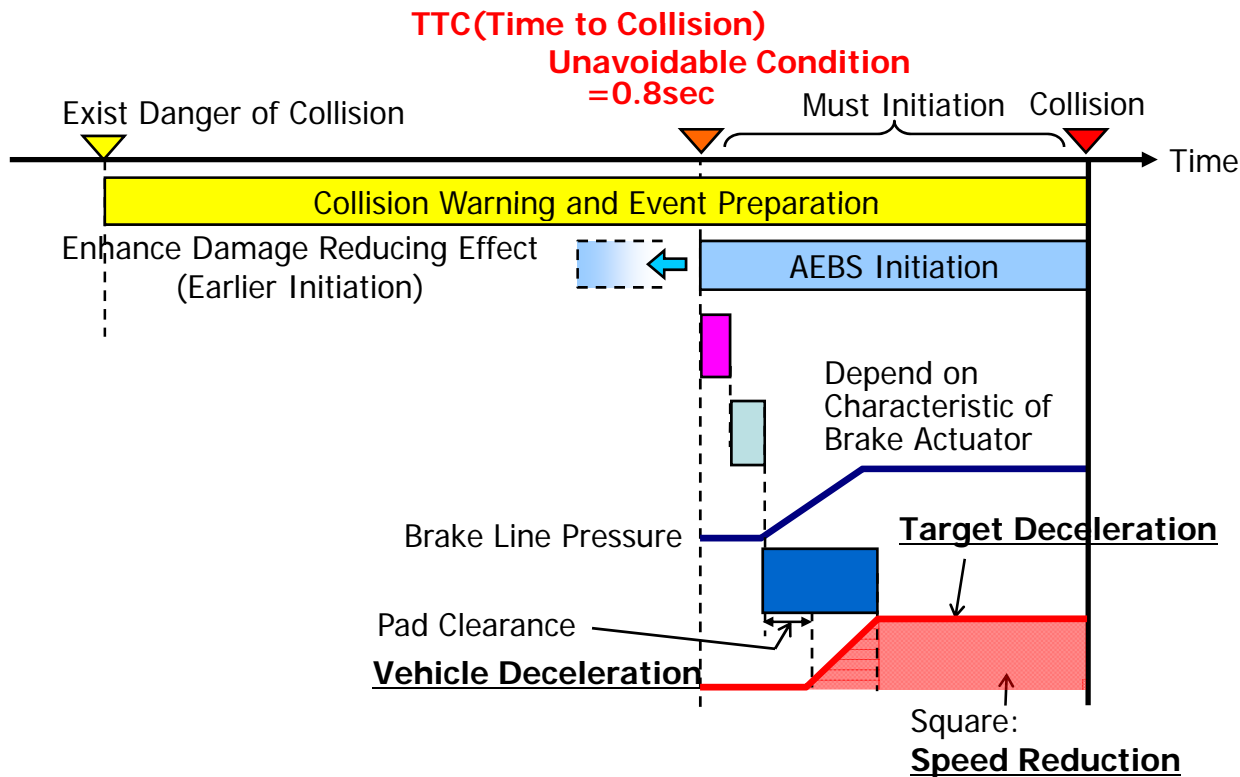


2. Specification - Requirement of Braking Deceleration -



AEBS has the time delay shown in the figure below. This time delay was considered in this draft.

Consideration of Delays



If a braking control based on the collision judgment line (**TTC=0.8s**), the start timing of braking control from the collision judgment line may be delayed **0.3s**.

$$TTC: 0.5s = 0.8s - 0.3s$$

When the relative speed is 60km/h or less (Refer page 19)

From Collision judgment line : **Braking shall be operated with average deceleration of 3.3 m/s² and 0.5s or more.**



+



+



= **0.3 seconds (Total delay time)**

Computing Time For Collision Forecast

Actuator Response Time

Response time to target deceleration

Draft : Para. 5.5.1





2. Specification - Enhance Damage Reducing Effect -



Operational Range Based on Driver's Normal Maneuvers Limit

Operational range based on driver's normal maneuvers limit

The timing of the braking control is called **collision risk judgment line** in this draft.

Collision risk judgment means a state that has a risk of a collision. The most of driver has already operated the braking or the steering in the emergency situation.

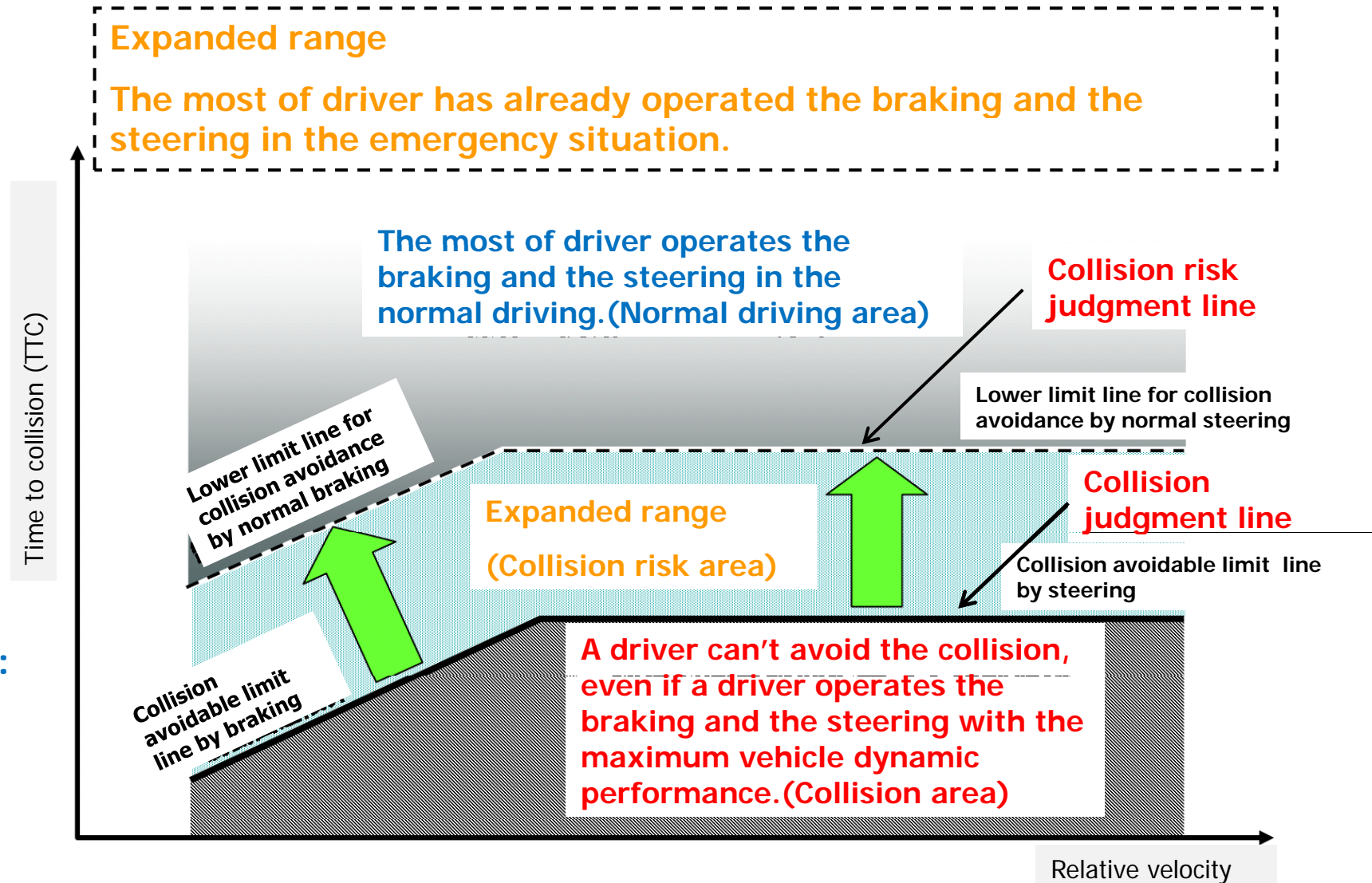
The braking control may be used by manufacture. Draft : Para. 2.14, 5.4.2



2. Specification - Enhance Damage Reducing Effect -



Operational Range Based on Driver's Normal Maneuvers Limit



Draft :
 Para.
 2.12,
 2.13,
 2.14 ,
 2.15

Braking control may start functioning in the collision risk area.

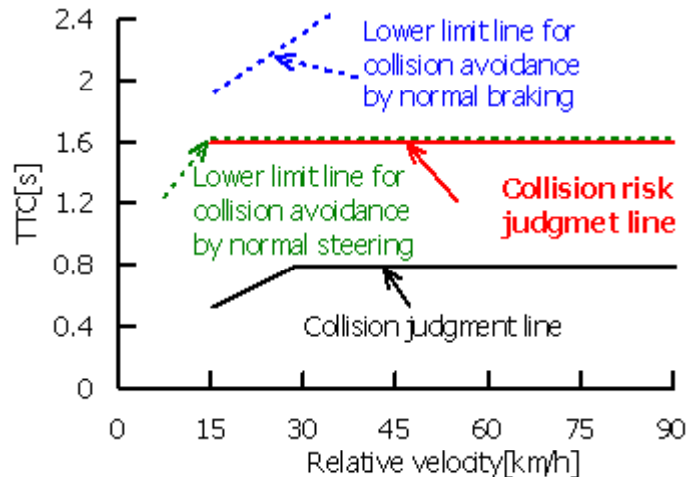




2. Specification - Enhance Damage Reducing Effect –



Collision Risk Judgment Line



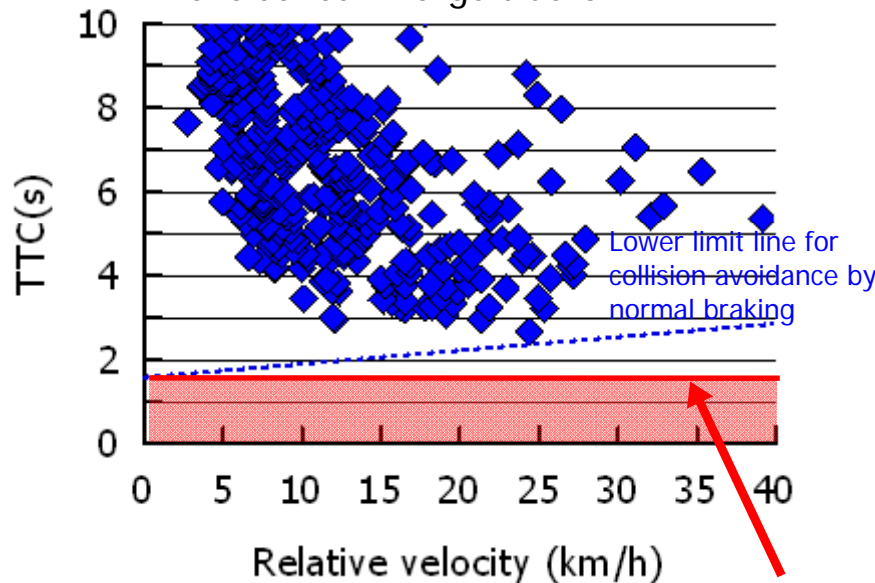
Collision risk judgment line is **the lowest limit of drivers' normal avoiding maneuver.**

Braking: $TTC = 0.0317 \times Rv + 1.54$ Rv : Relative velocity

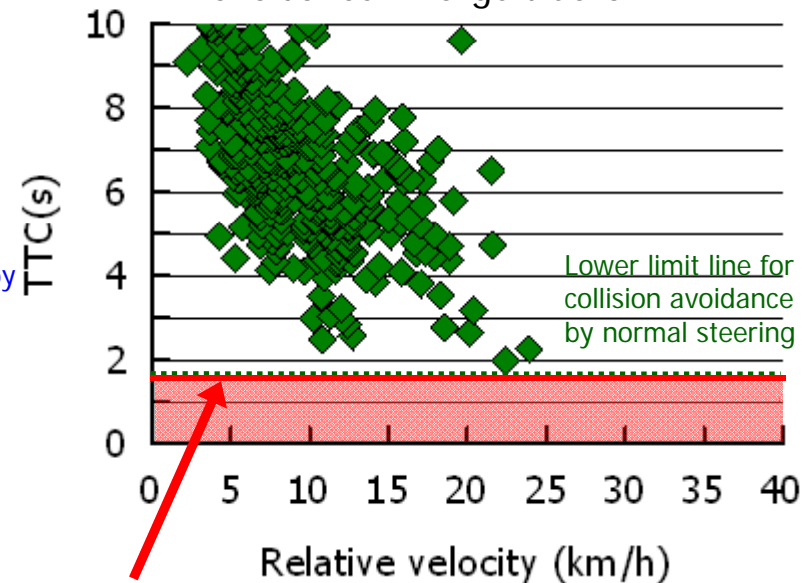
Steering: $TTC = 1.6$ (s)

(If the AEBS can detect the overlapping ratio, This draft permit to change $TTC=1.6s.$)

The **braking** timing for collision avoidance in large trucks



The **steering** timing for collision avoidance in large trucks



Collision risk judgment line

Confirmed by real world operation

Draft : Para. 2.12, 2.13, 2.14 ,
2.15, 5.4.2, 5.4.2.1, 5.4.2.2





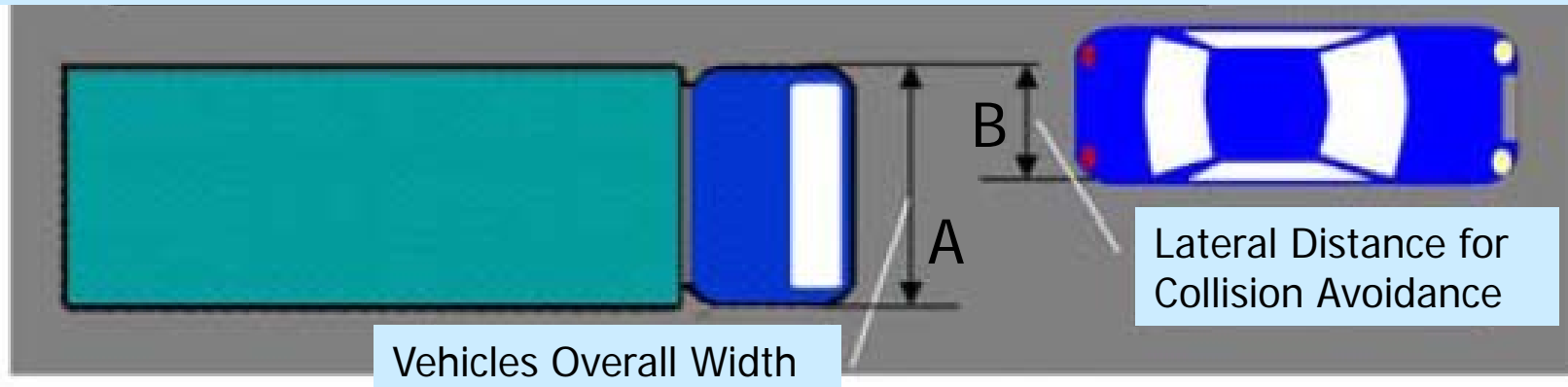
2. Specification - Enhance Damage Reducing Effect -



Collision Risk Judgment Line

Overlapping Ratio

Lateral Distance for Collision Avoidance (B) =
Overlapping Ratio x Vehicles Overall Width (A)



Steering: TTC = 1.6 (s)

$$\text{Overlapping Ratio} = \frac{B}{A}$$

If the AEBS can detect the overlapping ratio,
TTC can be increased by the overlapping ratio.





2. Specification - Enhance Damage Reducing Effect -



Speed Range for Expanded Range

In case of equal to or less than 60km/h (on the open road)

AEBS has a possibility of unnecessary braking control on the open road, because obstacles (for example, road sign, guardrail) are located in the nearer position from the vehicle equipped with AEBS compared to the highway. It is difficult for AEBS to distinguish between a forward vehicle and other obstacles. **In case of equal to or less than 60km/h, it is difficult to use the braking control from the collision risk judgment line.**

The change
of the
requirement



In case of more than 60km/h (on the highway)

The obstacles (for example, road sign, guardrail) are located in the farer position from the vehicle equipped with AEBS compared to the open road. **In case of more than 60km/h, AEBS may be able to use the braking control from the collision risk judgment line(Expanded range). Therefore, the braking control may be activated for the purpose of enhance damage reducing effect.**



This draft changes the requirement of the time delay in speed range.(Refer page 14) This draft permits the time delay 0.3s only in case of equal to or less than 60km/h, because AEBS should have a more effect in high speed range and AEBS can be activated from collision risk judgment line.



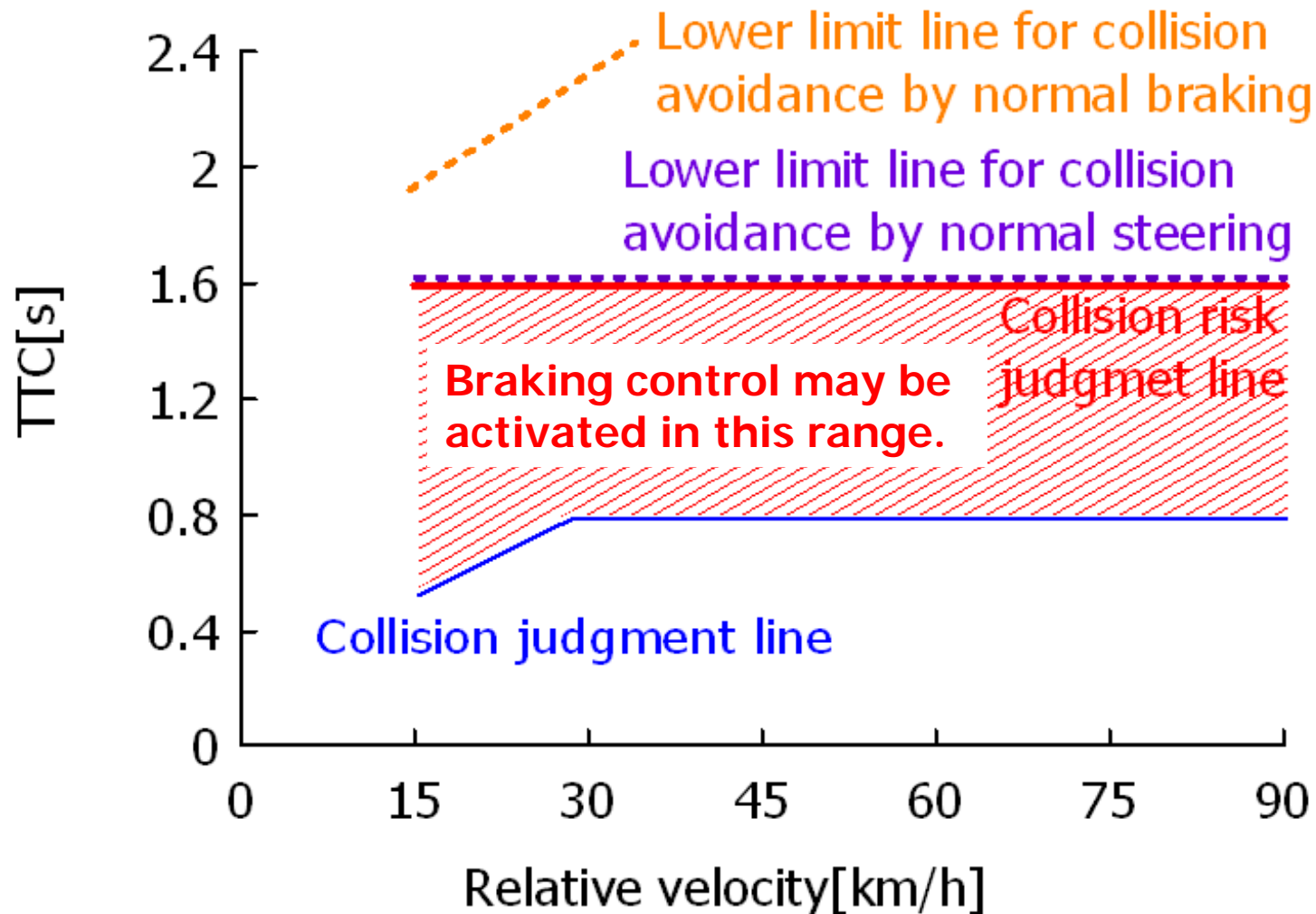
2. Specification - Enhance Damage Reducing Effect -



Requirement of Braking Deceleration

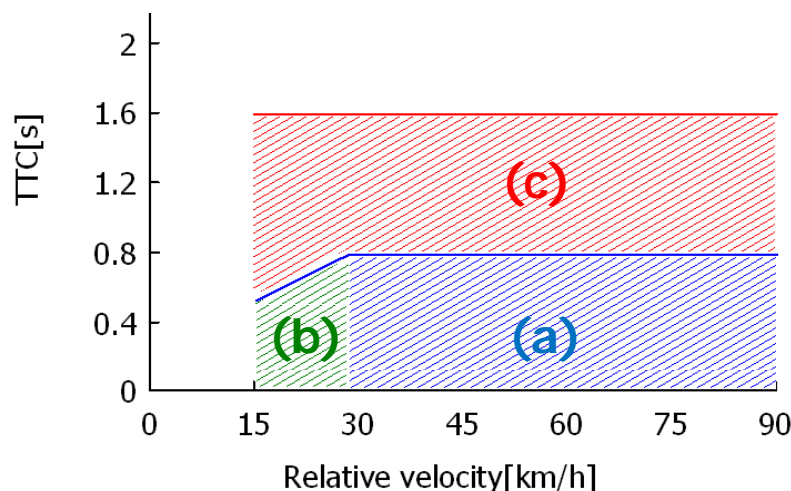
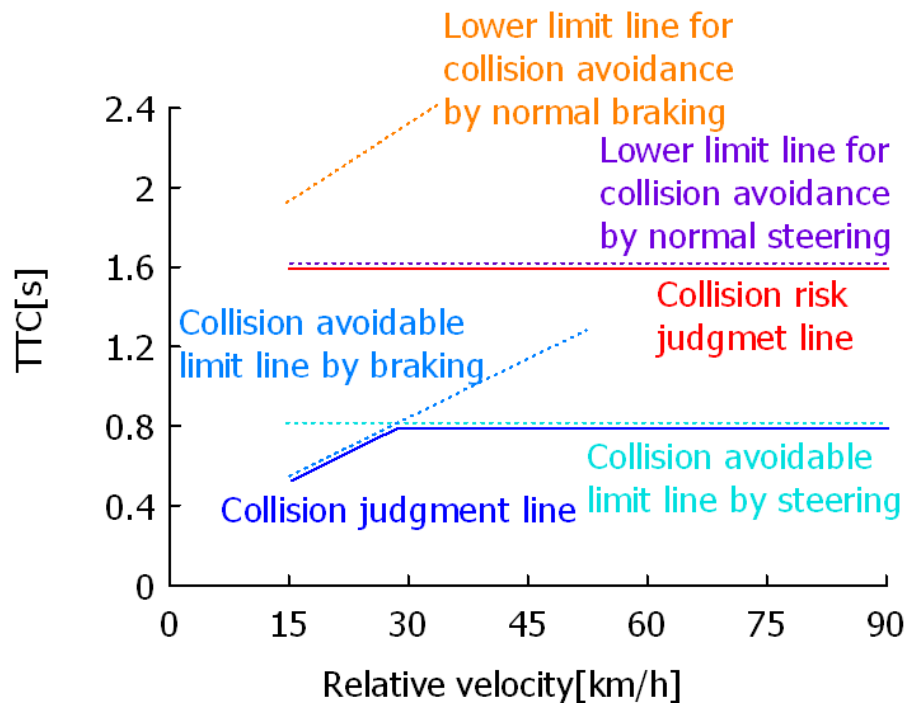
From collision risk judgment line :

Braking control may be activated. Deceleration is not specified.





2. Specification – Summary of Braking Control Timing and Braking Deceleration Requirement -



From collision judgment line :

(a)* If the collision avoidable limit by steering is lower than the collision avoidable limit by braking.

Braking control shall be activated with average deceleration of 3.3 m/s² or more.

(b) If the collision avoidable limit by braking is lower than the collision avoidable limit by steering.

Braking control shall be activated.

From collision risk judgment line :

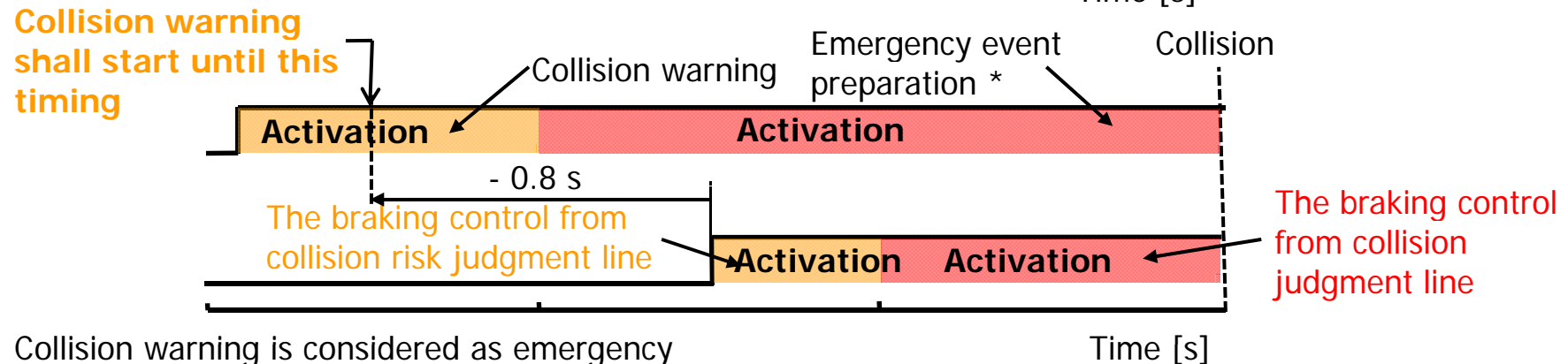
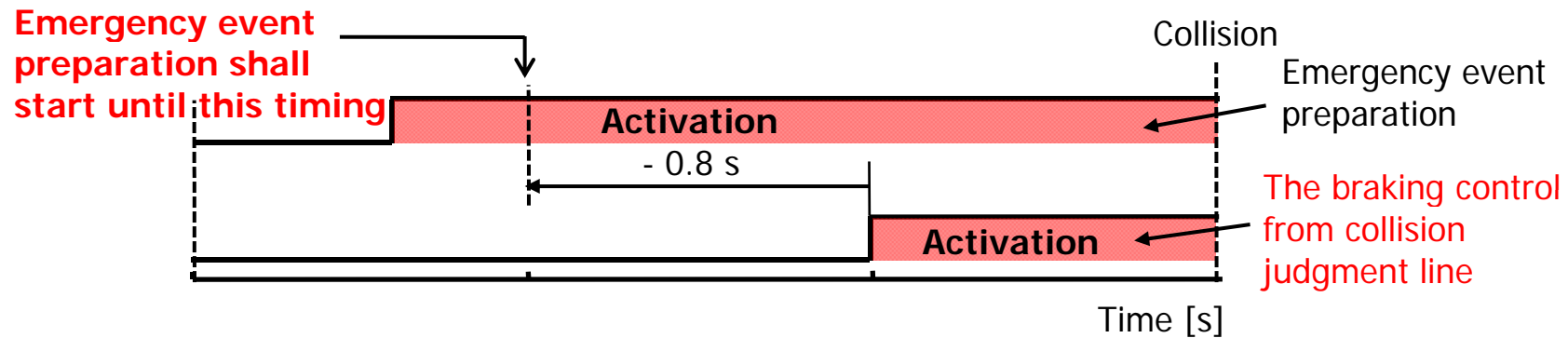
(c) **Braking control may be activated. Deceleration is not specified.**

*: Only equal to or less than 60km/h, if a braking control based on the collision risk judgment line has not been operated, the time delay 0.3s is permitted. This means that collision judgment line is changed from 0.8s to 0.5s in only equal to or less than 60km/h.



2. Specification - Emergency Event Preparation and Collision Warning -

- "Collision Warning" means a function that alerts the driver to a risk of collision in advance and prompts him/her to make an avoiding action.
- "Emergency Event Preparation" means a function that notices the driver in advance that the system detects an unavoidable collision and starts controlling the brake system.
- "Collision Warning Braking" means a function that alert the driver a risk of collision by the braking. Its maximum deceleration is 0.98 m/s^2 to 2.45 m/s^2 , and the time of continuation is less than 0.8 seconds.

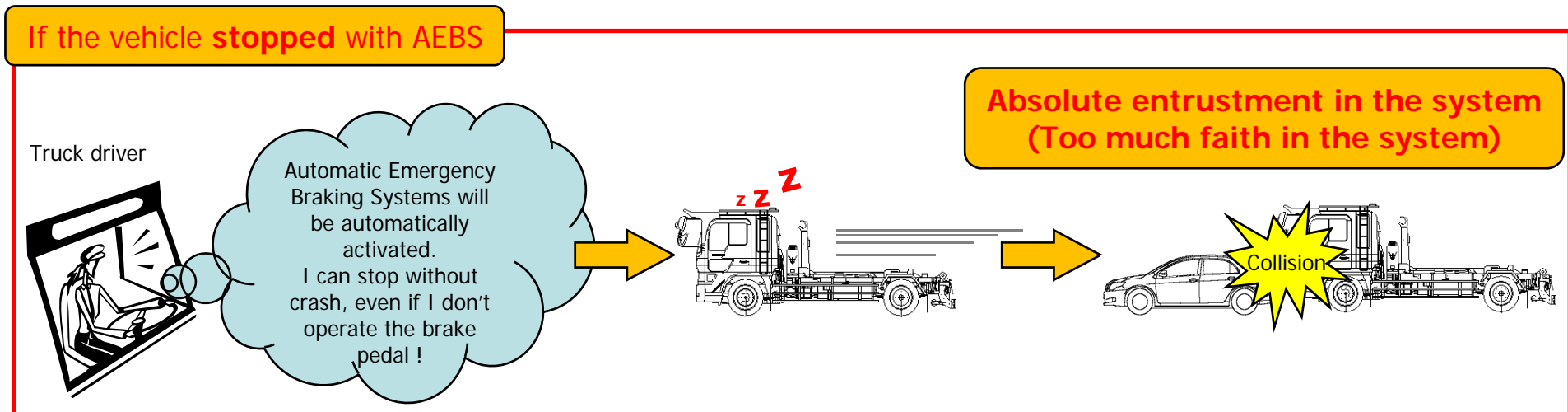


*: Collision warning is considered as emergency event preparation by continuing until collision

Draft : Para. 5.7

Time of 0.8 (s) (real-time) is based on the reaction time of driver.

2. Specification - Prevention of Excessive Dependence to System -



The AEBS shall be so designed that the driver does not rely on the system function excessively.

For example, a collision is not completely avoided except when the forward obstacle makes a rapid acceleration.

If the test vehicle collides or becomes the state considered that it collides with the forward obstacle after activation of AEBS in a test, this requirement is considered to be satisfied.



2. Specification - Off Switch -



If a “AEBS Off” control is provided to stop the activation of the AEBS temporarily in a situation such as a vehicle malfunction, the “AEBS Off” control shall comply with the following requirements.

1. When the activation of the AEBS is rendered unable by the “AEBS Off” control, the driver in the driver’s seat shall be warned by the optical warning signal indicating such situation.
2. The vehicle's AEBS system shall always return to the “On” mode at the initiation of each new ignition cycle.
3. To prevent any situation in which the AEBS does not function in normal driving caused by misusing of the “AEBS Off” control, it shall have a structure that the driver in the driver’s seat cannot operate it easily. The “AEBS Off” control located in a place not easily reached by the driver in the driver’s seat is considered to be a structure that the driver in the driver’s seat cannot operate it easily.
4. The vehicle manufacturers shall inform vehicle users through user’s manual that the “AEBS Off” control shall only be used when necessary to cancel the AEBS temporarily in an exceptional situation such as a vehicle malfunction, so the “AEBS Off” control shall not be used in normal driving.



2. Specification - Other Principal Requirements -

➤ **Fail safe function Draft : Para. 5.9**

The system shall have a function to monitor the operating state of the system, and shall detect failures by means of this function.

If any failure has occurred in the system, the operation of the system shall stop safely and the system shall return to its basic (manual) braking function as a brake system.

➤ **Malfunction tell-tale Draft : Para. 5.9**

If any failure occurs with the system, a visual alarm shall be given.

➤ **Indication of over limit of function Draft : Para. 5.11**

If AEBS recognizes an unfavorable situation which precludes its operation, such as when the system detects contamination on the forward obstacle sensor, the driver in the driver's seat shall be warned by an optical warning indicating that AEBS is not able to function.

➤ **Driver override Draft : Para. 5.10**

Driver override isn't inhibited in this draft. The system may have the means as identified by the vehicle manufacture to override the braking control.

When the braking control of AEBS is activating, if the driver operates the brake system to generate a braking force bigger than that by the AEBS, the system shall obey the driver's operation.



3. Test Procedures - Test Procedures for Stationary Obstacle



Target having equivalent magnitude of radar reflection to passenger cars
(for Millimeter wave sensor)

The forward obstacle used for the test shall have two reflectors with a radar cross section (RCS) of 15 dBsm or less. The position of the reflector shall be decided by a negotiation with a technical service.

Measurements:

- Distance
 - Velocity
 - Deceleration
 - Collision trigger
 - Sound pressure and video to check the emergency event preparation and the collision warning
- } to calculate TTC

Test velocity: 20, 40, 80 ± 2 [km/h]

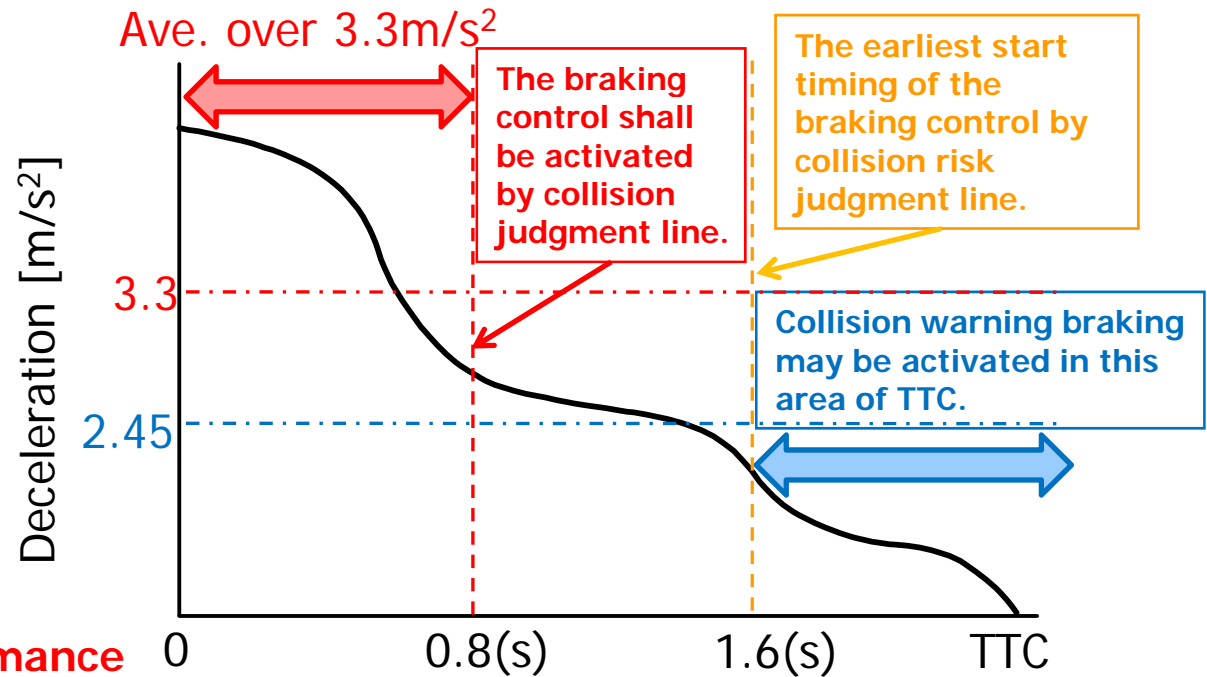


3. Test Procedures - Criteria for Stationary Obstacle -



➤ Test velocity is 80km/h

In case of AEBS
which can't detect
the overlapping ratio



1) Requirements of performance

Average deceleration shall be more than 3.3m/s^2 in the range of TTC $0.8(\text{s})$ to $0(\text{s})$.

2) The start timing of the braking control by collision risk judgment line.

Deceleration shall be 2.45 m/s^2 or less before TTC is $1.6(\text{s})$.

And deceleration at the range of 0.98 to 2.45m/s^2 shall not continue more than $0.8(\text{s})$.

3) Requirements of collision warning braking

Deceleration at the range of 0.98 to 2.45m/s^2 shall not continue more than $0.8(\text{s})$ in the area of TTC more than $1.6(\text{s})$.

And deceleration shall not exceed 2.45m/s^2 .





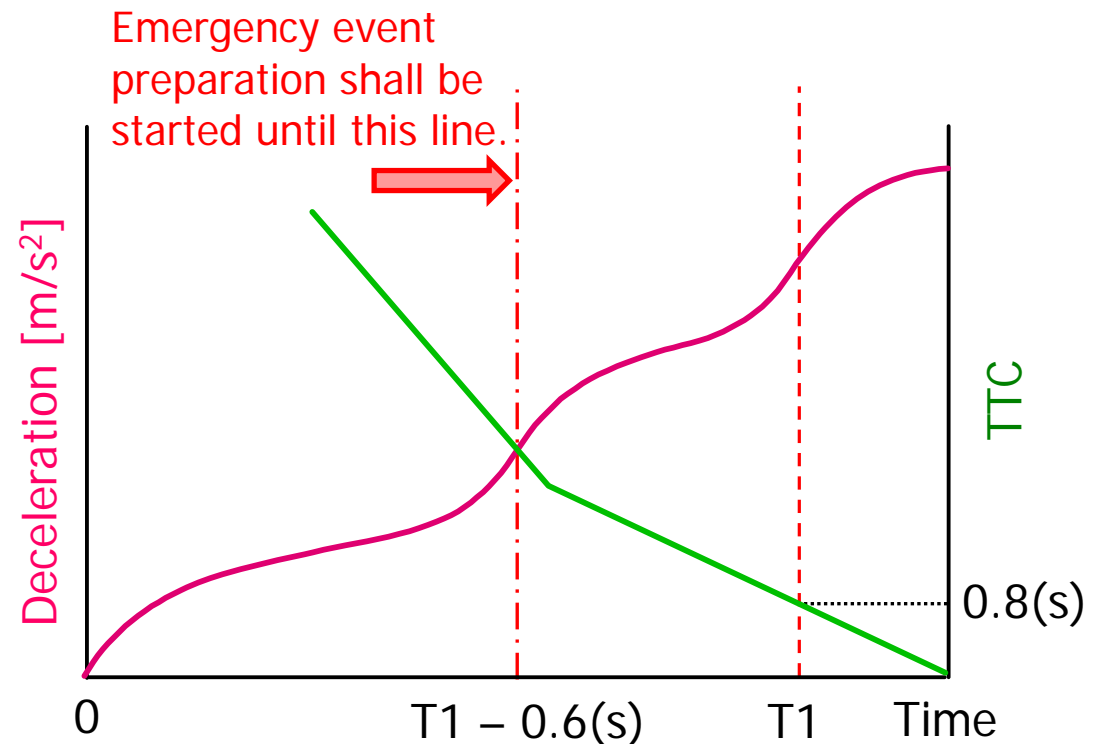
3. Test Procedures - Criteria for Stationary Obstacle -



➤ Test velocity is 80km/h

**In case of AEBS
which can't detect
the overlapping ratio**

Although in the specification, requirement of emergency event preparation timing shall be 0.8(s) earlier than the start timing of braking control, 0.6(s) was applied as the criteria by the consideration of the response time of millimeter wave sensor (0.2(s)).



Step 1 search for T1

Step 2 search for (T1 - 0.6(s))

Step 3 confirm the start of the activation of emergency event preparation until (T1 - 0.6(s))

1) Emergency Event Preparation

The emergency event preparation shall be activated 0.6 (s) earlier than the time when TTC is 0.8(s).





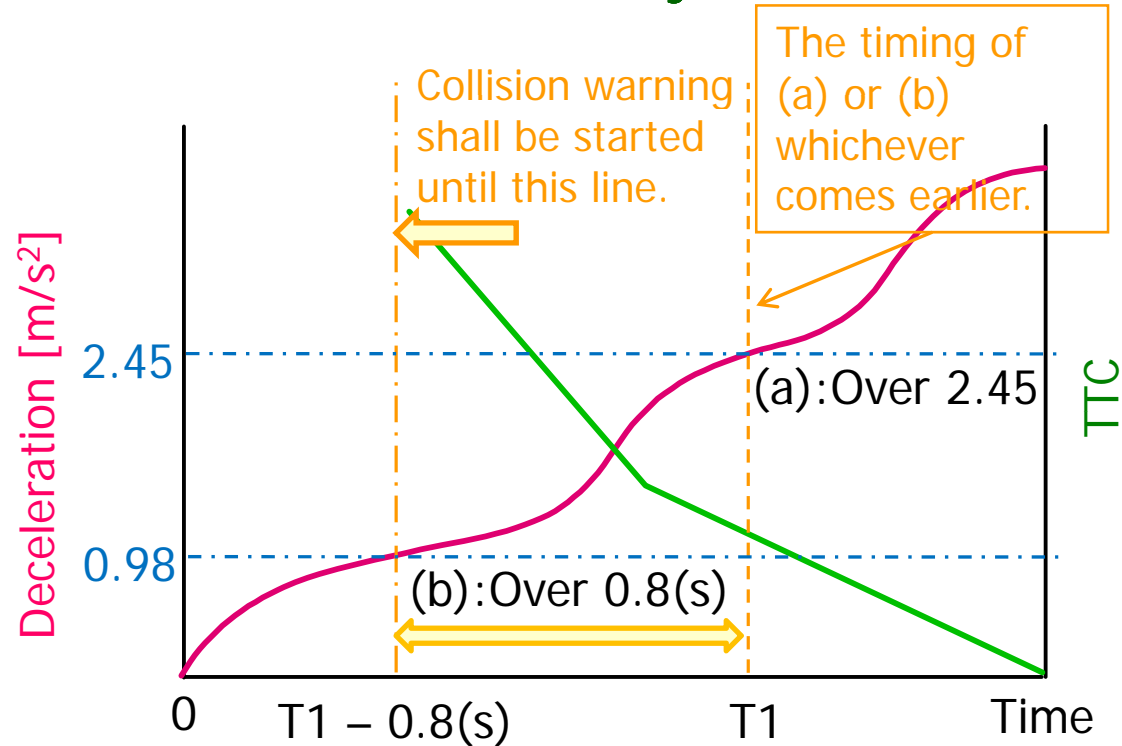
3. Test Procedures - Criteria for Stationary Obstacle -



➤ Test velocity is 80km/h

In case of AEBS
which can't detect
the overlapping ratio

Step 1 search for (a),(b)
Step 2 search for (T1 - 0.8(s))
Step 3 confirm the start of the
activation of collision warning
until (T1 - 0.8(s))



2) Collision Warning

- a) Time when deceleration exceeds more than 2.45 m/s².
- b) Time when deceleration at the range of 0.98 to 2.45m/s² continues more than 0.8 (s) .

Collision warning shall starts 0.8 (s) earlier than the timing of (a) or (b) whichever comes earlier.



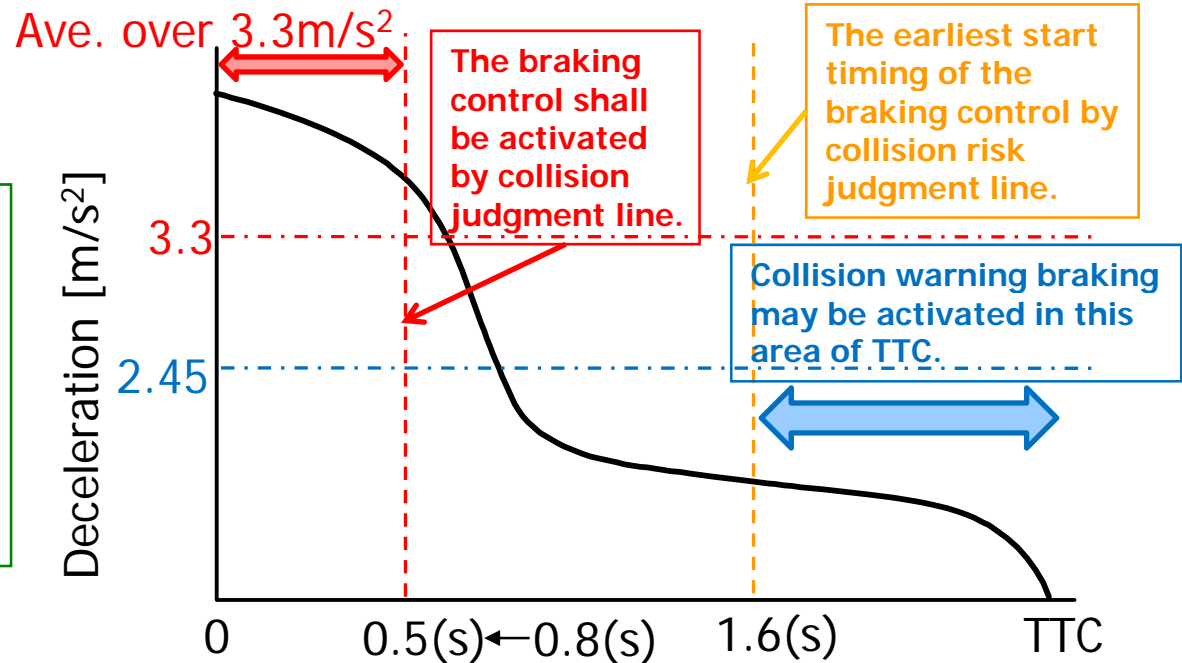


3. Test Procedures - Criteria for Stationary Obstacle -



➤ Test velocity is 40km/h

This criteria is adapted to the starting of the braking control from collision judgment line. If the braking control is started from collision risk judgment line, then the criteria is adapted to the criteria of test speed 80km/h



1) Requirements of performance

Average deceleration shall be more than 3.3m/s² in the range of TTC 0.5(s) to 0(s).

2) The start timing of the braking control by collision risk judgment line

Deceleration shall be 2.45 m/s² or less before TTC is 1.6 (s).

And deceleration at the range of 0.98 to 2.45m/s² shall not continue more than 0.8 (s).

3) Requirements of collision warning braking

Deceleration at the range of 0.98 to 2.45m/s² shall not continue more than 0.8 (s) in the area of TTC more than 1.6 (s).

And deceleration shall be less than 2.45m/s².



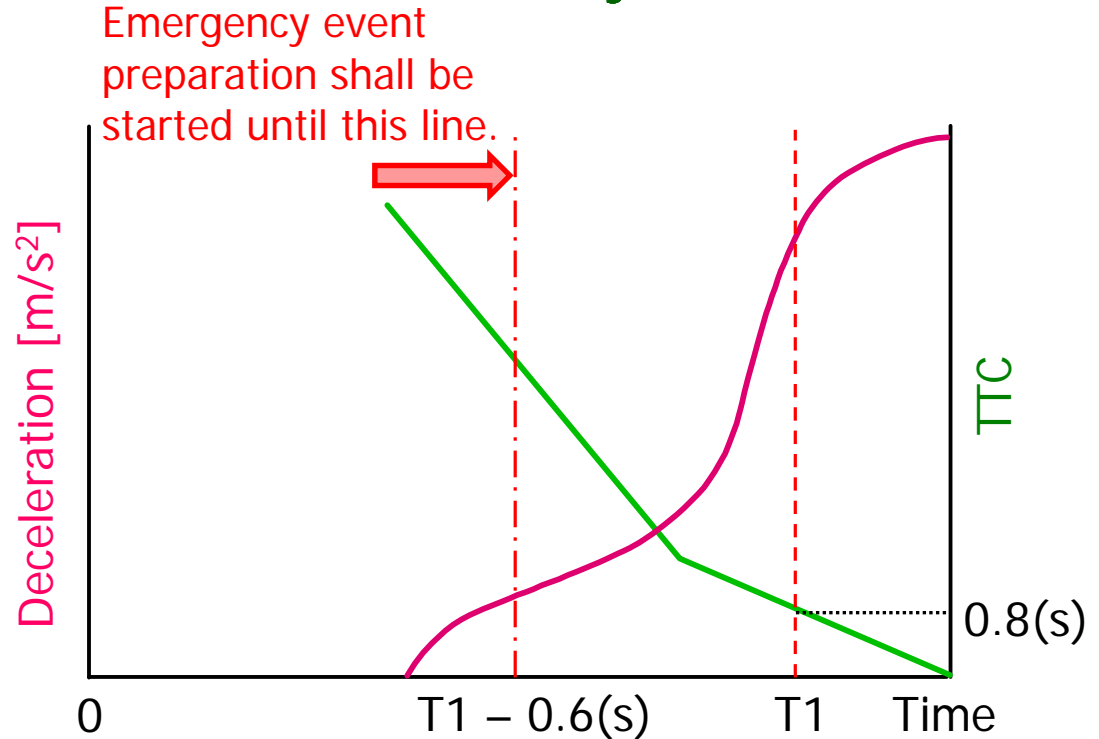


3. Test Procedures - Criteria for Stationary Obstacle -



➤ **Test velocity is 40km/h**

Although in the specification, requirement of emergency event preparation timing shall be 0.8(s) earlier than the start timing of braking control, 0.6(s) was applied as the criteria by the consideration of the response time of millimeter wave sensor.



- Step 1 search for T1
- Step 2 search for (T1 - 0.6(s))
- Step 3 confirm the start of the activation of emergency event preparation until (T1 - 0.6(s))

1) Emergency Event Preparation

The emergency event preparation shall be activated 0.6 (s) earlier than the time when TTC is 0.8(s).

2) Collision Warning

The collision warning shall be activated in case of the activating of braking control by collision risk judgment line.





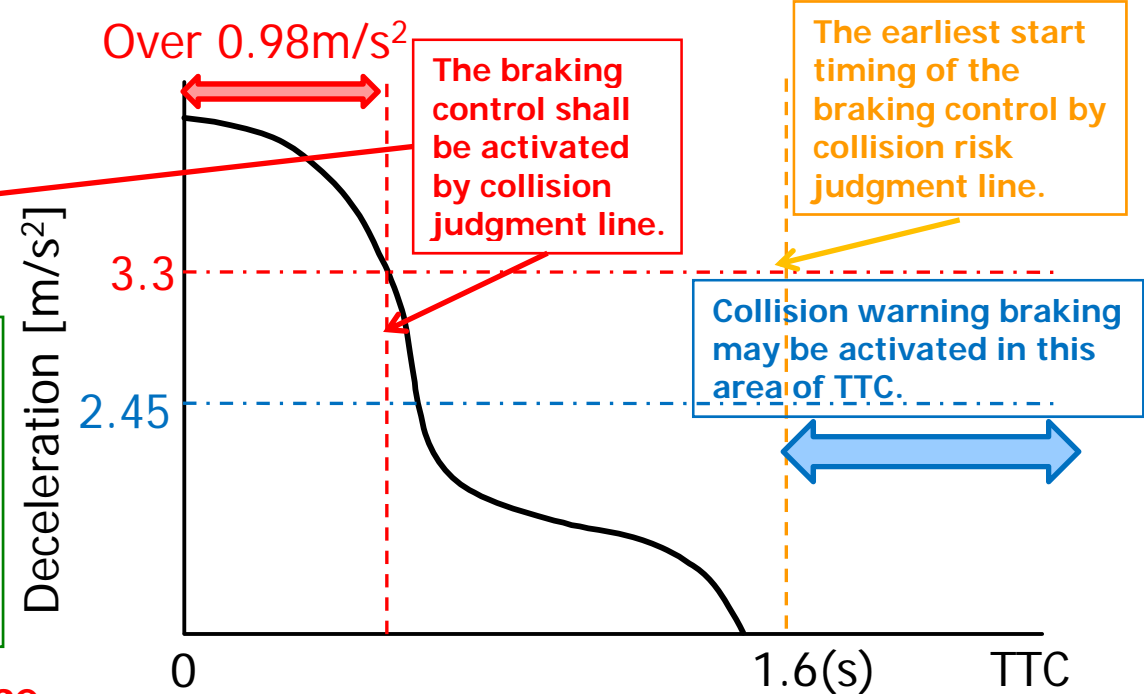
3. Test Procedures - Criteria for Stationary Obstacle -



➤ Test velocity is 20km/h

Collision judgment line (If the collision avoidable limit by braking is lower than the collision avoidable limit by steering)

This criteria is adapted to the starting of the braking control from collision judgment line. If the braking control is started from collision risk judgment line, then the criteria is adapted to the criteria of test speed 80km/h



1) Requirements of performance

Deceleration shall reach more than 0.98m/s^2 after crossing the collision judgment line.

2) The start timing of the braking control by collision risk judgment line.

Deceleration shall be 2.45 m/s^2 or less before TTC is 1.6 (s).

And deceleration at the range of 0.98 to 2.45m/s^2 shall not continue more than 0.8 (s).

3) Requirements of collision warning braking

Deceleration at the range of 0.98 to 2.45m/s^2 shall not continue more than 0.8 (s) in the area of TTC more than 1.6 (s).

And deceleration shall not exceed 2.45m/s^2 .



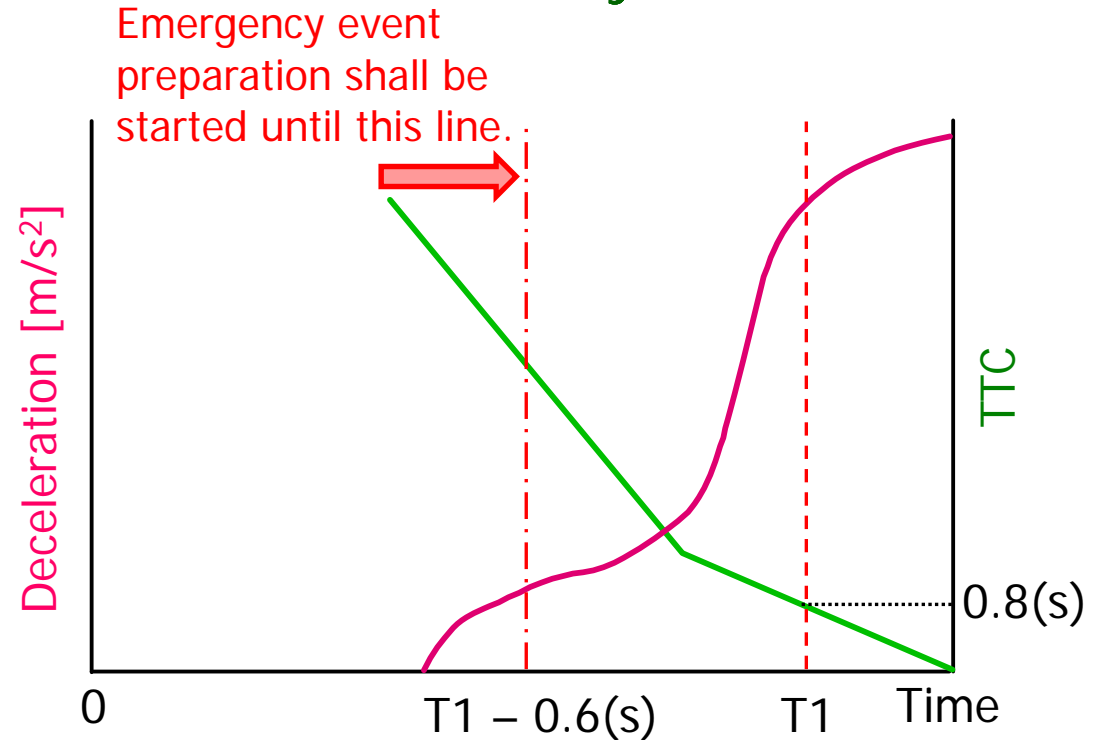


3. Test Procedures - Criteria for Stationary Obstacle -



➤ Test velocity is 20km/h

Although in the specification, requirement of emergency event preparation timing shall be 0.8(s) earlier than the start timing of braking control, 0.6(s) was applied as the criteria by the consideration of the response time of millimeter wave sensor.



Step 1 search for T1

Step 2 search for (T1 - 0.6(s))

Step 3 confirm the start of the activation of emergency event preparation until (T1 - 0.6(s))

1) Emergency Event Preparation

The emergency event preparation shall be activated 0.6 (s) earlier than the time when TTC is 0.8(s).

2) Collision Warning

The collision warning shall be activated in case of the activating of braking control by collision risk judgment line.





3. Test Procedures - Verification Test of deactivation of Braking Control to Obstacle Outside of the Test Lane -



The test vehicle shall be driven at 40 ± 2 km/h speed, keeping its centerline on the lane center, from a point at least 60 m before the obstacles outside of the test lane until the vehicle passes the obstacles. The test shall be repeated three times.

Criteria

AEBS shall not activate any braking control, in the specified number of tests. Provision above is not applied to collision warning brake.

VTR



3. Test Procedures - Curved Road -



➤ **Requirements related to brake system for easing frontal obstacle impact in curved road.**

The braking control system for damage mitigation of frontal obstacle impact shall operate normally even in a curved road (example: R380) where a vehicle may run at a high speed.



This statement indicates a direction of future development, as well as the technology to reduce collision speed by increasing average deceleration value. In the future, according to the technology circumstances of frontal obstacle detection and other technologies, the specific test methods need to be defined.



3. Test Procedures - Functioning Test of the Malfunction Warning Device of AEBS -



Forward obstacle sensor



Control unit

Test procedure

Turn off the ignition switch, then

- (1) disconnect a connector of the power supply or input or output port of the control unit
- (2) disconnect a connector of the power supply or input or output port of the forward obstacle sensor

Criteria

Turn on the ignition switch, then the failure warning optical signal shall be given within 15 seconds.



History of Discussion and Production of Automatic Emergency Braking Systems in Japan

2001 Design principles for ASV systems

2003 Technical guideline for Automatic Emergency Braking Systems

2003 First release of AEBS in passenger cars

2005 Revision of technical guideline for Automatic Emergency Braking Systems

2006 First release of AEBS in large trucks

2007 Discussion on the technical regulation of Automatic Emergency Braking Systems for Large Truck



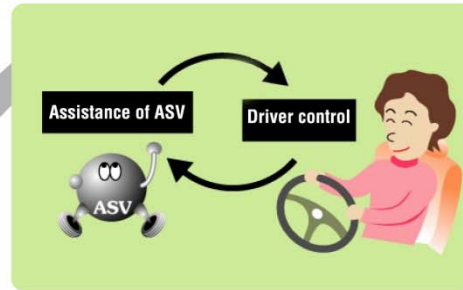
Study of Detailed Design Principles of ASV (Advanced Safety Vehicle)



Design Principles of ASV (Formulated in the ASV-2 Project)

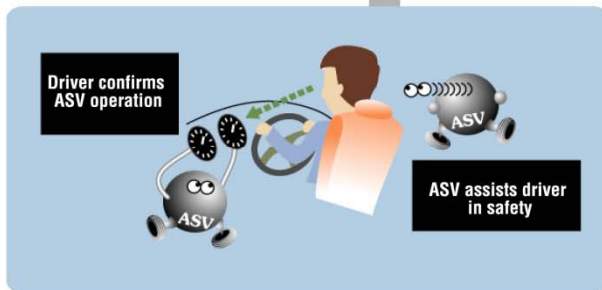
Driver Assistance

ASV technologies should understand driver's wills and support their safe driving based on the concept of driver responsibility.



ASV technologies should be easy to use and be trusted by drivers. This means that a human-machine interface design should be appropriately implemented.

ASV technology-equipped vehicle must operate with unequipped vehicles and pedestrians. Therefore, we must consider how to obtain proper understanding of the public.



Driver Acceptance



Social Acceptance

The concept of driver assistance was formulated for driver load reduction and accident avoidance assistance technologies in order to facilitate the interpretation of Design Principles of ASV.





Study of Guidelines for the Commercialization of Automatic Emergency Braking Systems (1)

Approach to Brake Control

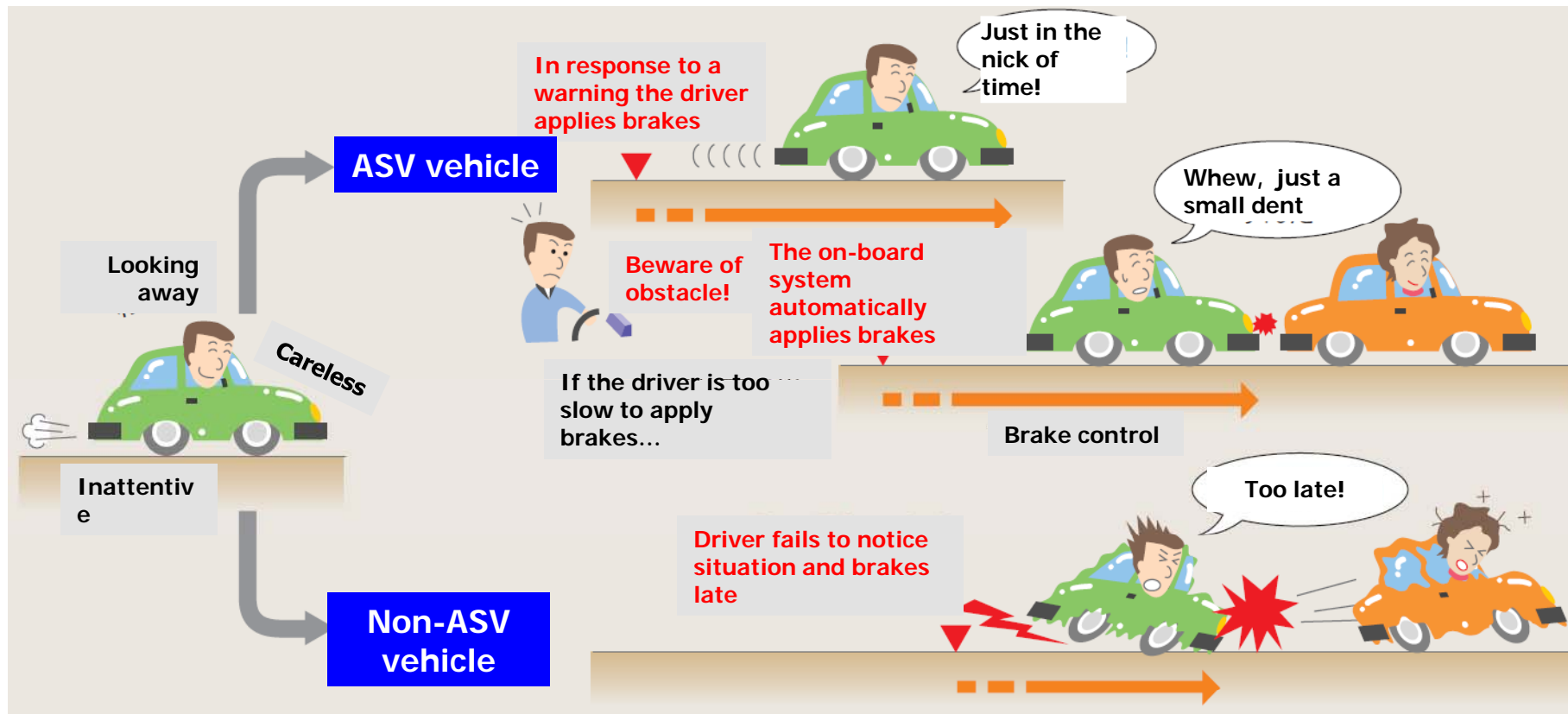
- Brake control by ASV systems is effective in reducing/avoiding collisions.
- There is a concern that if braking is automatically applied in a dangerous situation, the driver may neglect to take evasive action he/she should essentially perform (driver overconfidence in the system).
- If the Automatic Emergency Braking Systems is designed to brake when it determines that a collision is physically unavoidable, it is assumed the driver will not put too much confidence in the system.*
 - System starts applying brakes if it determines a collision is unavoidable.
 - Physical avoidance limit by braking
 - Physical avoidance limit by steering
 - Based on the Design Principles of ASV, system issues a warning to alert the driver to take evasive action before it applies brakes.

*This has been verified by a study of drivers' dependence on ASV systems.



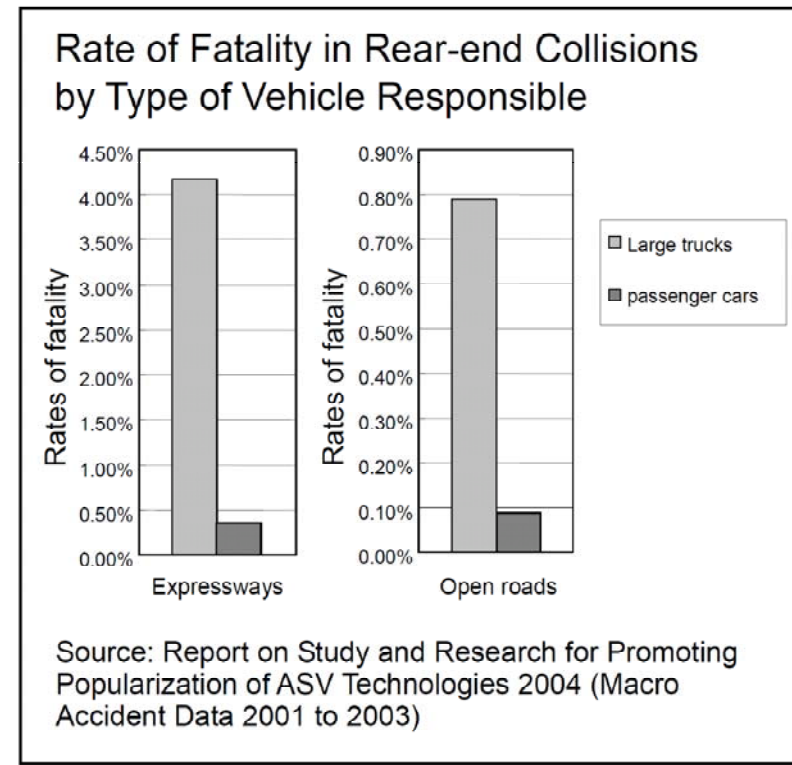
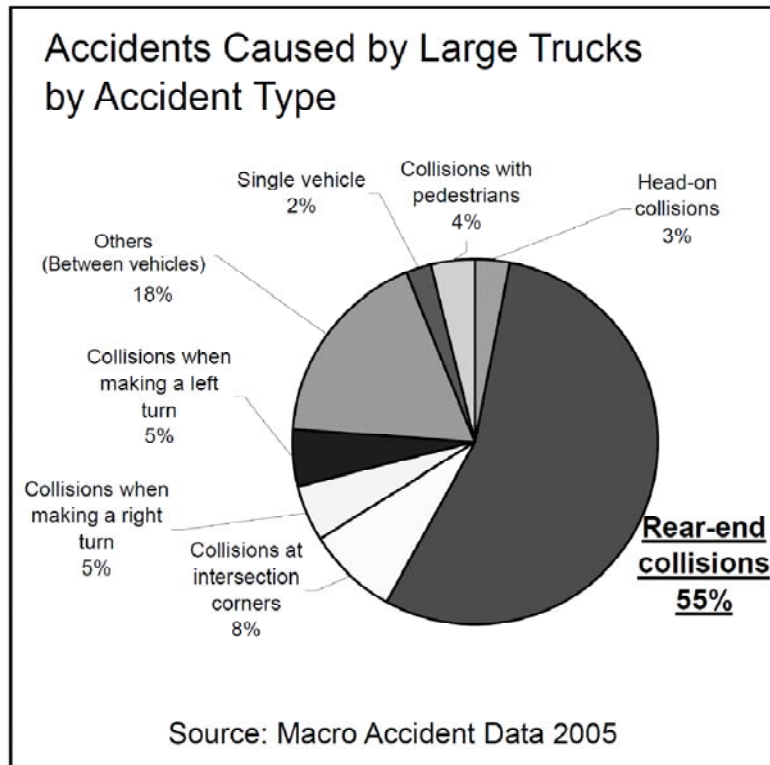
Study of Guidelines for the Commercialization of Automatic Emergency Braking Systems (2)

How Automatic Emergency Braking Systems Work

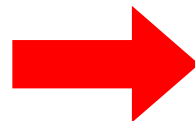




The State of the Traffic Accident in Japan (1)



- Half of Japanese traffic accidents caused by large trucks are the rear-end collisions. (55%)
- Rate of fatalities in rear-end collisions is much higher in large trucks.

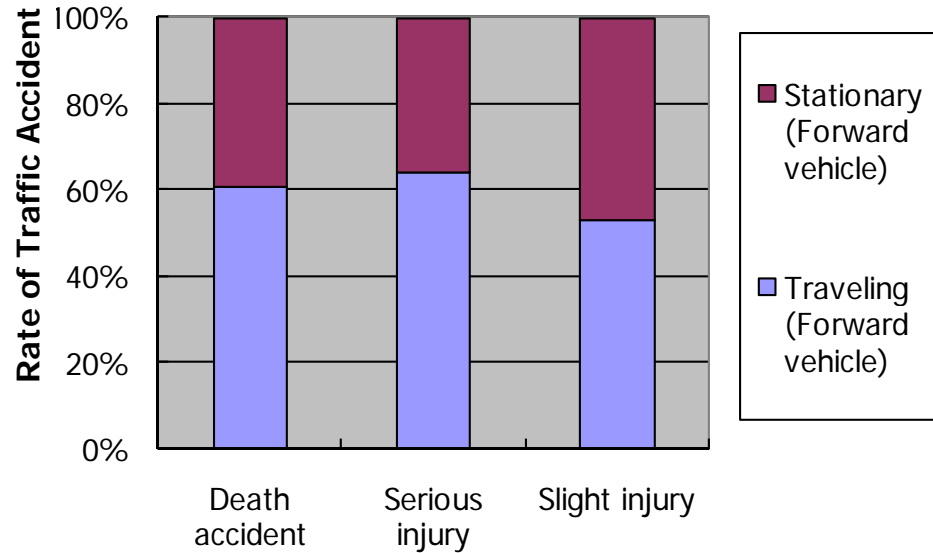


Automatic Emergency Braking Systems is effective in Japan.

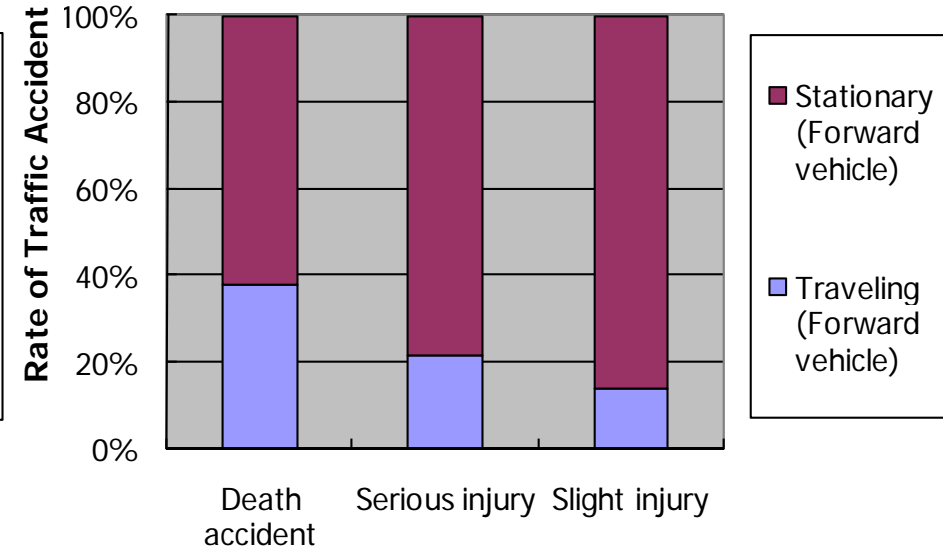


The State of the Traffic Accident in Japan (2)

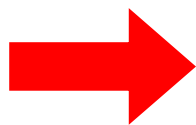
Rate of Rear-end collision (Highway)



Rate of Rear-end collision (Open road)



- On the highway, many accidents are against **traveling** vehicles.
- On the open road, many accident are against **stationary** vehicles.



Automatic Emergency Braking Systems should cover the forward vehicle which is travelling and stationary.