Japan Presentation

Consideration of Issues
a. Accident Scenarios in JAPAN

- The rear-end collisions of heavy duty truck accounts for more than half of the whole accidents. (Fig.1)

- The rate of fatality in rear-end collisions involving heavy duty truck >= 8t are about 12 times higher than that of passenger cars. (Fig.2)

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Source: Macro Accident Data 2005

The rear-end collisions of heavy duty truck accounts for more than half of the whole accidents. (Fig.1)

The rate of fatality in rear-end collisions involving heavy duty truck >= 8t are about 12 times higher than that of passenger cars. (Fig.2)

Source: Report on Study and Research for Promotion and Popularization of ASV Technologies 2004 (Macro Accident Data 2001 to 2003)
AEBS Basic System (Example)

System

- Sensing System (Radar, LiDAR, Camera)
- Collision Forecast Computer
- Warning System
- Brake Control Computer
- Brake Actuator
- Speed Sensor
- Yaw rate Sensor
- Steer Sensor

Initiation

- Exist Danger of Collision
- TTC (Time to Collision)
- Unavoidable Condition
- Collision

Should Consider the Following:
- Emergency Event Preparation
- Driver Response Time
- Nuisance or False Warning

Collision Warning and Event Preparation

Effort to Earlier Initiation

AEBS Initiation

ABS must be equipped
## b. Sensing Systems

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Resolution of Distance</th>
<th>Resolution of Direction</th>
<th>Ability of Object Discrimination</th>
<th>Robustness against Weather</th>
<th>Detection of Forward Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Millimeter-wave RADAR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Scanning-Beam</td>
<td>Good</td>
<td>Good</td>
<td>Good (Vehicle)</td>
<td>Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Switched-Beam</td>
<td>Good</td>
<td>Fair</td>
<td>Good (Vehicle)</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>LIDAR</strong></td>
<td>Good</td>
<td>Good</td>
<td>Good (Vehicle)</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Camera</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stereo</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent (Small vehicle and Pedestrian)</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td>Monocular</td>
<td>Poor</td>
<td>Good</td>
<td>Good (Small vehicle and Pedestrian)</td>
<td>Fair</td>
<td>Fair</td>
</tr>
</tbody>
</table>
The appearance (1)

Millimeter-wave RADAR (DENSO)

LIDAR (OMRON)
The appearance (2)

Stereo Camera
(LEXUS / TOYOTA)

Stereo Camera
(SUBARU)

Monocular Camera
(TOYOTA)
Collision Forecast Technology (Example)

Algorithm based on Millimeter-wave Radar

Forecast a Collision from the TTC (time to collision) and in the lane or not

① Time to Collision \( \leq \) Approx. 1 sec
\( (=D \div \text{Relative Speed}) \)
AND
② Lateral Distance \( \leq \) Vehicle Width + \( \alpha \)
\( (=D \times \tan \theta) \)

(Curve Detection)

(Course Prediction)

Position at Every Sampling

Steer Angle

Yew Rate

Obstacle

Distance: \( D \)

Obstacle

Direction: \( \theta \)

Lateral: \( L \)

Going Lane
C. Hierarchy and Decision Control

>TTC (Time to Collision)

Exist Danger of Collision | Unavoidable Condition | Collision

Hierarchy of Operation (Priority)

High

Expanded Area

ABS

Driver

AEBS

Must Initiation

ABS

AEBS

Driver

>AEBS equipped vehicle must have ABS.
> In case of unavoidable condition, AEBS has priority over the driver.
> In case of expanded area, eliminate obstruction of driver's avoiding maneuvers.
d. Braking and Driver Information

(1) Initiation Timing of AEBS

Basic Concept

The initiation timing of AEBS should be the case that a collision can not be avoided by the driver or the case that the possibility of the collision is judged high. In other cases, because there is possibility of interference with the driver’s maneuver, the AEBS should not be activated.

Effect to the Driver when the initiation timing of AEBS is not reasonable.

Interference with the Driver’s avoiding maneuver
  => Nuisance System
  => Obstruction of Driver’s avoiding maneuver

Estimated Case (for example)

When the subject vehicle overtakes the forward vehicle which speed is low by changing the lane, Mitigation Brake works and the subject vehicle can not overtake the forward vehicle. Additionally there may be a dangerous that the following vehicle collides the subject vehicle
Driver’s Avoiding Maneuver

1) Brake
2) Steer

1) Braking for Speed Reduction
2) Steer to different direction

AEBS Initiation Area (’03 First Step)

- There is possibility of interference with the driver’s maneuver.
- Interference with the driver’s maneuver could be ignored

Limit of Avoidance by Braking
Deceleration = Maximum constant

Limit of Avoidance by Steering
TTC = constant

Must AEBS Initiation Area

Japanese Technical Guideline = 0.8 sec
(Basic System)
Enhance the Damage Reducing Effect (Second Step Consideration)

- There is interference with the driver’s maneuver.
- There is not possibility of interference with the driver’s maneuver at usual condition.
  > Eliminate Obstruction of Driver’s avoiding maneuver
  > Eliminate Nuisance or False Braking
- Interference with the driver’s maneuver could be ignored.
(2) Deceleration and Speed reduction

Actual Case Study

TTC (Time to Collision)

Unavoidable Condition

= 0.8 sec

Exist Danger of Collision

Must Initiation

Collision Warning and Event Preparation

Effort to Earlier Initiation
(Enhance Damage Reducing Effect)

AEBS Initiation

Depend on Characteristic of Brake Actuator

Target Deceleration

Vehicle Deceleration

Rectangular: Speed Reduction

Computing Time
For Collision Forecast

Actuator Response Time

Brake Line Pressure

Pad Clearance

Japanese Technical Guideline for Target Deceleration

Peak Deceleration > 3.3 m/s^2
## Driver Information

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Audible</strong></td>
<td>- Warning sound</td>
</tr>
<tr>
<td><strong>Visual</strong></td>
<td>- Warning indication in the instrument panel</td>
</tr>
<tr>
<td><strong>Haptic</strong></td>
<td>- Warning braking</td>
</tr>
<tr>
<td></td>
<td>- Seat belt retraction</td>
</tr>
<tr>
<td></td>
<td>- Vibration of steering wheel</td>
</tr>
<tr>
<td></td>
<td>- Vibration seat, Active pedal</td>
</tr>
</tbody>
</table>
Collision Warning and Event Preparation

**Actual Case Study**

TTC (Time to Collision)

Exist Danger of Collision

Collision Warning

Collision Warning and Event Preparation

AEBS Initiation

Consider Driver Response Time
Japanese Technical Guideline $> 0.8$ sec

Earlier Warning is effective for the Collision Mitigation. However the nuisance or false Warning must be eliminated.
END

Thank you for your attention.