Vehicular Dynamics Research & Evaluation System – High-Precision Driving Simulator

NAGOYA UNIVERSITY

National Innovation Complex (NIC),
Nagoya University

FORUM8™

FORUM8 Co., Ltd.

Vehicular Dynamics Research & Evaluation System – High-Precision Driving Simulator

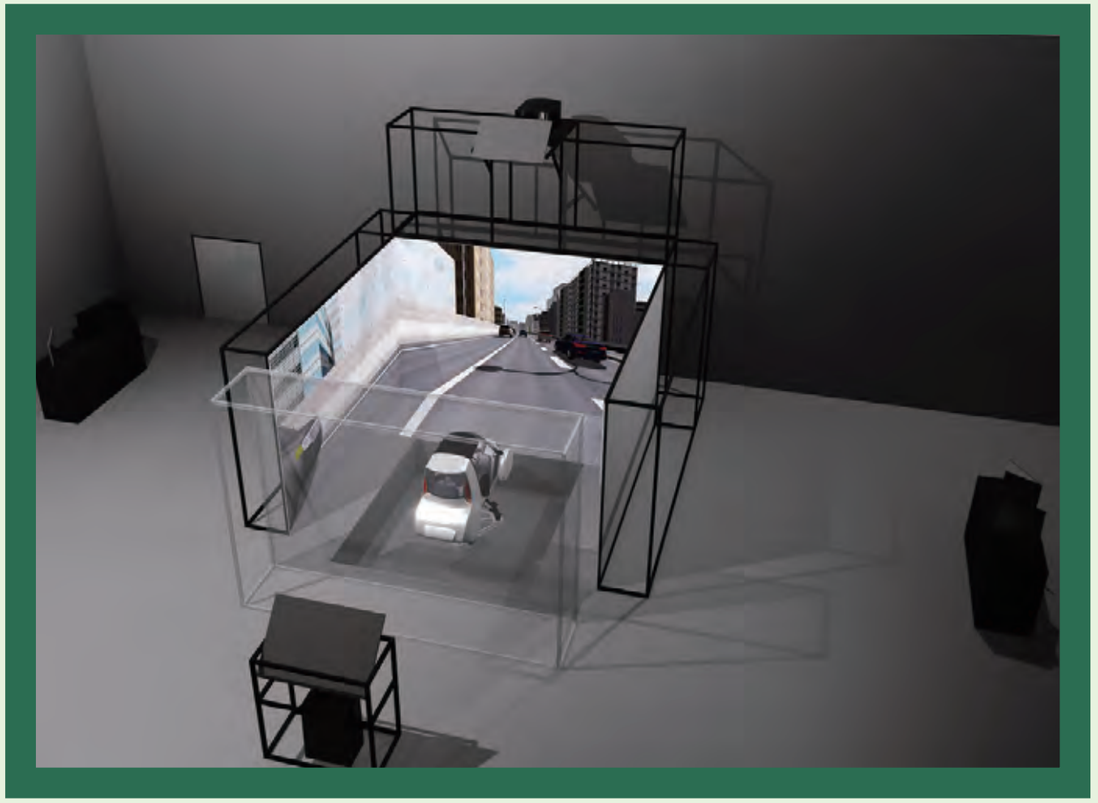
This is the world's first※1)、large-scale, 5-screen CAVE stereoscopic virtual reality (VR) driving simulator used for vehicle dynamics and driving behaviour simulations.

Though an accurate representation of visuals, motion, and vibration, this simulator is used for monitoring various factors such as vehicle and human cognition factors, with a future aim to derive a quantitative mathematical model.

1 The five 240-inch, high-luminance 3D HD displays deliver a 315 degrees field of view, allowing the driver to feel the sense of "presence" inside the virtual space through the combined effects of overlapping objects, the sense of depth and the sense of distance.

2 Most existing simulators require the driver to practice and become familiar with it first, but this simulator can be driven as if driving a real car. This can significantly reduce research cost and time, potentially allowing a larger research sample selection. These characteristics make the simulator very ideal for many driving behaviour and human-vehicle interaction oriented researches.

※1) As of June, 2015, this simulator is the first CAVE driving simulator that combines a large 5-screened 3D display, motion platforms, and a driving cockpit.



Motion & Motion-Control System(MOOG)

The 6-axis motion base by MOOG Inc. has 6 electrical cylinders that expand and contract to responsively simulate a 6-DOF (degree of freedom) environment. The cockpit seats installed above the platform will move in various directions according to the screen displayed.

Car Dynamics (CarMaker / CRUISE)

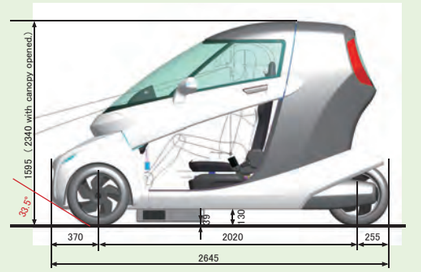
This simulator may be used for monitoring and evaluating numerous dynamic reactions due to various vehicular (e.g. gas, brake, steering, gear shifts) and environmental parameters (e.g. friction coefficient, road elevation, cross-wind)

3D・VR (UC-win/Road / VR-Design Studio)

This real-time 3D virtual reality soft allows users to create large-scale 3D environments easily on a standard PC, as well as performing various types of simulations.

Driving Cockpit

The cabin consists of all the needed driving components. It is also equipped with numerous sensors and audio speakers, to simulate as many factors as possible during driving.



Projector

4K Resolution, 120Hz frame rate, 3-chip DLP®
3D Active Stereoscopic Projector
Christie Mirage 4k35

Resolution	Brightness (Maximum)
4096 × 2160 pixels (4K)	35,000 centre (32, 500 ANSI) – 6.0kW lamp

Traffic Flow Simulator (AIMSUN)

AIMSUN can be coordinated with UC-win/Road (VR-Design Studio) to allow enhanced real-time traffic simulation. This allows the visualization of dynamic route selection and is useful for ITS-related researches.

Vehicular Dynamics Research & Evaluation System – High-Precision Driving Simulator

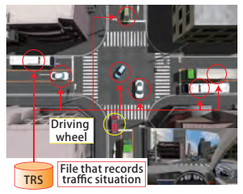
Definition of a Driving Simulator

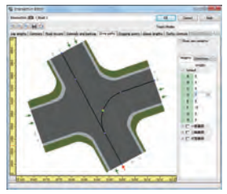
A simulation system loaded with 3D VR representation of roads and traffic flows that allow a realistic, real-time portrayal of a driving environment with little to no difference in perception compared to reality. A simulator should have highly accurate car physics models for accurate vehicular movement simulation and various other simulated factors such as visual, audio, and tactile cues. Simulators should also have the freedom to design set up many different situations such as sudden jaywalkers or AI car movement controls.

■Recreate road networks and city skylines with 3D VR models



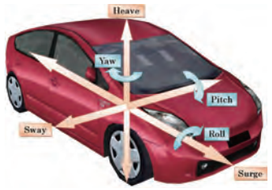
■Recreate the traffic flow



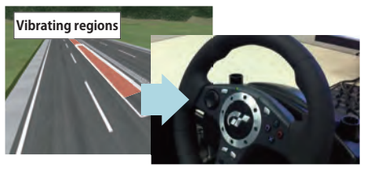

■Vehicle models to recreate accurate car movements

■Realistic driving conditions recreated through visual (video), audio (sound), tactile (acceleration, vibration) cues



▲Supports surge, sway, and heave directions of motion to allow 6-degree of freedom (DOF)

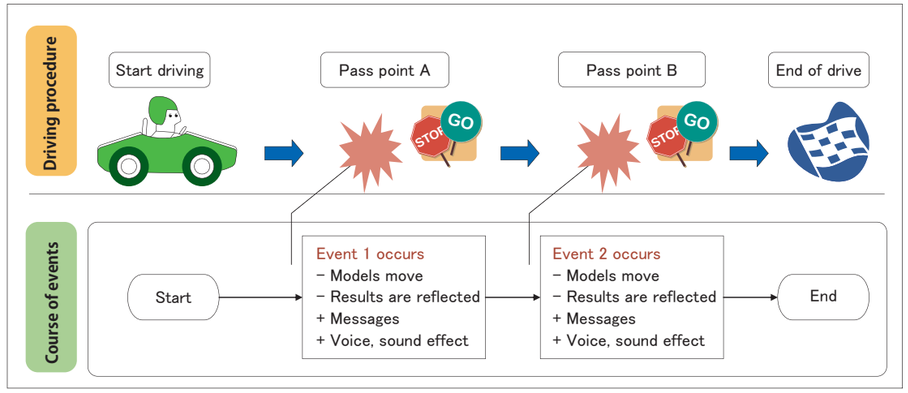

▲6-DOF motion platform



▲Force feedback

What can you do with a Driving Simulator?

■Different events on road can be assigned to occur depending on the driving behaviour (Scenario Editor function)



■Driving behavior can be monitored and recorded easily (Log feature)

Types of data that can be logged and saved to a file (only to name a few)	
Basic data	Duration of the simulation, name of car vehicle, model ID, vehicle type
Coordinates, Orientation	X-coordinate, Y-coordinate, Z-coordinate, pitch angle, yaw angle, roll angle, vector
Power, Velocity	Engine RPM, Gear Position, Velocity (km/h, m/s), Speed Limit
Input Data	Steering angle, Accelerator position, Brake position, Autonomous Driving
Distance	Mileage, Distance from the road's starting point, Distance from the edge of the road

■Past events can be 'replayed' as many times as you wish (Replay function)

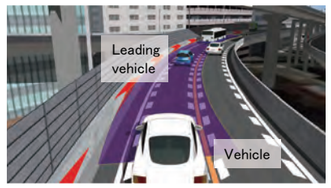
These can all be recorded for a 'replay'	
Vehicle	Coordinates, Roll, Pitch, Yaw, Winker, Brake lamp, etc
Pedestrians	Coordinates, Movement, Roll, Pitch, Yaw
Traffic Lights	Traffic light phases
Context	Context when scenarios are executed

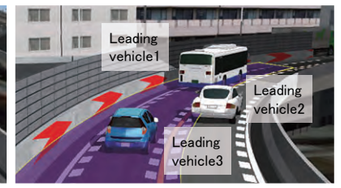
■Applications of this Driving Simulator

The ability to give combined effects of the sense of depth and the sense of distance to the driver makes the Driving Simulator ideal for many driving behaviour and human-vehicle interaction oriented researches.

Research on an ideal vehicle acceleration/deceleration behavior for lower fuel consumption when following another vehicle through the exploitation of dynamic 3D driving environment delivering a sense of depth no different to reality.

By understanding the way drivers perceive the difference in traffic flow speed, an ideal vehicle acceleration/deceleration behavior for merging safely into the flow of traffic can be derived.



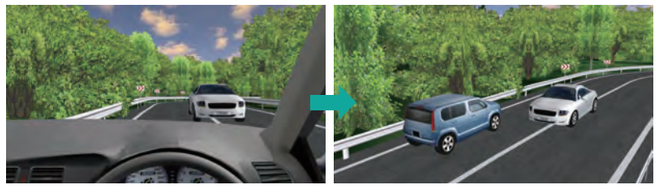


Research on the behavior of drivers driving under poor visibility by tracking their visual line.

By understanding the how drivers move their eyes and body to check their blind spot or what's ahead when driving under poor visibility to confirm safety, vehicle geometry fit for safe and easy driving as well as driver assistance systems can be validated from a driver's perspective.


Research on driver fatigue/stress based on realistic driving sensation.

Combination of realistic driving sensation and versatile features of the DS including the scenario editor function, log function, and replay function allows highly precise analysis of driver fatigue and stress.



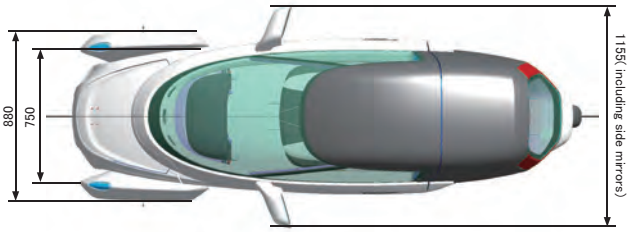
Detail of the Sub-system

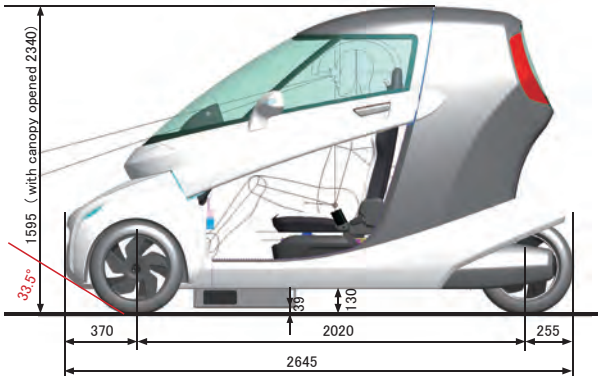
Structure and feature of the hardware components

1. Driver Cockpit

The driver cockpit is an innovative communicator manufactured using the real car components. The cabin consists of all the needed driving components. It is also equipped with numerous sensors and audio speakers, to simulate as many factors as possible during driving.

■Dimensions of the vehicle body





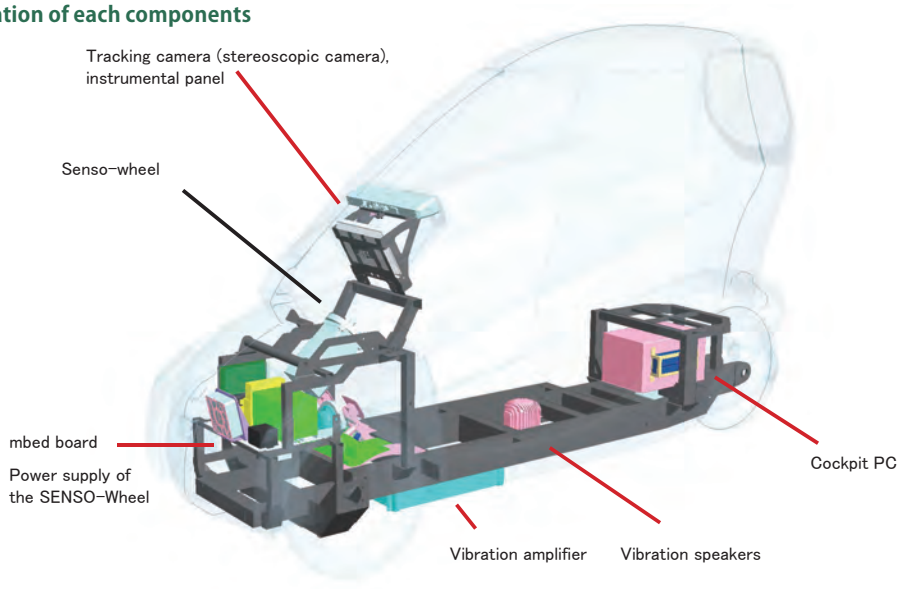
Total length	2645 mm
Total width	880 mm (including side mirrors1155 mm)
Total height	1595 mm (with canopy opened2340 mm)
Wheelbase	2020 mm

Front overhang	370 mm
Rear overhang	255 mm
Front wheel tread	750 mm

※Dimensions are based on the measurements in the DATA

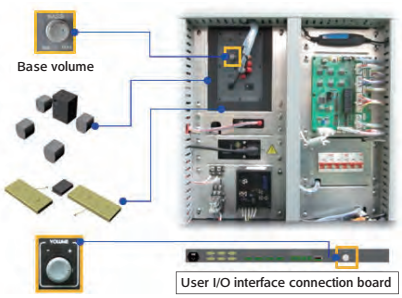
Gross weight: 300 kg

■Name and location of each components



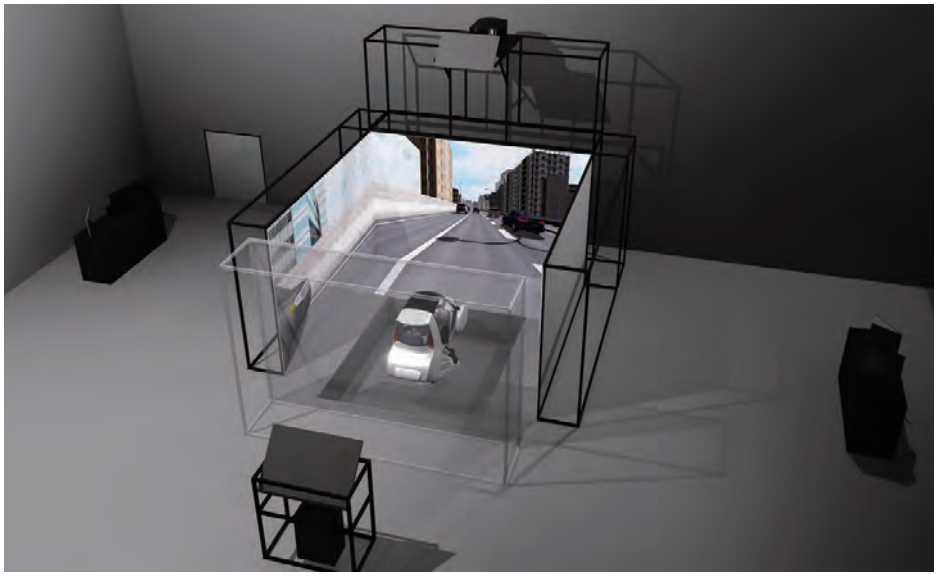
2. Audio and vibration speakers

7.1 channel audio surround speakers and woofer speakers are installed to add a sense of realism to engine sound of the driven vehicle as well as those around it plus other sound effects reproduced through the simulation computer. Vibration speakers are installed in the driver's seat to create highly realistic audio cues.



3. Large 5-screen 3D Stereoscopic View

■Panel resolution of 4k（4096×2160pixels） 4 screens (in the front, on the right and left, and on the floor)
■Full High Definition （1920×1080 pixels） 1 screen (at the back)



◀4 screens + rear screen

Projector

4K Resolution, 120Hz frame rate, 3-chip DLP®
3D Active Stereoscopic Projector Christie Mirage 4K35

Panel resolution
4K(4096x2160pixels)
Maximum Brightness
35,000 Center lumen （32,500 ANSI lumen） -6.0kW lamp

Head Tracking System

ARTTRACK5 Camera

SMARTTRACK Camera

Glasses Targets

Detail of the Sub-system

Structure and feature of the hardware components

4. Motion Platform

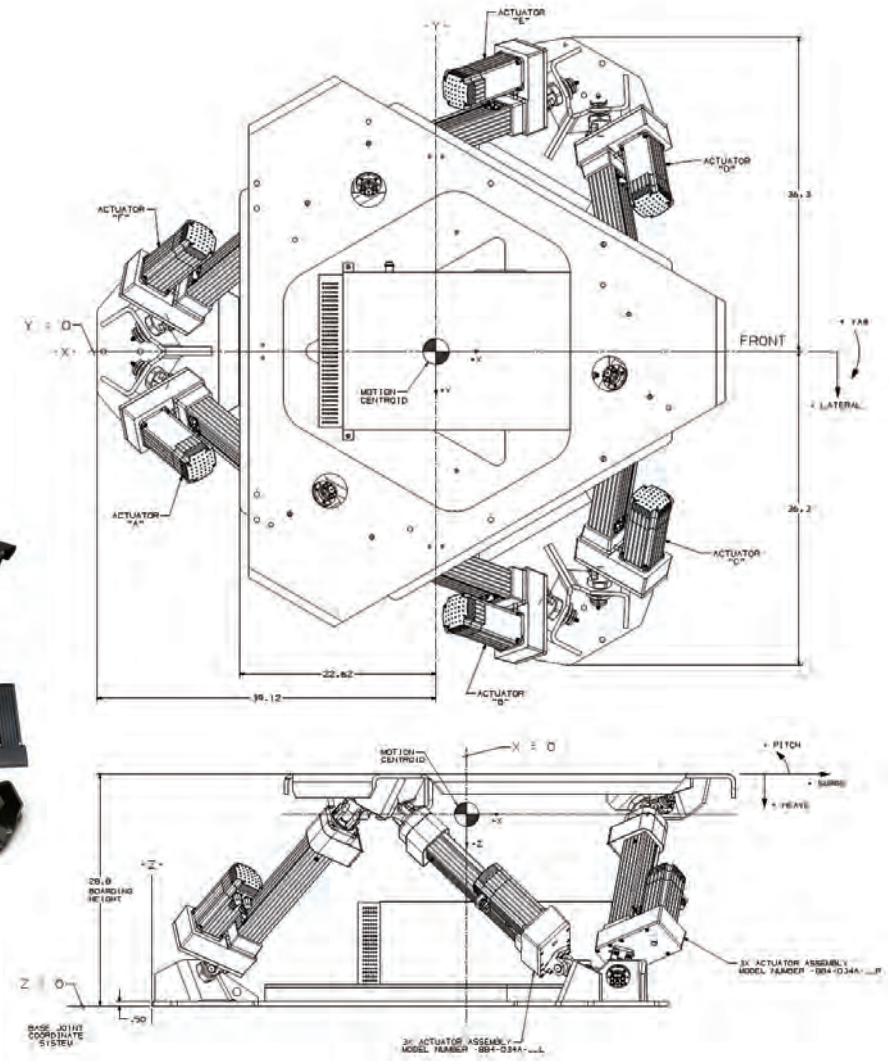
The 6-axis motion base by MOOG Inc. has 6 electrical cylinders that expand and contract to responsively simulate a 6-DOF (degree of freedom) environment. The cockpit seats installed above the platform will move in various directions whilst titling and rotating according to the screen displayed.

■Stewart platform

A mechanical system that uses several computer-controlled serial chains to support a single platform is called a parallel manipulator. The best known parallel manipulator is the Stewart platform formed from six linear electrical actuators that support a movable base renown for providing the greatest power, stiffness, speed, and precision. The motion base can be moved in the six degrees of freedom: The three linear movements x, y, z (lateral, longitudinal and vertical), and the three rotations pitch, roll, and yaw. The Stewart platform is clean, fireproof, and easy to maintain.

■External Dimensions

*Dimensions are measured in inches.



■Motion Performance (for type MB-E-6DOF/12/1000KG and type 1500)

Axis	Stroke	Velocity	Acceleration
Surge	+10.8 inch(+274 mm)−9.5 inch(-241 mm)	±20 inch(±508 mm/sec)	± 0.6 G
Sway	±9.2 inch(±233 mm)	±20 inch(±508 mm/sec)	±0.6 G
Heave	±7.5 inch(±190 mm)	±12 inch(±304 mm/sec)	(Upward direction) 0.5 G, (Downward direction) 0.7 G
Roll	±19.6 deg	±30.0 deg/sec	±500 deg/sec^2
Pitch	+19.8 deg, −19.0 deg	±30.0 deg/sec	±500 deg/sec^2
Yaw	±23.3 deg	±40.0 deg/sec	±400 deg/sec^2

Modeling & Simulation in UC-win/Road

1． 3D Real time／interactive Virtual Reality softwere UC-win/Road

UC-win/Road won the 2002 Software Product of the Year (Japanese Ministry of Economy, Trade and Industry). It is an advanced real-time interactive 3D VR simulation & modeling software product that enables the user to replicate the real world in 3D Space.

■Varied Displays Options Through the Visual Options Tool / Traffic Simulations

Control time, weather, lighting, and many other factors for different numerous simulation conditions. Users can display day and night scenes with a range of lighting conditions by using the artificial light features. Simulate complex urban traffic by generating traffic streams based on traffic volume, vehicle profiles, traffic light configurations, as well as examine traffic obstructions, disasters and accidents.

■Digital map of Geospatial Information Authority of Japan

- 50m mesh (elevation) (Approval Number: 2000, #173)
- 5m mesh (elevation)

■Geographical features of the world

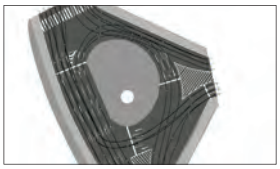
Forum 8 is granted the right to use the "CGIAR-CSI SRTM 90m Database" for making geographical data of the entire world. The terrain data of China and Australia are pre-installed in UC-win/Road.

■Before/After Analysis / Scripting / Manual Driving

UC-win/Road supports several driving options (vehicle speed, lane changing, height of viewpoint, viewpoint switching in 8 directions): dynamic movement of viewpoint and walk-throughs are also possible.More advanced simulations can be performed with manual driving and by installing a 3D cockpit and multi-monitors.

■Enhanced intersection function – Roundabout and Three-Way Intersection

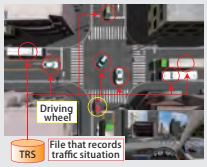
Generation of roundabouts and three-way junction is now possible. Complicated flat crossing and road signs can be exported to 3DS for further editing. Models can freely move inside the intersection.

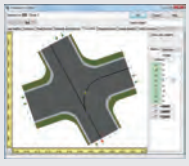


Main Simulation Features of UC-win/Road

Traffic Simulation Function

Various traffic simulation features have been enhanced: grouped vehicles, individual assignment of route probability for each group, maximum number of cars at a congested intersection, generation / deletion point of traffic. The Context feature has rich and varied options for different environmental settings, and can be executed with a simple mouse click.





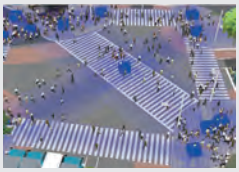
Audio System Features

Supports various OpenAL sounds: environmental sound, sound of vehicles in proximity, sound of the current car currently driven (engine, tire, wind noise, sound reflection in tunnels).

Grouped Pedestrian Movement

By placing flight paths (pathways) inside the 3D space, large-scale pedestrian movement can be set up:

- Setting starting / destination points, and average number of pedestrians.
- Addition of route variations, such as train station, staircase, or escalators
- Supports linked connections such as elevators, and waiting rooms
- Supports multiple pedestrian profile assignments and the pathfinding features for the shortest route.



Replay Option

This features records vehicle and pedestrian movements at a possible frequency of more than 10 times per second for review or replay. Can be coordinated with Scenario Plugin to record and replay the start and end timing of an event.

Log Plugin

This plugin saves and exports factors such as the coordinates, direction, steering angles, traffic flow condition, and character details into a CSV format for evaluation. UDP export is also supported, allowing users to retrieve log data in real time through networks.

Scenario Plugin

This feature supports detailed control of model movements at a particular time, such as “traffic light turns red” or “abrupt car movements”, to simulate many different real-world situations.

- Dynamic changes of speed, lane, and lane-keep offsets with respect to surrounding vehicles. For the car driven by the user, automatic cruise control can be set up.
- Lead car behaviour can be freely assigned to simulate reckless lane changes and zig-zagging maneuvers.

Developed by FORUM8 Co., Ltd. http://www.forum8.jp/
TEL：03-6894-1888 FAX:03-6894-3888

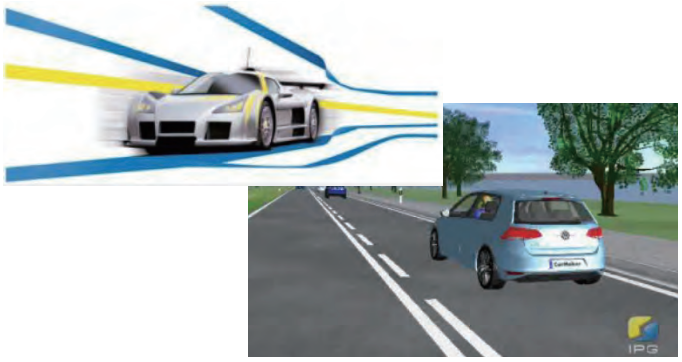
Subsystems Details

2. Vehicle dynamics CarMaker／CRUISE

CarMaker provides a wide range of seamless options for testing inside a virtual environment and supports MIL / SIL / HIL, based upon its robust vehicle dynamics models. This greatly assists in solving or evaluating various emerging traffic or vehicle designs problems and considerations, such as ITS active safety systems, driver comfort, and fuel economy.

■CarMaker

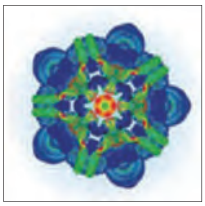
- A simulation platform to test the concepts, models and control systems of vehicles. It also has the capability of performing virtual driving through its powerful event-based simulation features and detailed vehicle controls.
- Intelligent self-learning driver models
- Faster than real-time analysis speed for large vehicles such as trucks and trailers.
- Real-time simulation of the vehicle dynamics with embedded control systems - Embedded control of Matlab / Simulink models.



Developer：IPG Automotive K.K.　URL：http://www.ipg-automotive.co.jp/
TEL：(+81) -3-5826-4301　FAX：(+81) -3-5826-4302

■AVL CRUISE

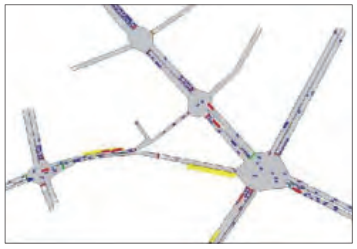
This simulation software predicts the vehicle power performance, mode fuel consumption and emissions. It is a great platform for vehicular parameters studies or energy efficiency managements.

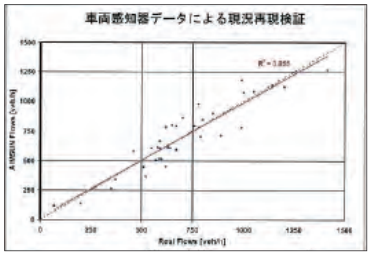


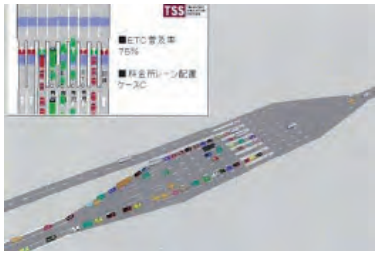
Developer: AVL JAPAN K.K.　URL：www.avl.co.jp
TEL：(+81) -44-455-9200　FAX：(+81) -44-455-9205

3. Aimsum - Real-time traffic flow simulator

Aimsun is a general microscopic traffic flow simulator. This supports to input both of OD tables and branch fraction and in case of OD model, it allows you to have a simulation in which the routes including new bypass and traffic controls need to be selected even there is no precondition. Selecting the dynamics routes enables you to consider about ITS. Also API helps users to do their own features expansion. This system simulate the real-time road traffic environment.







■Traffic demand can be defined by using either O-D matrices or traffic states.

■Pedestrians and bicycles can be represented.

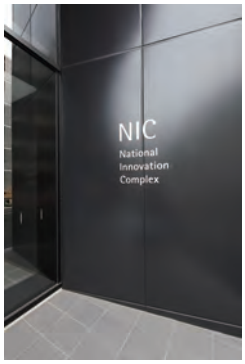
■City with different modes of traffic mingling together can be put under consideration.

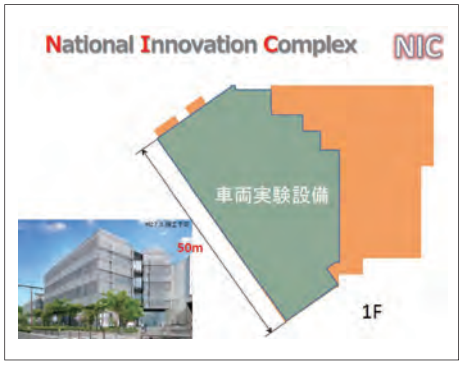
Developer: TSS-Transport Simulation Systems in Spain / Japanese Agent: You DEC Co. Ltd.
http://www.udec.co.jp　TEL：(+81) -3-5217-5051 FAX: (+81) -3-5217-5054

Installation Site

National Innovation Complex (NIC), Centre of Innovation (COI) mission under the research theme of Diversified and Personalized Society Innovation Design - A Senior-Friendly Society of Mobility"

National Innovation Complex (NIC) is Nagoya University's latest attempt to foster stronger ties between industry and research institutes for collaborative projects to contribute to the COI's mission. The complex is located in the Higashi-Yama Campus of Nagoya University. It is inside this building where Nagoya University houses FORUM8's newest simulator.





DesignFestival 2014 Driving Simulation Session

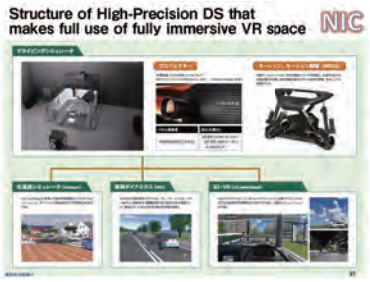
Report on Special Lecture

[Date and Venue:
November 19th, 2014
in Shinagawa Intercity Hall]

"Latest Research Towards the Realization of Green Mobility Society and the Use of VR Simulator"

Professor Tetsunori Haraguchi,
Specially Appointed Professor of Nagoya University

▲Professor Tetsunori Haraguchi



He gave an outline of his activities during his days in Toyota Motor Corporation and after he moved to Nagoya Univ., concepts and activities of "Nagoya COI (Center Of Innovation) Base" and "Social Innovation Design Study Center (SIDC)" established based on "COI Stream", a program of Ministry of Education, Culture, Sports, Science and Technology for creating innovation. Paying attention to possibilities of FORUM8 DS including the multi-driver function, he hit upon several ideas. Among them is a study on social acceptabilityof super-small personal mobility and the ride quality of the user, from a viewpoint of supplying mobility when the working generation shifts to the side of elderly generation. Another example is an application to the study on characteristics of vehicles by which tracking driving that tends to cause poor mileage can lead to improvement in practical mileage, from a viewpoint of controlling global warming. Then he explained the overview of DS he and others had introduced for the green mobility study, human engineering situations of using it so far, and problems found through them. He said that in NIC (National Innovation Complex), which is scheduled to be complete next spring, they plan to use DS of FORUM8 etc. to conduct studies on tracking driving, lane-change intervention assistance, drivers' behavior when reversing, and studies linking with simulators of traffic flow or vehicle motion. Finally, he drew future prediction of his own beyond the studies utilizing DS.

※Structure and components of the system may differ from their actual counterparts.
※Name of each company and products are generally registered or unregistered trademark of their respective company.

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System built and installed by
FORUM8
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Shinagawa Intercity A-21F, 2-15-1 Konan, Minato-ku, Tokyo 108-6021, Japan TEL：+81-(0)3-6894-1888 http://www.forum8.co.jp/

FORUM8 Co., Ltd.

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