1. THE CHALLENGE AND IMPORTANCE OF IMPROVING FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION (STI) DISSEMINATION

Question 1.

Are there unique problems associated with the dissemination of STI, or do Federal science agencies face the same challenge in disseminating information as other government agencies?

The Federal science agencies face several unique challenges in disseminating scientific and technical information developed by or for the Federal Government. Federal STI is uniquely important to the success of Federal research and development (R&D) and to realizing broader national goals such as international competitiveness in science and technology. The sheer volume of Federal STI, along with the balancing of free flow and limitations on the use of Federal STI, also set it apart from other types of Federal information. Federal STI is defined here to include data, documents, and directories or indices to data and documents resulting from Federal R&D and related activities. While Federal STI does have much in common with other types of Federal information, five distinguishing characteristics set STI apart and must be accounted for if policies on STI are to be effective.

The importance of STI to R&D. The first challenge to Federal science agencies (and Federal science units within larger government agencies or departments) is to recognize the importance of STI to the success of their R&D missions, and to build STI dissemination into the R&D infrastructure. STI is an integral part of the Federal research and development (R&D) process. The creation of new information is the major objective of R&D. This information takes many forms, for example, information from basic research on AIDS conducted by Federal laboratories, design and testing of prototype photovoltaic solar energy ceils by the Department of Energy, or the synthesis of satellite data collected by the National Oceanic and Atmospheric Administration to improve understanding of the interaction of the atmosphere and oceans in climate change.

Research and development are information intensive activities. Scientists and engineers involved in R&D often spend between one-quarter and one-half of their time on information-related activities that include both analyzing and reporting on one's own research and searching for and applying the research results of others. Scientific advancement and technical innovation are, in large measure, built on the cumulative knowledge base of the scientific and technical disciplines. Breakthroughs may come slowly or, on occasion, may occur quickly as a result of ground breaking research, a new interdisciplinary synthesis, or a "paradigm shift" where the cumulative knowledge leads scientists to revise their basic hypotheses– for example, with respect to the susceptibility of the earth to global change, and the role of the oceans, land, glaciers and ice sheets, biota, and the atmosphere in climate change. Geology, glaciology, oceanography, and climatology are among the several scientific disciplines that benefit from and contribute to Federal R&D and STI.

Improving the use of STI could increase the return on the Federal Government's substantial investment in R&D, which is currently about $65 billion per year and represents roughly one-half of the total U.S. investment in R&D. As a rule of thumb, each dollar spent on Federal STI dissemination generates a direct benefit of at least 2 to 5 dollars to users in the research community (e.g., in terms of time saved, duplications avoided, etc.).[1]

The linkages between R&D. STI and broader national goals. A second challenge is to recognize and strengthen the linkages between R&D, STI, and broader national goals. In a narrow sense, STI resulting from Federal R&D is intended to promote

[1] See, for exampl e, King Research, Inc., Value of the Energy Data Base, contractor report prepared for the U. S, Department of Energy, Mar. 31, 1982.

the advancement of scientific knowledge and technical applications of that knowledge. From a broader societal perspective, the Federal investment in R&D and STI also are intended to serve other national goals. These include: improving the ability of U.S. industrial firms to compete in the international economy; strengthening the U.S. defense and civilian technology base; improving U.S. science and engineering education; promoting international cooperation on global science and technology-reiated problems; and enhancing the free flow of STI required by an open, democratic society.

America's ability to achieve these national goals in part through STI has been limited by our inability to clearly define the role of STI and to reconcile the conflicts over competing goals that inevitably arise. The policy framework for STI dissemination needs to recognize and specify the role of STI at each stage of education, research, and application. For example, STI about solar photovoltaic energy can be structured in terms of what is needed for: educating future solar energy scientists and engineers; supporting basic research on the physics and electronics of photovoltaic energy; facilitating applied research on photovoltaic cells; enhancing the development of prototype and commercial photovoltaic energy systems, and the manufacturing technology for production of such systems; encouraging the integration of photovoltaics into U.S. commercial and defense energy applications; and informing the national and international debate on alternative energy and environmental policies.

The balance between free flow and limitations on the use of Federal STI. A third challenge is to forge an STI policy that strikes an appropriate balance between the basic premise of open exchange and the need for restrictions on certain categories of STI. The role of STI and its dissemination may vary depending on the area of science or technology. Historically, the Federal Government has encouraged the open exchange of Federal STI as a foundation of science and technology. Until recently, access to STI has been restricted only in narrowly defined areas of national security. Over the last decade or so, intensified international technical and economic competition has led to additional restrictions on access to Federally-sponsored STI. These restrictions are based primarily on reasons of national security, foreign policy, and international competitiveness. Electronic technologies speed the transfer of information on national and global scales. Concern over this rapid, uncontrolled dissemination has further fueled the debate over restrictions on access to STI.

This debate involves the balancing of competing interests. For example, in the area of export controls, the need to protect against export of militarily-sensitive technologies and technical data directly or indirectly to U.S. adversaries must be balanced with the need to minimize adverse effects on international scientific exchange and on international trade opportunities. in domestic technology transfer, the need to encourage the transfer of technology (and related technical data) from the Federal Government to the private sector must be balanced with the need to minimize restrictions on access to unclassified Federal STI. Thus, the short-term interest of a solar energy company conducting Federal R&D must be weighed in the context of the long-term development needs" of the U.S. solar energy industry as a whole and the interests of information vendors and users (e.g., librarians, entrepreneurs, policy analysis) who thrive on the open exchange of Federal STI. Too much emphasis on short-term commercialization of technology and related STI could impair the U.S. scientific and technical enterprise and long-term competitive posture.

STI and the "information literacy" of U.S. Scientists and engineers. A perhaps even greater danger is the failure to focus on an important underlying cause of U.S. competitive problems-the inadequate education and training of many U.S. researchers in basic information skills (e.g., search and retrieval of bibliographic databases).[2] Thus a fourth challenge is to vastly improve the "information literacy" of U.S. scientists and engineers. The deficiencies of U.S. mathematics and science education have received considerable

2See discussion in C.R. McClure and P. Hernon, United States Scientific and Technical Information Policies: Views and Perspectives, (Norwood, N. J. : Ablex Publishing Corp. , 1989).

attention;[3] but the information skills needed to be competitive in the 'information age' of modern science and technology have received little attention outside of the library and information science community. Even the best STI system would fail short if the users do not have the skills to search bibliographic databases, retrieve and manipulate data, scan documents, and the like.

In many fields of science and technology, STI developed by other countries is increasingly important. The across-the-board U.S. advantage that existed in the post-World War ii years no longer exists. Foreign patents now account for about 50 percent of all U.S. patents. U.S. researchers must pay more attention to foreign STI, as well as make better use of domestic STI. The experience with Japanese STI suggests that U.S. researchers are, by and large, not well-trained in the need and techniques for accessing and utilizing foreign STI.[4]

The immensity of Federal STI. A fifth challenge to Federal science agencies is managing the already immense and rapidly increasing volume of Federal STI. For example, over 200,000 new technical documents are generated each year as a result of Federal R&D, adding to the base of an estimated 4 million documents.[5] Satellite data and imagery are contributing to an STI explosion in the space and earth sciences. The total earth sciences data volume managed by Federal agencies (primary NASA, USGS, and NOAA) is roughly 100 thousand gigabytes.[6] The total volume is projected to increase by two orders of magnitude over the next 5 to 10 years to 10 million gigabytes (or 10,000 terabytes). When launched in the late 1990s, NASA's earth observing system will generate in one month more data than has been produced by all the Landsat satellites collectively over the last 18 years.

Electronic technologies can help the Federal science agencies manage the STI and ensure that Federal data and documents are made available to users in cost-effective, timely, and usable form. The potential for electronic STI dissemination is especially great because --whether data, documents, or directories to data or documents--it is well suited to electronic formats. Electronic dissemination makes it possible to provide STI to researchers in formats that are more convenient to obtain and easier to manipulate. This could open up or "unlock" many new kinds of research and analysis.

3See, for example, U. S. Congress, Office of Technology Assessment, Educating Scientists and Engineers: Grade School to Grad School, OTA-SET-377 (Washington, D .C. : U.S. Government Printing Office, June 1988); Elementary and Secondary Education for Science and Engineering, OTA-TM-SET-41 (Washington, D. C. : U.S. Government Printing Office, December 1988) ; and Higher Education for Science and Engineering, OTA-BP-SET-52 (Washington, D. C . : U.S. Government Printing Office, March 1989).

4See C.T. Hill, Japanese Technical Information: Opportunities to Improve U.S. Access, Report No. 87-818 (Washington, D. C. : Congressional Research Service, Oct. 13, 1987) ; C.T. Hill, "Federal Technical Information and U.S. Competitiveness: Needs, Opportunities, and Issues," Government Information Quarterly, Vol . 6, No. 1, 1989, pp. 31-38.

5The Department of Energy (DOE) has generated a cumulative total of about 800,000 technical documents that are estimated to represent about one-fifth of the governmentwide total , The National Technical Information Service (NTIS) clearinghouse includes about 2 million technical reports , estimated to represent about one-half of the governmentwide total . OOE generates about 15,000 new technical documents each year, estimated to be 10-15 percent of the governmentwide total ; NTIS adds about 65,000 new documents to its clearinghouse each year, estimated to represent about one-third of the governmentwide total . These estimates are for technical documents only and exclude articles published in the technical literature. For DOE, the annual volume of technical articles equals that of technical documents (about 15,000 each).

6One gigabyte is equivalent to the volume of information contained in about 450,000 double-spaced typed pages of text. One terabyte equals 1,000 gigabytes or one trillion bytes; 100,000 gigabytes equals 100 terabytes. The current and projected earth sciences data volumes are based on estimates by the Interagency Working Group on Data Management for Global Change.