



Newsletter Volume 4



Newsletter Volume 1



## Establishment of the Collaborative Research Center for Advanced Mobility (ITS Center)

### Introduction .....

In March 2005 the Collaborative Research Center for Advanced Mobility (ITS Center) was established within the Institute of Industrial Science (IIS), The University of Tokyo. The Center's establishment indicates recognition as an organization of the activities we have engaged in to date, notably the Sustainable ITS project. As the University's ITS research and development center, the ITS Center is proud to be the first and only such organization in Japan to embody cross-sectoral collaboration between industry, government, and academia.

Technical development in ITS began with research and development in the 1990s and has entered the second stage following a decade-long initial-deployment period. In this second stage of ITS, not only is the development of element technologies an urgent task, but also the transformation of research and development into integrated, interdisciplinary services to supplement these fundamental technologies is critical. When we consider services that combine various academic disciplines, the cultivation of promising new businesses requires an arena for industry, government, and academia to combine knowledge and fuse leading-edge technologies such as traffic engineering, electronics and information engineering, and control engineering. It is no exaggeration to say that, for the purpose of sweeping away past stereotypes and exploring completely new directions for services, the University's activity in developing a large number of researchers having a fresh, flexible way of thinking and the next generation of promising young researchers is essential for the future development of ITS.

Up until now ITS has been operating in a field in which progress is difficult within the University's existing research structure owing to its tendency to engage in conventional academic, discipline-centered, compartmentalized administration. To overcome this "academic barrier" in ITS research, the Institute of Industrial Science, The Univ. of Tokyo decided to launch the Collaborative Research Center for Advanced Mobility, to proactively engage in interdisciplinary fusion, by inviting ITS advocates from industry, government,

and academia, and by vigorously cultivating promising ITS businesses. The Center has as its core members Professor Katsushi Ikeuchi, which specializes in information engineering, Prof. Masao Kuwahara Laboratory, which specializes in traffic engineering, Prof. Yoshihiro Suda, which specializes in vehicle dynamics and control and Prof. Takahiro Suzuki, which specializes in system control engineering, Visiting Professor Toshihisa Tanaka who contributes his deep knowledge of ITS, and overseas cooperating member, Visiting Professor Edward Chung. Furthermore, in addition to the core members, the Center has sought broad-based cooperation from within and beyond the University. The Center has invited an electric vehicle specialist Prof. Yoichi Hori, a communications specialist Prof. Kaoru Sezaki, imaging specialists Prof. Shunsuke Kamijo and Prof. Yoichi Sato, environment specialists Prof. Shinsuke Kato and Prof. Ryoza Ooka, and a Geographic Information System (GIS) specialist Prof. Ryosuke Shibasaki to contribute as internal supporting members from within the University and it has invited a communications platform specialist Prof. Takaaki Hasegawa (Saitama University), a specialist in vehicle control Prof. Ichiro Kageyama (Nihon University), specialists in traffic engineering Prof. Hirokazu Akahane (Chiba Institute of Technology) and Prof. Takashi Oguchi (Tokyo Metropolitan University) as external supporting members from outside the University. In this way, the Center has as its goal the fusion of all fields of knowledge related to ITS without distinguishing between industry, government, and academia.

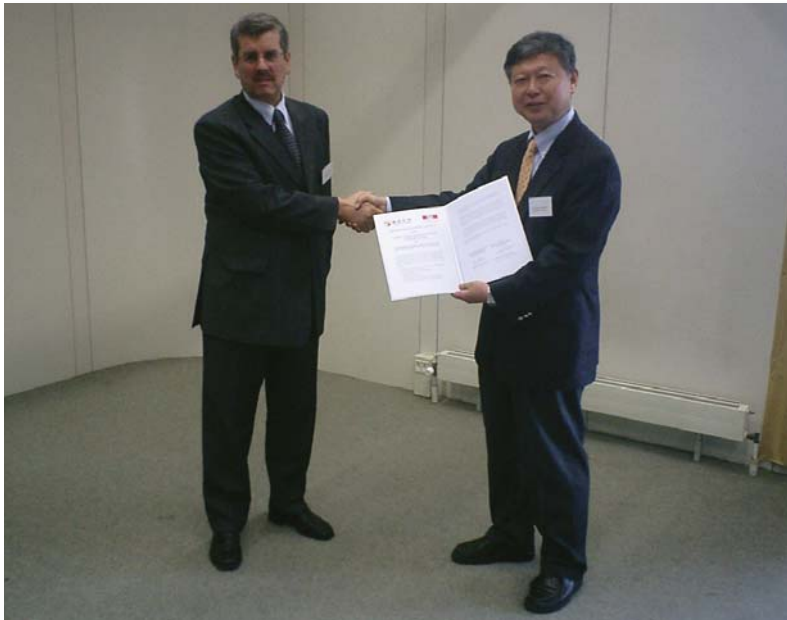
The Center is already actively engaging in international collaboration, as indicated by the signing in October 2005 of a Memorandum of Academic Exchange with the Ecole Polytechnique Fédérale de Lausanne (EPFL) of Switzerland, of which Visiting Professor Edward Chung is a faculty member, and the subsequent signing in November of a memorandum with California Partners for Advanced Transit and Highways (PATH). The Center also signed memorandums with the University of Seoul and Delft University of Technology in February 2006. Through this type of international collaboration, the Center plans to pursue a global standard for ITS.

## Projects and Activities at the Center

The Center's core project is the development of the Mixed-Reality Traffic Experiment Space in a collaborative effort between business and academia. Concretely, the center has been developing a sophisticated augmented-reality driving environment by integration of a traffic simulator (TS) developed by Kuwahara Lab and a driving simulator (DS) developed by Suda Lab and application of image processing technology developed by Ikeuchi Lab to provide more realistic images for the driving simulator. Through the development, the purpose of this project is specifically on clarifying human-driver models, the lack of which has been an obstacle in the development of ITS technology.

The design and implementation of this system are being carried out by means of industry-university collaboration involving the research staff of three laboratories and researchers from more than 10 companies. Although the planned short-term research task is to conduct research centered on this flagship project, the Center also promotes interdisciplinary research on topics related to multimodal advanced mobility and plans to include broad-based research in the scope of its activities.

Various projects are currently being conducted at the Center, including the following: Basic and Advanced Research on ITS, which has been continuously conducted since fiscal 1996 as research contracted by NILIM (the National Institute for Land and Infrastructure Management, Ministry of the Land, Infrastructure and Transportation); the above-mentioned CCR Sustainable ITS project; High-Resolution Air Pollution Evaluation System, a joint research project with Kato Lab, who is an internal support member; and joint research with the Laboratory of Traffic Facilities (LAVOC) of the Ecole Polytechnique Fédérale de Lausanne (EPFL), an example of an international collaborative project.

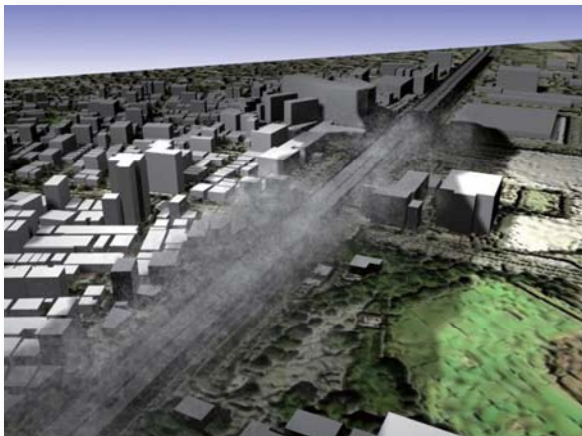


▲ Signing of the Memorandum of Academic Exchange with EPFL



▲ The Universal Driving Simulator for Human, Vehicle, and Traffic Research

The Center invites people from private industry, government, and academia who have a profound knowledge of ITS to serve as instructors and it founded the Research Committee on ITS in the Foundation for the Promotion of Industrial Science(FPIS) that serves as a forum for periodic exchanges of opinion. Furthermore, the Center is actively engaged in public awareness activities to expand the base of support for ITS: in October 2005 the Center, in cooperation with the CCR Sustainable ITS project and FPIS, conducted the Special Course in ITS for Working People and on Friday evening of each week from November to January the Center held the IIS Evening Seminars for the general public. Based on these activities, the Center intends to further deepen collaboration between industry, government, and academia, jointly explore directions to pursue for new ITS services, and actively cultivate promising new businesses.



▲ High-Resolution Air Pollution Evaluation System



▲ Scene of an Experiment  
(Tomei Expressway Yamato Sag Section)

Members of the Collaborative Research Center for Advanced Mobility (ITS Center),  
Institute of Industrial Science, The University of Tokyo .....

**Director** Information Engineering  
**Katsushi IKEUCHI**, Professor  
Graduate School of Interdisciplinary Information Studies

**Core Members**

Traffic Engineering

**Masao KUWAHARA**, Professor  
Center for Collaborative Research

Vehicle Dynamics and Control

**Yoshihiro SUDA**, Professor  
Center for Collaborative Research

System Control

**Takahiro SUZUKI**, Associate Professor  
Graduate School of Interdisciplinary Information Studies

Research Management

**Toshihisa TANAKA**, Visiting Professor  
Center for Collaborative Research

Traffic Engineering, International Collaboration

**Edward CHUNG**, Visiting Professor

**Internal Supporting Members**

Electric Vehicle

**Yoichi HORI**, Professor

Communication

**Kaoru SEZAKI**, Associate Professor

Image Processing

**Shunsuke KAMIJO**, Associate Professor  
Center for Information Fusion

Visual Interface

**Yoichi SATO**, Associate Professor  
Center for Information Fusion

Environmental Technology for Urban Architecture

**Shinsuke KATO**, Professor

Geographic Information System

**Ryosuke SHIBASAKI**, Professor

Environmental Technology for Urban Architecture

**Ryozo OOKA**, Associate Professor

**External Supporting Members**

Vehicle Motion, Motion Control, Sensing Technology

**Ichiro KAGEYAMA**, Professor  
Nihon University, College of Industrial Technology

ITS Communication Platform

**Takaaki HASEGAWA**, Professor  
Saitama University, Department of Civil and Environmental Engineering,  
Department of Electrical and Electronic Systems Engineering

Traffic Engineering

**Hirokazu AKAHANE**, Professor  
Chiba Institute of Technology, Department of Architecture and  
Civil Engineering

Traffic Engineering

**Takashi OGUCHI**, Associate Professor  
Tokyo Metropolitan University, Faculty of Urban Environmental Sciences



## Commemorative Symposium on Collaborative Research Center for Advanced Mobility (ITS Center)

On October 27 the Center conducted the Commemorative Symposium on Collaborative Research Center for Advanced Mobility (ITS Center) for the purpose of broadly publicizing the establishment of the Center both within and beyond the University.

At the symposium, following opening remarks given by Masafumi Maeda, the Director of Institute of Industrial Science, a keynote address on the topic “Realization of a Society with Sustainable Mobility—Expectations for ITS” was delivered by Hiroyuki Watanabe the senior Technical Executive of Toyota Motor Corporation. The speech was followed by guest speakers about the current state of ITS and its future outlook in Switzerland and Europe given by Professor Andre-Gilles Dumont of the Ecole Polytechnique Federale de Lausanne (EPFL), with which the Center has signed a Memorandum of Academic Exchange, and Visiting Professor Edward Chung, also of EPFL. In the afternoon session, following introductions of the research activities of the ITS Center’s projects, five panelists invited from private-sector companies involved in ITS participated in a panel discussion session in which there was an active discussion on the nature of ITS collaboration between business and academia.

A total of 113 participants from private-sector companies, incorporated foundations, universities, and other organizations attended the symposium. At a social reception following the symposium, the participants enthusiastically exchanged opinions on topics that extended beyond the boundaries of their own industry sectors and academic fields.



▲ Keynote address by Hiroyuki Watanabe, Senior Technical Executive of Toyota

## Special Course in ITS for Working People

On October 28 at the Komaba Convention Hall, the Special Course in ITS for Working People was conducted through cooperation between Center for Collaborative Research (CCR), the Foundation for the Promotion of Industrial Science, and the Collaborative Research Center for Advanced Mobility (ITS Center). The course was attended by 78 participants, including company employees, local government representatives, and students.

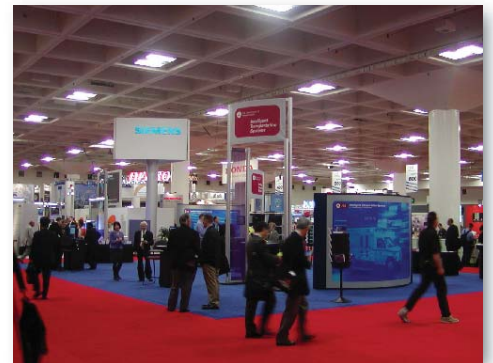
CCR has engaged in research and organizational activities related to the commercialization of ITS through collaboration between industry and academia since 2003 through its Sustainable ITS project and widely distributes the fruits of this effort to numerous companies and local government bodies. Another role that CCR considers important is to broadly contribute to society by offering special courses to develop ITS specialists among company engineers, local government representatives, policymakers, and other interested parties employed by participating members and other organizations. This is because ITS is a field in which companies and local governments find it difficult to develop solely. Accordingly, the Center conducted the Special Course in ITS for Working People in 2004 and 2005. The ITS Center will fully cooperate in this activity from this year.

Last year’s course began with opening remarks from Prof. Katsushi Ikeuchi, Director of Collaborative Research Center for Advanced Mobility, IIS, The Univ. of Tokyo. The opening remarks were followed by several lectures: “ITS Virtual Proving Ground Using a Universal Driving Simulator” by Dr. Yoshiyuki Takahashi (Suda Lab.), “Utilization of ITS Technology in Traffic Management” by Mr. Shinji Tanaka (Kuwahara Lab.), “Sensing Technology in ITS—A Focusing on Images and Lasers” by Dr. Masataka Kagesawa (Ikeuchi Lab.), and “Analysis and Control of Dynamics in Transportation Systems” by Prof. Takahiro Suzuki. After the lectures, the course ended with a tour of the four laboratories.



## The 12th ITS World Congress in San Francisco

The 12th ITS World Congress was held from November 6-10, 2005 at the Mosconi Center in San Francisco. The congress is held each year as a forum for international cooperation and interaction concerning ITS and as a venue for presentations on the latest research. Participants presented research papers and held exhibitions on this year's theme, Enabling Choices in Transportation. Following a congress held in Nagoya in 2004, the Sustainable ITS project presented papers in the technical sessions. The contents of the four papers are introduced below.



## Papers Presented

### Ken Honda [Chodai Co., Ltd.]

#### Evaluation of Driving Behavior using Virtual Reality Experiment at Expressway Sag and Merging/ Diverging Sections

Mr. Honda presented an evaluation of the dynamic infrastructure used in 'the Mixed-Reality Traffic Experiment Space' constructed up until now in the Sustainable ITS project. The main content of the paper was a comparison between the virtual environment used in the evaluation and actual roads, and an explanation of driver behavior when driving in sections where the lane marking changed by means of dynamic infrastructure realized in the virtual environment. On the basis of the results that the direct influence of the dynamic infrastructure on driver behavior is not very great, the direction was set for the other vehicle models of KAKUMO to be constructed.



### Yoshiyuki Takahashi [Suda Laboratory]

#### Development of the Universal Driving Simulator for ITS Researches

Dr. Takahashi presented the positioning of the Universal Driving Simulator in the Sustainable ITS project and an overview of the simulator. He explained a detailed introduction to the structure of the turntable developed as an improvement to the driving simulator and its utility on the basis of experimental results.



### Masataka Kagesawa [Ikeuchi Laboratory]

#### A Proposal to Simulate Driving Scene of Sag Zones in Highway by Using Image-Based Rendering

This paper discussed the development of a system for the creation of simulated driving images in 'the Mixed-Reality Traffic Experiment Space' constructed in the Center's core project. The paper explained that with this system it is possible to realize a high degree of reality and versatility by using two rendering methods: image-based rendering using live-action images and geometry-based rendering using a conventional driving simulator. Future plans involve contributing to the psychological analysis of drivers by applying the system to the Yamato sag experimental section of the Tomei Expressway and generating highly realistic driving images.



### Tomoyoshi Shiraishi [Kuwahara Laboratory]

#### A Development of Traffic Prediction System based on Real-time Simulation

This paper introduced the framework for a traffic prediction system using the macroscopic traffic simulation (TS) engine and explained the reproduction methods of actual traffic conditions by detector data obtained in real time and the prediction method of incoming traffic flow from on-ramp. In the future, these methods may be able to be included into 'the Mixed-Reality Traffic Experiment Space' and this system may be enhanced.





## The 4th ITS Symposium 2005

The 4th ITS Symposium 2005 was held on December 1 and 2, 2005 at the Komaba Convention Hall, IIS, Univ. of Tokyo. The event was sponsored by ITS Japan and co-sponsored by ITS Center, IIS, Univ. of Tokyo.

The symposium began with opening remarks from Prof. Masao Kuwahara in Center for Collaborative Research, Univ. of Tokyo, who was the chairman of the symposium's executive committee. The symposium featured paper sessions on 1) accidents and safety, 2) architecture and probes, and 3) traffic control and traffic planning, and 4) map technology; organized sessions on 1) safety and 2) probes; an invited lecture on the environment; and poster sessions on 45 research topics spanning the entire field of ITS. At all the sessions, the presenters and participants engaged in lively discussion. The well-attended symposium concluded with closing remarks from Prof. Takaaki Hasegawa in Saitama University, who was the chairman of the program committee. The symposium was attended by 235 participants, primarily from ITS industry, government, and academia.

Members of the Sustainable ITS project gave three presentations at the paper sessions and two presentations at the poster sessions. The presentations at the paper sessions were on the developmental elements of the Mixed-Reality Traffic Experiment Space that is the core system of the Sustainable ITS project: the driving simulator, the KAKUMO traffic micro-simulator's driver model, and driving image generation technology. At the poster sessions, applied research presentations were given on the evaluation of the effect of establishing roadside parking zones and on a route selection model.

The Center received valuable opinions and advice from a number of participants as a result of these presentations and believes that the presentations deepened the understanding of the Sustainable ITS project. The symposium also revealed the high expectations held for our ITS Center, newly established this year.



### Paper Sessions (3 presentations)

★Asterisks indicate the presenters.

1	<p>“Driver Characteristics Behavior by Means of Functional Improvement in Driving Simulator Rotational Motion”</p> <p>Yoshihiro Suda, Masaaki Onuki*, Yoshiyuki Takahashi, Hisanao Komine, Kosuke Matsushita</p>
2	<p>“Development of a Driver Behavior Model”</p> <p>Makoto Kano*, Tomoyoshi Shiraishi, Katsuyuki Maruoka, Hironori Ishikawa, Keiichi Kenmotsu, Takatsugu Yamamoto, Mayumi Sakai, Kyu Tsuji, Masao Kuwahara</p>
3	<p>“A Proposal to Simulate Driving Scene of Sag Zones in Highway by Using Image-Based Rendering.”</p> <p>Shintaro Ono*, Koichi Ogawara, Masataka Kagesawa, Hiroshi Kawasaki, Masaaki Onuki, Ken Honda, Katsushi Ikeuchi</p>

### Poster Sessions (2 presentations)

★Asterisks indicate the presenters.

1	<p>“Evaluation of On-Street Parking Bay for Parking Management—Efficiency and Safety Analysis Using the Mixed-Reality Traffic Experiment Space”</p> <p>Shinji Tanaka*, Masao Kuwahara, Tomoyoshi Shiraishi, Makoto Kano, Toshihiko Oda, Yoshito Mashiyma</p>
2	<p>“A Basic Model for Route Selection Based on User Knowledge and Traffic Information”</p> <p>Ken Honda*, Masao Kuwahara, Junichi Katsuro, Hisatomo Hanabusa, Toshikazu Arai, Makoto Furukawa</p>

## Other Academic Presentations (19 presentations)

Title	Author	Forum	Presentation date (2005)	Location
The Universal Driving Simulator for Human, Vehicle, and Traffic Research	Yoshihiro Suda, Yoshiyuki Takahashi, Masaaki Onuki	Journal of Society of Automotive Engineers of Japan, Vol. 59, No. 7	May 12	
Signal Control by Successive Updating of Control Parameters Based on Prediction of Traffic Flow	Toshihiko Oda	IEEJ Transactions on Industry Applications	August 1	
Development of a Traffic Prediction System Based on Real-Time Simulation	Tomoyoshi Shiraishi, Ryota Horiguchi	54th National Congress for Theoretical and Applied Mechanics (NCTAM2005)	January 27	Scientific Council of Japan
Construction of a 'Mixed-Reality Traffic Experiment Space' Involving Linkage of a Traffic Simulator and Driving Simulator	Ken Honda, Katsushi Ikeuchi, Masao Kuwahara, Yoshihiro Suda, Masataka Kagesawa, Tomoyoshi Shiraishi, Masaaki Onuki, Makoto Kano	54th National Congress for Theoretical and Applied Mechanics (NCTAM2005)	January 27	Scientific Council of Japan
The Research about the Dynamic Infrastructure	Tomoyoshi Shiraishi, Masao Kuwahara, Hiroshi Warita, Shinji Tanaka	31st Conference of Infrastructure Planning	June 5	Hiroshima University
Development of Universal Driving Simulator with Interactive Traffic Environment	Yoshihiro SUDA, Yoshiyuki TAKAHASHI, Masao KUWAHARA, Shinji TANAKA, Katsushi IKEUCHI, Masataka KAGESAWA, Tomoyoshi SHIRAISHI, Masaaki ONUKI, Ken HONDA, Makoto KANO	2005 IEEE Intelligent Vehicles Symposium	June 6	Las Vegas
A Photo-Realistic Driving Simulation System for Mixed-Reality Traffic Environment Space	S. Ono, K. Ogawara, M. Kagesawa, H. Kawasaki, M. Onuki, J. Abeki, T. Yano, M. Nerio, K. Honda, K. Ikeuchi,	2005 IEEE Intelligent Vehicles Symposium	June 6	Las Vegas
An Enhanced Traffic Simulation System For Interactive Traffic Environment	M.Kuwahara, S.Tanaka, M.Kano, M.Furukawa, K.Honda, K.Maruoka, T.Yamamoto, T.Shiraishi, H.Hanabusa, N.Webster	2005 IEEE Intelligent Vehicles Symposium	June 8	Las Vegas
Development of a simulator for estimating vehicle carbon dioxide emissions and its use for evaluating signal control methods	Oda T, Niikura S	12th World Congress on Intelligent Transport Systems	November 9	San Francisco
Development of a Universal Driving Simulator for ITS Research	Yoshihiro Suda, Yoshiyuki Takahashi, Masaaki Onuki	The Japan Society of Mechanical Engineers 14th Transportation and Logistics Conference (TRANSLUG 2005)	December 9	Kawasaki
Development of a Simulator for Estimating Vehicle Carbon Dioxide Emissions on an Urban Road Network and Evaluation of Signal Control Algorithms	Toshihiko Oda, Satoshi Niikura	The Papers of Technical Meeting on Transportation and Electric Railway and ITS ITS-05-1, pp.1-6	January 13	University of Tokyo Institute of Industrial Science
A Safety Study on Dynamic Lane Marking of Motorways in Mixed Reality	Akira Iwanaga, Ken Honda, Shinji Tanaka, Tomoyoshi Shiraishi, Masao Kuwahara	32nd Conference of Infrastructure Planning	December 3	Miyazaki University
The Importance of Next-Generation ITS Services and G-Contents -Creation of a New Market and New Industry by Means of Next Generation Digital Roadmaps	Toshihisa Tanaka	Meeting for announcing LBCS results	March 3	Aoyama Teletopia
The Next Car Navigation Strategy and Next-Generation Digital Roadmaps - ITS in Its Second Stage and the Importance of Digital Roadmaps	Toshihisa Tanaka	Special Seminar on Wireless and Mobile Strategy	May 27	Meiji Kinenkan
'From Navigation to Concierge' - Development of a Car Navigation Service and Market Strategy	Toshihisa Tanaka	MOT Business Course	December 7	Roppongi Academy Hills
Detection of Street-Parking Vehicles by Using Laser Range Sensor Mounted on a Measurement Vehicle ( in Japanese)	Shintaro Ono, Kiyotaka Hirahara, Masataka Kagesawa, Katsushi Ikeuchi	IEICE Transaction on Fundamentals of Electronics, Communications and Computer Sciences (Japanese Edition) Vol. J88-A, No.2, pp. 247-256	February	
Construction of Driving-Simulation View by Synthesizing Real Video Images ( in Japanese)	Shintaro Ono, Koichi Ogawara, Masataka Kagesawa, Hiroshi Kawasaki, Masaaki Onuki, Junichi Abeki, Toru Yano, Masami Nerio, Ken Honda, Katsushi Ikeuchi	Meeting on Image Recognition and Understanding (MIRU 2005), pp. 909-916	July 18	Awaji, Hyogo
Driving View Simulation with a Hybrid Synthesis of Virtual Geometry and Real Image in the Mixed-Reality Traffic Experiment Space	Shintaro Ono, Koichi Ogawara, Masataka Kagesawa, Hiroshi Kawasaki, Masaaki Onuki, Ken Honda, Katsushi Ikeuchi	4th IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR 2005), pp. 214-215	October 6	Vienna, Austria
Development of Photo-Realistic and Interactive Driving View Generator by Synthesizing Real Image and Artificial Geometry Model	S. Ono, K.Ogawara, M.Kagesawa, H. Kawasaki, M.Onuki, K. Honda, K. Ikeuchi	International Journal of ITS Research (ITSJ) Vol. 3, No. 1, pp. 19-27	November	

## An Experiment in The Yamato Sag and a Simplified Data Preparation Method

The purpose of this experiment is to develop a vehicle-following model that takes into consideration the effect of roadway vertical gradient for the purpose of explaining traffic congestion that occurs at sag sections of expressways.

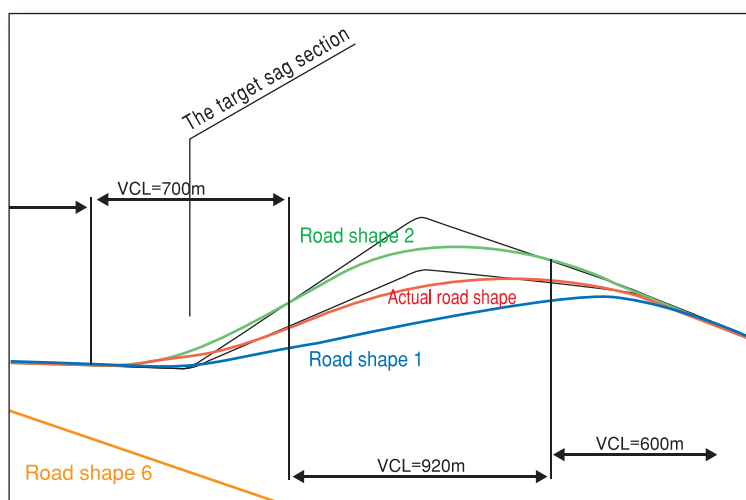
The experiment involves testing subjects in a virtual experimental space created by the Virtual Experiment Laboratory of the Sustainable ITS project. At the Virtual Experiment Laboratory, road networks used by KAKUMO and other simulations and 3D models of roads for display on the driving simulator are necessary. This experiment is performed using the actual specifications of the Yamato Sag on the Tomei Expressway and datasets are prepared for six simulated changes in the gradient of the sag.

In experiments that require multiple datasets like this, there is often concern that the long data preparation periods and the significant expense involved will hinder the carrying out of the experiment. To overcome this problem, we used an automated design tool, used in road design, to develop a simple method for creating datasets. Using this method the road network and the 3D model are prepared from the same road data and it is possible to produce mutually consistent data in a short time.

In this experiment, we used this dataset creation method to prepare experimental data for a stretch of expressway about 20 kilometers in length in the vicinity of the Yamato Sag on the Tomei Expressway. Although testing with subjects using this data has yet to be performed, if testing does yield good results, then this data preparation method is expected to be used as a means for simply conducting experiments using the driving simulator.



▲ The actual Yamato Sag and the 3D model used ▲



▲ Example of experiment patterns ▲



## Image Generator

To simulate a driving environment in Virtual Experiment Laboratory, a mechanism to dynamically display and provide users with driving scenes such as other vehicles, traffic signs, buildings, etc. is necessary. The imaging method implemented on conventional driving simulators, called geometry-based rendering or GBR, lacks photo-reality since all objects are represented by CAD models and simple textures. In contrast, our new method, called image-based rendering or IBR, can compose driving scene by processing real video images, which are obtained by running along a targeted road with our capturing vehicle in advance. Although the capturing run is carried out only once, it is possible to reconstruct a view of any direction from any viewpoint on the road using our image processing technology.

Each of the rendering methods has technical advantages and disadvantages. GBR is suited for superimposing other vehicles and for realizing dynamic traffic signs, meanwhile, IBR is suited for realistic scene reconstruction. Therefore, in this research we developed a technique to composite each method according to its characteristics: GBR for foreground part including road surface, traffic signs and other vehicles, where versatility is required, and IBR for background part including buildings and a sky where photo-reality is required. With the current system, IMG can display appropriate driving scene at a rate of 60 fps according to vehicle position information provided by the driving simulator.

Highly realistic driving view is expected to greatly contribute applied use through driving simulation in the Virtual Experiment Laboratory. For instance, IBR can be most effective for representing driving scene in sag zones ( a series of slight change of road gradient) in expressways, or changes in appearance due to lighting condition of the sun. At present, we are working on improving a quality of the view, extending and optimizing the GBR-IBR composition so that driving views of sag zones can be appropriately reconstructed.

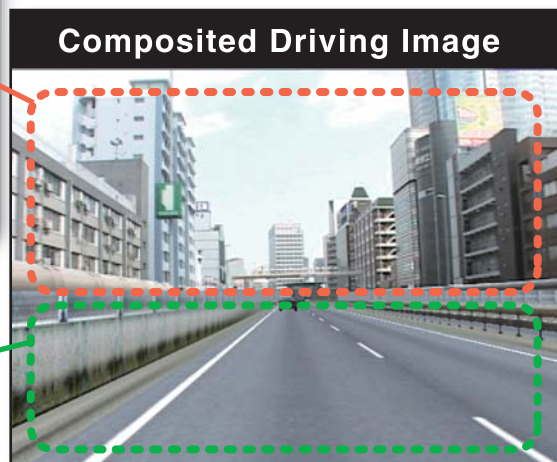
### Our original development



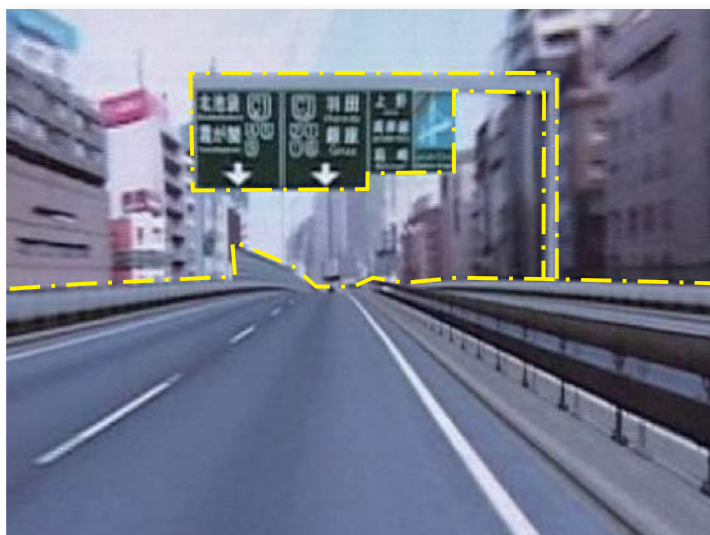
### Conventional Driving Simulator



### Composited Driving Image



▲ Conventional image generating system (full GBR)



▲ The boundary of IBR and GBR sections and composite image results (1)



▲ IBR and GBR composite image results (2)

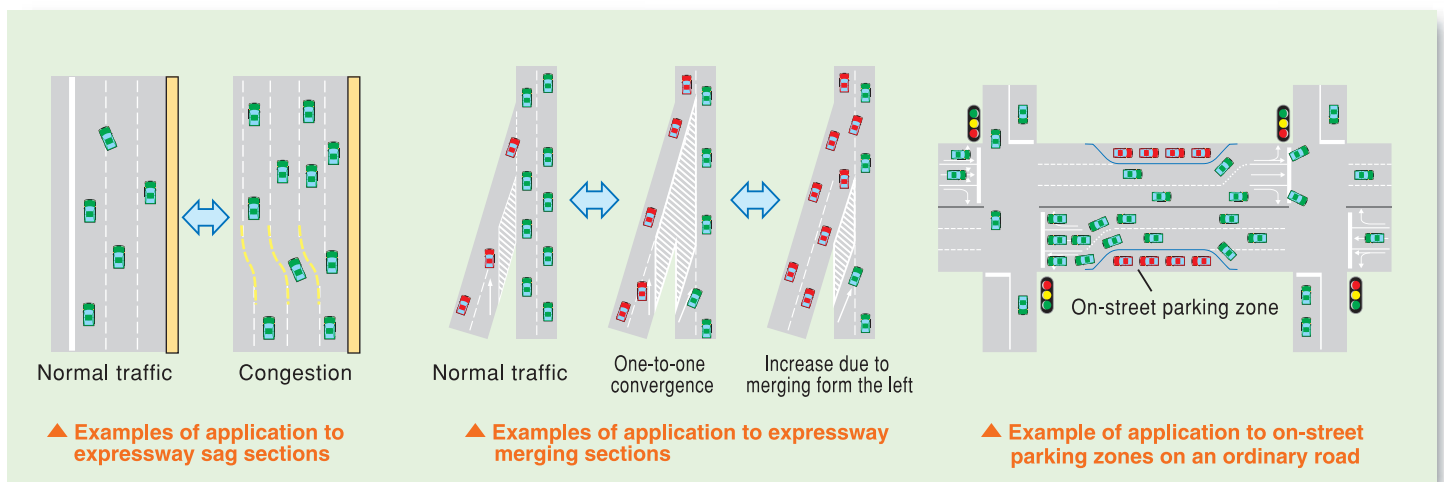
## Dynamic Highway Systems

### Purpose of the Research

Up until now development of ITS technology has centered on automobile control technologies and communication technologies, such as automated driving, driving support, and road-to-vehicle communication. However, development of the original function of roads—use as a space for locomotion—is an important constituent element of ITS, which has hardly progressed at all. The purpose of this research is to demonstrate the practicality of dynamic infrastructure that makes effective use of existing roads by dynamically changing lane markings and other indicators in response to traffic conditions.

### Overview

By carrying out experiments using the KAKUMO micro-simulator and the driving simulator, we simulate the application of dynamic infrastructure to sag sections and merging sections of expressways and to parking zones on ordinary roads, collect driver behavior data, and verify safety. On the basis of driver behavior data obtained from the experiment, we attempt to determine the traffic capacity of the target road sections and perform impact evaluation using the traffic simulator and KAKUMO.



### Current Situation and Future Outlook

At present, we are preparing KAKUMO driver models that respond to changes in dynamic infrastructure by constructing a virtual expressway and collecting data concerning driver behavior by testing carried out on a driving simulator. Dynamic infrastructure can be considered an important technology not only for all eviating traffic congestion, but also for solving a problem in a future mixed traffic between conventional vehicles and ITS vehicles with enhanced vehicle control technologies.



▲ Change in lane markings in a sag section simulation

▲ Change in a zebra in a merging section simulation



## The Universal Driving Simulator

Recently a turntable mechanism was added to the Universal Driving Simulator. The turntable mechanism is a device that generates the yaw-motion important in an automobile simulator, and use of the turntable makes it possible to impart to the driver sensations equivalent to those of an actual car. The motion system used in the Universal Driving System is the only one in Japan that combines a six-degree-of-freedom motion device with a turntable. The turntable is capable of generating maximum yaw angle speed of 80 deg/s and maximum yaw angle acceleration of 300 deg/s<sup>2</sup>. Since this makes the driving sensation more closely resemble that of an actual vehicle and also suppresses the occurrence of simulator sickness, the mechanism is expected to be effective, primarily in research concerning human factors.

In another development, in addition to the previously installed flexible driver's seat, the simulator has been newly equipped with an engine hood, body pillars and some interior equipment, and the mounting angles and positions of these accessories can be freely adjusted. This elaboration is expected to enable deployment of the simulator for research in differences in visibility according to body type (sedan, minivan, etc.) and evaluation of interior comfort.



▲ Motion system with turntable mechanism



▲ Mounting angle-adjustable body pillars



▲ Mounting position-adjustable hood and side mirror

## The Experimental-Measurement Vehicle

We have developed the MAESTRO (Measurement vehicle with Advanced Equipment System for TRaffic Operation) experimental-measurement vehicle (see the photo) as an effective tool to study traffic phenomena that occur on actual roads and to analyze driving behavior. The key features of MAESTRO are its capability to record data concerning driving operations such as steering-wheel angle, torque and accelerator-pedal pressure, the capability to accurately measure vehicle position, bearing, and movement by means of integrated process using a combination of speed sensors, gyrosensors, and other instruments to conduct highly accurate GPS-positioning measurement based on GPS-based time codes, and its function as an integrated data-processing system for accurately recording and synchronizing data on the behavior of nearby vehicles with data for the measurement vehicle using laser radar and images captured by front, side, and rear CCD cameras.

Currently we are performing functional validation of MAESTRO's data processing system and are working on increasing the practicality of the system while simultaneously beginning various on-road measurement experiments. For instance, to clarify the mechanism that creates bottlenecks at sag sections of expressways, we are conducting repeated vehicle-following tests under traffic conditions immediately before the occurrence of congestion on the Tomei Expressway and other expressways. Also, on the Tokyo Metropolitan Expressway network we are measuring the driving behavior of ordinary vehicles that merge into traffic in front of and behind MAESTRO. Furthermore, we are trying to improve vehicle movement models by validating the movement characteristics of the Universal Driving Simulator by using MAESTRO to conduct on-road testing of vehicle movement characteristics on test courses. Data accumulated in this way will be used to elaborate the KAKUMO driver model and is expected to contribute greatly to dramatically improving the simulated driving experience capabilities of the Universal Driving Simulator.

In this way, MAESTRO has a potential to unearth great many facts about driving operations, vehicle movement characteristics, behavior of itself and nearby vehicles in traffic environments, and road environment measurement. Using MAESTRO to elucidate these facts one by one and incorporating these results in KAKUMO and the driving simulator is expected to bring the capabilities of virtual-reality experimental devices even closer to the real world.



▲ The MAESTRO experimental measurement vehicle



## Media Announcements

An announcement of the establishment of the Collaborative Research Center for Advanced Mobility was made to concerned companies at an IIS press conference in May 2005. As a result of the tremendous response to the announcement, the Center received media coverage as shown in the table below. The extensive coverage can be regarded as an indication of the great public interest and high expectations for ITS. To fully meet these expectations and to pave the way for further practical application of ITS, the Center will intensify its research and development, public awareness activities, and other initiatives.

Medium	Publication or broadcast date	Details
Nikkei Business Publications	May 12, 2005	"Even Venture Companies Can Use Laboratory Equipment" "The University of Tokyo's Institute of Industrial Science establishes a specialized ITS research institute"
Nikkei Shimbun	May 13, 2005	"Highly realistic simulated driving including 360° imaging at the University of Tokyo's Institute of Industrial Science"
Nikkei Business Daily (page 7)	May 13, 2005	"The University of Tokyo's Institute of Industrial Science establishes an ITS base, unveils a driving simulator"
The Business & Technology Daily News (page 25)	May 13, 2005	"The University of Tokyo's Institute of Industrial Science establishes a next-generation center for ITS promotion"
Yomiuri Shimbun (evening edition)	May 17, 2005	"360° field of vision driving experience, slow driving creates line of following cars"
Yomiuri Online	May 17, 2005	"360° field of vision driving experience, development of a new type of simulator"
NHK (Ohayou Nippon)	May 20, 2005 (approx. 7:55 A.M.)	Live broadcast of the simulator on the Today's Live program segment
Tokyo Shimbun (morning edition)	May 24, 2005	Research center for ITS promotion
TV Tokyo (Opening Bell)	June 1, 2005 (approx. 9:15 A.M.)	Introduction of the simulator and professors in "Tohru-ga-Touru" program segment

## Contact



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