

Final report of ASV-3 (Summary)



Kenji WANI

Road Transport Bureau

Ministry of Land, Infrastructure and Transport, Japan

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- Main technical issues
 - Consideration of technical guidelines for introduction of autonomous ASVs (Attachment 1)
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- Future direction

1. Outline of the final report

(1) What are Advanced Safety Vehicles (ASVs) ?

- ASVs are highly intelligent vehicles which **enhance driving safety** through state-of-the-art technologies such as electronics
- ASVs aim to prevent the driver making mistakes and reduce the number of fatal accidents

ASV project has been promoted through mutual cooperation of government, academia and industries.

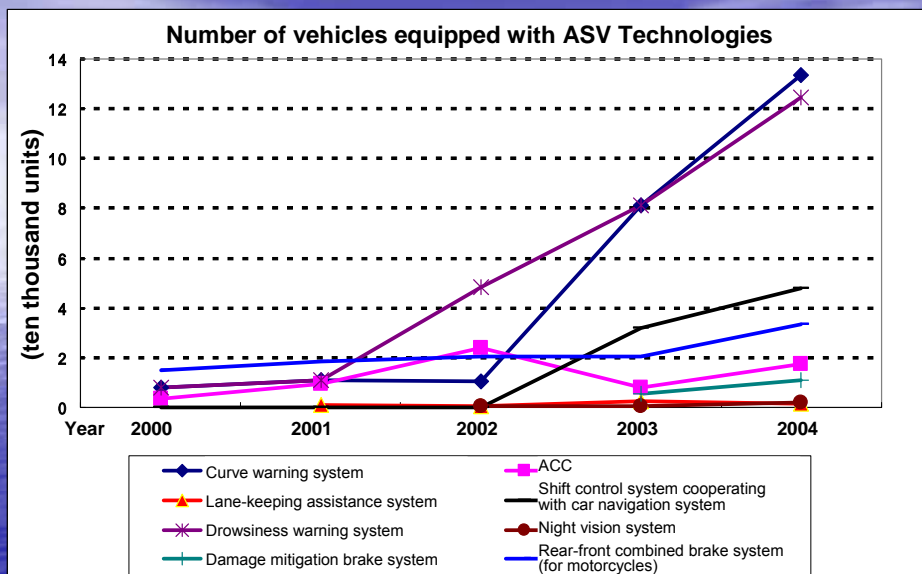
(2) Phase 1 to Phase 3 of the ASV Project

| | Phase 1 | Phase 2 | Phase 3 |
|-------------------------------|---|--|--|
| Implementation Periods | FYs 1991–1995 | FYs 1996–2000 | FYs 2001–2005 |
| Objectives | Verification of technological potential | Research and development for commercialization | Promotion of popularization Development of new technologies |
| Target of Vehicles | Passenger cars | All types of vehicles (passenger cars, trucks, buses, and motorcycles) | All types of vehicles (passenger cars, trucks, buses, and motorcycles) |
| Technologies Area | ASV systems (autonomous system) | Autonomous system Coordination with road infrastructure | Autonomous system Inter-Vehicle communication Coordination with road infrastructure |

(3) Output from the Phase 3 of ASV Project

- Promotion of popularization
 - Establishment of the Driver Assistance Concept and guidelines base on design principles
 - Arrangement of common names of ASV technologies for public information
 - Activities for public information on ASV project
- Development of new technologies
 - Development of driver assistance systems cooperated with road infrastructure
 - Development of inter-vehicle communication driver assistance systems

ASV Technologies in Japanese market



2. Technical issues (1) Consideration of technical guidelines for introduction of autonomous ASVs - attachment 1 -

the Design Principles of ASV

- Driver Assistance
 - ASV technologies should understand driver's wills and support their safe driving based on the concept of driver responsibility.
- Driver acceptance
 - ASV technologies should be easy to use and be trusted by drivers. This means that a human-machine interface design should be appropriately implemented.
- Social acceptance
 - ASV technology-equipped vehicle must operate with unequipped vehicles and pedestrians. Therefore, we must consider how to obtain proper understandings of the public.



The Concept of Driver Assistance
(8 items) was developed

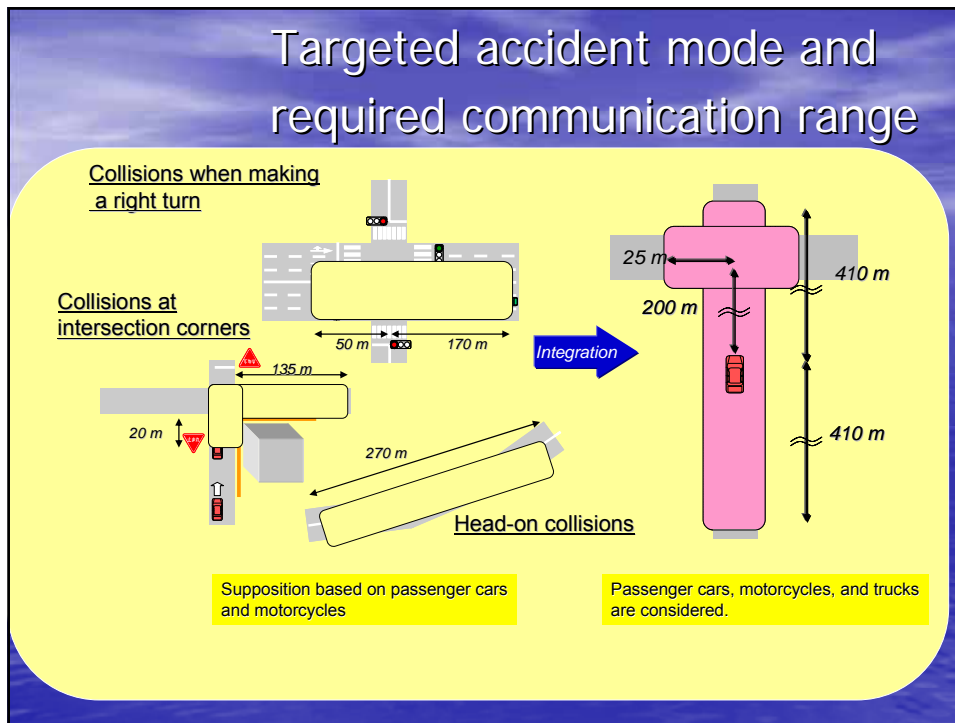


Application to the technologies
for the market

2. Technical issues (2)
Inter-Vehicle communication
for collision avoidance
- attachment 2 -

- Procedure to formulate “concept specifications of inter-vehicle communication for collision avoidance.”
 - Accident analysis study
 - Required communication range
- Verification and results of trials
 - Result of verification test in trial field

Targeted accident mode and required communication range



3. Future Direction

Project Title

Phase 4 ASV Promotion Project

Items

Promotion of popularization :

1. Assessment of the effectiveness of ASVs.
2. Information & experiences for drivers on ASVs.
3. Study on measures for promoting ASVs
(- Measures including incentives
- Promoting application to heavy duty vehicles)

New technologies:

1. Development of inter-vehicle communication type driver assistance systems
2. A comprehensive safety strategy utilizing communication technologies.

Goals

Promotion of popularization of ASVs:

Full-scale introduction of autonomous detection type driver assistance systems

New technology development

Introduction of some inter-vehicle communication type driver assistance systems

Project Period

5 years from FYs 2006 to FYs 2010

Report on Activities to Promote Popularization of ASVs ~ Study from the Technological Perspective (extract version) ~

Toshiaki Matsumoto

Leader, Task-Specific Working Group,

Special Group of the Subcommittee on Guideline for Commercialization,

Study Group for Promotion of the Advanced Safety Vehicle, Phase 3

Contents:

The Concept of Driver Assistance

Study of Guidelines for the Commercialization of Damage Mitigation Braking System

Study of Expanded Operational Range for Damage Mitigation Braking Systems

Study of the Concept of Full Speed Range Adaptive Cruise Control System (FSRACC)

Study of Considerations for Vehicles Equipped with Multiple ASV Control Systems

The Concept of Driver Assistance

1. Background to Study of the Concept of Driver Assistance

The sophistication of driver-assistance (control) technologies now makes it possible to allow the system (the vehicle) to perform some driving actions previously performed only by the driver. In order for that to occur, it is necessary to clearly differentiate the roles that the driver and the system should play in order to secure and enhance safety.

Having established the necessity of the principle of driver assistance, driver acceptance, and social acceptance as basic design principles, the ASV-2 Project has proceeded with plans for the development and subsequent spread of ASV technologies based on these principles.

In the course of commercializing ASV technologies, the principles should be further refined as detailed guidelines. It is necessary to examine basic considerations to deal with, for example, the problem that a driver's excessive dependence on advanced systems might compromise safety.

Therefore, we have embodied the concept of driver assistance in the form of detailed guidelines for ASV design principles.

2. Drivers, Systems and Society

A driver who is operating a vehicle is required by society to follow traffic safety rules. Accordingly, it must be kept in mind that vehicle safety cannot be achieved without drivers accepting responsibility for it. Given this principle, the results of a study into the relationship linking the driver, the system, and society are summarized in Fig. 1.

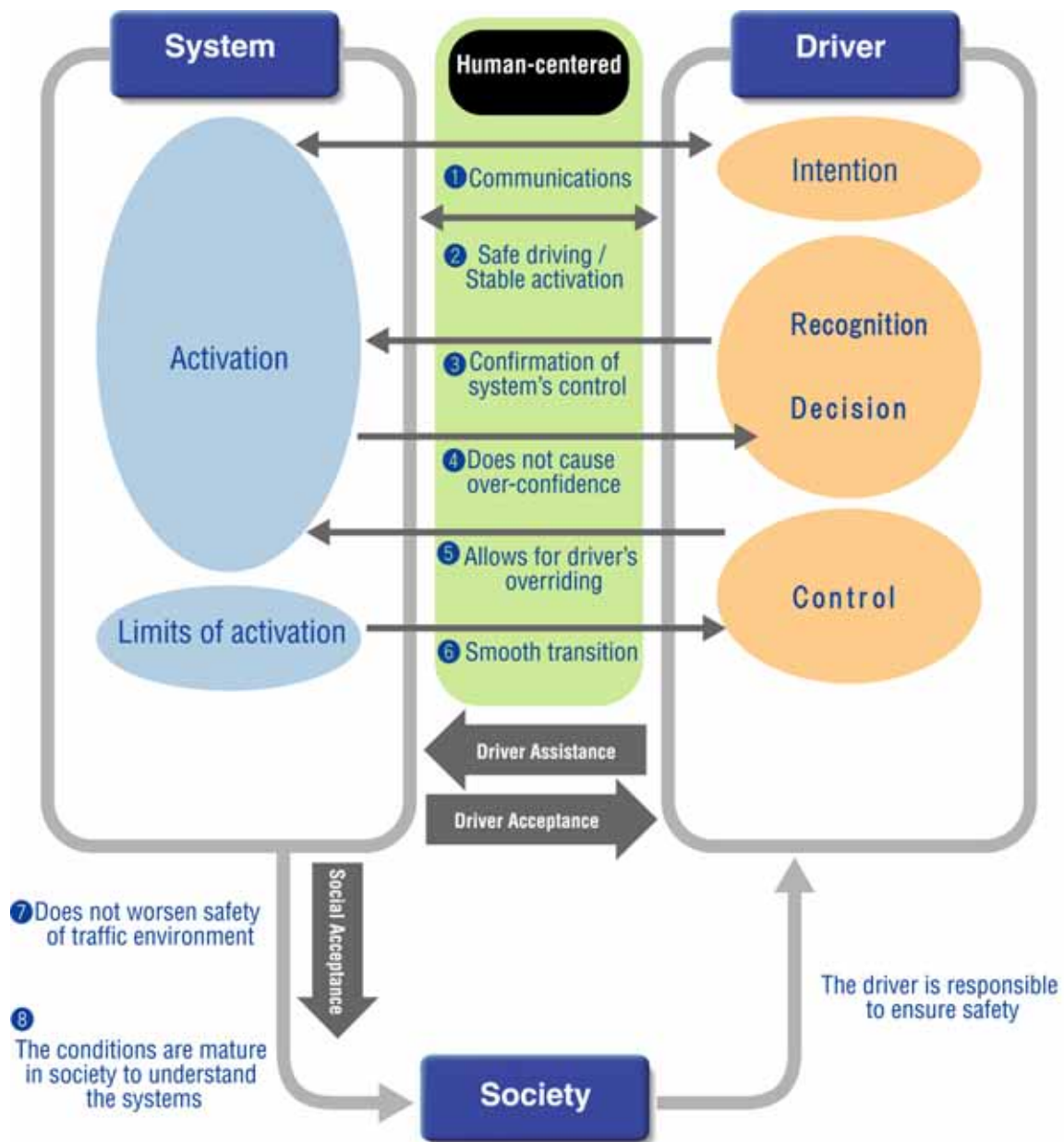


Fig. 1. The Driver, the ASV System and Society

In order for a driver to rely on the driver-assistance system without worry, the relationship between the two must be kept effective; i.e., (1) there must be two-way communication of intent between the driver and the system, and (2) the system must provide assistance in a safe and steady manner.

However, because there is no guarantee that the system will operate perfectly in all cases, (3) the driver must monitor system operation and, conversely, (4) the system must not engender overtrust or distrust in its capabilities that would interfere with such monitoring, i.e., the system must gain an appropriate level of trust.

Meanwhile, (5) the driver must intervene in the system’s operation as necessary, and (6) the system must transfer operational control to the driver when it recognizes its operational limits. Regarding the relationship between the system and society, (7) naturally the system must not compromise safety. However, (8) because advanced systems need some time to gain social acceptance, the gradual progress of current technologies will facilitate the process of winning public acceptance.

3. Categorization of ASV Technologies

As shown in Fig. 2, ASV technologies can be categorized in terms of driver intervention, system operation and controls.

| | | Braking System | Accelerator | A + B | Steering Wheel | A + B, S | A + B + S |
|---|-----------------|----------------------------------|-------------|-------|----------------|----------|-------------------|
| Driver intervention required | Partial | | CC | ACC | LKA | | |
| | Continuous | | | LSF | | | |
| Driver intervention not required | In an emergency | ABS | | VSC | | | |
| | Continuous | Damage mitigation braking system | | TRC | | | |
| | | | CBS | | | 4WS | |
| Reference: Reducing force exerted by driver | | Brake booster | AT | | Power steering | | |
| | | | | | | | Automatic driving |

Shaded areas indicate technologies already commercially available.

- A = accelerator
- B = braking system
- S = steering

Legend:
 CC: Conventional cruise controls (commercially available)
 ACC: Commercial ACC (commercially available)
 LSF: ACC operational in the low-speed range (bumper-to-bumper traffic)
 FSRACC: ACC operating at all speeds (seamless control from low speed to high speed)
 ABS: Antilock-braking systems (commercially available)
 4WS: Four-wheel steering (commercially available)
 LKA: Lane-keeping assistance (commercially available)
 VSC: Enhanced vehicle-stability control within operational limits (commercially available)
 TRC: Traction control (commercially available)

Fig. 2. Categorization of ASV Technologies

ASV technologies can be categorized in terms of controls, namely accelerator (A), braking system (B), and steering (S); ASV technologies or a combination of technologies for these components have already been introduced.

ASV technologies can also be classified according to systems operation. Some ASV technologies are designed to function in an emergency while others are intended to function continuously or partially under specified conditions. The introduction of emergency technologies has progressed, and technologies that function continuously are now very close to technologies that function in an emergency. Technologies that function partially are used solely on expressways.

In regard to whether driver intervention is needed or not, ASV technologies can be classified into driver load reduction technologies and accident avoidance technologies. Driver load reduction technologies, which have indirect safety effects by helping a driver to alleviate fatigue and stay attentive by performing some of the actions that normally would be performed by the driver, can be regarded as requiring driver intervention.

Automatic-driving technologies aim to allow the vehicle itself to secure safety on behalf of the driver through a combination of accident avoidance and driver load reduction technologies. However, it is difficult to produce such systems with current levels of technology.

As mentioned earlier, existing technologies can be classified roughly into three groups: accident avoidance technologies, driver load reduction technologies, and automatic-driving technologies. Because automatic-driving technologies are still some years away from commercialization, they are excluded from consideration in the discussion here about the concept of driver assistance.

4. Eight Requirements of the Driver Assistance Concept

Given the above, the following eight requirements of the driver assistance concept must be considered in designing driver assistance technologies. It should be noted that the driver's responsibility for safe driving is the most fundamental factor in designing driver assistance technologies and, needless to say, it is required by society.

(1) Driver load reduction technologies

- (a) When the system is in operation, it must confirm the driver's intent or aim.
- (b) The system must assist the driver in operating the vehicle safely.

- (c) The driver must be able to confirm the details of assistance provided by the system.
 - (d) The system must be designed so that it will engender the appropriate level of driver trust without inducing overdependence or distrust.
 - (e) The driver must be able to override the control being performed by the system.
 - (f) If the system exceeds its limits of assistance, it must smoothly transfer control to the driver.
 - (g) The activation of the system must not compromise safety.
 - (h) Groundwork must be done to gain public acceptance of the system.
- (2) Accident avoidance technologies
- (a) The system must provide assistance in line with the driver's intent.
 - (b) The system must assist the driver in operating the vehicle safely.
 - (c) The driver must be able to confirm the details of assistance provided by the system.
 - (d) The system must be designed so that it will engender the appropriate level of driver trust without inducing overdependence or distrust.
 - (e) When the driver operates the vehicle in a safer manner, the driver's actions must override control by the system.
 - (f) If the system exceeds its limits of assistance and if there are actions that should be performed by the driver, the system must smoothly transfer control to the driver.
 - (g) The activation of the system must not compromise safety.
 - (h) Groundwork must be done to gain public acceptance of the system.

5. Examples Relating to the Eight Requirements of the Driver Assistance Concept

Specific examples are presented below in order to provide a better understanding of the eight requirements of the driver assistance concept.

It should be noted that these examples are representative only, and some systems that use other principles might also be able to maintain safety. The validity of the examples should be examined on the basis of the outcome of future research or the performance of products introduced in the market.

- (1) Driver load reduction control
- (a) When the system is in operation, it must confirm the driver's intent or aim.
To meet this requirement, the system is designed so that:
 - It can be operated by the driver using an on/off switch
 - It can be operated by controls set by the driver
 - (b) The system must assist the driver in operating the vehicle safely.
The system is designed so that:

- Driver assistance does not exceed the limits of actions that the driver usually performs
 - It provides assistance in a steady manner that allows the driver to use the system with security.
- (c) The driver must be able to confirm the details of assistance provided by the system.
The system is designed so that:
- It provides visual, acoustic, and tactile signals that can be recognized by the driver.
- (d) The system must be designed so that it will engender the appropriate level of driver trust without inducing overdependence or distrust.
The system is designed so that:
- The range of driver assistance can be easily understood by the driver
 - If the range of assistance is exceeded, the driver can readily understand what to do
 - It leaves some continuous tasks, such as monitoring system operation and awareness of the traffic environment, to the responsibility of the driver
 - It does not perform all operations necessary to start the vehicle, accelerate, control the vehicle's movement, decelerate, and stop, leaving important operations such as starting the vehicle to the responsibility of the driver
- (e) The driver must be allowed to override the control being performed by the system.
The system is designed so that:
- If the driver acts to control a component that normally is controlled by the system in operation, the driver's action prevails
- (f) If the system exceeds its limits of assistance, it must smoothly transfer control to the driver.
The system is designed so that:
- If assistance is switched over to control by the driver, the timing and driving conditions of the switchover allow the driver to perform actions easily
- (g) The activation of the system must not compromise safety.
The system is designed so that:
- It prevents safety from declining to a level lower than that provided by vehicles not equipped with ASV technologies
- (h) Groundwork must be done to gain public acceptance of the system.
The system is designed so that:
- Levels of assistance are not excessively higher than those provided by conventional technologies
 - The range of assistance provided is easily understood by the general public

(2) Accident Avoidance Control – Example of Collision Damage Mitigation System

A collision damage mitigation system is presented here as an example of accident avoidance technologies. Requirements of such a system are described below.

- (a) The system must provide assistance in line with the driver's intention.
 - Applying the brakes to avoid imminent collision is an action that the driver should naturally perform for safety reasons. Accordingly, the collision damage mitigation system reflects the driver's intention.
 - In addition, the system must be designed so that it issues a warning to prompt the driver to take evasive action.
- (b) The system should assist the driver in operating the vehicle safely.
 - The collision damage mitigation system is intended to apply the brakes in order to alleviate damage from collisions, and therefore it enhances safety.
- (c) The driver must be able to confirm the details of assistance provided by the system.
 - Because the collision damage mitigation system allows the driver to detect whether the brakes are activated or not, it enables the driver to easily grasp the details of the assistance being provided.
- (d) The system must be designed so that it will engender the appropriate level of driver trust without inducing overdependence or distrust.
 - Because the collision damage mitigation system is intended to mitigate damage from collisions, the likelihood of overdependence is low.
 - The system will gain the driver's trust if it is designed so that the driver readily knows when and where the system will be activated.
- (e) When the driver can operate the vehicle in a safer manner than the system can, the driver's actions must override control by the system.
 - The system must be designed so that the driver's actions override control by the system if driver control is likely to promote safety.
 - The system must also allow the driver to avoid an accident by steering the vehicle.
- (f) When the system exceeds its limits of assistance and if there are actions that should be performed by the driver, the system must smoothly transfer control to the driver.
 - Because the collision-damage mitigation system is activated when a collision is unavoidable, there will be no circumstances that will require control to be transferred to the driver while the system is in operation.
- (g) The activation of the system must not compromise safety.
 - Because most traffic accidents are vehicle-to-vehicle collisions, a collision damage mitigation system that is highly effective in reducing damage from collisions is beneficial to society.
 - Because the collision damage mitigation system is intended to provide control in an emergency, it must be designed so that it helps to prevent other vehicles from being

involved in a collision.

(h) Groundwork must be done to gain public acceptance of the system.

- Because the collision damage mitigation system is intended to control the vehicle to alleviate collision damage, it will be able to gain social acceptance as long as the other requirements are met.

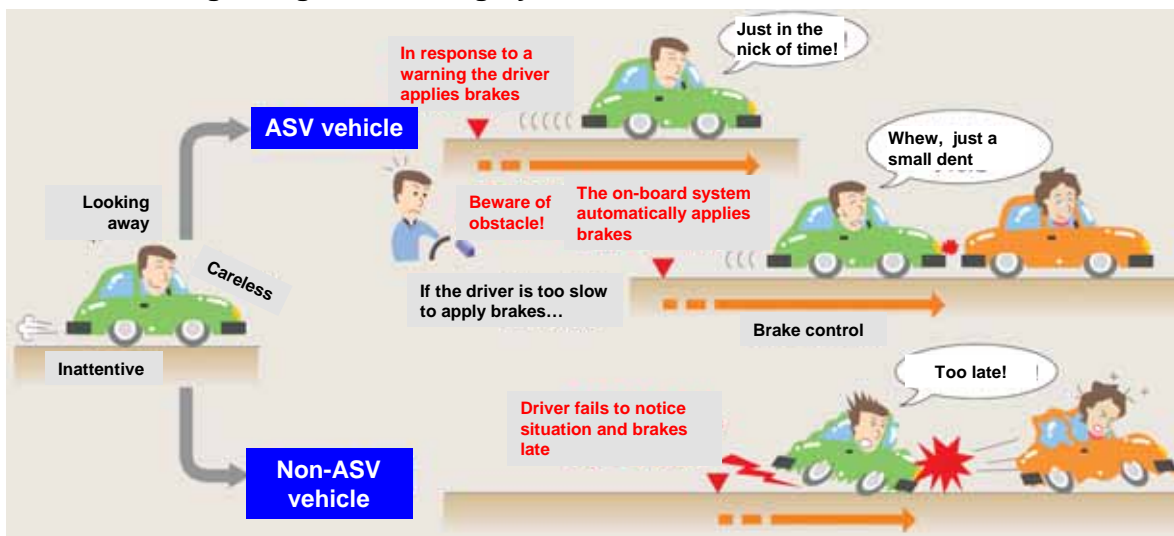
Study of Guidelines for the Commercialization of Damage Mitigation Braking System

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

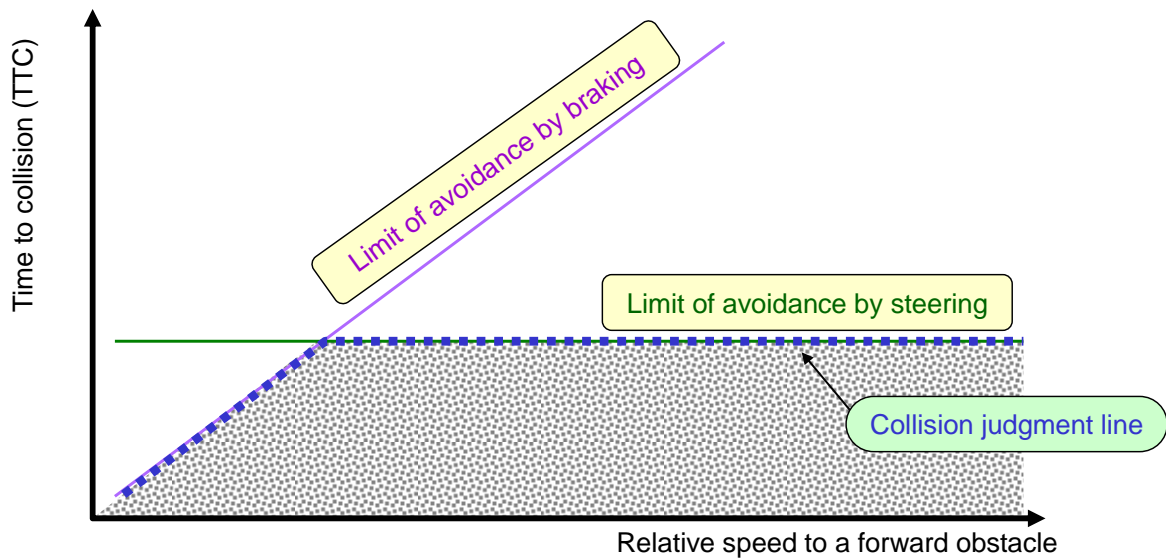
*This has been verified by a study of drivers dependence on ASV systems

2 . How Damage Mitigation Braking System Work



3 . Timing of Brake Control Start

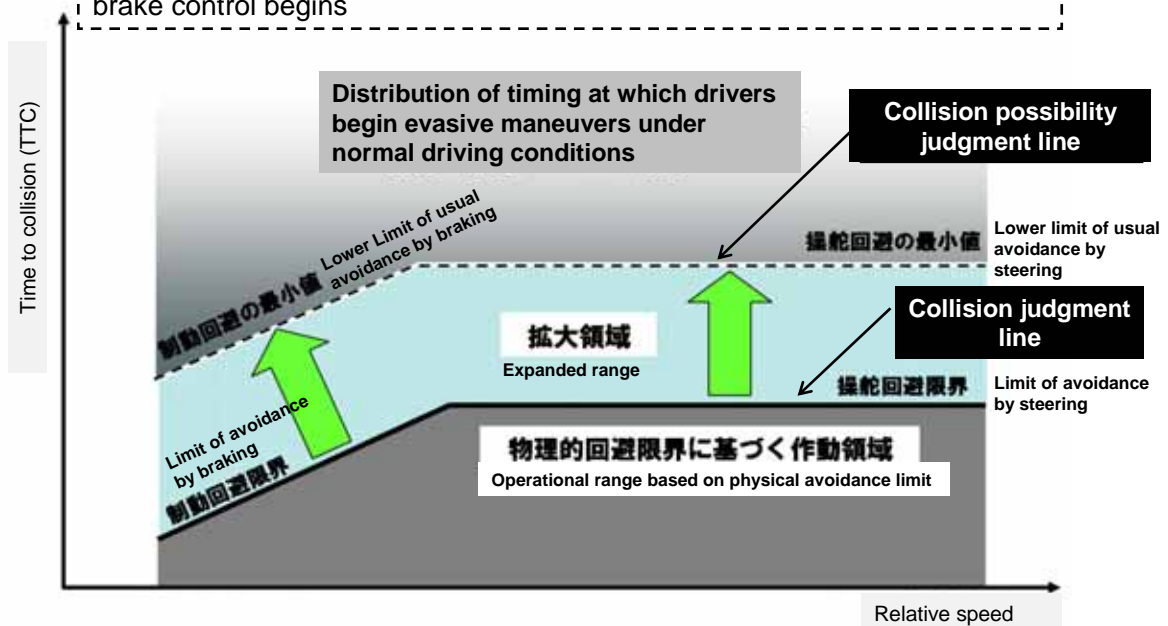
Brake control begins at the point the driver is unable to avoid a collision through either braking avoidance or steering avoidance (collision judgment line)



Study of Expanded Operational Range for Damage Mitigation Braking Systems

1 . Concept of Expanded Operational Range

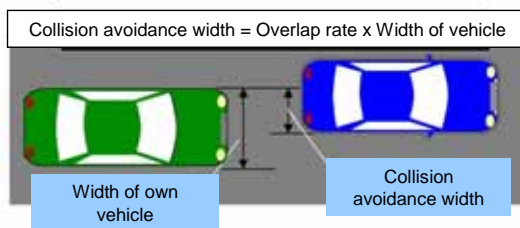
To enhance the damage-reducing effect, we examined how far the operational range can be expanded by bringing forward the timing at which brake control begins



2 . Approach to Expanded Operational Range

- If the damage mitigation braking system is timed to cut in later than the driver would take evasive action during normal operation, it will not interfere with the driver's evasive action
- Based on data on the timings of avoidance by braking and by steering under normal conditions, the minimum value of the timing distribution is established as the upper limit for the expanded operational range
- Based on data on changes in the timing of the driver's evasive action when an obstacle is a moving object and depending on the overlap rate*, a method of compensating for the "collision possibility judgment line" is formulated

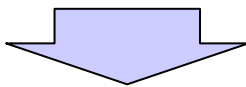
*Overlap rate: The extent to which the vehicle overlaps a forward obstacle.



The expanded operational range for heavy duty vehicles will be examined separately based on the principles applicable to passenger cars

3 . Timing of drivers' braking avoidance during normal operation

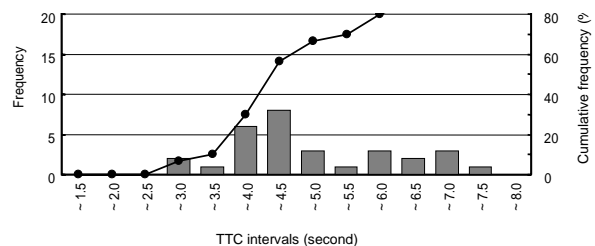
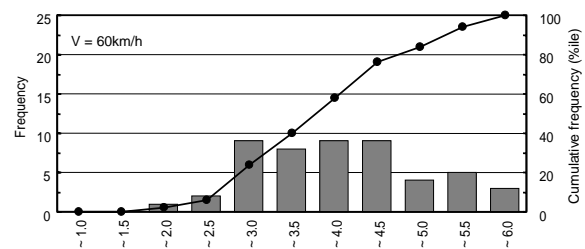
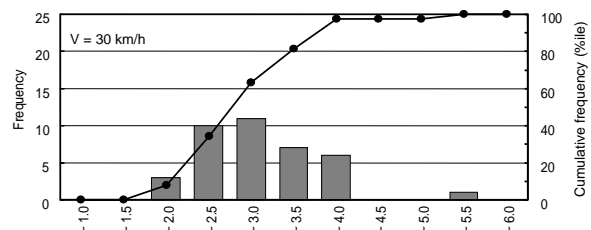
- Depending on the initial braking speed, the minimum TTC changes in a linear manner



The lower limit of usual avoidance by braking is set by a linear equation that does not fall short of any minimum TTC:

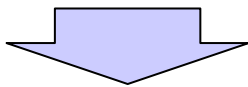
$$T = 0.0167 \cdot V_r + 1.00$$

T: TTC (second), V_r : Relative Speed (km/h)

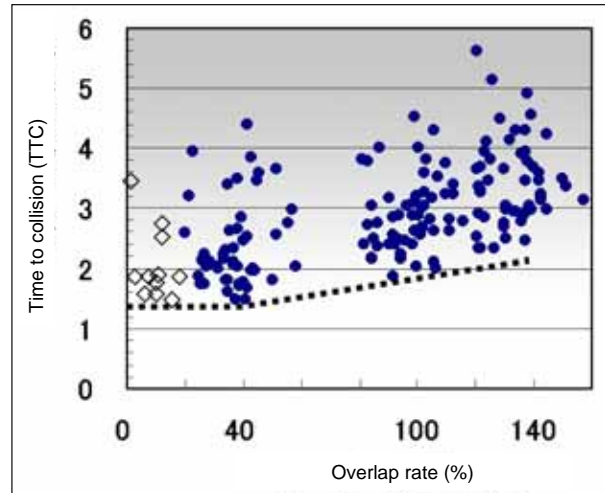


4 . Timing of drivers avoidance by steering during normal operation

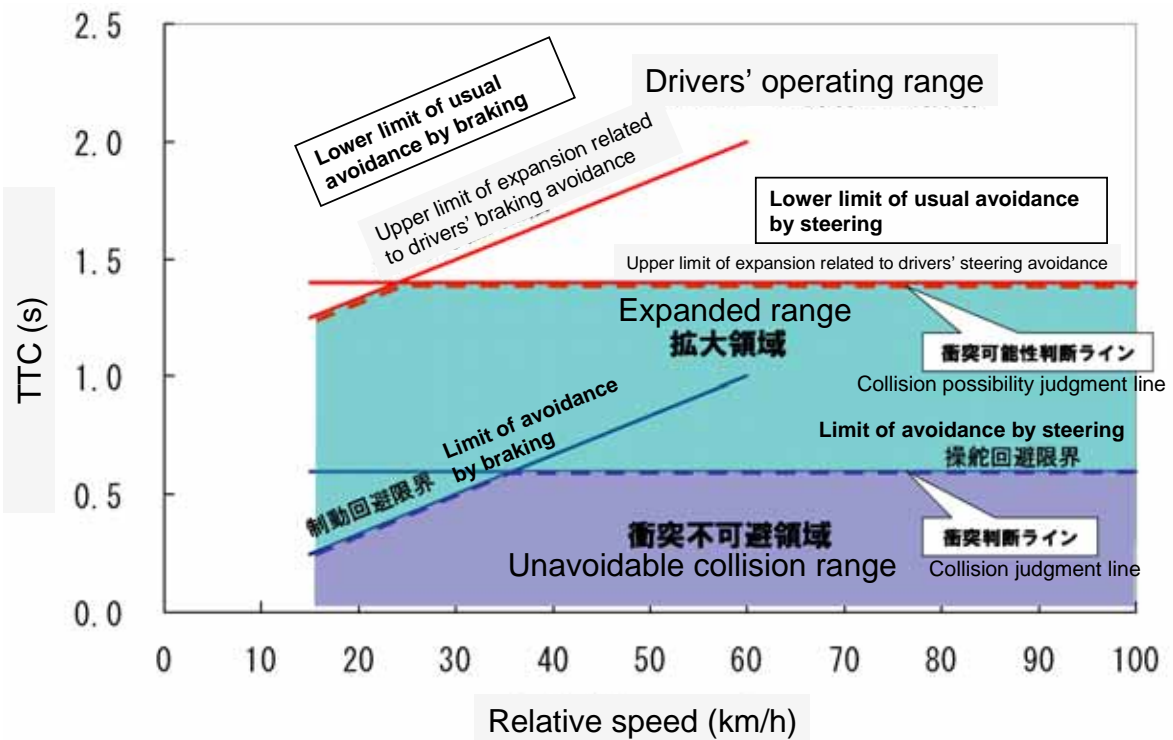
- The minimum value of avoidance timing, not affected by the overlap rate, is 1.4 seconds
- When the overlap rate ranges from 0% to 40%, the minimum value of avoidance timing is constant
- When the overlap rate exceeds 40%, the minimum value of avoidance timing increases in linear fashion



The lower limit of avoidance by steering is set at the minimum TTC of 1.4 seconds, which does not fall short of drivers' avoidance timing at any overlap rate



5 . Upper Limit Established for the Expanded Operational Range



6 . Testing Driver Dependence on ASV Systems

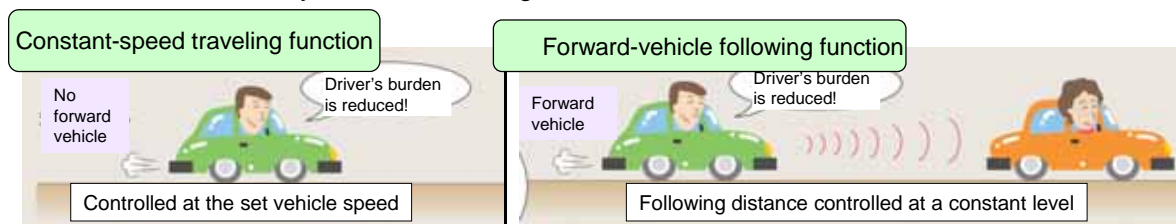
- Tests with driving simulator and actual vehicle
- If the system is designed so that its braking alone cannot avoid a collision, the driver is less likely to become dependent on it
- If the system is designed so that it will not interfere with the driver's evasive action, the driver is less likely to become dependent on it
- If the action of the system feels odd to the driver, he or she is less likely to become dependent on it

Study of the Concept of Full Speed Range Adaptive Cruise Control System (FSRACC)

1 . Concept of FSRACC

A system that:

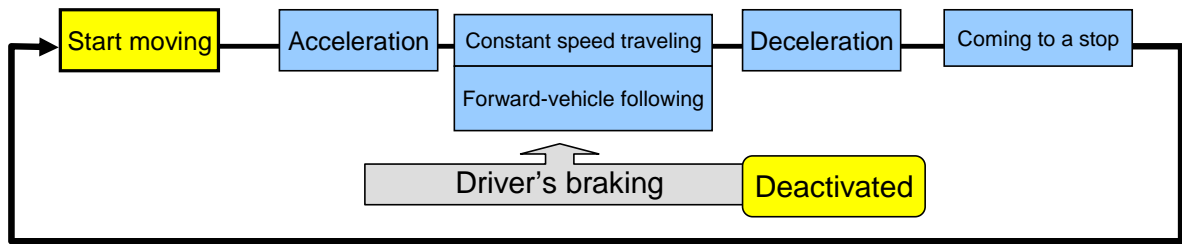
- Is capable of constant-speed traveling and following forward vehicles
- Operates in all vehicle-speed ranges including stopping range
- Is capable of stopping the vehicle in the stopping range and keeping it at rest
- Is capable of setting vehicle speed in the all vehicle-speed range for constant-speed traveling (however, the system does not need to be capable of setting vehicle speed in the low-speed range)
- In the forward-vehicle following mode, is capable of automatically switching from one target to another in the all vehicle-speed range
- Is designed to generally select four-wheeled vehicles as targets to follow
- Is deactivated by driver's braking action



2 . Considerations for FSRACC

In order to develop a system in line with the Concept of Driver Assistance:

- The system should not have the capability to automatically follow a forward vehicle that starts moving
 - ✓ Essential operating maneuvers are left in the hands of the driver
- The system should be designed so that it deactivated when the driver brakes
 - ✓ Compatibility with conventional ACC systems



System designed for use on expressways

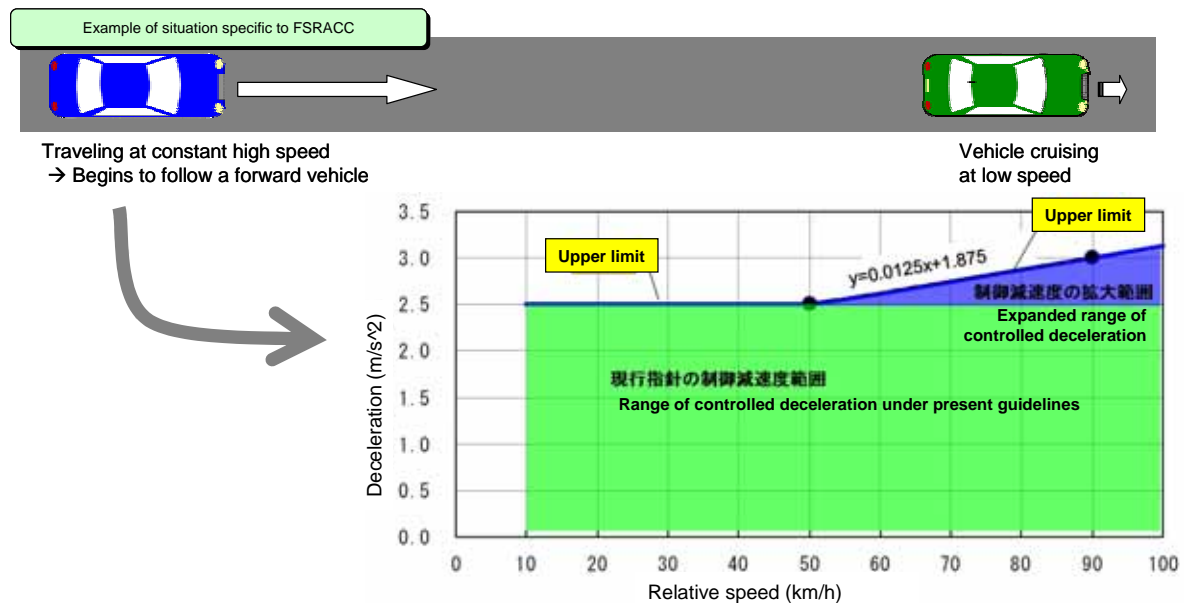
- System informs driver that it is for use on roads used exclusively by motor vehicles
- User is informed of danger of recklessly using system on ordinary roads

System designed for use on all kinds of roads

- Activation of the system does not result in violation of traffic rules
- System does not jeopardize the safety of pedestrians and cyclists
- System does not jeopardize the safety of vehicles at rest

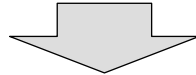
3 . Situations Specific to FSRACC

To deal with specific situations encountered while FSRACC is in operation, the upper limit of deceleration must be expanded



4 . Survey of the Effects of Functions of FSRACC on Driver Behavior

- Is it conceivable that while an FSRACC capable of stopping the vehicle and keeping it at rest is in service, the driver may become so careless that he/she is unable to take necessary action as the need arises?
- Using a driving simulator, a study was conducted to see if the driver is able to take proper action in response to changes in the situation, such as sudden braking by a forward vehicle
 - System that deactivates before the vehicle comes to a stop
 - System capable of bringing the vehicle to a stop
 - System capable of keeping the vehicle at rest



- Study found that all systems are properly operated in situations requiring driver action and FSRACC does not induce the driver to become less attentive in assuring safety



Study of Considerations for Vehicles Equipped with Multiple ASV Control Systems

1 . Study on Vehicle Equipped with Damage Mitigation Braking System with Expanded Operational Range and FSRACC

- Distinction between deceleration by the FSRACC and braking by the damage mitigation braking system
 - When one system switches over to the other, the FSRACC issues a warning regarding approaching objects or alerts the driver to the system limit, while the damage mitigation braking system sounds a warning, making it possible for the driver to identify which system is in effect
- Driver's response to sudden change from normal situation to emergency situation
 - A warning issued by the damage mitigation braking system must prevail in order to allow the driver to take quick action in response to a sudden change to an emergency situation
- Necessity for driver to be able to sense deceleration by either system
 - The damage mitigation braking system should be designed to decelerate more rapidly than the FSRACC

**Report on Technology Development Activities
~ Development of Inter-Vehicle Communication Type
Driver Assistance Systems (extract version) ~**

Yoshimi Furukawa

Leader of the Communications Technology Study Working Group

Subcommittee of Next Generation Technology,

Study Group for Promotion of the Advanced Safety Vehicle, Phase 3

Contents:

Main Items for Consideration

Positioning

Concept Study

Trials

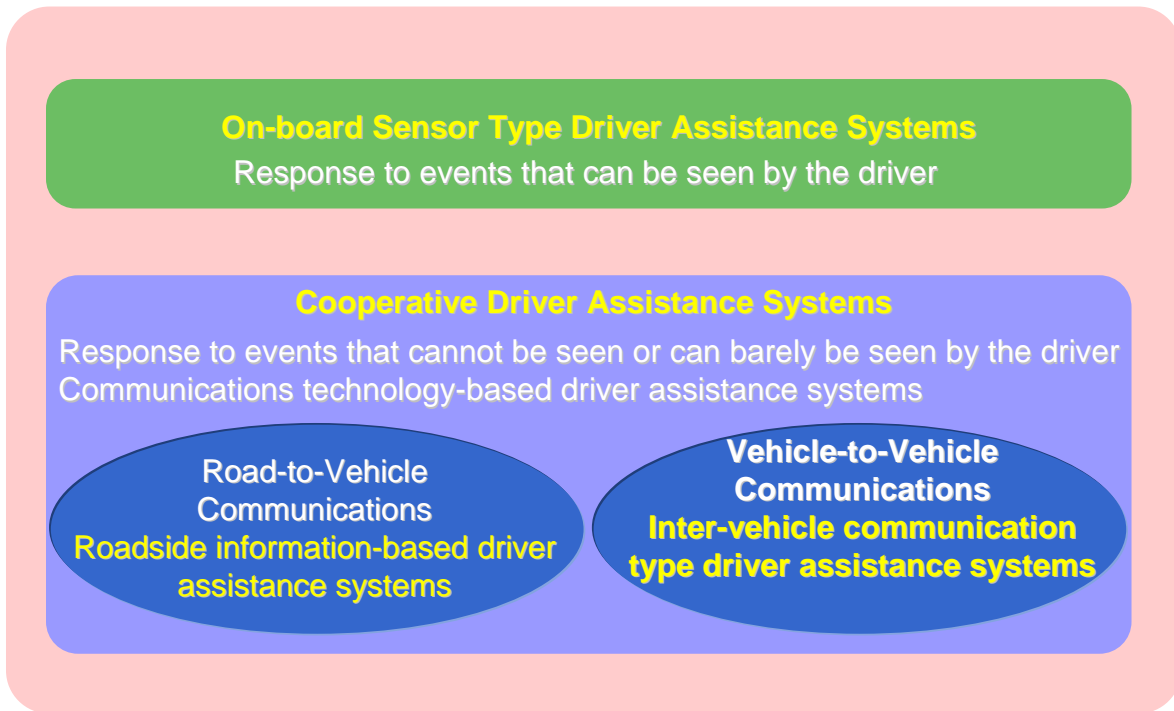
Main Items for Consideration

Promoting the development of driver assistance systems that enhance safety through an exchange of information among all road users including pedestrians

1. Role of Inter-vehicle communication type
driver assistance systems
2. Concept study
3. Summary of verification experiments and results
4. Public information activities
 - Demonstrations
 - International symposium

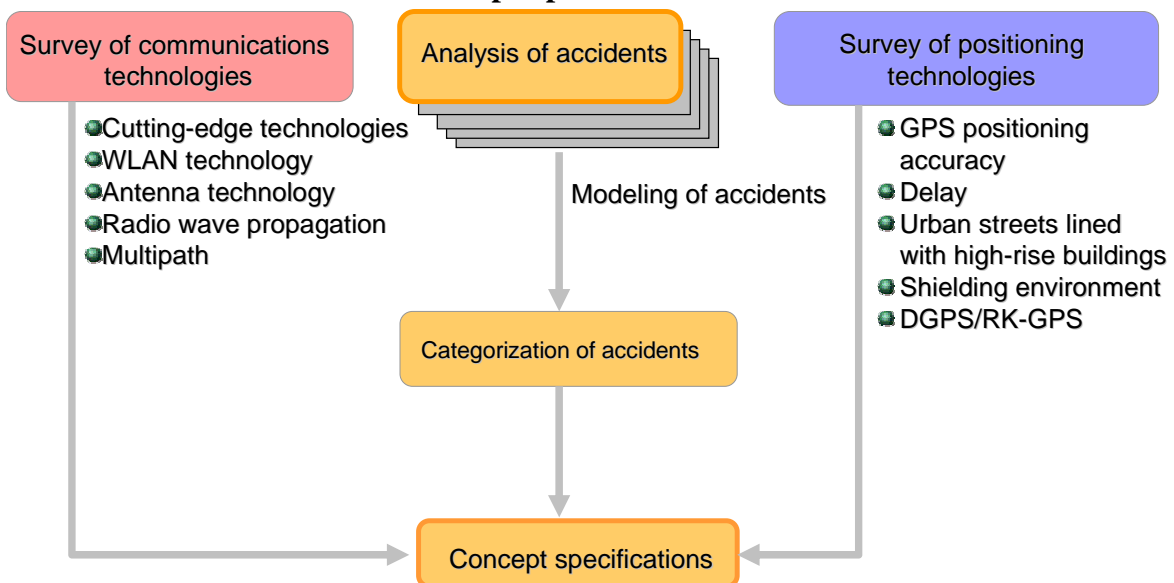
Positioning

1 . Role of Inter-Vehicle Communication Type Driver Assistance Systems

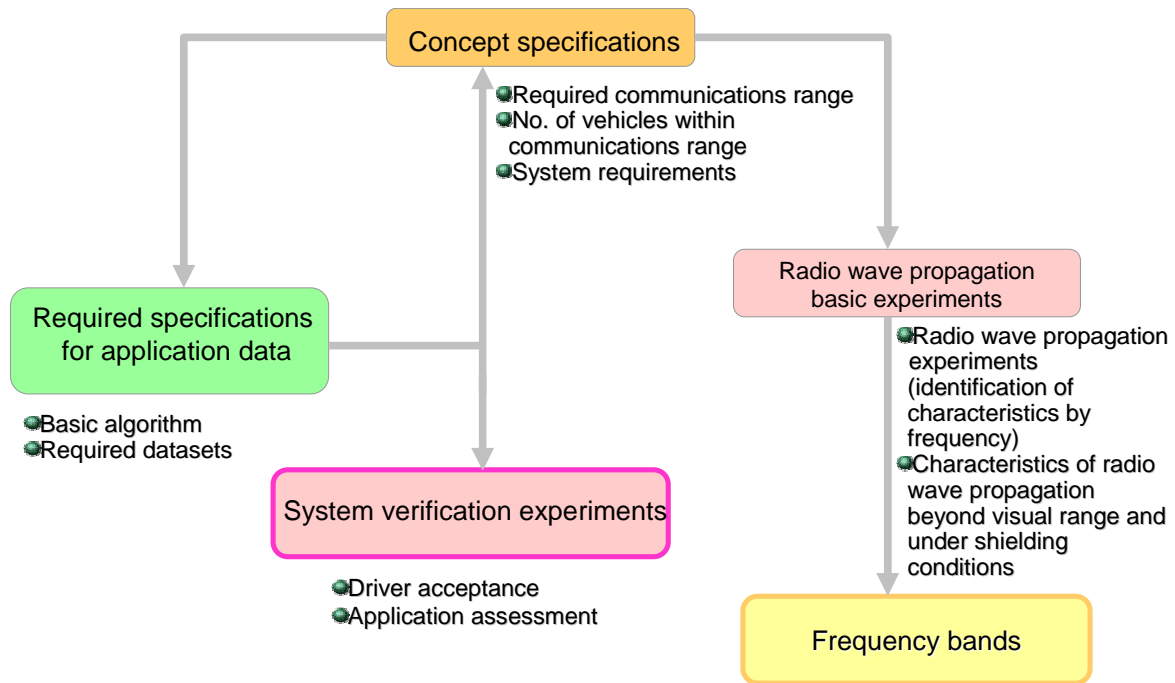


Concept Study

1 . Procedure to Formulate Concept Specifications

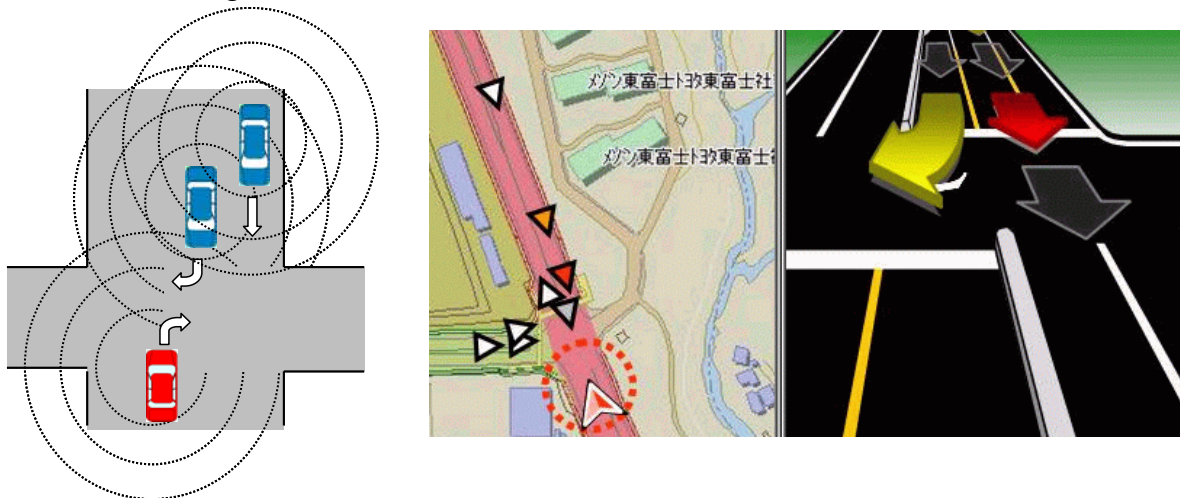


2 . Verification of Concept Specifications



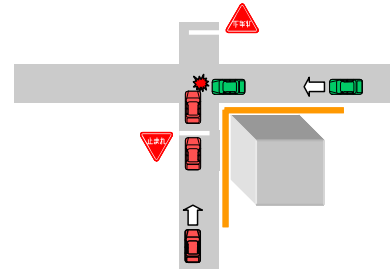
3 . Concept of Inter-vehicle Communication Type Driver Assistance Systems

- Each vehicle periodically communicates information on its speed, position and status
- Information from other vehicles allows the driver to get a picture of the surrounding traffic environment

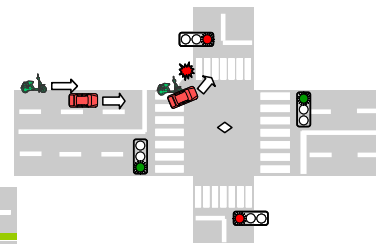
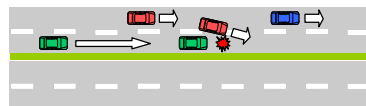


4 . Collision Accident Categories

- Accidents primarily caused by oversight
 - ✓ Collisions when making a right turn
 - ✓ Head-on collisions
 - ✓ Collisions at intersection corners
 - ✓ Collisions with pedestrians

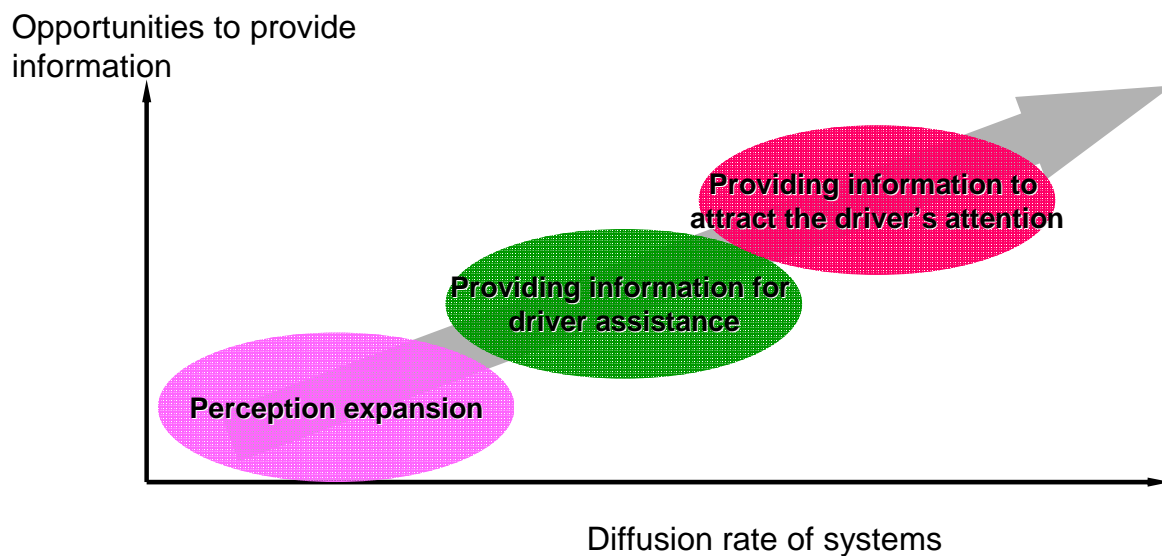


- Accidents resulting in serious damage and requiring serious public attention, regardless of the number of occurrences
 - ✓ Rear-end collisions
 - ✓ Collisions when making a left turn
 - ✓ Collisions when changing lanes



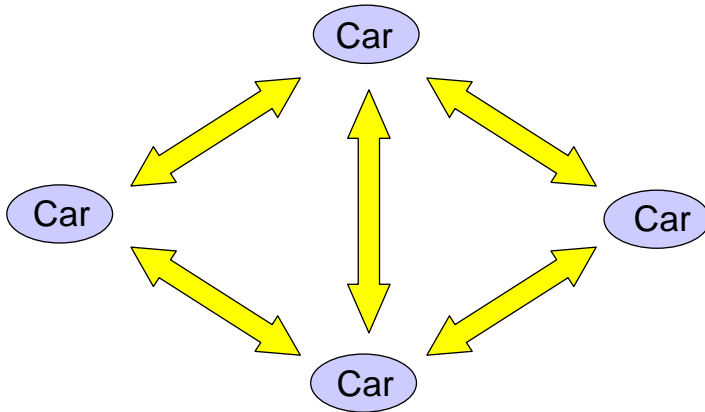
5 . Functions and Diffusion Rate of AVS Systems

- With a rise in the proportion of vehicles with AVS systems installed (the diffusion rate), system functions are expected to become more sophisticated



Trials

1 . Communications Systems



Information

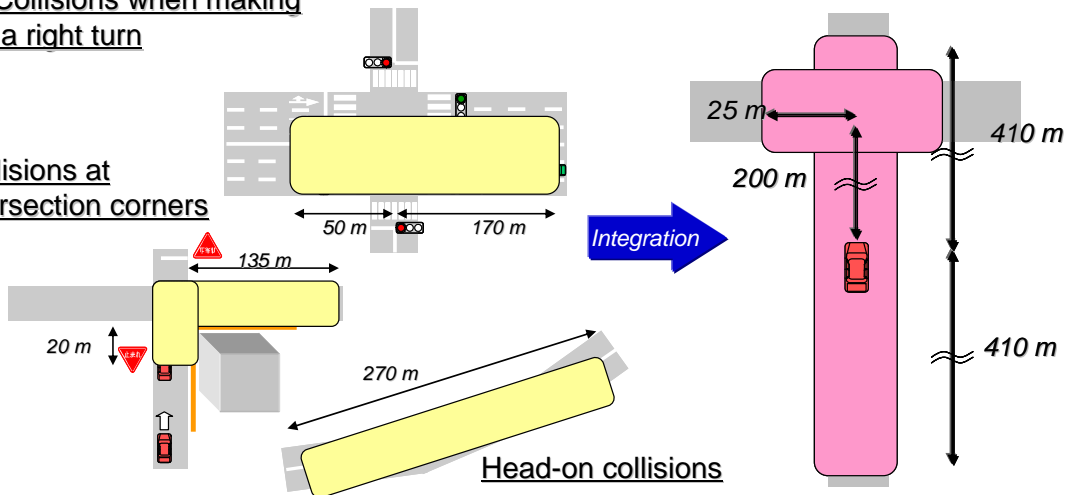
- Basic information
 - Vehicle ID
 - Vehicle type
 - Present position
 - Vehicle speed
 - Direction of travel
- Equipment information
 - Gear position
 - Braking
 - Direction indicators
 - Hazard lights

2 . Required Communications Range

- System's communications range derived from analyses of accident categories

Collisions when making a right turn

Collisions at intersection corners



Supposition based on passenger cars and motorcycles

Passenger cars, motorcycles, and trucks are considered.

3 . Purpose of Assessment

To verify how effectively information from surrounding vehicles will help the driver of a vehicle equipped with an inter-vehicle communication type driver assistance system to drive safely under conditions close to actual traffic conditions

4 . Checkpoints

- (1) Was there any deficiency in the temporarily established communications area?
- (2) Could the positioning accuracy of the currently available vehicle-positioning technology fulfill the intended functions of the system?
- (3) Is the timing of information provision appropriate?
- (4) Were data formatting and signal processing as expected?
- (5) Was the driver able to understand the meaning of information provided?
- (6) Is it possible to provide the driver with effective information without misleading or confusing him/her in a traffic environment where there are many vehicles that are not equipped with driver assistance systems?

Note: Communications were conducted under experimental conditions that would allow secure communications within the communications range prescribed by the concept specifications, and communications technologies were not assessed.

5 . Period and Location of Trials

✓ Preliminary trials

June 2005

✓ Assessment trials

August-October 2005

6 . Accidents Assessed

- (1) Collisions when making a right turn
- (2) Collisions at intersection corners
- (3) Collisions with pedestrians
- (4) Head-on collisions
- (5) Rear-end collisions
- (6) Collisions when making a left turn
- (7) Collisions when changing lanes

7 . Results of Trials

| Items for Assessment | Results of Trials | Tasks Ahead |
|----------------------|--|---|
| Communications area | No specific deficiency was observed | Identify communications area that would be available with a commercialized system. |
| Positioning accuracy | It was found that ordinary GPS accuracy would not identify correlations for some services (to be described later) | Hard to evade because of GPS-based system configuration. Identify effects when accuracy declines in urban areas. |
| Timing | It was found that a delay in positioning would cause data delay by up to 2 seconds or so. | Hard to evade because of GPS-based system configuration. Identify compensatory effect on receiving side by simultaneously transmitting anticipated data delay. |
| Data formatting | Although there was no significant deficiency, inadequate rules on the above timing and a flaw in the specifications for interpretation of data were found. | Need to determine maximum data delay and additionally define the extent of delay. Detailed definitions are needed for the interpretation of data, such as bearing and speed. |
| Signal processing | It was confirmed that the vehicle to be noted by the driver could be identified from among data on numerous vehicles | Identify effects of decline in positioning accuracy in urban areas on the extraction logic |
| HMI | It was confirmed that the situations could be communicated to the driver within the prescribed range of information provision | Capability to provide information about the existence of vehicles not equipped with ASV systems (providing information all the time to alert the driver) Examination of HMI approach at the time of change |

| Items for Assessment | Results of Trials | Tasks Ahead |
|---|---|---|
| Collisions at intersection corners Collisions when making a right turn | Capability to provide information to alert the driver is feasible but some device must be provided to deal with the existence of vehicles not equipped with ASV systems | Need to identify problems at intersections, including the presence of traffic signals, various types of traffic signals, and diverse conditions |
| Collisions with pedestrians | Degree of positioning accuracy proved sufficient for the limited function of detecting presence of pedestrians | Need to define limitations and conduct trials to verify effectiveness |
| Head-on collisions | Degree of positioning accuracy proved sufficient for the limited function of detecting presence of vehicles coming from the opposite direction on a mountain pass | Need to define the limitations and conduct experiments to verify effectiveness |
| Collisions when making a left turn | Degree of positioning accuracy proved sufficient for the limited function of detecting presence of motorcycles and other objects that could be involved in an accident | Need to define limitations and conduct experiments to verify effectiveness |
| Rear-end collisions | Degree of positioning accuracy proved sufficient for the limited function of detecting presence of vehicles on the roadway that are stopped or traveling at low speed | Need to define limitations and conduct experiments to verify effectiveness |
| Collisions when changing lanes | It was confirmed that this capability would be hard to achieve because of insufficient positioning accuracy | |