

Outline of the Earth Simulator Project

1. Mission and Basic Principles of the Earth Simulator

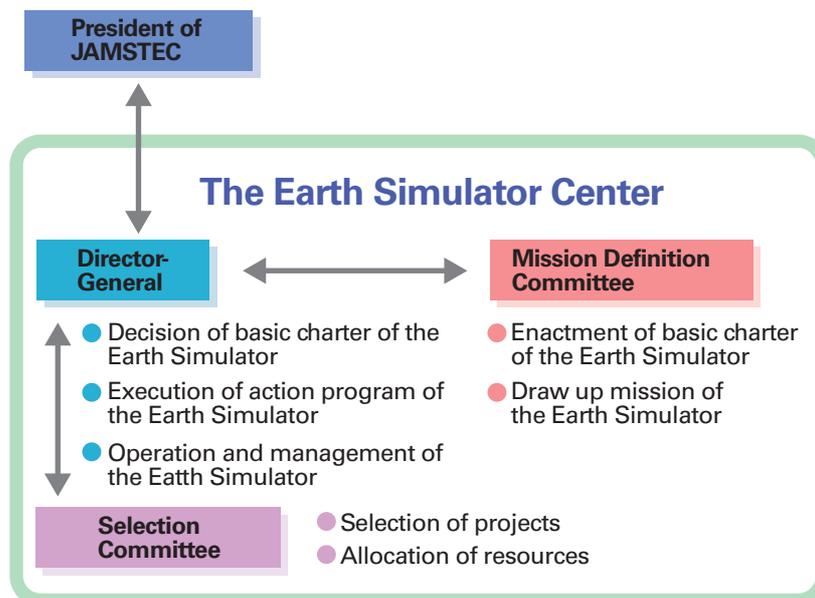
The Earth Simulator was developed for following aims and objectives. The first ensures a bright future for mankind by predicting the variable global environment accurately, and the second contributes to the development of science and technology in the 21st century. Based on these purposes, four principles, as follows, are established for projects of the Earth Simulator.

- 1) Each project should be open to researchers in the same field and to the public, not to be confined within limited researchers.
- 2) In principle, research achievements by the Earth Simulator should be swiftly published and delivered to the public.
- 3) The Mission Definition Committee will examine research achievements and encourage effective operations.
- 4) Each project should be carried out for peaceful purposes only.

2. Managing System for the Earth Simulator Project

The Earth Simulator Project is managed under policy decided by the Mission Definition Committee and the Selection Committee. The Mission Definition Committee enacts the basic charter of the Earth Simulator and draws up its mission. Research projects using the Earth Simulator are selected by the Selection Committee every year.

Fig. 1 Managing System for Projects in FY2004



3. Earth Simulator Research Project

There are four fields of Earth Simulator Research Projects, as follows:

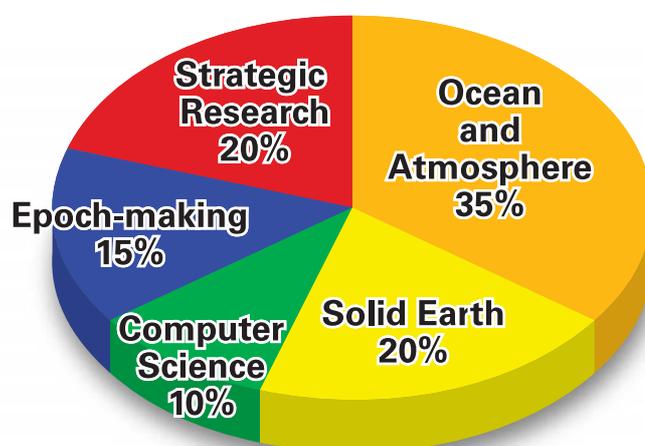
- Atmospheric and Oceanic Simulation
- Solid Earth Simulation
- Computer Science
- Epoch-making Simulation

Allocation of Earth Simulator resources is planned by the Mission Definition Committee each fiscal year. The allocation of resources for each research field in FY2004 was decided to be as shown in following circle graph (Fig. 2).

Public project recruitment for Earth Simulator Research Projects in FY2004 was held in February 2004, and 37 research projects were selected by the Selection Committee. The allocation of resources for each project was also decided by the Selection Committee.

International Collaboration Projects were carried out under the allocation of "Strategic Research".

Fig. 2 The allocation of resources of the Earth Simulator in FY2004



Authorized Projects in FY2004

Atmospheric & Oceanic Simulation (14 projects)

	Title	Project leader	Affiliation of project leader
1	Future Climate Change Projection using a High-Resolution Coupled Ocean-Atmosphere Climate Model	Akimasa Sumi	Center for Climate System Research, The University of Tokyo
2	Development of high-resolution atmosphere-ocean coupled model and global warming prediction	Kouki Maruyama	Central Research Institute of Electric Power Industry
3	Development of Integrated Earth System Model for Global Change Prediction	Taro Matsuno	FRCGC, JAMSTEC
4	Development of Super High Resolution Global and Regional Climate Models	Akira Noda	Meteorological Research Institute
5	Research Development of 4-dimensional data assimilation system using a coupled climate model and construction of reanalysis datasets for initialization	Toshiyuki Awaji	FRCGC, JAMSTEC

6	Atmospheric Composition Change and Climate Effect Studied by Global and Regional Scale Chemical Transport Models	Hajime Akimoto	FRCGC, JAMSTEC
7	Mechanism and predictability of atmospheric and oceanic variations induced by interactions between large-scale field and meso-scale phenomena (AFES CFES OFES)	Wataru Ofuchi	ESC, JAMSTEC
8	Development of holistic climate simulation codes for a non-hydrostatic atmosphere-ocean coupled systems	Keiko Takahashi	ESC, JAMSTEC
9	Advanced parameterization of physical processes	Toshiyuki Hibiya	Graduate School of Science, The University of Tokyo
10	Construction of advanced prediction system of regional - and meso- scale water cycle	Hiromasa Ueda	Disaster Prevention Research Institute, Kyoto University
11	Study on mechanisms of climate and ocean variability and their predictability	Toshio Yamagata	FRCGC, JAMSTEC
12	High resolution modeling of multi-scale cloud and precipitation systems using cloud-resolving models	Kazuhisa Tsuboki	Hydrospheric Atmospheric Research Center, Nagoya University
13	Development of a numerical model of urban heat island	Yasunobu Ashie	Building Research Institute
14	Development of a coupled atmosphere-ocean-land general circulation model (GCM) at the Frontier Research System for Global Change	Tatsushi Tokioka	FRCGC, JAMSTEC

Solid Earth Simulation (9 projects)

	Title	Project leader	Affiliation of project leader
15	Global elastic response simulation	Seiji Tsuboi	IFREE, JAMSTEC
16	Simulation study on the generation and distortion process of the geomagnetic field in Earth-like conditions	Yozo Hamano	IFREE, JAMSTEC/Graduate School of Science, The University of Tokyo
17	Numerical simulation of the mantle convection	Yoshio Fukao	IFREE, JAMSTEC
18	Predictive Simulation for Crustal Activity in and around Japan	Mitsuhiro Matsuura	Graduate School of Science, The University of Tokyo
19	Numerical simulation of seismic wave propagation and strong ground motions in 3-D heterogeneous media	Takashi Furumura	Earthquake Research Institute, The University of Tokyo
20	Simulation of Earthquake Generation Process in a Complex System of Faults	Kazuro Hirahara	Graduate School of Environmental Studies, Nagoya University
21	Development of Solid Earth Simulation Platform	Kengo Nakajima	Graduate School of Science, The University of Tokyo
22	Dynamics of Core-Mantle Coupled System	Akira Kageyama	ESC, JAMSTEC
23	Numerical simulation of physical properties of earth's materials	Mitsuhiro Toriumi	Graduate School of Frontier Science, The University of Tokyo

Computer Science (2 projects)

	Title	Project leader	Affiliation of project leader
24	Performance Evaluation of Large-scale Parallel Simulation Codes and Designing New Language Features	Yasuo Okabe	Academic Center for Computing and Media Studies, Kyoto University
25	Development of Micro-Macro Interaction Simulation Algorithm	Kunihiko Watanabe	ESC, JAMSTEC

Epoch-making Simulation (12 projects)

	Title	Project leader	Affiliation of project leader
26	Numerical Simulation of Rocket Engine Internal Flows	Masao Furukawa	Japan Aerospace Exploration Agency
27	Large-scale simulation on the properties of carbon-nanotube	Kazuo Minami	Research Organization for Information Science & Technology
28	Development of the next-generation computational solid mechanics simulator for a virtual demonstration test	Ryuji Shioya	Graduate School of Engineering, Kyushu University
29	Study of the Standard Model of Elementary Particles on the Lattice with the Earth Simulator	Akira Ukawa	Center for Computational Sciences, University of Tsukuba
30	Large-scale simulation for a terahertz resonance superconductors device	Masashi Tachiki	National Institute for Material Science
31	Geospace Environment Simulator	Yoshiharu Omura	Research Institute for Sustainable Humanosphere, Kyoto University
32	Development of Transferable Materials Information and Knowledge Base for Computational Materials Science	Shuhei Ohnishi	CAMP (Collaborative Activities for Materials Science Programs) Group
33	Large scale simulation on the atomic research*	Hiroshi Okuda	Atomic Energy Society of Japan
34	Direct Numerical Simulations of Fundamental Turbulent Flows with the Largest Grid Numbers in the World and its Application of Modelling for Engineering Turbulent Flows	Chuichi Arakawa	Interfaculty Initiative in Information Studies, Graduate School of Interdisciplinary Information Studies, The University of Tokyo
35	Bio-simulation	Toshikazu Takada	Forum on the Bio-Simulation
36	Particle modeling for complex multi-phase system with internal structures using DEM	Hide Sakaguchi	IFREE, JAMSTEC
37	Cosmic Structure Formation and Dynamics: A Novel Approach for Hydrodynamic, Magnetic and Radiative Processes to Link up the Hierarchical Structure	Ryoji Matsumoto	Faculty of Science, Chiba University

***Sub-theme under the “Large scale simulation on the atomic research”**

Title	Project leader	Affiliation of project leader
Large-Scale Numerical Simulations on Complicated Thermal-Hydraulics in Nuclear Cores with Direct Analysis Methods	Kazuyuki Takase	JAERI
First Principles Molecular Dynamics Simulation of Solution	Masaru Hirata	JAERI
Research on structure formation of plasmas dominated by hierarchical dynamics	Yasuaki Kishimoto	JAERI
A simulation of the interaction among the pressure wave propagation of liquid mercury, the wall deformation and the bubble dynamics in the mercury target	Chuichi Arakawa	CCSE, JAERI
Numerical Studies for Novel Superconducting properties and Neutron Detector Applications by Superconductor Nano-fabrication Techniques	Masahiko Machida	CCSE, JAERI
Electronic and atomistic simulations on the irradiation induced property changes and fracture in materials	Hideo Kaburaki	CCSE, JAERI
Large-Scale Simulation of Groundwater Flow and Radioactive Nuclide Transportation	Hiroshi Okuda	Research into Artifacts, Center for Engineering, The University of Tokyo
First-principles molecular dynamics simulation of oxide layers for radiation-tolerant SiC devices	Atumi Miyashita	JAERI
Direct Numerical Simulation of Turbulent Flows in Subchannels of a Tight Lattice Bundle	Hisashi Ninokata	Research Laboratory for Nuclear Reactors in Tokyo Institute of Technology

JAMSTEC : Japan Agency for Marine-Earth Science and Technology

FRCGC : Frontier Research Center for Global Change

IFREE : Institute for Research on Earth Evolution

JAERI : Japan Atomic Energy Research Institute

CCSE: Center for Promotion of Computation Science and Engineering

ESC: The Earth Simulator Center

4. International Collaboration Projects

We place special emphasis on elevating the worldwide power of simulation science and technology. As one way to achieve this task, we are doing our best to promote international collaboration based on institution-to-institution agreement.

Table 1 International Collaboration Projects as of March 2005

Scripps Institution of Oceanography, USA
Hadley Centre for Climate Prediction and Research, The Met Office, UK
Centre for Global Atmospheric Modelling, Centres for Atmospheric Science, UK
Italian Aerospace Research Center, Italy
Numerical Prediction Research Division, Environment Canada Meteorological Service of Canada, Canada
National Energy Research Scientific Computing Center, USA
Center for Computational Visualization, Department of Computer Sciences and Institute for Computational Engineering and Sciences, The University of Texas, USA
French National Centre for Scientific Research, France
French Research Institute for Exploitation of the Sea, France
Department of Geology & Geophysics, University of Minnesota, USA
International Arctic Research Center, University of Alaska Fairbanks, USA

5. Domestic Collaboration Projects

We launched three domestic collaboration projects this year (Table 2). One is a collaboration study with the Japan Automobile Manufacturers Association (JAMA). This work is the first case of collaborative study with industries. We will continue to promote cooperation with industries.

Table 2 Domestic Collaboration Projects as of March 2005

Automobile Simulation: Japan Automobile Manufacturers Association
Economic Simulation: Institute of Economic Research, Hitotsubashi University
Aerodynamic Simulation: School of Engineering, Tohoku University Mitsubishi Heavy Industries, Ltd.

6. System Configuration of the Earth Simulator

The Earth Simulator is a highly parallel vector supercomputer system of the distributed-memory type, consisting of 640 processor nodes (PNs) connected by 640x640 single-stage crossbar switches. Each PN is a system with a shared memory, consisting of 8 vector-type arithmetic processors (APs), a 16 GB main memory system (MS), a remote access control unit (RCU), and an I/O processor. The peak performance of each AP is 8 Gflops. The ES as a whole thus consists of 5120 APs with 10 TB of main memory and theoretical performance of 40 Tflops.

Table 3 Specifications of the Earth Simulator

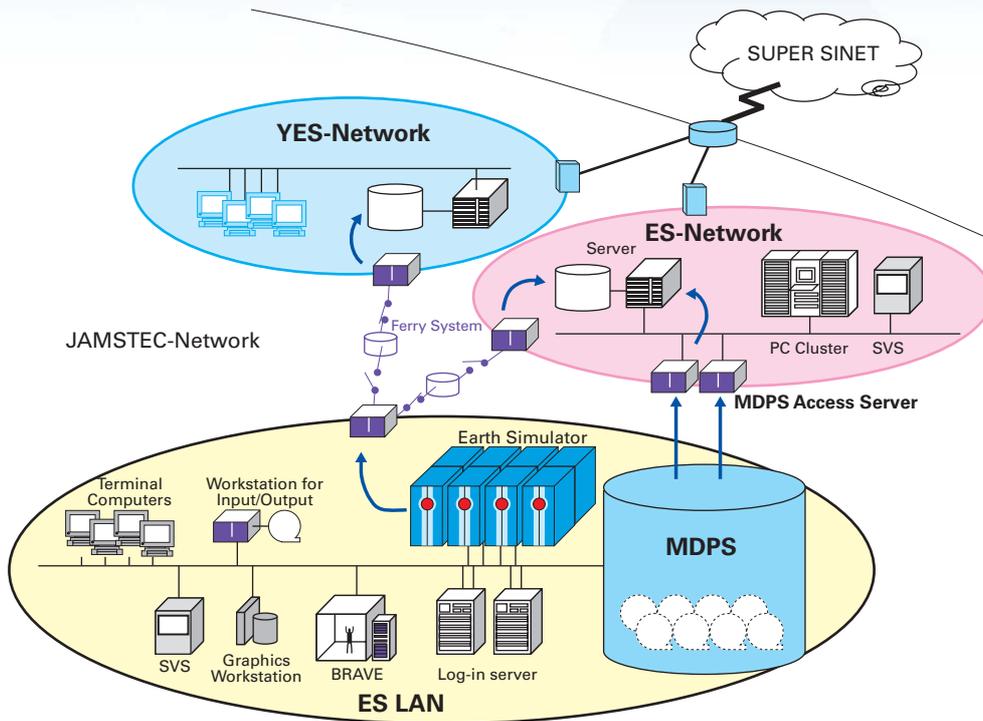
Peak performance/AP	8 Gflops	Total number of APs	5120
Peak performance/PN	64 Gflops	Total number of PNs	640
Shared memory/PN	16 GB	Total peak performance	40 Tflops
		Total main memory	10 TB

From October 2003, an MDPS (Mass Data Processing System) was installed as a new data storage system, which renews the archive system. It consists of four file service processors, 250 TB disks, and a currently used 1.5 PB cartridge tapes library (CTL). The MDPS was adopted aiming to improve manageability for data transmission performance and access.

In October 2004, the Earth Simulator Center/JAMSTEC was connected with the Super SINET(*) with four lines of 1Gbps. It is expected to contribute to effective use of data obtained from the Earth Simulator.

(*) The Super SINET is an ultra-high-speed network operated by the National Institute of Informatics.

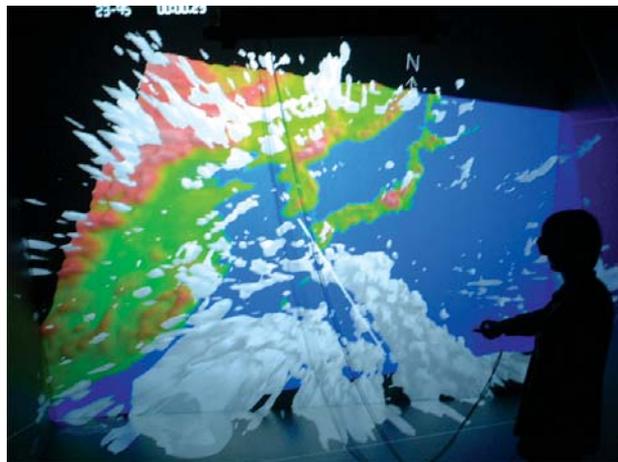
Fig. 3 Network Composition around the Earth Simulator



7. Visualization

In 2003, we introduced the Earth Simulation Virtual Reality System: BRAVE (Booth for Resolving Aspects of Virtual Earth), which is a visualization environment in which the images on each of four big screens (3 m x 3 m) of right and left, front, and the floor side can be projected deeply from different angles, and observes inside can view as three-dimension images.

BRAVE



8. History and Event Calendar

Year 2001

Apr. 1	Earth Simulator Center established in the Japan Marine Science and Technology Center.
Dec. 1	Dr. Tetsuya Sato became director of the Earth Simulator Center.
Dec. 7	1st Advisory Committee

Year 2002

Jan. 28	2nd Advisory Committee
Mar. 1	Started operation of the Earth Simulator
Mar. 6	1 st Orientation for users
Mar. 11	2 nd Orientation for users
Mar. 15	Opening Ceremony at the Earth Simulator Center
Apr. 18	Earth Simulator achieved 35.61 Tflops using Linpack HPC, registered as No.1 in the Linpack report dated April 17, 2002. (press release by JAMSTEC)
Jun. 5	1st meeting of the Mission Definition Committee
Jun. 20	Earth Simulator certified as the world's fastest supercomputer, with performance of 35.86 Tflops, in the TOP500 list of June 2002.
Jun. 21-30	Public project recruitment of FY2002
Jul. 10	1 st Selection Committee
Jul. 16	Start of the authorized projects of FY2002
Sep. 28	1 st Earth Simulator Center Symposium "Harmonious Relationship between the Earth and Mankind"
Oct 23	2 nd Mission Definition Committee
Nov. 1-30	Additional public project recruitment of FY2002
Nov. 20	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of November 2002.
Nov. 21	Won the Gordon Bell Award at SC2002 in US; <ul style="list-style-type: none"> • "A 26.58 Tflops Global Atmospheric Simulation with the Spectral Transform Method on the Earth Simulator" (Award for Peak Performance) • "14.9 Tflops Three-dimensional Fluid Simulation for Fusion Science with HPF on the Earth Simulator" (Award for Language) • "16.4 Tflops Direct Numerical Simulation of Turbulence by a Fourier Spectral Method on the Earth Simulator" (Awards for special accomplishment)
Dec. 13	2 nd Selection Committee
Dec. 24	Start of the additional authorized projects of FY2002

Year 2003

Feb. 1-2	Annual Meeting for research projects in FY2002
Feb. 28	3 rd Advisory Committee
Mar. 5	3 rd Mission Definition Committee
Mar. 12-30	Public project recruitment of FY2003
Apr. 10	3 rd Selection Committee
Apr. 19	Open House of the Yokohama Institute for Earth Sciences
Jun. 3	Won the 2003 Computerworld Honors 21 st - Century Achievement Awards in the Environment, Energy & Agriculture category
Jun. 19	2 nd Earth Simulator Center Symposium "A message from another Earth"

Jun. 25	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of June 2003.
Aug. 21	4 th Mission Definition Committee
Nov. 16	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of November 2003.
Nov. 20	Won the Gordon Bell Award at SC2003 in U.S.; <ul style="list-style-type: none"> • "A 14.6 Billion Degrees of Freedom, 5 Teraflop/s, 2.5 Terabyte Earthquake Simulation on the Earth Simulator." (Award for Peak Performance)

Year 2004

Jan. 10-11	Annual Meeting for research projects in FY2003
Jan. 21	4 th Advisory Committee
Jan. 22	5 th Mission Definition Committee
Feb. 2-29	Public project recruitment of FY2004
Mar. 11	4 th Selection Committee
Mar. 19	Won the Tokyo Creation Award 2003
Apr. 01	Start of the authorized project of FY2003
Apr. 17	Open House of the Yokohama Institute for Earth Sciences
May. 20	Won the IPSJ Industrial Achievement Award
Jun. 16	ESC made a contract with the Japan Automobile Manufacturers Association for collaborative research.
Jun. 23	Earth Simulator certified as the fastest supercomputer, in the TOP500 list of June 2004.
Sep. 15	1st meeting of the reorganized Mission Definition Committee
Oct. 13	3 rd Earth Simulator Center Symposium at Iino Hall (Tokyo). "A Harmonious Relationship between the Earth and Mankind ~ the Earth is changing this way."
Oct. 25	ESC made a contract with the Institute of Economic Research of Hitotsubashi University for collaborative research.
Nov. 8	Earth Simulator certified as the 3 rd fastest supercomputer, in the TOP500 list of November 2004.
Nov. 11	Won the Gordon Bell Award at SC2004 conference in U.S.; <ul style="list-style-type: none"> • "A 15.2 TFlops Simulation of Geodynamo on the Earth Simulator" (Award for Peak Performance)
Nov. 29	Mid-term Evaluating Committee starts evaluating the research activities associated with the Earth Simulator

Year 2005

Jan. 07-08	Annual Meeting for research projects in FY2004
Jan. 13	2 nd Mission Definition Committee
Jan. 19	Initiation of international collaborative research with Hadley Centre for Climate Prediction and Research
Feb. 2-28	Public project recruitment of FY2005
Mar. 10	5 th Selection Committee