# Toward Human-oriented Transportation

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*OVERVIEW: Hitachi focuses on various aspects of transportation including automobiles, trains, and elevators, and undertakes research and development of human-oriented products and technologies with the aim of creating a society that is safe, secure, and comfortable. In the automotive sector, information from multiple sensors is combined to achieve a comfortable ride using highly precise torque-based engine control technology while congestion forecasting is used to guide the vehicle along the route that will reach the desired destination quickly. In the rail sector, digital ATC systems improve ride quality while reducing train intervals and train travel times, and technology for simulating rolling stock dynamics is used to estimate and evaluate carriage safety and ride quality and reduce development times. In the elevator sector, waiting times can be reduced through the use of target route control and passengers' abnormal behavior can be detected automatically by camera surveillance and relevant warnings issued.*

## INTRODUCTION

SINCE its formation as Hitachi, Ltd. in 1910, Hitachi has contributed to society through the supply of infrastructure products based on highly reliable core technologies, including nuclear, thermal and hydroelectric power generation, electricity delivery system, plant for the steel and chemical industries, railway systems, automotive electronics systems, urban development solutions, IT (information technology) solutions and services, and IT platforms. Meanwhile, in the future there will be a need to exist in harmony with the surrounding environment and the diversity of people in a world where IT infrastructure is becoming more pervasive and amidst concerns such as the aging society and protection of the global environment.

This article focuses on forms of transportation such as automobiles, trains, and elevators, and gives examples of Hitachi's involvement in the research and development of products and technologies that take account of the human factor with the aim of creating a society that is safe, secure, and comfortable while also taking care to protect the environment.

## HUMAN-ORIENTED TRANSPORTATION

Fig. 1 shows an overview of human-oriented transportation (automobiles, trains, elevators, and so on). Safety and comfort can be achieved in a mobile vehicle by fitting sensors that provide sensory information to an operation control system, such as information about the surrounding environment or the actions of people. A secure and harmonious transportation environment can then be achieved by collecting and analyzing this information to draw up operating plans and by performing control in such a way that it does not place stress on people.

Human-oriented transportation has progressed in step with advances in microcomputer, electronic

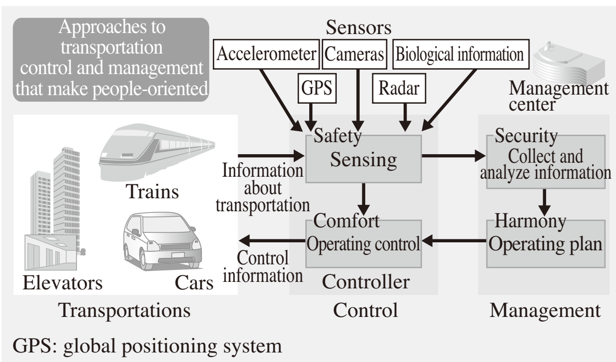


*Fig. 1—Human-oriented Transportation.*
*Operating plans that are in harmony with people and the surrounding environment can be produced by collecting and analyzing sensor information from people, the surrounding environment, and elsewhere. Similarly, safe, secure, and comfortable transportation can be made possible by performing control in such a way that it does not place stress on people.*

device, and MEMS (micro-electromechanical systems) technology. Sensors such as accelerometers that measure the movement of a vehicle, cameras that observe the driver and surroundings, radar, and GPS (global positioning system) for obtaining the vehicle's position have become available and have made it possible to obtain a high level of understanding about the behavior of people in transportation systems, including their location and actions. The increasing performance of embedded controllers that can be mounted on-board has expanded their scope of use to include control applications that require a high speed range and a high degree of safety.

Through the introduction of highly reliable wide-area communication networks and control centers able to process huge volumes of data, advances in information and communication technology have made it possible to analyze the actions of a number of people in a transportation system and to develop an optimum operating plan based on this information.

## HUMAN-ORIENTED AUTOMOBILES

### Driver Perception and Judgment Support System

Although the number of deaths from traffic accidents in Japan is trending downwards thanks to measures to improve collision safety such as airbags, ABS (antilock brake systems), and collision-safe bodies, the number of injuries is on the rise. The cause of traffic accidents has been identified as errors in the basic driving actions of "perception," "judgment," and "operation." Errors of perception in particular make up approximately 50% of all accidents.

The sensor-based traffic conditions recognition and vehicle control technologies shown in Fig. 2 are key elements in preventing these errors of perception and judgment. Hitachi is working on the development of sensor fusion technology[1] that merges information from multiple sensors such as vehicle-mounted cameras, radar, and navigation systems. The image recognition technology used with vehicle-mounted cameras first entered use in automatic inspection equipment and assembly equipment on production lines in the 1970s, and technologies developed in a range of different fields including surveillance, security, and logistics systems have been integrated into common platforms.

Coordinated operation of the engine, brakes, and steering was facilitated by the precise operation of torque-based engine control in which the target control values for air-intake, fuel injection, and ignition timing are gathered to calibrate the "engine torque" in accordance with the driver's intention expressed by how much he or she is applying the accelerator[2]. Driver perception and judgment support systems make driving safer, easier, and more comfortable by reducing the load on the driver, and prevent accidents by warning the driver of danger and taking part in as an active control of the vehicle.

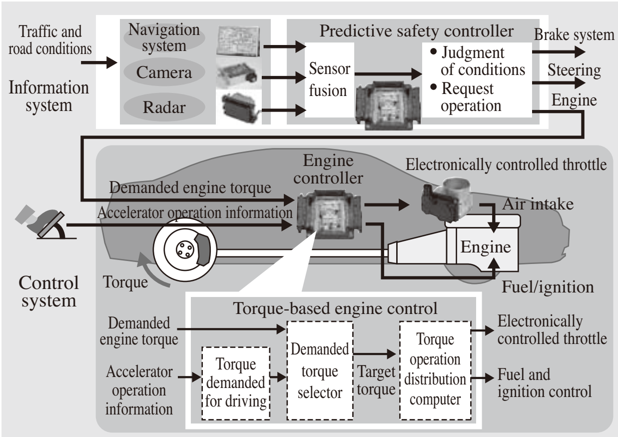


*Fig. 2—Driver Perception and Judgment Support System.*
*Sensor fusion technology that merges information from multiple sensors such as cameras, radar, and navigation systems and torque-based high-precision engine control provide safe and comfortable driving while protecting the environment.*

### Navigation with Congestion Prediction

Traffic congestion can stress and fatigue drivers and lead to nose-to-tail accidents. Because idling during congestion or frequent acceleration and deceleration lead to $CO_2$ emissions, congestion is also undesirable for energy conservation reasons. The core function of a car navigation system is to display

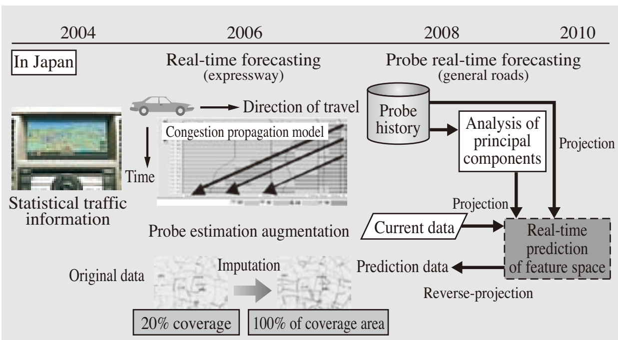


*Fig. 3—Navigation with Congestion Forecasting.*
*High-precision congestion prediction based on statistical processing that looks at correlations in congestion and how congestion varies over time can guide vehicles to their destination in a shorter time.*

the car's position on a map and provide guidance on the best route to the destination and these system have developed by incorporating locator (vehicle positioning) technology and large volumes of digital map data in vehicle-mounted units.

Hitachi has been developing technologies for predicting traffic conditions over a wide area and with high accuracy (see Fig. 3). One example is route guidance[3] that takes account of the time of departure to avoid roads that are predicted to be congested based on statistical analysis of past traffic data. Also, the area covered can be expanded by imputation technology using vehicle probe information (position, speed and other information from vehicles on the road). To predict traffic congestion several hours ahead in real time and with high accuracy, Hitachi has also developed a model of how congestion propagates along expressways and a correlation model for general roads that uses probe information.

## HUMAN-ORIENTED RAILWAYS

### Safe and Highly Efficient Railway Control System

The role of railways as means of transport that minimizes the load placed on the global environment is becoming important. Providing safe and reliable transport is what railways are for and it is the role of the signal maintenance system to support this activity[4].

Fig. 4 shows a digital ATC (automatic train control) system. ATC is a technology for detecting the position on the track of the preceding train and automatically controlling speed to ensure the appropriate gap between trains is maintained. The analog ATC system used staged braking control with separate speed limits for each stage and controlled speed through continuous transmission of speed control information to trains based on the presence of other trains on the track ahead.

In contrast, the digital ATC systems use digital transmission and information technology and send stopping position information as digital data packets from the wayside system to the following train based on the presence of other trains on the track ahead. They also perform optimized single-stage smooth braking control in the train itself using a speed-check profile that is based on the train's braking characteristics and on track conditions such as curvature and gradient. This improves ride quality and allows a shorter inter-train interval and shorter train braking time[5].

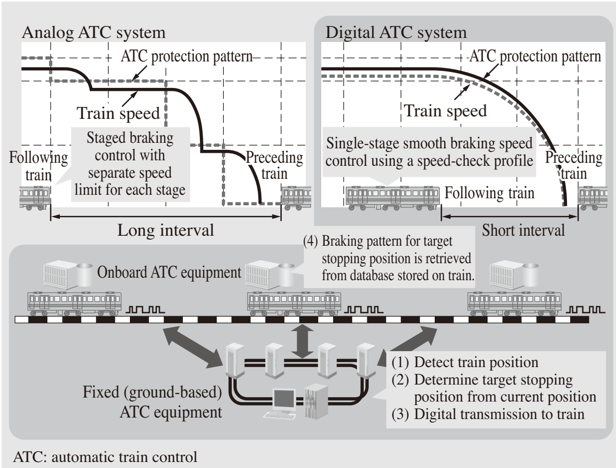


*Fig. 4—Digital ATC System.*
*The digital ATC system reduces the stopping distance from a given speed compared to the analog system and this allows higher traffic density.*

### Technology for Evaluating Safety and Ride Quality of Rolling Stock

Because of their size, it is difficult to determine all performance parameters from actual rolling stock during design and development. For this reason, it is important to predict rolling stock performance using simulation and utilize this information in the design process.

Advances in railway-related environmental protection have been achieved by introducing enhancements such as environmentally friendly front-end shapes, safe and comfortable rolling stock and wagons, lighter weight, low-noise cooling, and high-efficiency drive systems with the aim of saving energy, making carriages more comfortable, and

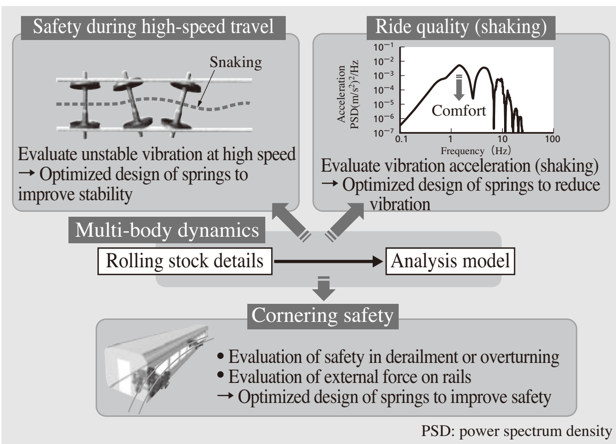


*Fig. 5—Rolling Stock Dynamics Simulator.*
*This simulation technology can predict and evaluate safety and ride quality by analyzing the motion and behavior of rolling stocks.*

minimizing noise alongside tracks used for high-speed and high-density transport operations.

Hitachi has developed a dynamics simulator[6] for designing rolling stock that can be used to predict rolling stock behavior and evaluate the dynamic characteristics of the rolling stock in situations such as when cornering or traveling at high speed. The simulator is used for design and development (see Fig. 5).

## HUMAN-ORIENTED ELEVATORS

### Elevator Management System with Predictive Function to Assist People to Move around Buildings in Comfort

An elevator group supervisory control system treats a number of separate elevators as a group and controls their operation based on consideration of the overall building efficiency so that the many people who use the building each day can be transported smoothly and in comfort.

The key performance measure for a group supervisory control system is how much it can shorten waiting time and the best way to do this is to arrange the elevator cars at equal time intervals. While previous control methods worked by controlling the relationship between the different elevator cars at each instant, there is a limit to how well this can work especially if the elevators stay congested.

Hitachi responded to this problem by developing “future reference trajectory control ” (see Fig. 6)[7].

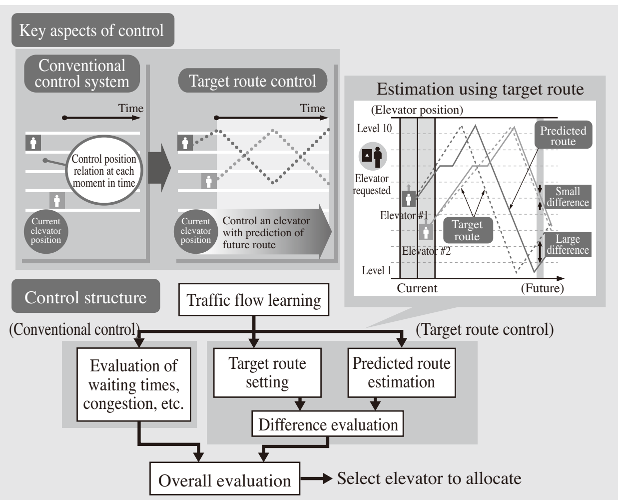


*Fig. 6—Predictive Target Route Control.*
*Use of “predictive target route control” to control the future route of each elevator reduces waiting times during times when large numbers of people are traveling on the elevators.*

This method works by (1) determining the target route such that the elevator cars will continue to be positioned at equal time intervals in the future, (2) estimating the future trajectory (predicted route) of each car based on the result of traffic flow learning for the building, and (3) allocating cars for which the difference between the target and forecast route is small. This allows the control system to look ahead continuously as it positions the cars so that they are at equal time intervals even when congestion continues for some time, with the result that the proportion of extended waiting times that occur during times of congestion is reduced by 6 to 12% compared to previous systems.

### Safe and Secure Elevator System with Abnormal Behavior Detection to Improve Security

To keep elevator passengers safe, Hitachi has developed technology that uses video from cameras mounted in the elevator cars to detect aggression or other abnormal activity by people in the elevator[8], and has incorporated this in the Helios Watcher feature of its security cameras.

Instead of the abnormal activity it is intended to detect, the abnormal activity detection system

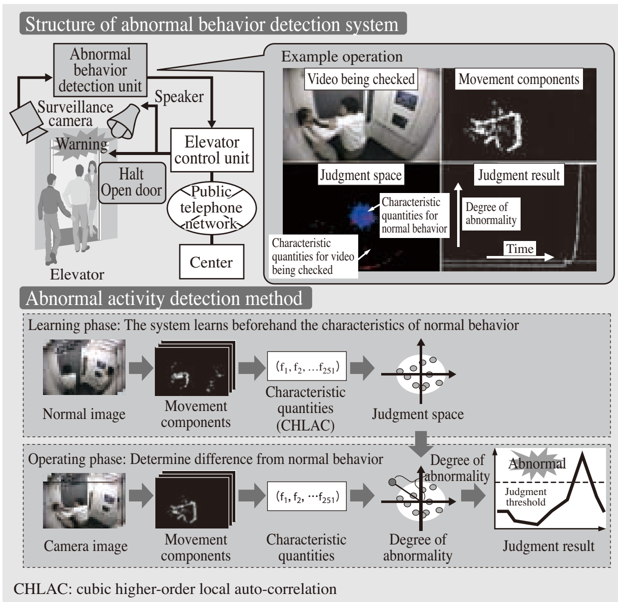


*Fig. 7—Structure and Detection Method Used in Abnormal Activity Detection System.*
*The system detects aggression and other abnormal activity by elevator passengers by comparing the characteristics of the current video from the elevator with the characteristics obtained beforehand by a learning system from video of passengers behaving normally.*

developed by Hitachi models normal behavior (see Fig. 7). If the people being monitored are not determined by this model to be behaving normally, the system judges this to be abnormal activity.

This method consists of a learning phase for learning normal activity and an operating phase when the system is actively detecting abnormal activity. In the learning phase, the system learns the characteristic quantities for a large volume of video capturing normal activity to determine the judgment space used to calculate the degree of abnormal activity. Here, the term “judgment space” means the domain that adequately represents the distributions of the characteristic quantities for normal behavior. Also, the CHLAC (cubic higher-order local auto-correlation) method developed by the National Institute of Advanced Industrial Science and Technology[9] is used to obtain the characteristic quantities for the video. In the operating phase, the degree of divergence of the characteristic quantities for the camera images are calculated to obtain the degree of abnormal activity. Next, whether or not abnormal activity is present is determined by comparing this result with threshold values for the distribution of characteristic quantities for normal behavior obtained by learning.

The method is able to detect aggression and other abnormal activity by elevator passengers with a high degree of accuracy.

## CONCLUSIONS

This article has described Hitachi activities concerned with human-oriented values such as environmental protection, comfort, and safety in the fields of railways, automobiles, elevators, and other forms of transport.

Hitachi contributes to society through infrastructure products based on highly reliable core technologies. Hitachi intends to continue incorporating into each of its products the benefits of products and technologies that take account of harmony between people and the environment from the perspectives of global environmental protection and our aging society.

## REFERENCES


(1) T. Nishigaito et al., “Sensor Fusion Technology for Advanced Active Safety,” Hitachi Hyoron **89**, pp.654 - 657 (Aug. 2007) in Japanese.

(2) S. Sato et al., “Improvement for Torque Control Precision in Torque-based Engine Control,” JSAE Transaction **38**, pp.115 - 120 (Jan. 2007) in Japanese.

(3) K. Yamane et al., “Estimation of Statistical Traffic Data for Navigation Systems,” International Journal of ITS Research **2**, pp.1-9 (2004).

(4) E. Sasaki et al., “SAINT Integrated Signaling System with High Reliability and Safety,” Hitachi Review **57**, pp. 41-45 (Mar. 2008).

(5) M. Osawa et al., “Delay Recovery Simulation Using Digital ATC,” Japan Society of Mechanical Engineers, 7th Symposium on Railway Technology, 3307 (Dec. 2000) in Japanese.

(6) K. Goda et al., “Simulation for Automotive and Railway Vehicles,” Hitachi Hyoron **90**, pp.914-919 (Nov. 2008) in Japanese.

(7) T. Yoshikawa et al., “Elevator Group Control System with the Advanced Forecasting Trajectory Technique (AFTT) to Achieve Equal Time Interval Operation,” Elevator Technology 16, Proc. ELEVCON 2006, pp.373-382 (July 2006).

(8) M. Nakamura et al., “Remote Monitoring System for Elevators and Escalators Providing Safety and Security,” Hitachi Hyoron **90**, pp.742-745 (Sept. 2008) in Japanese.

(9) T. Nanri et al., “Anomaly Detection in Motion Images Containing Multiple Persons,” Journal of Information Processing **46**, No.SIG15 (CVIM12) (2005) in Japanese.

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