DEVELOPMENT OF PRE-CRASH SAFETY TECHNOLOGY FOR LARGE TRUCK

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ABSTRACT

As one of the key technologies to improve safety of large trucks, pre-crash safety technology (PCS) was studied. PCS is the system which automatically activates brake when a collision is unavoidable.
From the accident analysis, it was found that collision to the stationary vehicles and accidents on expressways shall be considered in the study. To cope with the accidents on expressways where collision speeds are usually high, the PCS system needs to detect the objects and apply brake from a long distance. To achieve this, sensor shall be tuned to enable the sensing from long distance, however, generally this can result in difficulties to clearly divide real objects on the road and something on the road side especially at curves. If we can limit the activation of the system only on expressways, there is possibility that this can be improved. Because on the expressways, traffic lanes are wider and thus road side objects are a little far from the center of the traffic lane, and radius of curves are more than certain value. Activation timing of the brake shall be decided so that the driver does not place too much trust in the system. For this reason, the brake shall not be activated when there is certain possibility that the collision is avoidable.

INTRODUCTION

Fatal accidents on which large trucks are responsible, rear-end collisions to passenger cars are most common. Over the half of this rear-end collisions occurred on expressways and usual cause of the accidents are large truck driver's not looking ahead carefully or misjudgment.
To reduce the rear-end collisions, distance warning system and adaptive cruise control system which keeps safety distance to the preceding vehicle were developed and put into practical use.
In case that the collision is not avoidable, systems which reduce collision speed and mitigate the damage to the passenger cars are desirable. Impact energy of the large truck is big because of the vehicle mass and if we could reduce the impact speed, it can result in large reduction of impact energy and can mitigate the damage considerably.

ACCIDENT ANALYSIS

Based on the accidents statistic data of the year 2002, fatal accidents on which the large trucks are responsible were analyzed. Here large truck is with the GVW of more than 8 tons and number of fatalities includes only the death within 24 hours after the accidents. In large trucks to four wheel vehicle accidents, rear-end collision is most common and it accounts for 59% (See figure 1).

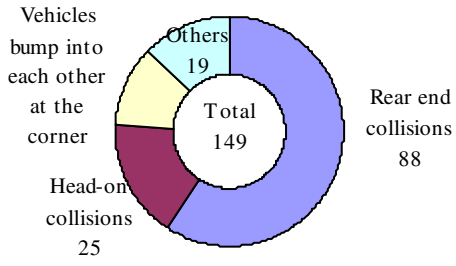

Figure 1. Fatalities in large trucks to four wheel vehicle accidents responsible to large trucks (in 2002)

Within the rear-end collisions, fatalities in passenger car occupants make up the largest shear. The most common case is the ones that the stationary cars are hit from behind (See figure 2). When classified by road types, almost 50 % of the rear-end collision occurred on expressways (See figure 3). Fatality rate of passenger car occupants in rear-end collision on expressways is eight times higher compared to that of on general roads.

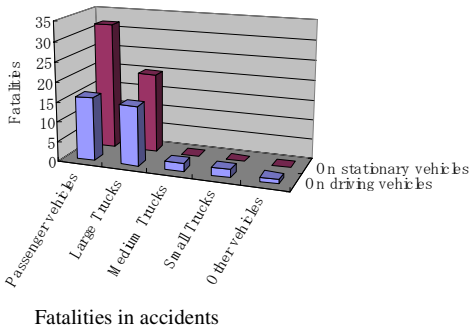

Figure 2. Fatalities in rear-end collisions (in 2002), classified by stationary and on driving vehicles.

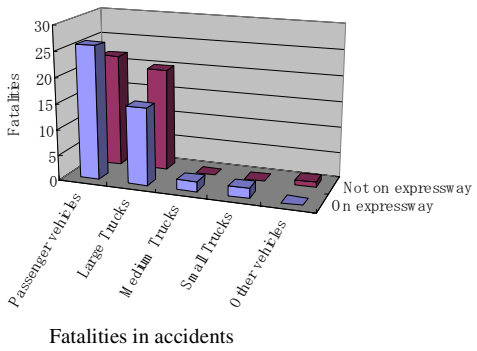

Figure 3. Fatalities by rear-end collisions (in 2002), classified by on highway and not on highway.

Figure 4 shows one example of accidents where a large truck collided to the rear of passenger car. Eleven vehicles were involved and four persons in passenger cars died. Accidents of large truck have possibility to result in loss of many lives and loss of economic activities. It is strongly desired to reduce these accidents or reduce damages in these accidents.

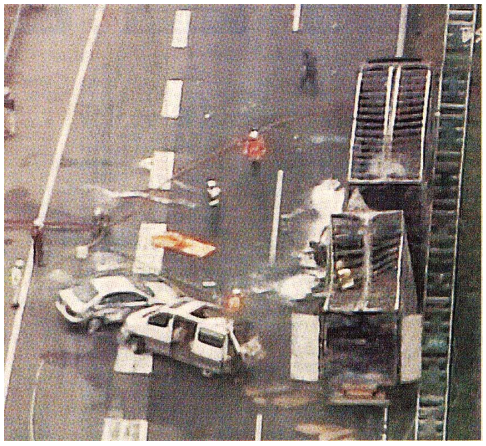

Figure 4. One example of accidents; large truck collided to passenger cars on a highway (quoted from Asahi Shinbun)

From the accident analysis above and general understanding of the operation of the large trucks, it was concluded that the following points shall be considered in the study of PCS for large trucks.

1) Collision to stationary vehicle
2) Rear-end collision on expressways

OBSTACLE DETECTION

When the system targets the activation of the brake with stationary vehicle ahead, obstacle detection technology which can clearly separate the objects on the road and road side objects is the key. If the target of the system is just the moving preceding vehicle ahead, it is easy to separate it from the road side objects, by utilizing the speed of own vehicle and exclude the road side objects as objects which have relative speed equal to the vehicle speed. In case we need to treat stationary vehicle, development of new algorithm to detect only the objects on the road is necessary. An example of unwanted detection occurs when there are reflectors and other road side objects on curves. One idea to cope with this example is to use yaw rate of the vehicle and estimate the curvature of road ahead and add the information to the object detection algorithm.

To cope with the accidents on expressways where collision speeds are usually high, the PCS system needs to detect the objects and apply brake from a long distance. To achieve this, sensor shall be tuned to enable the sensing from long distance, however, generally this can result in difficulties to clearly divide real objects on the road and something on the road side. If we can limit the activation of the system only on expressways, there is possibility that this can be improved. Because on the expressways, traffic lanes are wider and thus road side objects are a little far from the center of the traffic lane, and radius of curves are more than certain value. To maximize the effectiveness of PCS system, study of how to extend the distance of obstacle detection shall be continued.

Some ideas to separate the stationery objects on the road and road side objects are to add the image processing, or to obtain information of road ahead from navigation system.

BRAKE CONTROL

Activation timing of the brake shall be decided so that the driver does not place too much trust in the system. For this reason, the brake shall not be activated when there is certain possibility that the collision is avoidable. Figure 5 shows the guideline of brake activation in the system in Japan. In the guideline, the brake can only be activated when the collision cannot be avoided neither by braking or steering maneuver.

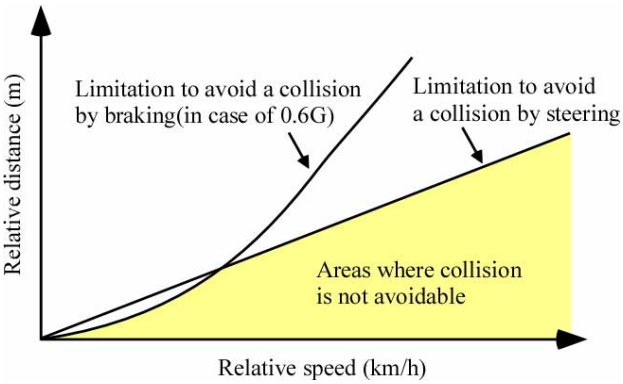

Figure 5. Guideline for brake activation

CONSIDARATIN ON SENSORS

Table 1 shows comparison of sensors for object detection. For PCS system, millimeter wave radar must be the current choice because of its environmental robustness compared to infrared laser sensor.

Table 1.
Comparison of sensors

Items	Infrared raser sensor	Millimeter wave radar	Imaging sensor
Detectable objects	Laser reflector or Assembly of tail lights	Mainly metals	Edges of contrast on the screen
Maximam distance of detection	≥120m	≥150m	30m - 60m
Detectable maximam relative speed	≥100km/h	≥100km/h	≤100km/h
Environmental robustness	↓Fog Rain Light snow	↓Fog ↓Rain ↓Light Snow	

SYSTEM CONFIGURATION

Figure 6 shows an example of Pre-crash safety system configuration. Components of the system are millimeter wave radar for object detection, yaw rate sensor for vehicle movement information, computer for estimation of possibility of collision, human machine interface for warning to driver, and Electronic brake system for braking.

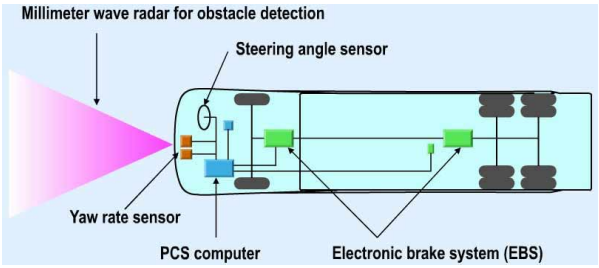

Figure 6. System configuration

CONCLUSION

Pre-crash safety technology for large truck was studied and following points became clear.

1) From the accident analysis, collision to the stationary vehicle and accidents on the express way shall be considered to have effective system.
2) For obstacle detection, development of ways to separate objects on the road and road side objects is the key. Millimeter wave radar together with yaw rate sensor can improve the accuracy to certain extent. If we can limit the activation of the PCS system only on the expressway, obstacle detection can have better performance.
3) Activation timing of the brake shall be decided so that the driver does not place too much trust in the system. Influence to the stability of the vehicle shall be also considered.

Accidents of large trucks can result in many loss of human lives and loss of economic activity. Prevention of the large truck accidents is highly expected. However, human error can not be perfectly eliminated. From this point of view, technology which mitigates the damage in case of accident is necessary. The pre-crash safety technology is a key technology to mitigate damage in large truck accident. Development of safety technology to prevent the occurrence of accidents and to minimize the damage in accidents shall be continued until the accident free society would be finally realized.