CHAPTER 1

INTRODUCTION

Alvin W. Trivelpiece

BACKGROUND OF THE STUDY

This project was initiated in late 2003 by the Department of Energy (DOE), the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) in cooperation with Dr. David B. Nelson, Director of the National Coordination Office for Information Technology R&D. These organizations asked WTEC to organize a group of scientists and engineers with appropriate knowledge to review, analyze and report on Japanese projects in high-end computing (HEC).

According to the sponsors, the purpose of this study was to gather information and disseminate it to government decision makers and the research community on the status and trends in Japanese supercomputer systems R&D in comparison to that in the United States. The panelists were to gather information on Japanese HEC R&D useful to the U.S. government in planning its own HEC R&D programs, and to compare Japanese HEC research, development, and applications activities with those in the United States. This was to focus primarily on long-term research on high-end computing in Japan, including follow-on machines to the Earth Simulator and other high-end computing architectures. As a part of this assessment of future research directions, the study was also to include a review of the development process and operational experience of the Earth Simulator (ES), including the user experience and the impact it has had on the computer science and computational science communities.

The study was to assess future trends in high-end computing in Japan in terms of how they are being affected by, and are affecting, three primary interest groups:

1. *Government agencies*. The Earth Simulator project was funded initially by three Japanese agencies: the National Space Development Agency (NASDA), the Japan Marine Science and Technology Center (JAMSTEC), and the Japan Atomic Energy Research Institute (JAERI). What other agencies will be supporting advanced computing research and applications development in the future? What is the trend in Japanese government support for high-end computing R&D? Is there a strategic plan, and if so, what is it? What is the role of the National Aerospace Laboratory (NAL) versus the ES?
2. *Computer science and computational science research communities in Japan*. What are the leading research groups, and where do they see the future of computer science and computational science going? What are the formal and informal relationships among universities, vendors and government that were utilized in developing strategies and approaches to future HEC systems and their application?
3. *Vendors*. There are three main players now – NEC, Hitachi and Fujitsu. Are there other contenders that may emerge in the future? Are these companies self-contained, or do they depend on suppliers; if the latter, who are the suppliers? Do they have alliances with key component manufacturers; if so, who are those manufacturers?

The sponsoring agencies asked WTEC to recruit a panel of six individuals who would travel to Japan and conduct a review consistent with this purpose and scope. Table 1.1 lists the panelists and other members of the delegation; short biographies are in Appendix A.

Table 1.1
WTEC Delegation

Member of Delegation	Organization
Alvin W. Trivelpiece (Chair)	Senior Consultant, Sandia Corporation
Rupak Biswas (Panelist)	NASA Ames Research Center
Jack Dongarra (Panelist)	University of Tennessee
Peter Paul (Panelist)	Brookhaven National Laboratory
Katherine Yelick (Panelist)	University of California at Berkeley
Stephen Meacham (Sponsor Rep.)	National Science Foundation
Y. T. Chien (Staff)	WTEC
Masanobu Miyahara (Staff)	WTEC

WTEC organized the initial meetings of the panel on December 10, 2003, and January 9, 2004, with sponsoring agencies to identify the individuals and sites in Japan that should be visited. WTEC also provided the advance work that gained access to the sites that the panel selected. Following these preliminary activities, the panel conducted a formal study tour in Japan from March 29 to April 3, 2004. In order to visit as many sites as practical in one week, the panel was divided into two teams. The members of each team were selected based on their experience and the activities at the site to be visited. A list of sites is given in Table 1.2, and Appendix B provides detailed reports from each site visit.

After returning from Japan, the panel presented its preliminary findings at a workshop held in the boardroom of the National Science Board in Arlington, VA, on May 25, 2004. Presentations from that workshop are posted at http://wtec.org/hec, and a summary is included here in Appendix D.

RATIONALES FOR INVESTMENT IN HEC IN THE U.S. AND JAPAN

In the U.S. much of the motivation for the development of high-end computing came from the signing of the nuclear Comprehensive Test Ban Treaty (CTBT) and the imposition of a zero-yield condition therein, which made it impossible to conduct tests to assure the reliability of the U.S. nuclear weapons stockpile. One of the results of that was the initiation of an extensive computation program at the U.S. national laboratories to replace some aspects of the process of testing with some forms of analysis. This is one of the reasons that the Advanced Super Computing Initiative (ASCI) came into being. The imperative of maintaining U.S. stockpile surety was sufficient reason to warrant and justify the costs of the acquisition of several advanced state-of-the-art supercomputers for the national security labs. While there have been other grand challenge problems, such as environmental and cryptographic concerns, cited as justification for new generations of supercomputers, none have been as compelling in the U.S. as the stockpile stewardship considerations.

In Japan no such national security justification for supercomputers was possible. However, Japan has a strong interest in environmental problems, particularly those associated with global warming from greenhouse gases. This interest led in part to a major initiative to build a supercomputer dedicated to making progress in understanding these environmental problems. The result is the Earth Simulator. This new supercomputer captured a great deal of attention around the world as it set new world records for performance, and the

Japanese have a justifiable right to be proud of this accomplishment. Although the ES has called attention to the Japanese efforts in HEC, it is only one element in an extensive effort by the Japanese government to bring about a comprehensive computational capability that is intended to ensure an ability to remain at the leading edge in various areas of science and technology, which it regards as vital to its long-term economic well-being and progress.

Table 1.2
Sites Visited in Japan

Site	Panelists	Date
Frontier Research System for Global Change (FRSGC)	Biswas, Chien, Meacham, Trivelpiece, Yelick	29 March 2004
National Institute for Fusion Science (NIFS)	Dongarra, Paul	29 March 2004
Earth Simulator Center	Biswas, Chien, Meacham, Trivelpiece, Yelick	29 March 2004
Council for Science and Technology Policy (CSTP)	Chien, Dongarra, Meacham, Trivelpiece, Yelick	30 March 2004
University of Tokyo	Biswas, Paul	30 March 2004
Japan Aerospace Exploration Agency (JAXA)	Biswas, Meacham, Paul	30 March 2004
Ministry of Economy, Trade and Industry (METI)	Chien, Dongarra, Meacham, Trivelpiece, Yelick	30 March 2004
Tokyo Institute of Technology	Biswas, Dongarra, Miyahara	31 March 2004
Fujitsu	Biswas, Dongarra, Miyahara	31 March 2004
University of Tsukuba	Chien, Meacham, Paul, Trivelpiece, Yelick	31 March 2004
High Energy Accelerator Research Organization (KEK)	Chien, Meacham, Paul, Trivelpiece, Yelick	31 March 2004
National Institute of Advanced Industrial Science and Technology, Grid Technology Research Center (AIST-GRID)	Chien, Paul, Meacham, Yelick, Trivelpiece	31 March 2004
Research Organization for Information Science and Technology (RIST)	Biswas, Dongarra, Miyahara, Yelick	1 April 2004
Institute of Physical and Chemical Research (RIKEN)	Chien, Meachma, Paul, Trivelpiece	1 April 2004
IBM	Biswas, Dongarra, Miyahara, Yelick	1 April 2004
Ministry of Education, Culture, Sports, Science and Technology (MEXT)	Chien, Dongarra, Trivelpiece, Yelick	1 April 2004
National Institute of Informatics (NII)	Chien, Meacham, Paul, Trivelpiece	1 April 2004
Hitachi, Ltd.	Biswas, Dongarra, Miyahara, Yelick	1 April 2004
NEC Corporation	Biswas, Chien, Dongarra, Yelick	2 April 2004
Japanese Atomic Energy Research Institute (JAERI)	Meacham, Paul, Trivelpiece	2 April 2004
Sony Computer Entertainment, Inc.	Biswas, Chien, Dongarra, Yelick	2 April 2004

This report documents the observations and findings a group of scientists and engineers with experience in HEC and related programmatic issues based on a one-week visit to leading laboratories, government agencies, and industrial organizations.

The delegation's arrival in Japan coincided with the beginning of the fiscal year on the first of April. This event was a prominent element in some of our discussions, because it was not just the routine beginning of a new budget year. Rather, this year’s new budget also came along with some dramatic changes in the structure of how the government funds certain universities and research institutions. The principal element was a move

toward "privatization" of institutions that have historically been funded directly by government and staffed by individuals who were direct employees of the central government. "Privatization" is used in a different context than would be understood in the U.S. The intent that underlies these moves is the desire to reduce the number of central government employees, and lessen the direct control of the central government on budget decisions that influence government-funded research and development. This is not a recently made decision, but has been part of an overall long-range Japanese government plan to focus on certain areas of science and technology as part of a strategy to provide stimulation to Japanese business enterprises. This privatization confers new freedoms on faculty and research scientists, but at the same time burdens them with some new fiscal responsibilities to control costs. This move to privatization and its effects on the long term remain to be seen, but they will have an influence on the thrust of science and technology funding generally and for HEC in particular.

The "Unofficial Version" of the "The Science and Technology Basic Plan" (2001-2005) adopted by the Japanese government, contains an element that lays out the plan for information and telecommunications. Some excerpts follow:

> In R&D in IT area, the level of Japan is considered to be superior to that in European countries and the United States, especially in mobile-phone systems, optical communication technology, and IT terminals. The United States, however, leads the world in both PCs and their related technology and in software technologies.
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> In this area there are a great variety of needs and technologies innovating rapidly, so that Japan will promote R&D with mobility. It is also important to promote R&D concerning common technologies necessary to realize an advance IT network society in which people can use their capabilities to the maximum in a creative way through freely sending, receiving, and sharing of information. Specifically Japan will focus on the followings:
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> - advanced network technology that enables all network activities to be performed safely, at any time, at any place, and without stress.
> - high performance computing technology that enable rapid analysis process, storage and search of a tremendous amounts of distributed information
> - human interface technology that allows everyone to enjoy the benefits of an IT society without mastering complicated equipment and feeling stress
> - device technology and software technology to support the foregoing points

PREVIEW OF REPORT

In Chapter 2 Jack Dongarra introduces the Japanese Earth Simulator design and some of its initial achievements. In Chapter 3 the role of the main Japanese government agencies in setting policies for HEC is reviewed by Alvin W. Trivelpiece. There are two chapters on various scientific applications of HEC in Japan: Chapter 4 by Rupak Biswas, and Chapter 5 by Peter Paul. Another section (Chapter 6) by Jack Dongarra reviews the supercomputer offerings of the three main Japanese companies: NEC, Fujitsu, and Hitachi. Katherine Yelick has also provided two sections: Chapter 7 on software for HEC in Japan, and Chapter 8 on grid computing in Japan.

Appendix A lists the bios of the panelists. Appendix B is a compilation of the detailed reports from the 22 sites visited. Appendix C provides an update on the Top500 data, which was released in November 2004. The highlights from the U.S. workshop, held on May 25, 2004, are provided in Appendix D. A glossary is in Appendix E.