

Introduction of Honda ASV-3 (Passenger Car)

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ABSTRACT

Honda participated in the Advanced Safety Vehicle Project Phase 3 (ASV-3), which was a national project managed by the Ministry of Land, Infrastructure and Transport (MLIT). In addition to Phase 3, Honda participated in Phases 1 and 2.

Honda's work for the ASV-3 project was based on accident analysis results and focused on the types of accidents caused by phenomena that are outside or barely within a driver's field of view. The three technical approaches of "Collision avoidance," "Collision mitigation," and "Lifesaver" were selected as the three principles supporting the basic Honda ASV-3 concept. The relevant clusters of technology were organized under these headings. The new systems applied the latest sensor and vehicle dynamics control technologies for the driving support systems developed during Phases 1 and 2. The systems use inter-vehicle communication (IVC) technology and a system to assist in emergency rescue activities after accidents occur. These systems were developed with the aim of expanding the range of accident types that ASV systems are capable of handling. An experimental vehicle with these systems installed was built, and future safety technology suggestions were made.

1. Introduction

Following participation in Phases 1 and 2, Honda participated⁽¹⁾ in the Advanced Safety Vehicle Project Phase 3 (ASV-3) managed by the Road Transport Bureau of the Ministry of Land, Infrastructure and Transport (MLIT).

The goal of the Honda ASV-3 project was to build the technologies that had the capability to deal with the types of accidents caused by phenomena that are outside or barely within the driver's field of view. This involved enhancing on-board sensors

that provide external sensing and vehicle dynamics control technology. Both systems were developed for ASV-1 and 2. An additional application of inter-vehicle communication (IVC) technology was also studied. Furthermore, the project involved the study of technology which assists rescue activities after accidents. Additionally, the concepts for these applications were suggested.

This article will provide an overview and introduction of the suggested technical concepts of the Honda ASV-3 on-board systems.

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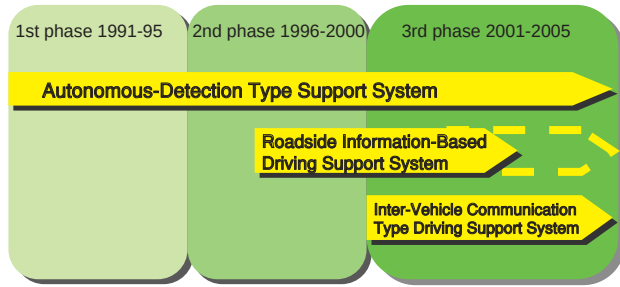


Fig. 1 Technical developments pursued in ASV project

2. The Development Process of ASV

MLIT advocated the ASV project and inaugurated the ASV Promotion Study Group, with the joint participation of representatives from industries, government, and academia. The ASV Promotion Study Group formulated the concept plan for advanced safety technology (hereafter ASV technology). Through the open trials of ASV, it intended to appeal and penetrate the availability of ASV technology to society at large⁽²⁾. MLIT initiated the ASV project in 1991 as a national government project. It finished at the end of fiscal 2005 (Fig. 1).

The objective of Phase 1 (ASV-1, FY91–95) was to verify technical feasibility. ASV technology that could be realized using current advanced technology was developed on that basis, and the effectiveness of the resulting ASV technology in reducing accidents was then verified.

During Phase 1, Honda developed the adaptive front lighting system (AFS) and adaptive cruise control (ACC)⁽³⁾. These technologies were then put to practical use.

The objective of Phase 2 (ASV-2, FY1996–2000) was to perform research and development to find practical applications for ASV technologies. Basic principles and development guidelines were therefore formulated so that the development and dissemination of ASV technology could proceed properly. The development guidelines organized 58 technical items, and projected their effect. New technological developments included a driving support system that uses roadside infrastructure and the roadside information-based driving system. The system was built and proving tests^{(4),(5)} were conducted.

During Phase 2, Honda carried out technical developments for a collision mitigation brake system (CMBS), a night vision system (NVS) and a lane-keep assist system (LKAS)⁽⁶⁾, and implemented practical applications of these technologies. Motorcycles were also included, beginning with Phase 2.

The objective of Phase 3 (ASV-3, FY01–05) was to perform studies for the purpose of penetration of ASV technologies. The technologies which evolved in Phases 1 and 2 were applied, along with the IVC technology.

As described above, the objectives of the ASV project were defined for each phase, with the development and penetration of ASV technology carried out accordingly.

3. Development Goals

An investigation of current traffic accident situations in Japan shows there are a total of over 930 000 accidents and over 1 160 000 casualties (with 9 000 fatalities) in 2000, that is previous FY of the

beginning of ASV-3. This continues to be a major social issue.

According to the percentage of accidents resulting in deaths and severe injuries by accident type (Fig. 2), collisions with pedestrians make up the greatest proportion of fatal accidents (30.9%). Intersection collisions make up the greatest proportion of accidents resulting in severe injury (27.9%).

Figure 3 shows the causes of accidents related to human factors that result in deaths and severe injuries. Accidents caused by recognition errors (failure to confirm safety and failure to watch the road ahead) account for 71% of the total. The next most frequent causes are errors in judgment (20%) and errors in operation (9%).

Given the traffic accident situation described above, Honda worked to develop ASV-3 technology that would reduce collisions with pedestrian and intersection collisions. Three technological approaches were derived from the perspective of mitigating the severity of these kinds of accidents, and were defined as the guiding principles behind the basic Honda ASV-3 concept. The associated clusters of technology were organized as described below. Building on the foundation of these clusters, the on-board systems for the experimental vehicle of Honda ASV-3 were created.

(1) Collision avoidance

This is a technology to prevent and avoid collision, for example, to provide information on the presence of other vehicles or pedestrian for recognition error, and to support the driver's operation for operation error.

(2) Collision mitigation

This is a technology to mitigate collision damage under the circumstances an accident is unavoidable. For example, it provides operational support for misjudgment or operation error.

(3) Lifesaver

This is a technology to assist rescue activities, for example, to automatically notify the status of accident and passengers.

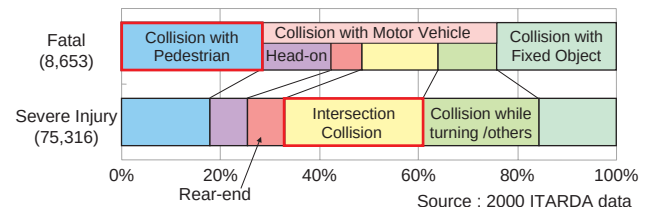


Fig. 2 Rate of the fatalities and severe injuries

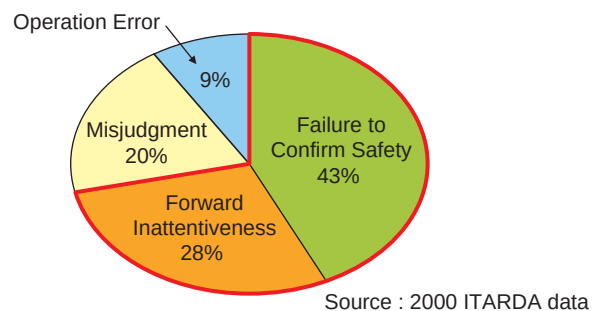


Fig. 3 Rate of Accident Causes

4. Construction of On-board Systems

The three guiding principles of the basic concept, the purposes of the various on-board systems, and the roles played by the systems are depicted in relation to each other in Fig. 4.

4.1. Systems for “Collision Avoidance”

The systems described below were developed to address collisions with pedestrians and intersection collisions.

- Pedestrian detection system with IVC
- Vision-based pedestrian detection system
- Intersection stop assistance system
- Intersection go assistance system
- Forward obstacle collision avoidance assistance system

These systems inform the driver of the presence of vehicles and pedestrians that are outside or barely within the driver’s field of view, which helps prevent collisions. With using on-board sensors, they provide driving assistance, which aids collision avoidance. The systems are intended to help reduce the occurrence of errors in recognition and operation.

4.2. Systems for “Collision Mitigation”

Technology development was conducted for an intersection collision accident mitigation brake system that was intended to address intersection collisions.

This system is intended to mitigate collision damage with using on-board sensors.

4.3. Systems for “Lifesaver”

Technology was developed for the Advanced Mayday System to help assist rescue activities after accidents occur.

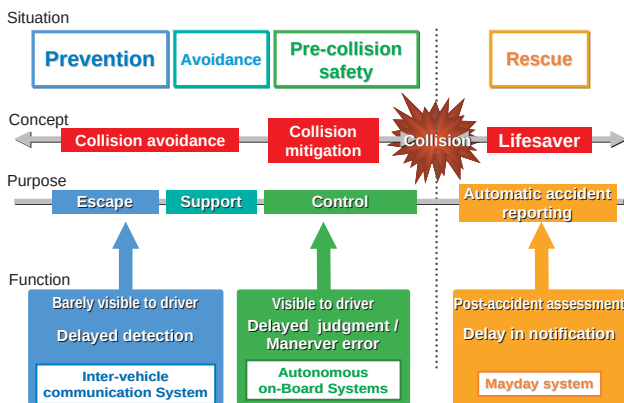


Fig. 4 System concept of Honda ASV-3

5. Technology Introduction of On-Board Systems

Honda ASV-3 experimental vehicle was fabricated as a way of moving this project forward. An appearance of the vehicle is shown in Fig. 5.

5.1. System Configuration

The configuration of the on-board systems is shown in Fig. 6.

5.2. Systems for “Collision Avoidance”

5.2.1. Pedestrian detection system with IVC

This system coordinates information from the on-board sensors with IVC. The system helps detect the presence of pedestrians who are outside or barely within the driver’s field of view.

(1) Functions

The system communicates with mobile communication terminal equipment for pedestrian use and thus can acquire positioning information on pedestrians carrying the equipment, even when they are hidden in the shadow of obstacles ahead of the vehicle. This information is provided to drivers using the on-board screen and voice guidance (Fig. 7, A).

(2) Basic technologies in this system

- Pedestrian detection technology with IVC

The IVC experimental equipment for pedestrians was developed so it can directly acquire the location data of pedestrians and determine the distance and direction of pedestrians with respect to the vehicle. The basic specifications are as shown below. The appearance of the equipment and its circuit diagram are shown in Fig. 8.



Fig. 5 Experimental vehicle of Honda ASV-3

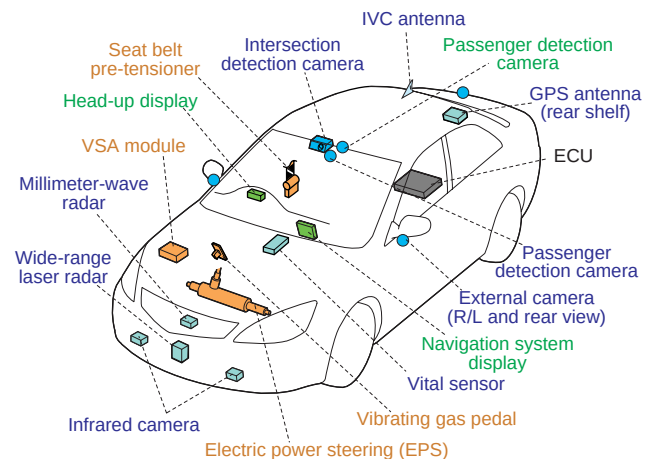


Fig. 6 Configuration of Honda ASV-3

- Basic specifications of IVC experimental equipment for pedestrian
 - Transmission frequency: 5.8 GHz band
 - Transmission power: 10 dBm
 - Positioning system: GPS
 - Size: 150 mm × 110 mm × 39 mm

5.2.2. Vision-based pedestrian detection system

A pedestrian detection system was developed to help detect pedestrians in the daytime, which is out of function of NVS.

(1) Function

Images acquired by the on-board camera are subjected to recognition processing for pedestrians who are in front of the vehicle. The positions of pedestrians are detected and the pedestrian information is provided with the on-board screen and voice guidance (Fig. 7, B).

(2) Basic technology in this system

- Pedestrian detection technology using image processing

This technology is applicable to pedestrians within the driver's field of view. It detects pedestrians by means of pattern matching to recognize and isolate pedestrian silhouettes (Fig. 9).

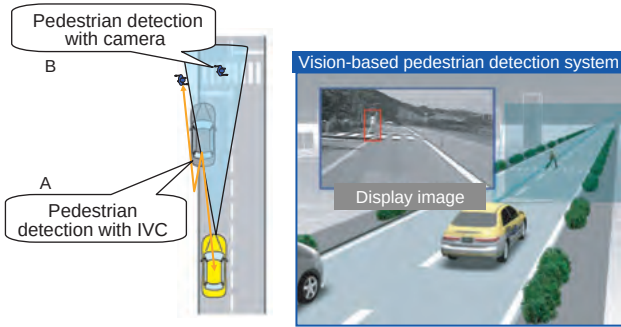


Fig. 7 Function of pedestrian detection system with IVC and vision-based pedestrian detection system

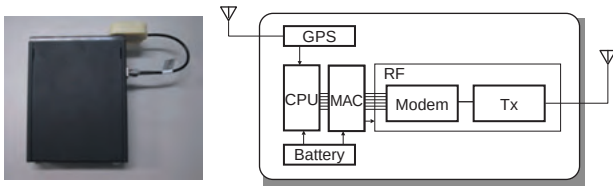


Fig. 8 Appearance and block diagram of IVC experimental equipment



Fig. 9 Vision-based pedestrian detection

5.2.3. Intersection stop assistance system

The purpose of this system is to help reduce intersection collisions due to failure to recognize a stop sign and/or stop line at an intersection (recognition error), resulting in a vehicle suddenly or carelessly entering the priority road.

This system decides the area to provide information with using digital data of intersections and roads in the GPS navigation system, along with Vision-based recognition of stop signs and stop lines.

(1) Function

- This system acquires data of frontal intersections without traffic signals using GPS navigation system. The system provides information on such intersections using the on-board screen to remind drivers stop before they enter the intersections (Fig. 10, A and B).
- The system detects stop signs and stop lines on the road with using Vision-based recognition technology (Fig. 10, C).
- The stopping distance L that allows stopping before the stop line is calculated by the following formula (1). If the vehicle approaches the line closer than the calculated distance without braking, the system provides voice guidance and haptic warning by brake actuation⁽⁷⁾.

$$L = \frac{V^2}{2a} + V \cdot T_d \quad (1)$$

where, V : Vehicle velocity

a : Deceleration in the emergency stop

T_d : Free running time

(2) Basic technologies in this system

- Intersections detection technology using GPS navigation system

The system acquires digital data of intersections by the GPS navigation system. The determination of whether the driver is on a priority road or not, is decided referring to the data of road width, category and structure.

- Vision-based recognition of stop sign

This technology detects stop signs to judge whether the intersections acquired by (a) requires to stop once or not. The system recognizes the placement of a stop sign near an intersection by means of the raw imagery captured with using an on-board camera (Fig. 11, A). It isolates the sign shape based on differences in luminance relative to the surroundings (Fig. 11, B). Next, it ascertains the

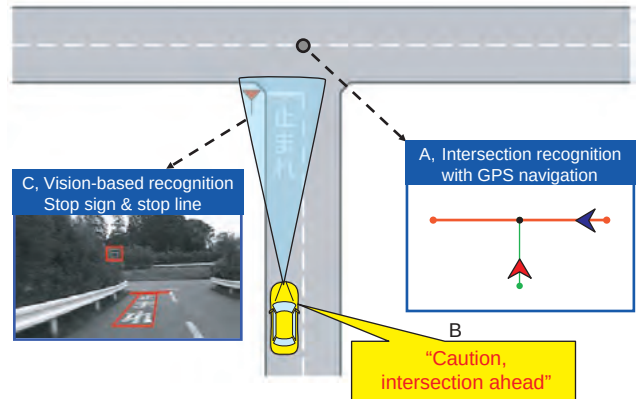


Fig. 10 Function of intersection stop assistance system

characteristic inverted triangle shape to determine that it has identified a stop sign (Fig. 11, C).

(c) Vision-based recognition of stop line

This technology detects stop line to correctly calculate the distance to an intersection. Stop lines are whiter than the road surface and are at right angles to the direction of movement. The line is detected using these characteristics (Fig. 12).

Next, the system calculates the distance to the detected stop line. The distance L to the stop line is derived from the height where on-board camera is mounted, and the angle between the line from the camera to the stop line and road surface, using the following formula (2).

$$L = \frac{H}{\tan \theta} + l' \quad (2)$$

where, H : Height of the camera

θ : Angle between the line from the camera to the stop line and road surface

l' : Correction value with pitching

5.2.4. Intersection go assistance system

The purpose of this system is to help reduce intersection collisions that occur at an intersection when a vehicle emerges suddenly and carelessly into a priority road. This could be caused by a failure of judgment or a failure to recognize an oncoming vehicle. This system detects other vehicles using IVC and provides information on the presence of oncoming vehicles.

(1) Function

- (a) This system acquires position and velocity data of other vehicles on priority roads with using IVC. Also, it provides information on the presence of such vehicles using the on-board screen (Fig. 13, A).

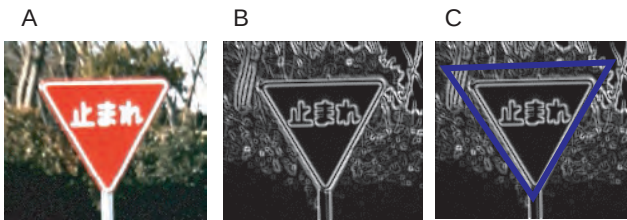


Fig. 11 Vision-based recognition of stop sign

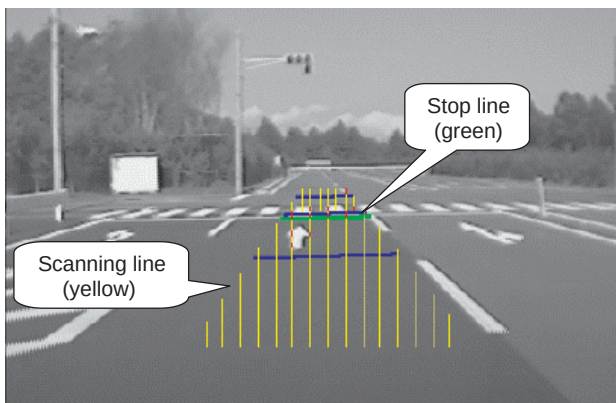


Fig. 12 Vision-Based Recognition of Stop Line

- (b) Based on the acquired data by means of (a), the system calculates a time to arrive at the intersection for other oncoming vehicles. Then it provides information on the presence of other vehicles and informs the driver which will arrive first at the intersection. To enhance the driver's awareness a high-intensity-display on the on-board screen is used (Fig. 13, B).

5.2.5. Forward obstacle collision avoidance assistance system

The purpose of this system is to help reduce intersection collisions with another vehicle that suddenly emerges from a branch road. It assists the driver's operation to avoid collisions by using new systems which were applied during Phase 1 and 2⁽⁸⁾. These systems employ the latest sensor and vehicle dynamics control technologies to support the driver.

(1) Function

- (a) It detects other vehicles that suddenly emerge from branch roads with using on-board radar, and provides braking with using CMBS to decelerate (Fig. 14, A).
- (b) It controls the delay of steering and understeer at the initial stage of driver's operation to avoid collision with using cooperative control between EPS and VSA (Fig. 14, B).
- (c) It controls overshooting the steering at the stage of driver's operation is to avoid a collision. It uses cooperative control between EPS and VSA (Fig. 14, C).
- (d) And it controls the delay of the steering wheel return and oversteer after the driver's operation to avoid a collision. It also uses cooperative control between EPS and VSA (Fig. 14, D).

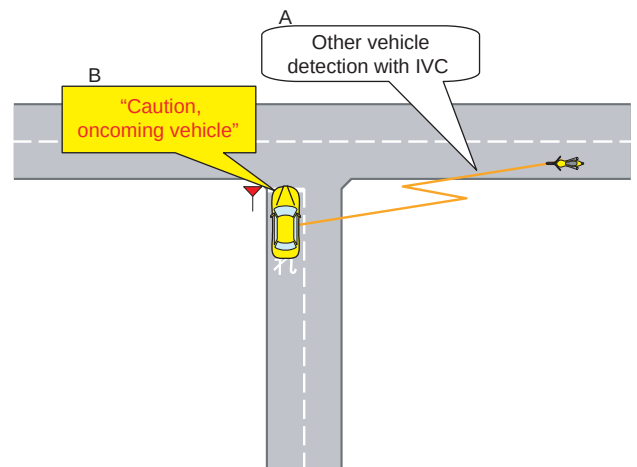


Fig. 13 Function of intersection go assistance system

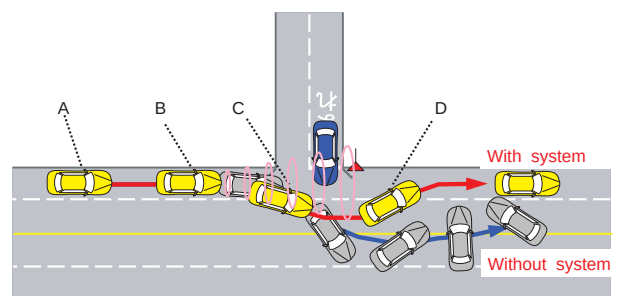


Fig. 14 Function of forward obstacle collision avoidance assistance system

5.3. Systems for “Collision Mitigation”

5.3.1. Intersection collision mitigation brake system

The purpose of this system is to help mitigate collision damage in intersection collisions with the other vehicle that suddenly emerges from a branch road. It helps assist the driver’s recognition for the other vehicle that suddenly emerges from a branch road and helps reduce collision damage by using a CMBS, which has had its sensor function enhanced.

(1) Function

- (a) This system detects the other vehicle that suddenly emerges from a branch road by using an on-board wide-range laser radar. And when there is a possibility of collision with another vehicle, the system applies a voice warning and haptic warning in where the E-Pretensioner gently retracts the seatbelt (Fig. 15, A).
- (b) If the system determines that a collision is unavoidable, the E-Pretensioner strongly retracts the seatbelt and brakes

forcefully. Braking forces from both the system and driver’s operation will help reduce vehicle velocity at the time of impact (Fig. 15, B).

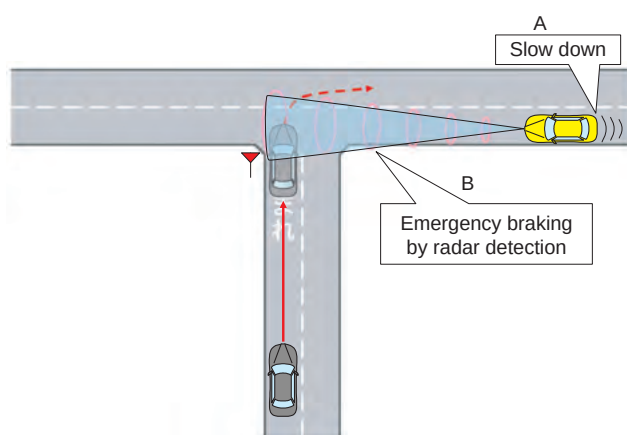


Fig. 15 Function of intersection collision mitigation brake system

6. Conclusion

- (1) Honda participated in the ASV-3 project managed by the MLIT and developed its technologies.
- (2) Based on the results of accident analysis, Collision avoidance, Collision mitigation, and Lifesaver were established as the three principles in support of the basic Honda ASV-3 concept.
- (3) The experimental vehicle of Honda ASV-3 was produced and the future safety technology suggestions were made based on the basic Honda ASV-3 concept.
- (4) The latest sensor and vehicle dynamics control technologies were applied to the ASV-3, therefore the technologies that had the capability to deal with more types of accidents were constructed.
- (5) IVC was applied to the ASV-3, therefore the foundation of technology which has the capability of dealing with the types of accidents which occur due to phenomena that are outside or barely within the driver’s field of view was constructed.

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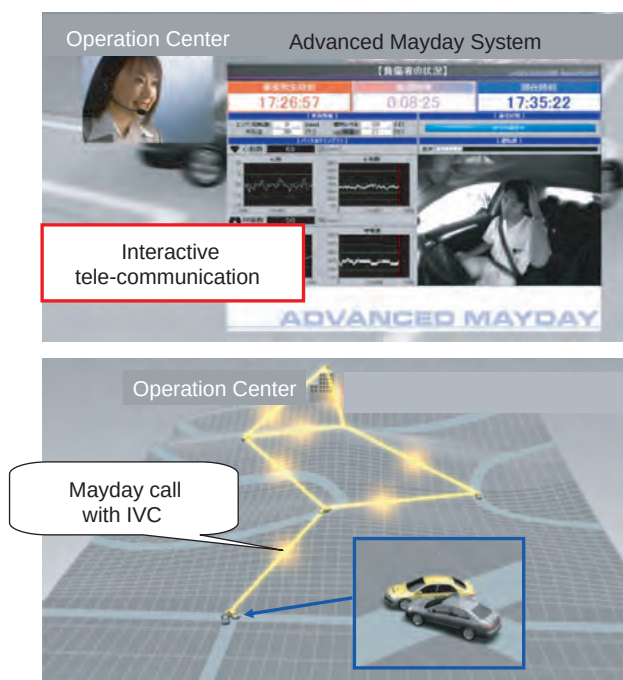


Fig. 16 Advanced Mayday System

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