PROMOTION PLAN OF THE DEVELOPMENT OF ADVANCED SAFETY VEHICLE (ASV)

Shinichi Yahagi
Kanji Nakayama
Ministry of Transport
Japan
Paper Number 98-S2-O-01

SUMMARY

The Ministry of Transport has established the "Study Group for Promotionof Advanced Safety Vehicle (ASV) " consisting of several university professors and manufacturers and has conducted research & development of ASVs equipped with numerous driver-friendly devices to ensure high-level safety by applying advanced electronics technology.

BACKGROUND OF THE PLAN FOR PROMOTING DEVELOPMENT OF THE "ADVANCED SAFETY VEHICLE"

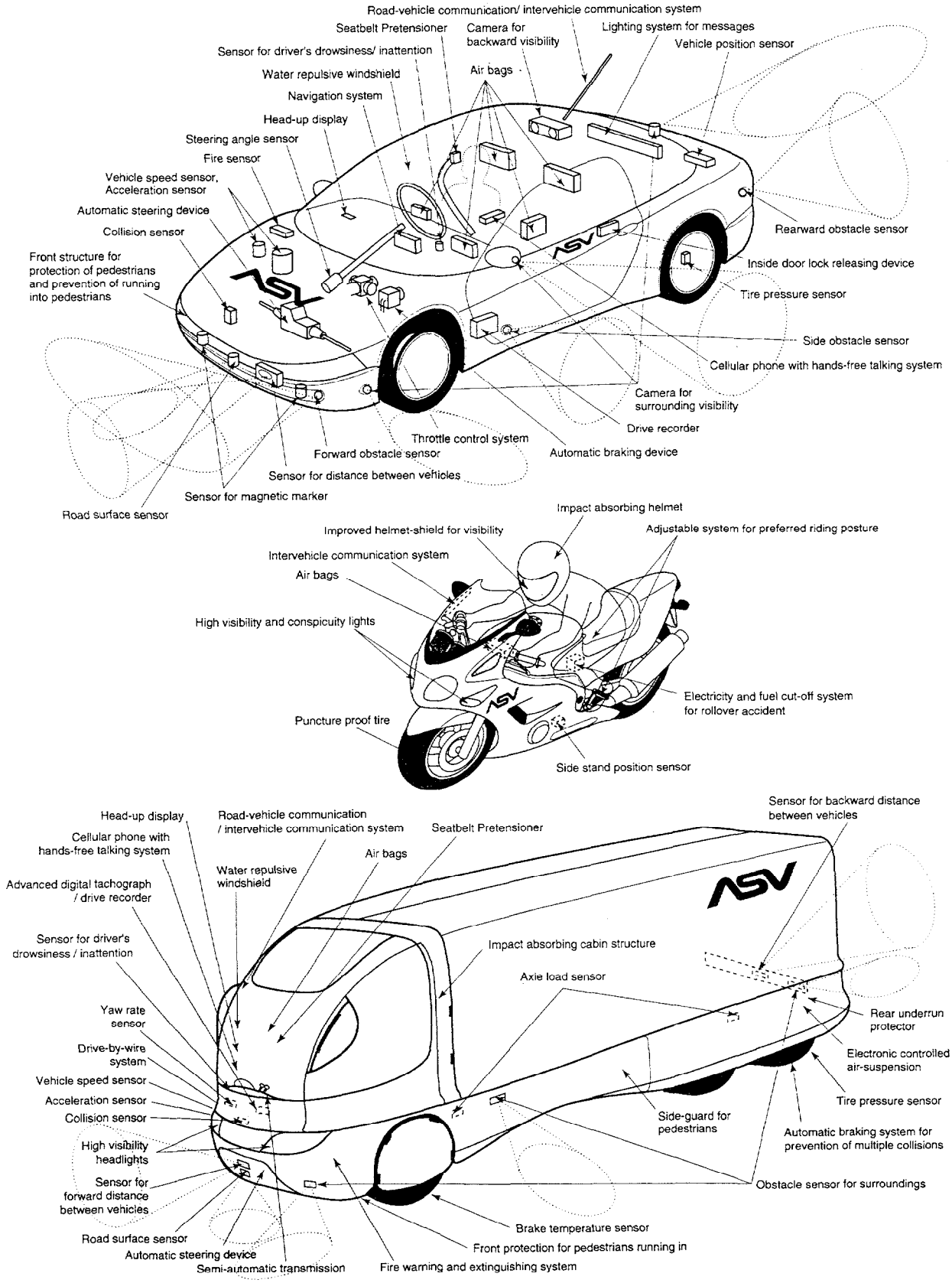
The automotive society has given birth to such problems as increased traffic accidents and traffic congestion, which need resolution. Particularly in the area of traffic accidents, the number of traffic fatalities in Japan for the year 1996, at 9,942, dropped to just barely below 10,000 persons for the first time in 9 years, however we are still in a undesirable situation. One method which the Ministry of Transport has been thinking of to respond to this drastic traffic accident problem is improvement of the automobile, to make highly intelligent vehicles through the utilization of new technologies such as electronics technologies which have been advancing rapidly in recent years, and research and development into the ASV (Fig. 1) to raise the level of safety overall. The ASV would also become the platform as the vehicle used for Intelligent Transport Systems (ITS). To accomplish this, the Ministry of Transport enlisted the participation of university researchers related to automotive technologies, Japanese automobile and motorcycle manufacturers (First Period: 9 Companies; Second Period: 13 Companies) and research organizations, etc. related to the automobile and established the "Study Group for Promotion of Advanced Safety Vehicle (ASV) " (Chairman: Masakazu Iguchi, Emeritus Professor of Tokyo University; Administration: the Ministry of Transport, Engineering and Safety Department).

The aim of the ASV plan is to equip vehicles with sensors which detect the surrounding traffic environment as well as road surface conditions and with information and communication processing equipment for accident avoidance, and to conduct research into advanced technologies for automatic braking systems and automatic steering systems necessary for lessening the damage resulting from collisions, and then, by pointing out technological guidelines for the ideal ASV of the future, ASV is to attempt to promote higher levels of research and development of automotive safety technologies among the people (automobile and motorcycle manufacturers). In addition, ASV research and development is not being financed by government funding, in any way, in view of the importance of preserving the independence of private enterprise.

FIRST PERIOD-OUTLINE OF THE ASV DEVELOPMENT PROMOTION PLAN

Study Group for Promotion of ASV and ASV Research and Development Maker Activities

In the first period between 1991 and 1995, the Study Group for Promotion of ASV set 4 fields of major safety technologies, (1) preventive safety technologies, (2) accident avoidance technologies, (3) damage decreasing technologies and (4) post-impact injury mitigation and prevention technologies, and carried on investigative research into methods of these four major safety technologies, and ascertaining the effects, of introducing these ASV technologies on accident reduction. Furthermore, together with the



(Fig 1. Image of ASV)

fruits of the above investigation, the opinions of manufacturers, etc. involved in ASV research and development were concentrated and a policy for ASV technologies was developed. In addition, each of the ASV research and development manufacturers was engaged in research on the various factors involved, systems research, and in fundamental research, to make technologies practical as well as research and development of ASV element technologies. Then 16 prototype vehicles were manufactured by the various companies in which most of the ASV element technologies were incorporated.

Research and Development Conditions of Systems Technologies in the 4 Fields

Under the above mentioned 4 fields of major safety technology, 20 systems technology items were decided upon and research and development was promoted. Here we will introduce some representative examples from 3 of these fields.

Preventive Safety Technologies (Example of Drowsy Driving Warning System)

Objective

The purpose of this technology is to detect driver drowsiness (reduced awareness) and not only awake the driver corresponding to his drowsy state but stop the vehicle automatically if the driver is in a condition where he cannot drive, and thus attempt to reduce accidents.

System Functions

(1) Driver Drowsiness Detection Function: There are two methods for detecting if the driver is drowsy, by detecting the vehicle's running state, or by detecting the driver's physiological condition. The former utilizes a steering wheel angle sensor, CCD camera, yaw rate sensor and other instruments. On the other hand, the latter utilizes a pulse sensor, a CCD camera to monitor the driver's eye movements and similar sensors.

(2) Drowsy Driving Prevention Function: The method used to judge whether the driver is in the drowsy state is to process the signals detected by the various types of drowsiness sensor with a computer, which would judge that the driver is in the drowsy state when the observed values exceed the proper threshold level.

In addition, the driver could be awakened by showing something on a display, a warning sound, a voice, vibrating the seat, or by releasing a menthol scent, etc. Furthermore, if the driver continues in a dangerous condition even after being warned, the vehicle could be halted by automatic braking, while steering itself automatically and while flashing the hazard warning lamps to caution other drivers.

Results

It was determined that when a driver lapses into a drowsy state, the steering correction period becomes long, and changes in the heart beat interval become broader. In addition, it was confirmed that the drowsiness detection accuracy differs depending on individual differences.

Future Themes

It is necessary to improve detection technologies and technologies for awaking drowsy drivers, and to study automatic avoidance technologies.

Accident Avoidance Technologies (Example of Automatic Operating System for Avoiding Accidents)

Objective

To monitor objects in the area surrounding the vehicle (other vehicles, pedestrians, road structures, etc.) and, if there is danger of a collision, first warn the driver, then, if the driver doesn't take the appropriate action, carry out automatic braking or automatic steering to reduce accidents.

System Functions

(1) Recognition of the driving environment around the vehicle: Scanning type laser radar, mili-wave radar, CCD cameras, are methods used.

(2) Alerting the Driver to the Danger of Collision: This is done using a head up display (HUD) which portrays the positional relationships of the driver's own vehicle to objects surrounding it in easy to understand pictures, and sound and display are used together to warn when the situation becomes dangerous.

(3) Emergency Collision Avoidance Functions: If the driver's response is delayed and it is judged that it is difficult to avoid a collision, it is proposed that the most appropriate avoidance action will be taken using automatic braking or automatic steering.

Results

The functions of systems focused on avoiding accidents involving other vehicles or pedestrians in cases where the driver is incapacitated, as well as the functions of systems which apply the brakes automatically to reduce speed as much as possible in cases where a collision cannot be avoided, and systems which avoid collisions by automatic steering in addition to automatic braking were confirmed.

Future Themes

It is necessary to improve the reliability of automatic steering, study interference between automatic braking and driver operation, establish a method for canceling automatic braking, clarify automatic braking system operating conditions and form

a consensus in society that automatic operation is a means of assisting in avoiding accidents.

Damage Decreasing Technologies (Example of a Pedestrian Injury Severity Reduction System)

Objective

The purpose of this research and development is to reduce the number of accidents involving pedestrians through countermeasures to decrease the severity of injury to pedestrians when there is an impact. Furthermore, although this item is classified as "damage decreasing technologies", it includes accident prevention technologies which are geared to protection of pedestrians.

System Functions

(1) Functions for Prevention of Hitting Pedestrians: This system would use scanning laser radar to detect pedestrians and would warn the driver using an indication in HUD and a warning sound or voice, then if the danger becomes greater, operate the brakes automatically. At night, it would detect infrared rays radiated from pedestrians and improve the visibility of pedestrians, without causing an illusion for vehicles approaching in the opposite direction, then with ultrasonic sensors it would detect pedestrians who are crossing the street and warn the driver that there is danger of hitting someone by showing a warning in the HUD or by a warning sound and voice, making it possible to take evasive action.

(2) Functions to Reduce the Severity of Injury to Pedestrians: When an impact with a pedestrian is detected by the pedestrian impact sensor, an airbag mounted in the hood could work, reducing the severity of injury to the pedestrian's head. In order to reduce the severity of injury to a pedestrian, the bumper, hood front end, the hood itself and front pillars use impact absorbing construction.

Results

It was determined that, by making high performance scanning laser radar, it is possible to detect a pedestrian wearing clothing which is difficult to see at night (with a detection distance of 45 meters or greater), and that through the development of recognition logic with the features of pedestrian behavior incorporated into it, pedestrians who cross the roadway should be recognizable. In addition, it was confirmed that the severity of head injuries is reduced for impacts where a hood airbag is operated in the area of the pedestrian's head and that the severity of limb can be reduced by impact absorbing bumpers.

Future Themes

It is necessary to meet problems with mutually interfering ultrasonic waves in systems which employ ultrasonic sensors, and to distinguish infrared radiation from objects other than the human body as well as prevent malfunction due to emitted or reflected infrared radiation. Also, it is necessary to establish legal permission concerning the freedom to switch on lights for a pedestrian lighting system.

Technology Guidelines

Establishing Technology Guidelines

Technology guidelines were conceptualized in the form of a target "Position After 5 Years" and "Ideal Position after 10 Years," after taking into consideration the likelihood of success in making these systems practical in the 4 fields (1) preventive safety technologies, (2) accident avoidance technologies, (3) damage decreasing technologies and (4) post-impact injury mitigation and prevention technologies, by clarifying the development conditions for safety technologies up to the present and the research results, and by further clarification of future technological themes and various themes other than the vehicle itself, then, by considering these themes overall, with the purpose of showing the directivity of technological developments aimed at the 21st century.

The accident reduction effects shown here are the anticipation reduction with respect to the total number of traffic related fatalities in mid-1993 (4,846). This accident reduction effect is the maximum value that can be expected if the current fatal accident occurrence conditions do not change in the future, if all the vehicles on the road are equipped with ASV technologies, and supposing that all the necessary infrastructure is in place. However, if we simply total up the anticipated reduction in fatalities for each system, the effects multiply and the results become overly large, so it is necessary to look at the results for each system only.

Technology Guidelines for Preventive Safety Technologies

(Using the Drowsy Driving Warning System as an Example)

Target Position

The "Position after 5 Years" for this system is to detect a drop in the driver's awareness under specific conditions, and to give an alarm as well as apply stimulation to awaken the driver. The "Ideal Position after 10 Years" is to detect a drop in the driver's awareness under various conditions, give the optimum level of alarm, apply stimulation, and then, if the dangerous condition continues, stop the vehicle automatically while giving careful attention to

surrounding vehicles.

Vehicle Related Technology Themes

It is desirable to establish the methods of detection which won't be a nuisance to the driver or cause feelings of disorder, and to establish judgment methods, which take individual differences into account. Also, the overriding themes should be assuring system reliability and durability, miniaturization of components and reduction of system costs. (This theme is a common item in each system other than this system.)

Themes Other than Vehicle Related Themes

It is desirable that a road environment with easily recognizable lane markings be provided and that long distance night driving be monitored.

Accident Reduction Effects

It is expected that the reduction in fatal accidents could be up to 330 lives per year.

Technology Guidelines for Accident Avoidance Technology

(Using the Accident Avoidance Automatic Driving System as an Example)

Target Position

The "Position after 5 Years" for this system, is that it will be capable of detecting the driving environment and, if there is a great danger rear-end collision with the vehicle ahead, the overtaking speed would be reduced by automatic control. Also, the "Ideal Position after 10 Years" it is desirable that, through integration with road surface prediction and steering avoidance technologies, it become possible to achieve automatic accident avoidance under various circumstances.

Vehicle Related Technology Themes

It is desirable that the recognition power for surroundings under bad conditions such as curves and hilly roads be improved, that the performance of pedestrian recognition logic be improved and that technologies for monitoring surroundings under various conditions be improved. It is also necessary to predict and respond to other dangers which may occur due to automatic avoidance and verify the effectiveness of the system under various conditions.

Themes Other than Vehicle Related Themes

Provision of a road environment with easily recognizable lane markings, road markers and other infrastructure are very important. Furthermore, it is desirable to standardize the installation and setting methods for roadside reflectors, and to establish vehicle to road communication systems for accident avoidance.

Accident Reduction Effect

It is predicted that the fatal accident reduction effect per year will be up to 2,192 persons, with the effect maximized in the First Period of ASV system use.

Technology Guidance for Damage Decreasing Technologies

(Using the Pedestrian Injury Severity Reduction System as an Example)

Target Position

The "Position after 5 Years" for this system is that, under specific conditions, pedestrians in front of the vehicle will be detected, and, if it is estimated that there is danger of hitting any person, the driver will be warned that he or she is there. As for the "Ideal Position after 10 Years" it is desirable that, if the danger of an impact becomes even greater, it will be possible to apply the brakes automatically under specific conditions.

Vehicle Related Technology Themes

Concerning detection of pedestrians, it is essential that detection technologies, and monitoring and recognition technologies, be improved so that there will be no miss-detection and non-detection of pedestrians.

Themes Other than Vehicle Related Themes

In order to reduce accidents involving pedestrians, it is desirable that facilities be provided to separate pedestrian lanes from traffic lanes. It is also necessary that all drivers become more knowledgeable of the importance of protecting the weak and defenseless pedestrians.

Accident Reduction Effect

It is predicted that the annual reduction in fatal accidents will be up to 570 persons.

SECOND PERIOD-OUTLINE OF THE ASV DEVELOPMENT PROMOTION PLAN

Expansion of the Promotion System and Affected Vehicle Models

The Second Period Advanced Safety Vehicle (ASV) Promotion and Investigation Group, organized for the five-year period beginning in 1996 and composed of men of learning and experience, automobile manufacturers and related government authorities undertook, in addition to research and development concerning element technologies begun in the First Period, optimization of the human interface indicated as a future investigation theme, and its integration with and linkage to the ITS and other

infrastructure, as well as the promotions among private citizens to facilitate research and development of automotive safety technologies. Expanding the types of vehicle model, trucks, buses and motorcycles have been added as objects of ASV research and development.

In accordance with this change, the number of manufacturers engaged in ASV research and development has been in total 13.

Adjustment of ASV Research and Development

In the year 1996, ASV research and development conditions were adjusted, and the current conditions of research and development related to the human interface and current infrastructure conditions were investigated.

6 Fields of Major Safety Technology

As a result of the readjustment, 6 major safety technology fields were set, (1) Preventive Safety Technologies, (2) Accident Avoidance Technologies, (3) Autonomous Driving Technologies, (4) Damage Decreasing Technologies, (5) Post-impact Injury Mitigation and Prevention Technologies and (6) Fundamental Automotive Engineering Technologies, then from these fields, 32 system technologies were classified and introduced into ASV research and development items. Detailed element technologies identified in System Technologies totaled 107 items as of April, 1997.

In the future, in Second Period ASV plans, research and development are being promoted with the objective of gradually introducing each of the ASV system technologies by incorporating them into vehicles in the marketplace within the period remaining of this century, and of developing a system which can carry out integrated control of these system technologies. Along with the stream, as the 21st Century begins, the aim is to make ASV vehicles equipped with the integrated system available to everyone.

The 32 Systems Technologies

(1) Preventive Safety Technologies
- 1 Warning System for Dangerous Driver Conditions
- 2 Warning System for Dangerous Vehicle Conditions
- 3 Vision Enhancement System
- 4 Vision Enhancement System in Nighttime Driving and Nighttime Object Detection
- 5 Blind Area Monitoring/Warning System
- 6 Surroundings Warning System
- 7 Road Environment Information Acquisition and Warning System
- 8 Inter-vehicle Communication and Warning System
- 9 Driver Workload Reduction System

(2) Accident Avoidance Technologies
- 10 Intelligent Vehicle Control System
- 11 Driver*s Hazardous Condition Detection System
- 12 Blind Area Accident Avoidance System
- 13 Collision Avoidance System with Surrounding Obstacles
- 14 Collision Avoidance System Utilizing Road Information

(3) Autonomous Driving Technologies
- 15 Autonomous Driving System Utilizing the Existing Infrastructure
- 16 Autonomous Driving System Utilizing Newly Installed Infrastructure

(4) Damage Decreasing Technologies
- 17 Impact Absorbing System
- 18 Occupant Protection System
- 19 Pedestrian Injury Severity Reduction System

(5) Post-impact Injury Mitigation and Prevention Technologies
- 20 Emergency Door Lock Release System
- 21 Secondary Impact Reduction System
- 22 Fire Extinguishing System
- 23 Automatic Emergency Reporting System

(6) Fundamental Automotive Engineering Technologies
- 24 Safer Usage System of Cellular Phone
- 25 Advanced Digital Tachometer/Drive Recorder
- 26 Electronic Vehicle Identification Tag (Number)
- 27 Automatic Reporting System of Vehicle Condition
- 28 Advanced Global Positioning System
- 29 Drive-by-wire System
- 30 Advanced System for Elderly Drivers
- 31 Physiological Detection System for Fatigued Drivers
- 32 Advanced Human Interface System

Future Investigation Themes, etc.

Optimization of Human Interface

Problems with the human interface include how to transfer information detected by each sensor, and how to carry out the various types of automatic control without causing feelings of disorder in the driver. It is necessary to transfer the required information unfailingly in an easy form to understand, and it is feared that as information increases, it will be difficult to judge appropriately and that the driver will get tired from repeated warnings. In addition, concerning control, there is the problem that what kind of control would be desirable in response to the surrounding

environment and the driver's operations.

As for information transfer and control methods, at present, there are differences depending on the manufacturer, so that consideration is given to the study of standardization in the ISO activity. There also needs to be study of the necessity for standardization of methods for warning, timing and automatic control, etc.

Integration with and Linkage to Infrastructure

Concerning the themes of integration with and linkage to the infrastructure, there are problems with which methods to use to transfer information from the infrastructure, such as road conditions and traffic signals and information from the vehicle. If it is possible to obtain information on the occurrence of an accident or a traffic jam up ahead through a vehicle-to-road communications system, it can be expected that safety will improve, so there should be study on the technologies for such a system. Concerning autonomous driving system vehicles, studies should be divided between independent autonomous driving systems and autonomous driving systems which utilize newly installed infrastructure such as magnetic nails.