Transmitted by expert from Japan

Informal document No. **GRRF-S08-12**
Special GRRF brainstorming session
9 December 2008
Agenda item 3

Damage Mitigation Braking System

Advanced Emergency Brake Systems (AEBS)

Progress in Technical requirements

1. History of Discussion and Production of Damage Mitigation Braking System in Japan

2001 Design principles for ASV systems

2003 Technical guideline for Damage Mitigation Braking System

2003 First release of DMBS in passenger cars

2005 Revision of technical guideline for Damage Mitigation Braking System

2006 First release of DMBS in large trucks

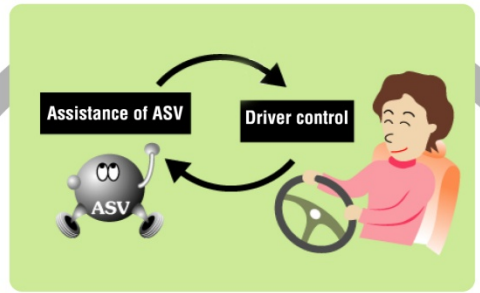
2007 – Discussion on the technical regulation of Damage Mitigation Braking System for Large Truck

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

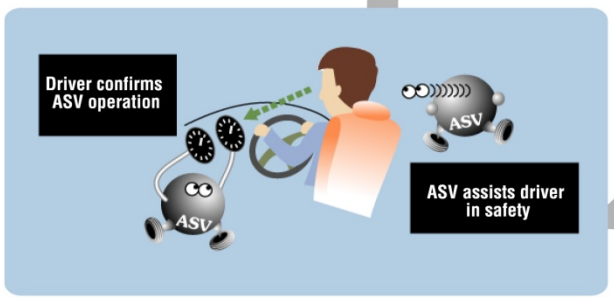
Design Principles of ASV
(Formulated in the ASV-2 Project)

Driver Assistance

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

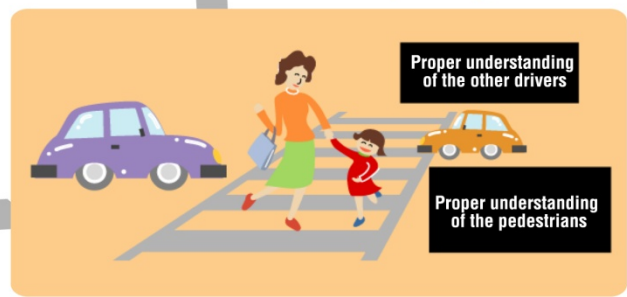


ASV technologies should be easy to use and be trusted by drivers. This means that a human-machine interface design should be appropriately implemented.



Driver Acceptance

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



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

2. Study of Guidelines for the Commercialization of Damage Mitigation Braking System (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 damage mitigation braking system 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.*

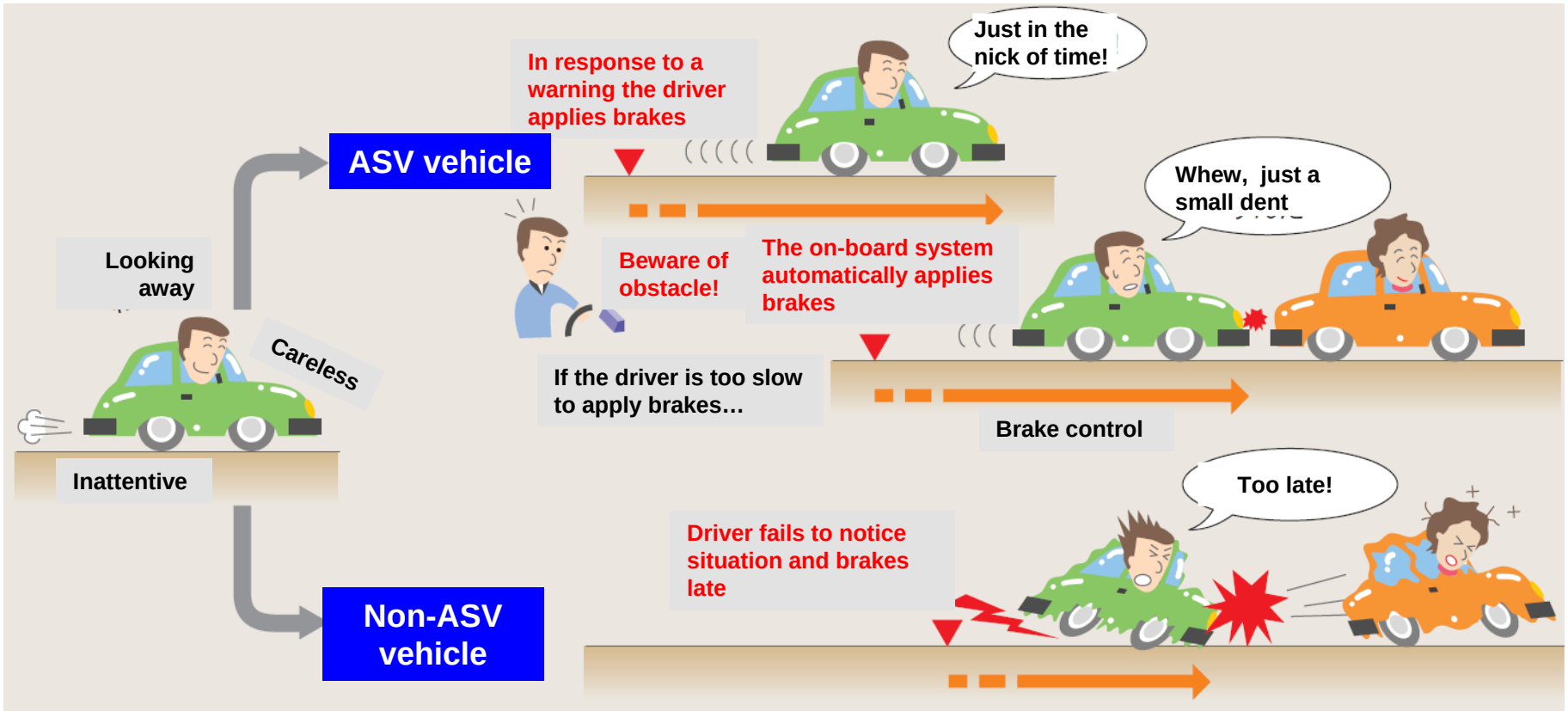
➢ System starts applying brakes if it determines a collision is unavoidable
- Physical avoidance limit by braking
- Physical avoidance limit by steering

➢ Based on the Design Principles of ASV, system issues a warning to alert the driver to take evasive action before it applies brakes

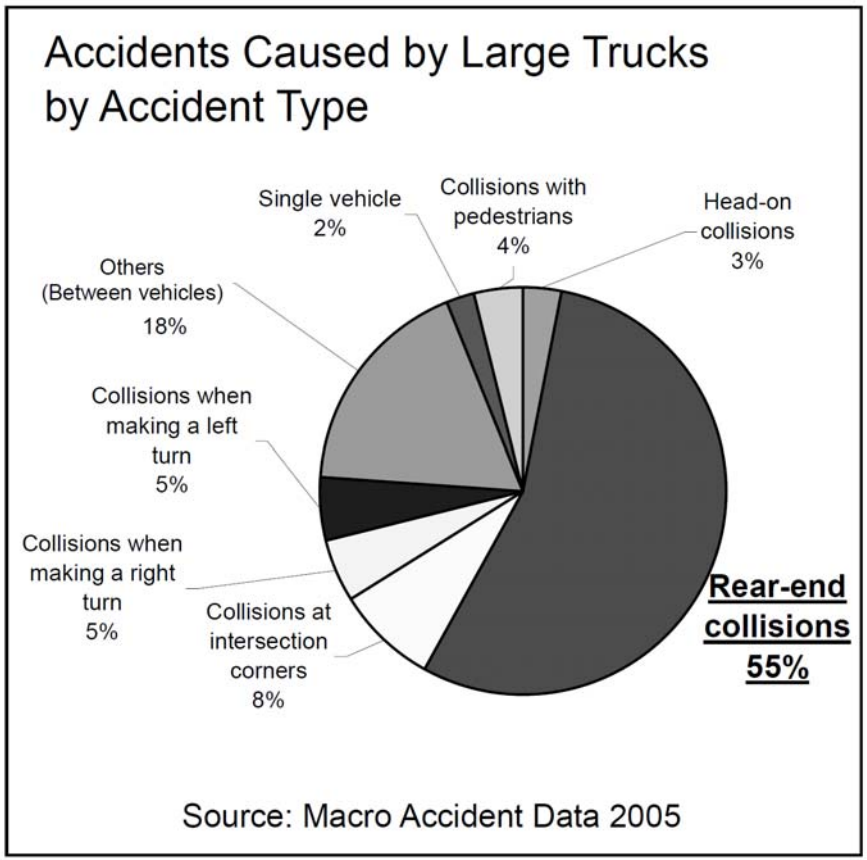
*This has been verified by a study of drivers' dependence on ASV systems

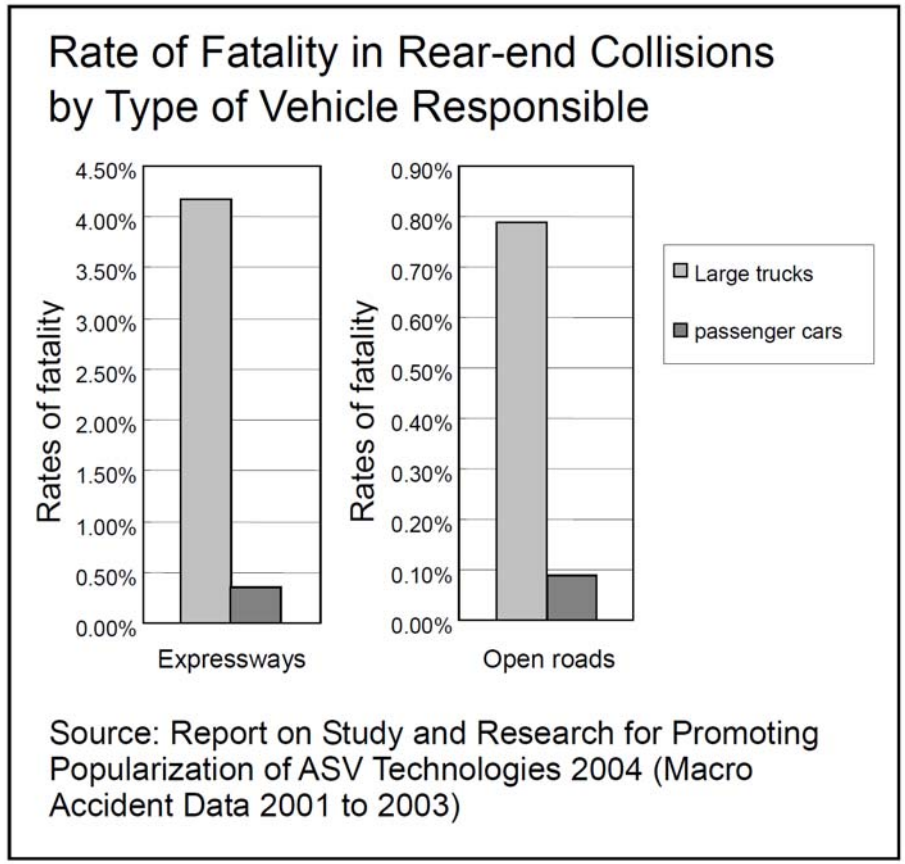
2. Study of Guidelines for the Commercialization of Damage Mitigation Braking System (2)

How Damage Mitigation Braking System Work



3. The state of the traffic accident in Japan (1)

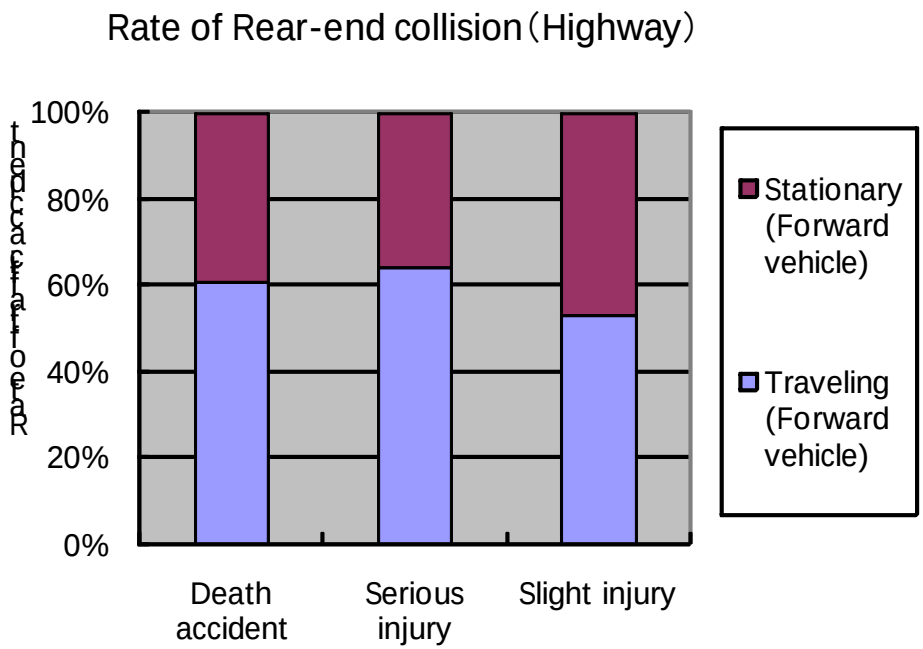


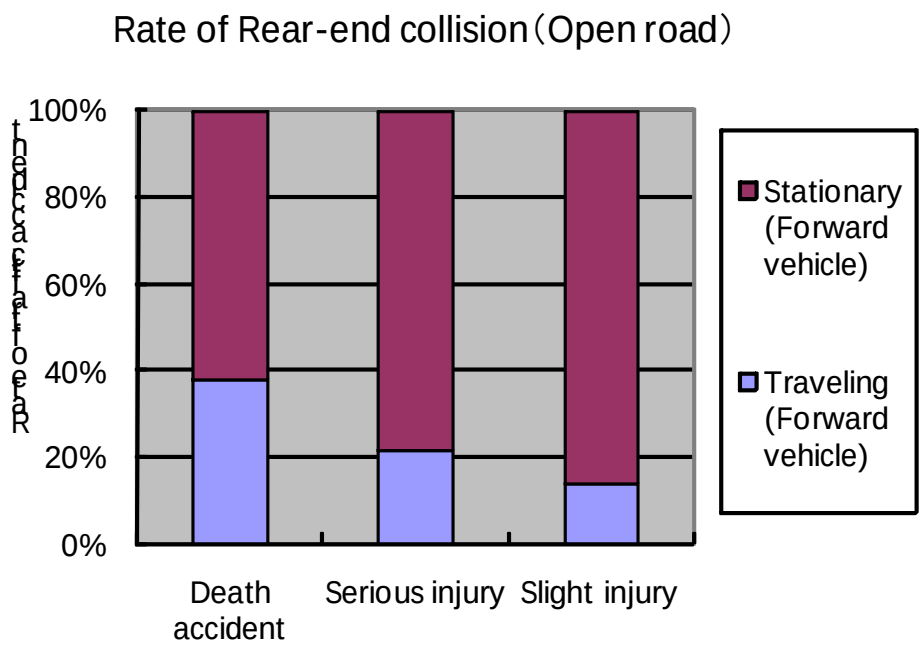


- Half of Japanese traffic accidents caused by large trucks are the rear-end collisions. (55%)
- Rate of fatalities in rear-end collisions is much higher in large trucks.

→ Damage Mitigation Braking System is effective in Japan

3. The state of the traffic accident in Japan (2)

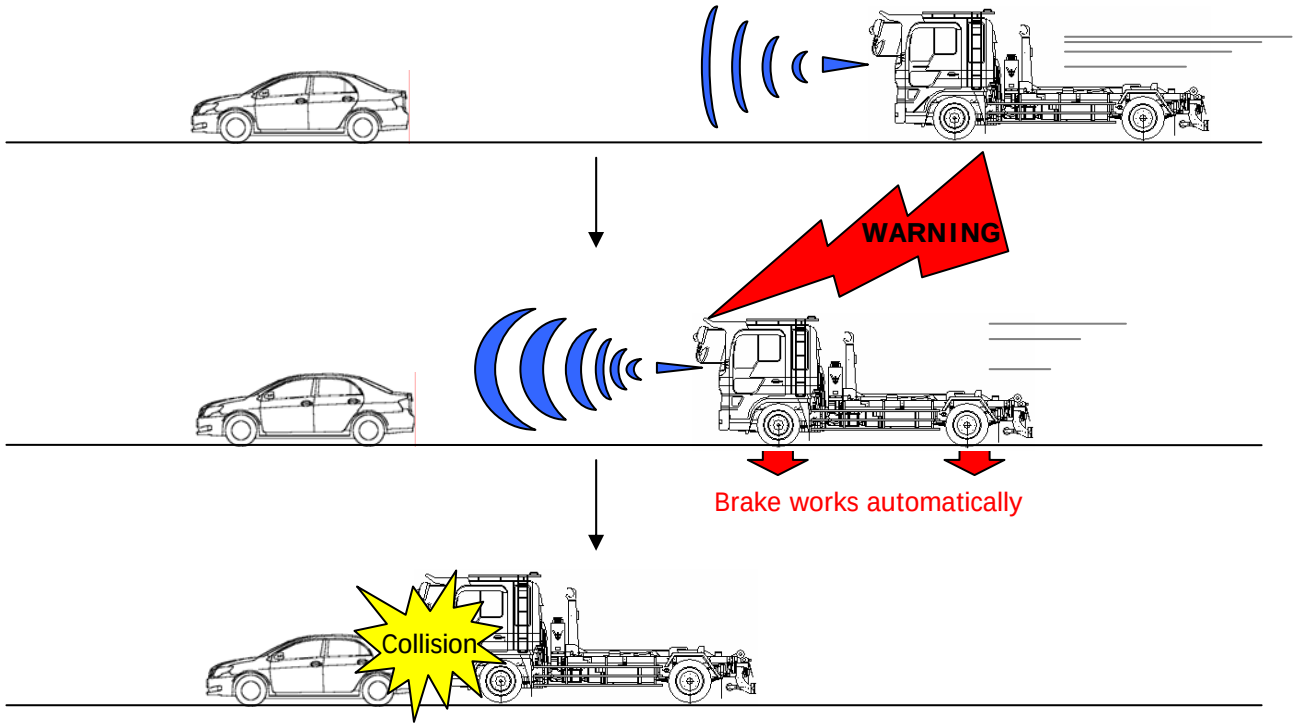




- On the highway, many accidents are against **traveling** vehicles
- On the open road, many accident are against **stationary** vehicles

Damage Mitigation Braking System should cover the forward vehicle which is travelling and stationary

4. Timing of Brake Control

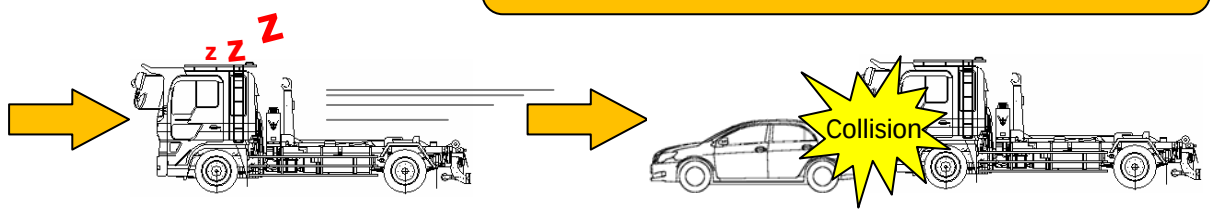


If the vehicle **stopped** with Damage mitigation braking system

Absolute entrustment in the system (Too much faith in the system)

Truck driver

Damage mitigation braking system will be automatically activated.
I can stop without crash!



Timing of brake control is important for the view point of driver sovereignty

4. Timing of Brake Control - Point of view -

First step:

Operational range based on physical avoidance limit

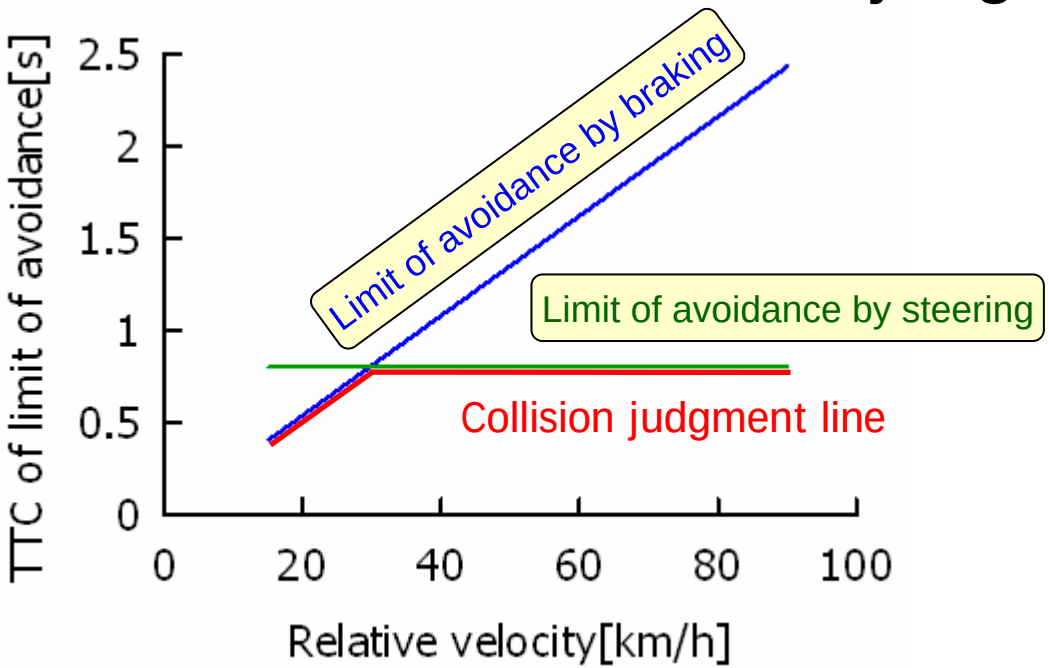
Brake control begins at the point the driver is unable to avoid a collision by either braking or steering **(collision judgment line)**

Second step:

Operational range based on driver's usual maneuvers limit

To enhance the damage-reducing effect, we examined how far the operational range can be expanded by bringing forward the timing at which brake or steering control begins **(Collision possibility judgment line)**

4. Timing of Brake Control - Collision judgment line



Limit of avoidance by braking

Minimum TTC which is necessary that a vehicle avoids a collision by **braking**.

TTC is calculated by minimum stopping distance with the braking test.

Limit of avoidance by steering

Minimum TTC which is necessary that a vehicle avoids a collision by **steering**.

TTC is calculated by minimum lateral displacement with the steering test.

Japan applies the timing with the following values

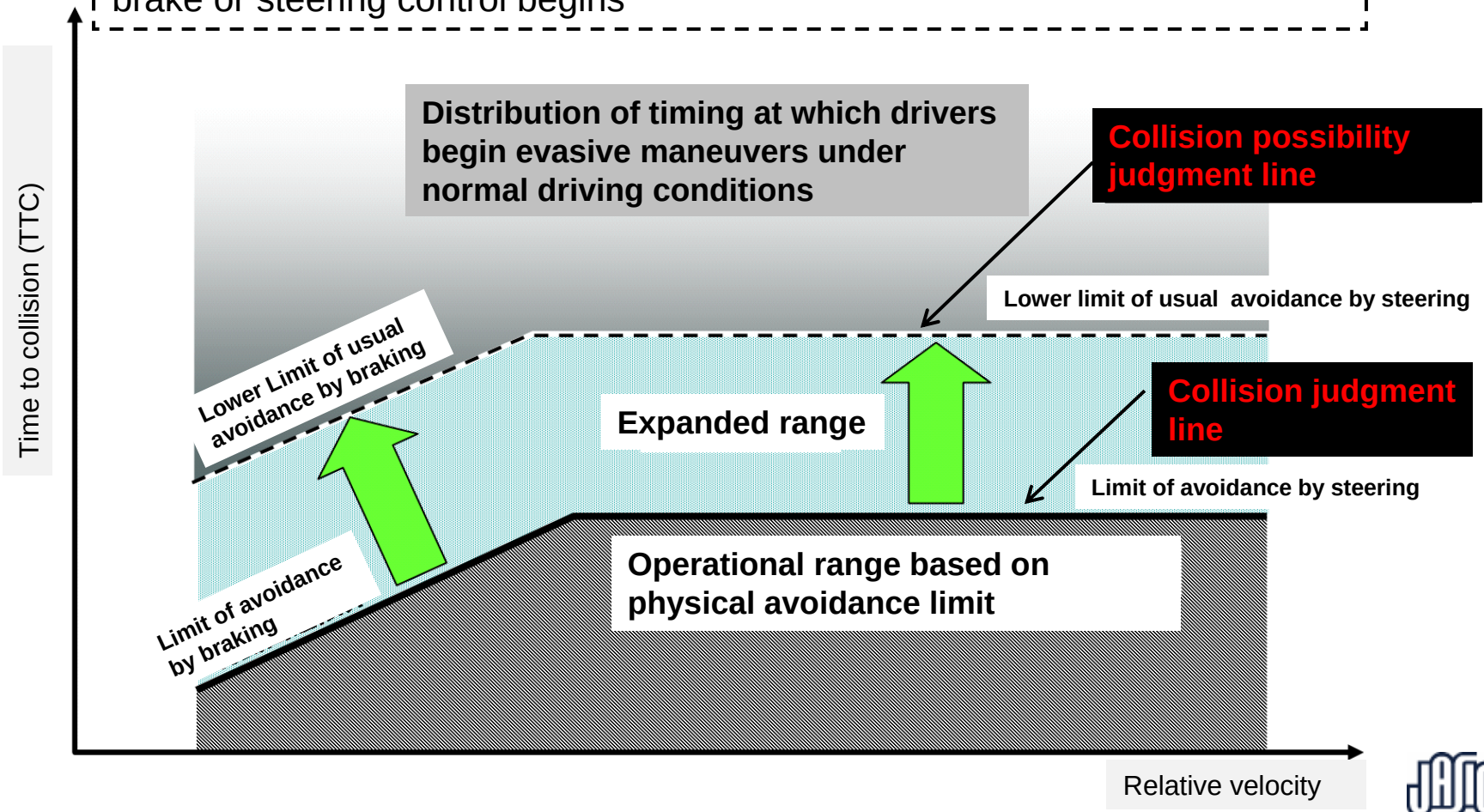
Braking: Braking performance is different from vehicle to vehicle. Therefore, this line is changed by each vehicle.
Steering: TTC = 0.8 (s) fixed value is used for all large trucks.

4. Timing of Brake Control

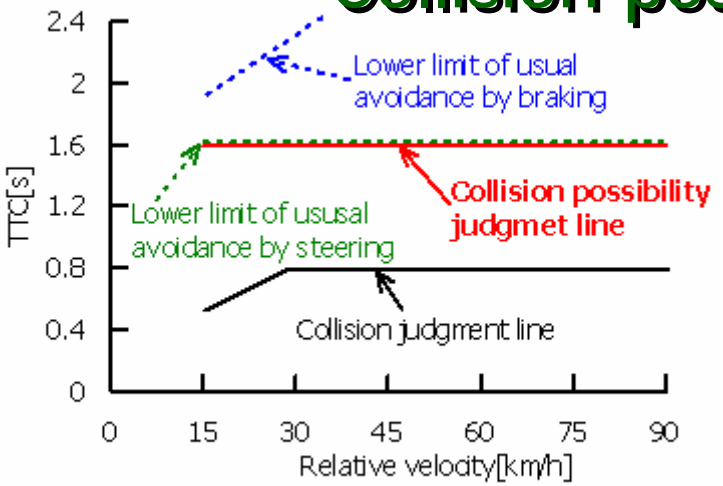
- Collision possibility judgment line -

Operational range based on driver's maneuvers limit

To enhance the damage-reducing effect, we examined how far the operational range can be expanded by bringing forward the timing at which brake or steering control begins



- Collision possibility judgment line -

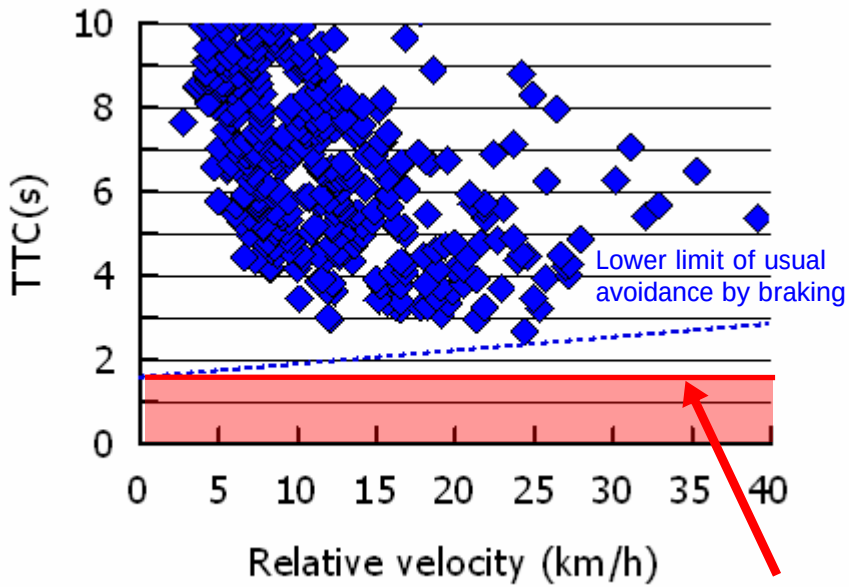


Collision possibility judgment line is **the lowest limit of drivers' usual avoiding maneuver.**

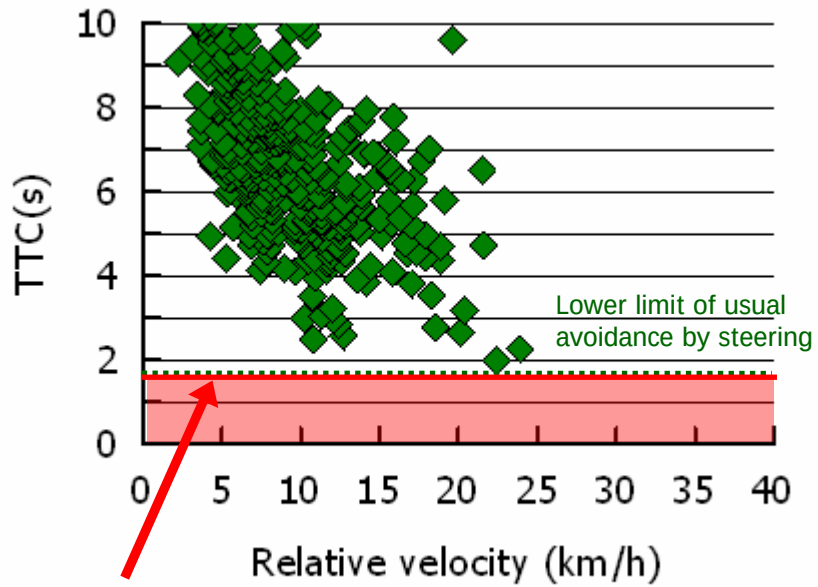
Japan applies the timing with the following values provided from an experiment result

Braking: TTC = 0.0317 × Rv + 1.54
Steering: TTC = 1.6 (s) Rv : Relative velocity

Avoidance timing by the **braking** in large trucks



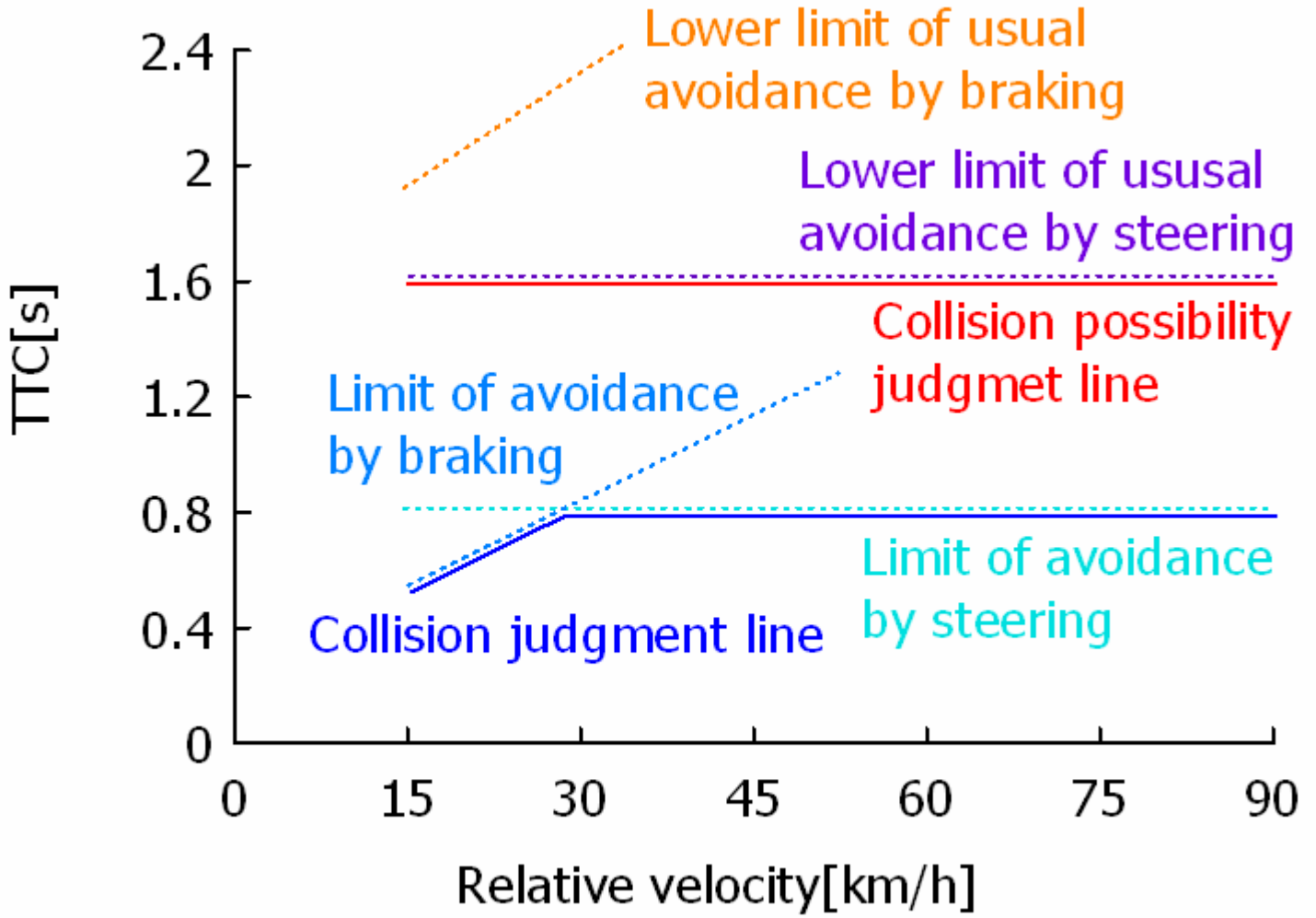
Avoidance timing by the **steering** in large trucks



Collision possibility judgment line

Confirmed by real world operation

4. Timing of Brake Control



Requirements in the regulation

System is activated over 15[km/h].

From Collision judgment line :

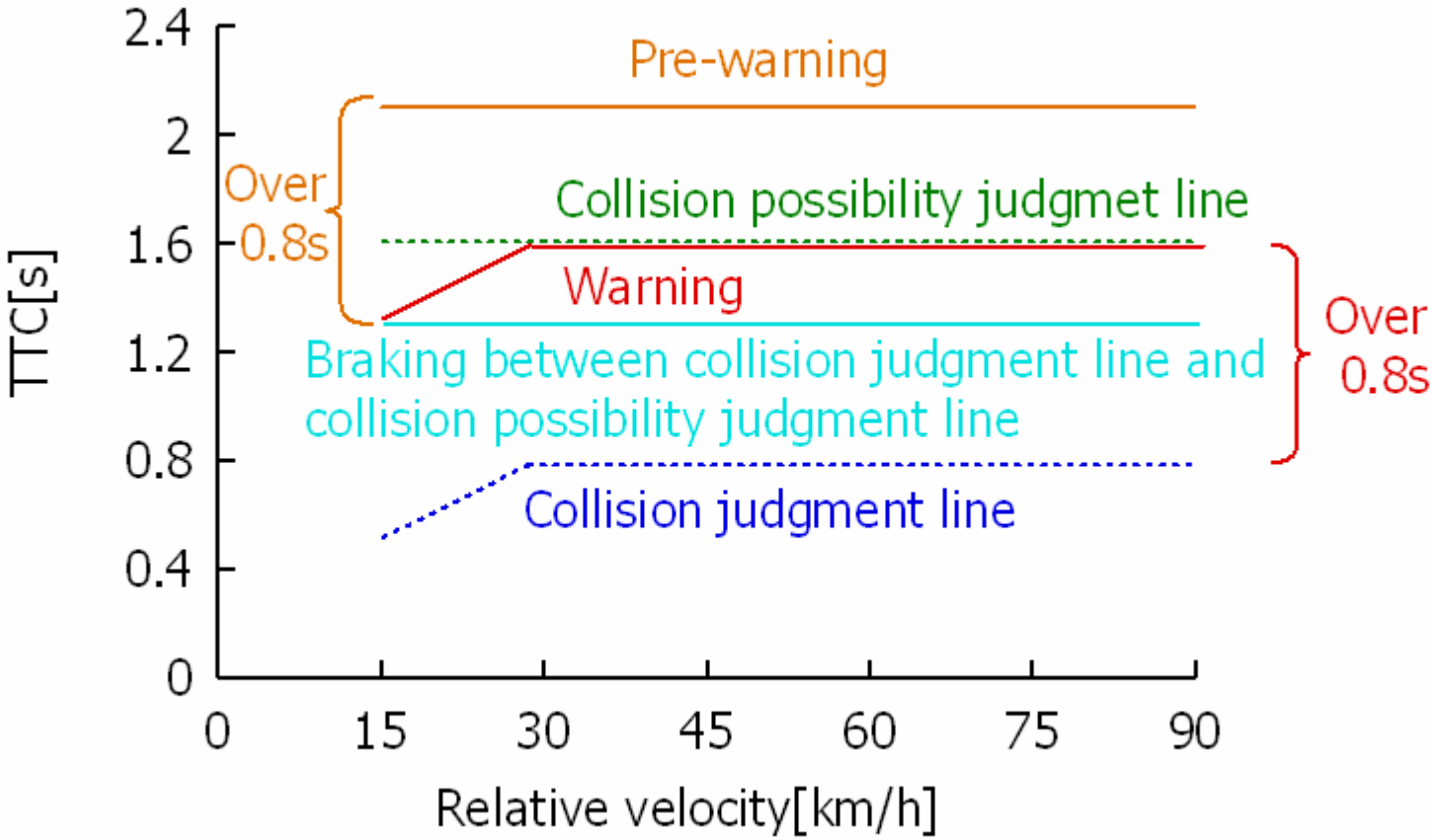
Braking shall be operated with average deceleration of 3.3 m/s^2 or more.

From Collision possibility judgment line :

Braking may be operated. Deceleration is not specified.

5. Warning and Pre-warning

- "Pre-warning" means a function that alerts the driver to a risk of collision in advance and prompts him/her to make an avoiding action.
- "Warning" means a function that notices the driver in advance that the system detects an unavoidable collision and starts controlling the brake system.
- Braking that causes a maximum deceleration of 0.98 m/s2 to 2.45 m/s2, and of continuation for less than 0.8 seconds can be used for warning purpose.



Time of 0.8 (s)（real-time）depends on the reaction time of driver

6. Other principal requirements

- **Fail safe function**

  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 original function as a brake system.

- **Malfunction tell-tale**

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

- **Warning of over limit of function**

  If the said system recognizes that the current situation does not allow its operation, such as when the system detects contamination on the frontal obstacle detector, driver in the driver seat shall be provided with a visual message indicating that the current situation does not allow the system to function.

- **Off switch**

  The vehicle may be equipped with a off switch. While the operation of the said system is disabled by the cancellation device, the driver in the driver seat shall be provided with a visual message indicating such situation.

7. Performance Test

Target equivalent to passenger cars
(for Millimeter wave sensor)

Japan is now investigating the validity of the target. This target isn't the final conclusion.

Measurements:
- Distance
- Velocity

} to calculate TTC

- Deceleration
- Collision trigger
- Sound pressure and video to check pre-warning and warning

Test velocity:20,40,80 [km/h]

Japan will continue to investigate the test method for both stationary and travelling target.

VTR

7. Performance Test - Other items -

- **Test for operation to obstacle on outside track**
- **Test for operation of alarm upon system failure**
- **Requirements related to brake system for easing frontal obstacle impact in curved road** *

* This standard indicates a direction to be adopted in the future for the development of brake system for easing frontal obstacle impact, 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 as necessary.

VTR

7. Performance Test - Other items -

- **Test for operation to obstacle on outside track**
- **Test for operation of alarm upon system failure**
- **Requirements related to brake system for easing frontal obstacle impact in curved road** *

* This standard indicates a direction to be adopted in the future for the development of brake system for easing frontal obstacle impact, 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 as necessary.

VTR

Thank you very much
for your attention