Federal Scientific and Technical Information in an Electronic Age: Opportunities and Challenges

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FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION IN AN ELECTRONIC AGE: OPPORTUNITIES AND CHALLENGES

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SUMMARY AND INTRODUCTION

The Federal Government is the largest single source of scientific and technical information (STI) in the world. Scientific advancement and technological innovation depend on the open exchange of STI. Federal STI ranges from stream flow data collected by the U.S. Geological Survey, to imagery and technical reports on the Voyager Ii interplanetary mission produced by the National Aeronautics and Space Administration's Jet Propulsion Laboratory, and to the energy research database prepared by the Department of Energy.

The House Committee on Science, Space, and Technology asked the Office of Technology Assessment (OTA) to examine the opportunities and challenges facing the Federal Government with respect to the dissemination of STI. This staff paper presents the results of OTA's inquiry.

OTA found that the government does not have an overall strategy on dissemination of STI. An overall strategy would help (1) maximize the return on the substantial Federal research and development (R&D) investment, and (2) meet other national goals to which STI can contribute-such as improving the education of U.S. scientists and engineers, the international competitiveness of U.S. industry, and the strength of the U.S. civilian technology base.

An overall STI strategy is needed if the potential of new electronic technologies is to be fully realized, and if questions about access to Federal STI are to be resolved. Technologies such as online electronic databases or high-density optical disks and magnetic tape cartridges offer great promise for timely, cost-effective storage and dissemination of Federal STI. Electronic technologies offer the only real hope for managing the already massive Federal archives of scientific data and documents.[1] But at the same time, these technologies aggravate conflicts between the basic need for the free flow of Federal STI balanced against concerns about protection of national security and international competitiveness.

Federal science agencies and interagency coordinating groups have made progress in a variety of STI areas. While these modest achievements were adequate for the earlier stages of the transition to a competitive, electronic environment, bolder initiatives are now necessary. Stronger executive branch commitment and leadership are essential to a successful STI strategy. This could be accomplished in part by expanding the role of the Office of Science and Technology Policy (OSTP) in the Executive Office of the President in STI policy, and improving coordination between OSTP and the Office of Management and Budget with respect to STI. Leadership also could be strengthened by: (1) establishing an OSTP outside advisory committee; (2) appointing a high-level interagency coordinating committee for Federal STI; and (3) upgrading STI dissemination functions within the agencies.

A comprehensive strategy needs to address several issues:

- basic principles of STI dissemination (e. g., user charges, user training, private sector involvement);
- basic policy on the free flow of STI;
- technical standards and directories for STI dissemination; and
- the roles of the individual Federal science agencies and governmentwide dissemination or archival agencies.[2]

This OTA staff paper is organized around the four questions posed to OTA by the House

1 In the earth and space sciences, the Interagency Working Group on Data Management for Global Change estimates that the Federal agencies manage a total data archive of roughly 100,000 gigabytes, which is equivalent to 45 bi 11 ion pages of text.

2 These include the Superintendent of Documents sal es program and Depos i tory L i brary Program administered by the Government Printing Office, the Nati onal Techni cal Information Service, and the National Archives and Records Admi ni strati on.

Committee on Science, Space, and Technology:

- 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?
- What technologies could be applied to make dissemination of STI more efficient and effective for Federal science agencies?
- How can the Federal Government improve public access to its resources of STI?
- What changes could be made, both in internal agency organization and in interagency coordination, to enhance public access to STI?

This paper answers these questions within a framework for an overall strategy on STI dissemination, and identifies key elements that could be useful in such a strategy. A followup OTA report (Spring 1990) will analyze selected strategic elements in greater depth.

The staff paper has benefited from comments on an earlier draft discussed at an August 1989 OTA workshop and circulated for outside review. OTA appreciates the participation of the OSTP, OMB, and Federal agency officials and members of the scientific, academic, library, business, and consumer immunities, among others, who provided useful comments and information. The paper is, however, solely the responsibility of OTA, not of those who assisted us.

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

2 See 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.

2. TECHNOLOGICAL OPPORTUNITIES FOR DISSEMINATION OF FEDERAL STI

Question 2.

What technologies could be applied to make dissemination of STI more efficient and effective for Federal science agencies?

Dissemination of Federal STI is being transformed by the ongoing revolution in electronic information and telecommunication technologies. The scientific and technical community is one of the heaviest and most advanced users of computers. The vast majority of U.S. scientists and engineers have a microcomputer at work and/or at home, and many have access to mainframe and high performance computer resources either onsite or through telecommunication networks. The microcomputer or workstation provides the scientist or engineer with a versatile tool. Continuous, steady improvement in the price/performance of microcomputers has resulted in the power of a 1970s-vintage mainframe computer now being on the desktop the typical scientist. The microcomputer can be used to search, recover, and store STI on magnetic or optical media, manipulate and analyze STI using a variety of software, and access STI remotely via online bulletin boards, computer conferences, and database networks.[1]

Online information networks serve at least three important needs of the scientific and technical community. First, they are used for the transfer of very large streams of STI, for example, from a central repository of data collected by earth-observing satellites to regional data repositories and to individual research institutions or user groups. Second, online networks are used to search STI bibliographic databases and to remotely access large-scale high performance computers. Third, online networks are used for informal exchange of STI among researchers, for example, an electronic bulletin board on research in progress or upcoming key events, a computer conference for exchanging working notes and ideas among scientists conducting related research, and electronic mail for submission of manuscripts and review comments to scientific and technical journals and to funding agencies.[2] Online STI dissemination benefits from both a proliferation of online gateways that provide channels for electronic information exchange (offered by telecommunication common carriers, value-added carriers, and not-for-profit and governmental systems), and a growing variety of STI services (especially bibliographic and reference services offered by commercial and not-for-profit organizations as well as some government agencies). Advances in online STI gateways and information services are made possible in part by progress in underlying digital telecommunication technologies (such as packet switching, fiber optics, and satellite networking). The net result is that online is feasible over a broader range of STI dissemination applications than ever before.

The package of online and optical disk technologies offers a powerful combination. Online can be effectively used when time or geographic factors are most important (e.g., bibliographic updates on just published research, access to remote computing resources or to international STI databases) and off-line optical disks can be used for large data sets and/or extensive data manipulation and analysis requirements that are not time sensitive and would be much more expensive online (even at off-peak rates).

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[1]See U.S. Congress, Office of Technology Assessment, Informing the Nation: Federal Information Dissemination in an Electronic Age (Washington, D.C.: U.S. Government Printing Office, 1988).

[2]See National Academy of Sciences, Committee on Science, Engineering, and Public Policy, Information Technology and the Conduct of Research (Washington, D.C.: National Academy Press, 1989); U.S. Congress, Office of Technology Assessment, High Performance Computing and Networking for Science (Washington, D.C.: U.S. Government Printing Office, 1989).

The future of STI dissemination will be dominated by electronic formats. Some major types of STI--such as satellite remote sensing data or the results of large-scale computer models--are created, stored, transmitted, and used in electronic form. These data are rarely, if ever, converted to paper or microfiche, except when summarized and analyzed in technical reports and scientific papers. By comparison, STI bibliographic and reference materials are currently offered and used in paper, microfiche, and electronic formats (principally online and Compact Disk-Read Only Memory (CD-ROM)). Full-length reports and documents are still largely distributed on paper or microfiche. However, electronic publishing is rapidly taking over the document preparation and production process. Most STI documents are created electronically with word processing systems or software, even though the output is still on paper or microfiche. Electronic publishing makes it possible to carry the advantages of electronic word processing through all stages of document preparation and information dissemination. Electronic publishing creates an electronic document database that can be accessed online, stored on magnetic or optical media, or printed out in whole or in part on paper or microfiche.

The price/performance of all electronic publishing components continues to improve. This is resulting in a continued narrowing of the gap between relatively inexpensive desktop systems and expensive, high-end electronic publishing and phototypesetting systems. Desktop systems can be linked to very fast, very high quality phototypesetters and printers.[3]

Desktop publishing and dissemination functions benefit from steady progress in development of expert systems. The expert systems applicable to STI dissemination are no different in principle from the systems that have been successfully applied to other scientific, industrial, and educational areas. Expert systems with sophisticated search strategies can be used to retrieve and deliver bibliographic or full text STI from offline (e.g., CD-ROM) or online information systems. Expert systems can improve the dissemination process by accounting for such factors as: the profile of the information product (number of pages, layout, type style, use of graphics, etc.), anticipated user needs (e.g., size of demand by format), and the modes of dissemination (press run, provisions for demand printing in paper or microform, online database access, optical disk distribution, etc.). Expert systems can also assist SDI (selective dissemination of information) by matching user interest profiles with available databases, and, potentially, in translation of STI from foreign languages to English (and vice versa).

Over the next 3 to 5 years, use of printed Federal STI is likely to decline modestly and microfiche rather markedly, while the use of electronic formats will likely increase dramatically. Some transitional effects are already evident. For example, the National Technical Information Service (NTIS) experienced a roughly 50 percent reduction in sales of paper and microfiche copies of reports between 1980 and 1987. The reduction is attributed in part to the effectiveness of online searching of the NTIS bibliographic database (offered via private vendors).[4] The fastest growing NTIS product line now is computer products. The Office of Scientific and Technical Information at the Department of Energy has noted a similar declining demand for paper and microfiche copies over the past decade as reliance on computerized bibliographic databases increases.[5]

Surveys conducted by the General Accounting Office have documented the plans of Federal agencies to increase their use of electronic formats for STI, and the growing demand of STI users for electronic formats. The survey results indicated a 50 percent or greater anticipated increase over a 3-year period in the number of civilian agencies using electronic mail, electronic

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3See U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Information Dissemination in an Electronic Age* (Washington, D.C.: U.S. Government Printing Office, 1988).

4Ibid., pp. 112-114; U.S. National Technical Information Service, *Annual Report to the Congress on NTIS: Operations, Audit, and Modernization*, January 1989.

5Bonnie C. Carroll, "DOE Reports Distribution Program: Current System and Why Change Is Needed," Office of Scientific and Technical Information, U.S. Department of Energy, April 30, 1986.

bulletin boards, floppy disks, and compact optical disks for STI dissemination. The results showed a doubling over the next 3 years in the number of scientific and technical associations desiring Federal STI in electronic formats. For Federal depository libraries, the results indicated, for example, about an eight-fold increase over the next 3 years in demand for Federal STI on compact optical disks. in contrast, the results showed a projected decline in demand for paper and microfiche formats of about 15 to 20 percent.[6]

A key to realizing the potential for technology-enhanced dissemination is the 'information life cycle," where STI dissemination is part of the larger process of collection/creation, storage, processing, and archiving. The stages in the STI process need to be integrated with interconnected technologies to be cost-effective. Thus the cost and delays associated with rekey boarding, incompatible equipment, and the like can be reduced.

The convergence of trends in technology and in user preference for electronic data, combined with the emergence of systems integration and standards for the STI life cycle, offer an almost limitless array of possibilities for STI dissemination. Several of these are highlighted below in the context of Federal science agency applications.

Cartographic /Geographic information. Many aspects of science and technology depend on geographic information--frequently in the form of maps that show the location of transportation networks, natural resources, climate regimes, environmental sources, and the like. in the past, these maps were prepared by hand and printed on paper. Over the last 15 years or so, mapmaking has been computerized, and satellite imagery has been incorporated along with data from field surveys and aerial photogrammetry. But the final product was and still is largely printed on paper. Over the last 5 years advances in computer technologies have culminated in 'nothing less than a cartographic revolution."

This revolution is being driven by digital cartography combined with powerful hardware and software that can access and manipulate geographic data from multiple sources. By collecting information in digital (as opposed to analog form), or by converting analog data (e.g., aerial photographs) to digital form, the data can be readily processed by computers to produce a vast array of computer products. Digitized maps can be displayed on computer screens and recorded on magnetic and optical media, for example, as well as used to produce traditional printed maps.[7]

The U.S. Geological Survey (USGS) expects that many of these digitized maps will be produced in CD-ROM format at a fraction of the cost of the equivalent magnetic tapes or printed paper documents. USGS pilot tests of CD-ROM indicate that it is likely to bean order of magnitude less expensive than computer tapes, and will require only a microcomputer and CD-ROM reader rather than a more expensive mini- or mainframe computer needed for tapes.

Optical disks will revolutionize STI storage and dissemination. Optical disk technology uses a laser beam to record data on plastic disks by engraving pits in the surface. Encoded disks can be read by a low-power laser beam to retrieve the data. Other members of the optical disk family include: WORM (Write Once Ready Manytimes); Eraseable disks; Videodisk (for storing film or still photos); and CO-I (Compact Disk-interactive) that combines text, data, video, audio, and software capabilities on one disk.

The CD-ROM is rapidly gaining acceptance, and the basic technical standards are already in place. The marginal cost of producing CD-ROMs

6U. S. General Accounting Office, Federal Information: Agency Needs and Practices, Fact Sheet for the Chairman, Joint Committee on Printing, U.S. Congress, GAO/GGD-88-115FS, September 1988; and U.S. General Accounting Office, Federal Information: Users' Current and Future Technology Needs, Fact Sheet for the Chairman, Joint Committee on Printing, U. S . Congress, GAO/GGD-89-20FS, November 1988.

7U. S. Federal Interagency Coordinating Committee on Digital Cartography, Coordination of Digital Cartographic Activities in the Federal Government, Sixth Annual Report to the Director, Office of Management and Budget, 1988.

is very low-currently about $2 per disk at volumes of several hundred or more. The full cost can be as much as $50 per disk for several hundred, if the costs of data preparation, premastering, and mastering are included. But even this compares favorably with other storage media. Each CD-ROM can store up to about 600 megabytes (millions of bytes) of data. This is equivalent to about 300,000 text pages (assuming 250 words or about 2,000 bytes per page). One CD-ROM can store the equivalent of about 1,650 floppy diskettes, 30 of the 20-megabyte hard disks, 15 of the 1,600 bits-per-inch 9-track magnetic computer tapes, or 4 of the 6,250 bits-per-inch computer tapes. Thus a $2 CD-ROM can store as much as several hundreds of dollars worth of magnetic media.

USGS plans to issue CD-ROMs with cartographic and geographic information on a variety of topics, such as:

- Gloria Sidescan Sonar Data-contains data for the Gulf of Mexico and parts of the eastern Pacific Ocean, produced by USGS, NOAA, and NASA, and available from USGS;
- Aerial Photography Records-contains aerial photographs from the USGS National Cartographic Information Center (recently renamed the Earth Science Information Center);
- Joint Earth Sciences-contains sidelooking airborne radar data, prototype produced by and available from USGS, Bureau of Land Management, and Soil Conservation Service;
- Hydrodata--contains daily measurement data for USGS water gage stations, produced and sold by Earth Info., Inc. (for profit, formerly U.S. West Optical Publishing); and
- USGS Reference Materials-contains GEO Index (a database of geologic maps) and Earth Science Data Directory, produced and sold by OCLC, Inc. (not-for-profit, Online Computer Library Center).

Space science data. The collection of scientific data by satellites and rockets--already very extensive--will increase further over the next few years, as a new generation of earth- and space-observing satellites, manned space missions, and interplanetary and deep space probes is launched. The storage and dissemination of these data pose a major challenge to the Federal science agencies - and especially to the National Aeronautics and Space Administration (NASA). Several new electronic technologies have the potential to avoid total systems overload from the expected avalanche of space data.

NASA's primary institution for space data management and dissemination is the National Space Science Data Center (NSSDC) located at the Goddard Space Flight Center in Greenbelt, Maryland. NSSDC is the largest space data-archive in the world, with about 85,000 magnetic tapes of digital data currently on file (along with another 35,000 backup magnetic tapes). The NSSDC archives only processed data, not the raw telemetry data received directly space. The center also archives a large volume of photographs and film taken by satellites and space missions. Some data are maintained on microform or hard copy. At present, the center archives about 4,000 different data sets, mostly from NASA missions but with a few from Department of Defense or foreign missions. The center retains no classified data, and the primary users are researchers from the disciplines of astronomy, astrophysics, lunar and planetary science, solar terrestrial physics, space plasma physics, and earth sciences.[8]

The opportunities are substantial for use of optical disks to store and disseminate space science data. NASA is beginning to experiment with both 12-inch WORM (Write Once Read Manytimes) and 4.75-inch CD-ROM (Compact Disk-Read Only Memory). No WORM products are currently available for dissemination, but 3 prototype CD-ROM products are available: (1) a CD-ROM space science sampler that includes a cross-section of planetary, land, oceans, astronomy, and solar-terrestrial data ($50 for the CD-ROM, software on floppy disk, and docu-

8See U.S. National Aeronautics and Space Administration, Goddard Space Flight Center, The National Space Science Data Center, NSSDC-88-26, January 1989.

mentation); (2) a 3-disk CD-ROM set of Voyager/Uranus images ($100 for the disks, software, and documentation); and (3) a CD-ROM produced by the NOAA National Geophysical Data Center that includes solar wind and magnetic field data from NASA and various geomagnetic and solar data from NOAA (disk and basic software free while they last; $100 for advanced software and updates).

An understanding of the potential of optical disks can be gained from the following hypothetical examples. The Apollo 17 lunar mission generated about 240 magnetic computer tapes of digital data, 32,000 feet of 16 mm color photographs, and 39,000 feet of 16 mm black and white photographs.[9] These digital data could be stored on about 4 double-sided 12-inch WORM disks. (One 12-inch WORM disk can store 1.2 gigabytes per side--equivalent to 30 of the 1,600 bits-per-inch magnetic tapes. A two-sided WORM disk can store 2.4 gigabytes or 60 tapes of data.) With 4:1 data compression, it would be possible to store the Apollo 17 data on one WORM disk. The 16 mm photographic data, which in this example are equivalent to roughly 650,000 individual photographs, could be stored on about 17 analog videodisks (at the standard 54,000 images per videodisk).

For some of the earlier missions, data for entire series of mission activities could be consolidated. For example, the Mariner interplanetary mission series generated the fallowing volumes of digital data in number of magnetic tapes: Mariner 2 (5 tapes); Mariner 4 (10 tapes); Mariner 9 (42 tapes); and Mariner 10 (164 tapes) .[10] The total of 266 magnetic tapes could be stored on about 5 double-sided 12-inch WORM disks (without data compression). The NSSDC archive provides clear evidence of the proliferation of space data over time, as the number and sophistication of space missions increased.

New optical and magnetic storage technologies make it possible for NSSDC to carry out a gradual transition from magnetic tapes and photographic film to higher density storage media such as optical disks or digital tape cartridges (not tape reds, see later discussion on earth sciences data) for digital data and videodisks for analog data. This transition will be quickest for newly acquired data, and for historical data that needs to be rerecorded on new media (i. e., due to deterioration of magnetic tapes, many of which are more than 10 years old and written on obsolete technology).

At the same time, demand for online data dissemination is also increasing. NSSDC is making more data sets available online either over networks or on a dial-up basis. Network options currently include: SPAN (the Space Physics Analysis Network) that links DECnet-based computers in the United States, Canada, Europe, Japan, Australia, New Zealand, and South America; NSN (NASA Science Network) that links with NSFnet and the ARPANET-based Internet; BITNET that links various universities and research organizations; and Telenet, a public packet switching data network.[11]

Second, technical evaluations and guidelines will need to be developed on when and how to use these media for storing and disseminating data. How fast should high-density storage media be phased in, and what kinds of data sets are best suited for WORM, CD-ROM, videodisk, digital tape cartridge, and other storage technologies? These guidelines will need to take into account the ability of users to accommodate high-density storage media, in terms of training, equipment, and cost. What are the highly leveraged data sets that are both best suited for the new media and matched to user capabilities to handle high-density storage? And the guidelines will need to consider the appropriate balance between offline high-density storage media and online dissemination.

At present, NSSDC includes only a small number of data sets in the online program, and

9U. S. National Aeronautics and Space Administration, Goddard Space Flight Center, National Space Science Data Center, NSSDC Data Listings, NSDDC-88-01, January 1988.

10Ibid.

11U.S. NASA, Data Center, op.cit., pp. 15-16; also see U.S. OTA, High Performance Computing, op. cit.

generally limits online time to one-half hour or less. This restriction is based in part on the limited transmission speeds (e. g., still 9.6 kilobits or occasionally 56 kilobits per second, for many universities) such that longer transmissions cost more than offline dissemination. However, online will become more cost-effective as transmission speeds increase. NASA itself already has a 1-megabit/second transmission network for use by NASA laboratories and centers. And the proposed multi-agency national research and education network (NREN) anticipates transmission speeds of 1-gigabit/second or more in the future.[12] Some current online space science data sets include:

- International Ultraviolet Explorer Satellite, contains ultraviolet spectral data, sponsored by NASA, European Space Agency, and British Science and Engineering Council;
- Total Ozone Mapping Spectrometer, contains 120 days of ozone data from the Nimbus 7 satellite, sponsored by NASA;
- Space Telescope Archive and Catalog, contains catalogs of astronomical data and various observing logs from spaceborne astronomy missions, sponsored by European Space Telescope and Southern Observatory; and
- Crustal Dynamics Data Information System, contains catalog of data from Satellite Laser Ranging, Lunar Laser Ranging, Very Long Baseline Interferometry, and Global Positioning System experiments, sponsored by NASA, National Geodetic Service, and various universities.

Earth sciences data. Over the last several years, the Federal science agencies, and the scientific community generally, have made a significant effort to improve the collection, management, and dissemination of earth sciences data. This effort is driven by the widespread concern over problems of global change - ranging from climate change and deforestation to air and water pollution to soil erosion and demineralization to drought – and the recognition that better understanding of these global problems requires much better information. The concept of the earth system has emerged as an important organizing principle, since global change involves all major earth subsystems - the atmosphere, oceans, snow and ice, lakes and rivers, land formations, and the biosphere (e.g., trees, plants, and animals) and can be affected by forces from deep within the earth (e.g., volcanoes and earthquakes) and from far in space (e.g., changes in solar radiation).[13]

The earth system concept is being used to organize the vast array of data relevant to the disciplines that comprise the earth sciences -- climatology, oceanography, glaciology, hydrology, biology, biogeochemistry, geology, etc. in the U.S. Government, the long-term objective is to develop a "virtual" interagency information system for global change data. "Virtual" means that the information system will be a family of decentralized data centers, most of which already exist in some form, linked together by common directories, standards, and policies on access, user charges, quality control, and the like. The goal is to have the system fully implemented by the time that NASA's planned earth observing system is operational in the late 1990s (and thus generating a large additional volume of earth sciences data).

As is the case for space science data, the most effective technology for managing this massive volume of data is high-density storage. Some of the smaller data centers could be converted entirely to a combination of WORM and CD-ROM. For example, The National Oceanographic Data Center, operated by NOAA, maintains about 12 gigabytes of processed data in the following categories: chemical data (marine chemistry), pol-

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[12] See U.S. Office of Science and Technology Policy, Executive Office of the President, The Federal High Performance Computing Program, Sept. 8, 1989; and U.S. OTA, High Performance Computing, op.cit.

[13] See J.A. Eddy, "The Earth As A System," Earth Quest, 1987, Vol. 1, No. 1, pp. 1-2, available from the Office of Interdisciplinary Earth Studies, University Corporation for Atmospheric Research, Boulder, CO.; U.S. National Aeronautics and Space Administration, Earth Systems Science Committee, Earth System Science: A Closer View, Washington, D.C., January 1988; F.B. Wood, Jr., "The Need for Systems Research on Global Climate Change," Systems Research, 1988, Vol. 5, No. 3, pp. 225-240; and U.S. National Oceanic and Atmospheric Administration, Panel ● on Global Climate Change, The Vision: A Rededication of NOAA, January 1989.

[14] See, for example, U.S. Interagency Working Group on Data Management for Global Change, "Interagency Session on Data Management for Global Change," minutes of meetings dated September 18, 1987, November 24, 1987, and March 18, 1988.

lutants/toxic substances); biological data (e.g., fish/shellfish, marine birds, plankton); and physical data (e.g., wind/waves, current, subsurface temperature). NODC also maintains about 12 gigabytes of raw, unprocessed data. The entire NODC database of 24 gigabytes would fit on about two to twelve double-sided 12-inch WORM optical disks, depending on the data compression ratio. As new data accumulate, the WORM disks could be updated. Those portions of the database in high demand could be extracted, mastered, and duplicated at very low cost on CD-ROM, and updated CD-ROMs could be issued periodically.

Several Federal earth science data centers are experimenting with CD-ROM. One is the National Snow and Ice Data Center, operated by the University of Colorado for NOAA's National Geophysical Data Center. The Snow and Ice Data Center has issued a prototype CD-ROM with data on Northern Hemisphere "brightness temperature grids," which are collected by a NASA satellite and used to estimate the polar sea ice parameters. The CD-ROM disk comes with a software diskette and a user's guide, and is available free while supplies last. This is the first in what is planned as a series of CD-ROMs, and reflects a shift in data dissemination philosophy to offline low cost optical disks for many research purposes.[15] In general, the NGDC believes that CD-ROM will greatly improve the accessibility and useability of STI by the research community, as well as by governmental and private sector organizations that depend on geophysical data.

The larger data centers are also considering high-density magnetic as well as optical storage. For example, the EROS (Earth Resources Observing Satellite) Data Center, operated by USGS, archives about 9 million frames of aerial photographs and Landsat images. The Landsat imagery alone is roughly equivalent to 55 terabytes (or 55,000 gigabytes) of digitized data. Because of this large volume, the EROS Data Center is considering the digital tape cassette as the next generation high-density storage medium. Each cassette can store up to 50 gigabytes of data, much more than either CD-ROM (about 0.6 gigabyte per disk, or 4 gigabytes with 6:1 data compression) or WORM (1.2 gigabytes per disk up to about 12 gigabytes for a 2-sided disk with 6:1 data compression). Digital cassettes have a faster data transfer rate than optical disks. On the other hand, the digital tape cassette is a magnetic medium that, like magnetic computer tape reels, deteriorates over time and needs a tape refresh every 7 to 15 years. This compares with a projected lifetime of 20 to 30 years or more for optical disks (the longevity of optical media is still uncertain). The cassettes and equipment cost considerably more than comparable optical disk systems. Optical disks also have the advantage of random (as opposed to sequential) access and microcomputer compatibility (with inexpensive, user friendly software). Preparation and duplication cost, expected level of use, storage capacity, data transfer rate, data access time, longevity, and equipment and training requirements are among the factors that need to be considered in evaluating alternative storage media.

Drought monitoring information. Electronic technologies open up new alternatives for dissemination of time-sensitive Federal STI, such as drought information, that is widely used (contrasted with the very large space and earth sciences data sets that are less time sensitive and have fewer users). Drought information is collected and disseminated by the U.S. Department of Agriculture and NOAA. The NOAA/USDA Joint Agricultural Weather Facility and NOAA Climate Analysis Center produce several drought-related reports and bulletins, such as the Weekly Weather and Crop Bulletin.

Should the government decide to prepare and distribute a weekly or monthly electronic drought bulletin, it might include: temperature and precipitation trends and forecasts; streamflow, lake (and reservoir) level, and snow pack trends and forecasts; soil and plant (including forest) moisture conditions; soil quality conditions (e. g., mineral content, depth of topsoil); crop conditions; and overall drought indices (such as the Palmer drought severity index). The information could be presented on a county, State, regional, and national (and international) level, and would be ideally suited for use with analytical and presentation software (e.g., using spreadsheet or graphics techniques).

15U. S. National Geophysical Data Center, National Snow and Ice Data Center, Data Announcement, "Scanning Multichannel Microwave Radiometer (SMMR) Brightness Temperatures for the Northern Hemisphere," June 1, 1989; also see R. Weaver, C. Morris, and R.G. Barry, "Passive Microwave Data for Snow and Ice Research: Planned Products from the DMSP SSM/I System," *EOS*, September 29, 1987, pp. 776-777.

Agency pilot tests and experience in other areas suggest several prototypes for electronic dissemination that could be applied to drought (or other) time-sensitive Federal STI. The "best" approach depends on the type of information, number and types of users, importance to the agency mission and statutory guidance, agency precedents, budgetary constraints, related private sector alternatives, and the historical and political context.

A weekly or monthly drought bulletin could be made available on an agency electronic bulletin board for dial-up access by users over commercial telecommunication lines. This approach is used, for example, by the National Science Foundation's "science indicators" bulletin board and the Department of Commerce's "economic bulletin board." Or the drought bulletin board could be disseminated online via the computer center of a single agency contractor, an approach used by the Securities and Exchange Commission (for corporate financial information) and USDA (for various agricultural reports and bulletins). Alternatively, an agency computer center could be employed. For instance, the Environmental Protection Agency is making its toxic release inventory" available online via the National Library of Medicine computer center. Finally, the drought bulletin board could be offered as a service of private sector commercial or not-for-profit value-added information gateways and vendors.[16]

Energy research documents. Electronic information technologies also open up new possibilities for the dissemination of Federal scientific and technical documents that traditionally have been maintained in paper and microfiche formats. An estimated 200,000 such documents are generated annually, with more than half of the total originating from the Department of Energy, Department of Defense, or NASA.

Advancing technologies create new alternatives for electronic dissemination of both Federal STI bibliographic databases and the STI documents themselves. The activities of the DOE office of Scientific and Technical Information are illustrative. DOE/OSTI currently distributes about 14,000 documents per year in paper or microfiche format to NTIS and in microfiche to the Depository Library Program (DLP). Abstracts of the documents are included in both the DOE bibliographic database called "Energy Data Base" and the NTIS bibliographic database. While the depository libraries receive paper copies of Energy Research Abstracts, which contains abstracts of DOE-funded research, the libraries have online access to the DOE and NTIS bibliographic databases only through private vendors at commercial rates.

To meet its own internal needs, DOE has implemented an Integrated Technical information System (ITIS), which provides DOE employees and contractors with online access to the most recent 14 months of the Energy Data Base. DOE has proposed a pilot test to offer depository libraries similar online access. Besides timely access to the Energy Data Base (compared with the paper format Energy Research Abstracts), the pilot would provide access to other related DOE databases, an electronic "gateway" to archival energy research summaries (maintained on a database by a commercial vendor), and "electronic cataloging" of DOE documents in a format compatible with that used by depository libraries (and the Library of Congress). During the pilot test, the cost of online depository library access to the Energy Data Base will be $16 per hour.[17]

Another aspect of the DOE pilot testis a study of alternative formats for document distribution. Over the next few years, DOE, like other Federal

16 See statements of Edward J. Hanley, Director, Office of Information Resources Management, U. S, Environmental Protection Agency, John Penhol 10W, Director, Office of EDGAR Management, U. S. Securities and Exchange Commission, and John J. Franke, Assistant Secretary of Administration, U.S. Department of Agriculture, before a hearing of the Subcommittee on Government Information, Justice, and Agriculture, House Committee on Government Operations, April 18, 1989. Also see U.S. Department of Commerce, Under Secretary for Economic Affairs, "Request for Comments on the Preliminary Implementation Plan of Subtitle E, Part I of the Omnibus Trade and Competiveness Act of 1988, the National Trade Oata Bank," April 21, 1989.

17 U.S. Department of Energy, Office of Scientific and Technical Information, "DOE/Depository Library Gateway: Access to OOE R&O Results in Electronic Form, A Pilot Project Proposal," August 1986; U.S. Congress, Joint Committee on Printing, "Dissemination of Information in Electronic Format to Federal Depository Libraries: Proposed Project Descriptions," June 1988.

science agencies, has the opportunity to convert from paper and microfiche to optical disk as the primary document format. One possibility is to require DOE research offices, laboratories, and contractors to submit ail documents in an electronic form (e.g., magnetic tape, online, diskette) that can easily be converted to high-density optical disks (e.g., WORM or CD-ROM). Since the demand for STI documents is generally small, any desired paper copies could be printed on demand. (The more popular documents could be printed in larger volumes with traditional printing processes.)

The study may show, as a hypothetical example, that DOE could distribute copies of the documents via a bimonthly CD-ROM, rather than on microfiche. A standard double-sided CD-ROM can store about 300,000 pages of material (double-spaced, typewritten) or about 1,500 documents at 200 pages per document. Thus the 14,000 documents could fit on about 10 CD-ROMs. The CD-ROM cost probably would be significantly lower than microfiche (and much lower than paper). At present, DOE pays about $350,000 per year for microfiche production of depository library materials, compared to an estimated $210,000 for mastering CD-ROMs and duplicating 1,400 copies of each (one per depository library). If DOE was able to piggyback depository CD-ROM duplication onto mastering and production for internal and possibly NTIS needs, the cost could be even lower (and savings greater). Compared to microfiche, CD-ROM should be easier to use, permit full-text searching, and provide higher quality document resolution (on the screen or when printed out on demand).

One disadvantage of using a bimonthly CD-ROM is the up to two month delay in getting some energy research documents to the depository libraries (and other users). This delay could be alleviated by maintaining the most recent 2 (or perhaps 4) months of documents online in full text format, for retrieval and printing on demand. Many private vendors are adopting a similar approach, which combines the strengths of online with CD-ROM formats. Another possible disadvantage is that ail participating depository libraries (and other users) would need to have adequate CD-ROM facilities (one or several microcomputer, CD-ROM drive, and local printer set-ups, depending on the level of use). As CD-ROM readers continue to drop in price and become standard equipment on microcomputers, the availability of CD-ROM equipment will improve, at least in the larger research libraries. Special provisions may be needed-whether through the DLP or otherwise-to ensure that smaller, rural, or economically disadvantaged libraries have CD-ROM equipment.

An inherent advantage of electronic formats such as CD-ROM is that powerful bibliographic, retrieval, and even expert search system software can be included directly on the optical disk or loaded into the microcomputer via diskette. CD-ROM or online versions of the “Grateful Meal” user--friendly software developed by the National Library of Medicine (NLM) will be commonplace, whether developed by the government and/or private vendors. NLM developed “Grateful Meal” to facilitate user access to MEDLINE and other databases on the NLM MEDLARS (MEDical Literature And Retrieval System). Tens of thousands of copies at $29.95 each have been sold through NTIS. The package includes 2 floppy disks, a user’s guide, and an application for a MEDLARS access code. The capabilities of user-friendly software such as “Grateful Meal” or numerous commercial software packages can be easily replicated on CD-ROM.

in considering the appropriate role for Federal agencies in online dissemination of STI bibliographic databases, three aspects warrant particular attention. First, most of the Federal scientific and technical agencies have a statutory charter and/or mission objective to promote the wide distribution of information on the results of Federal research and development. Even agencies that operate under restrictions (such as NASA) have a strong dissemination mandate. Bibliographic databases are key tools in facilitating access to information on R&D results, and online databases (or for some purposes CD-ROM) offer significant advantages in terms of timeliness and ease of search and retrieval. Thus agencies need to be sensitive to equity of access to Federal STI, and ensure that, whatever means of online dissemination may be employed, certain user groups are not disadvantaged. Students, teachers, retired scientists, small business persons, and the like may need special consideration.

Second, development and dissemination of online bibliographic databases (and now CD-ROM versions of same) are strengths of the private commercial and not-for-profit information industry. A wide range of excellent STI bibliographic databases has been developed by private vendors that offer a portfolio of STI databases (including some from Federal agencies) over information gateways and value-added networks. Again, equity of access is a concern since full commercial online rates can range from $75 to $150 per hour or higher for privately developed databases, and commercial rates range from about $40 to $80 per hour for government databases (2 to 4 times the comparable government rate). On the other hand, commercial vendors increasingly are proposing or offering a variety of discounts for off-peak or bulk volume use, that are more affordable for students, teachers, and the general public. Private sector not-for-profit vendors are providing some databases at rates between full commercial and governmental levels.

Third, a Federal STI bibliographic database may or may not be less expensive if offered online by the government. There is no clear cut answer. Each situation requires individual analysis. For example, adding an online database to an already existing online computer capability (e.g., at NLM) or providing expanded access to an existing online system (e.g., depository library access to the DOE system) may have minimal marginal costs, if the existing computer center could handle the additional file and/or users without costly upgrades or expansion. In these situations, the incremental or marginal cost of additional computer use may be minimal, and competitive with comparable private sector costs. On the other hand, if this required an upgrade of agency computer capability, the cost could be higher. For setting up a small electronic bulletin board, the cost of a new system is likely to be modest, but for a large, heavily used bibliographic database, the cost could be substantial. In making decisions on online bibliographic (or other online) systems, agencies will need to consider the quality of service, agency mission, equity of access, and related private sector activities, in addition to cost-effectiveness.

With respect to CD-ROM (and other optical storage media), the situation is clearer. It seems likely that for some types of Federal information, and especially various STI documents, high-density optical storage will largely supplant paper and microfiche. It is not a question of whether this will happen, but when. Federal agencies will, in all probability, make this transition themselves in order to meet their statutory mission and records management responsibilities. The agencies may employ any of several means to make this transition, including private contractors, NTIS, and/or GPO. But the end result is likely to be the availability of many or most Federal STI documents on optical disk, at affordable prices, with powerful built-in search and retrieval capabilities, that will be cost-effective compared to paper or microfiche. This upgrade may also offer many new opportunities for the private sector to develop more value-added applications and products.

3. IMPROVING PUBLIC ACCESS TO FEDERAL STI

Question 3.

How can the Federal Government improve public access to its resources of STI?

During the 1980s, the Office of Management and Budget (OMB) has been the dominant force in setting policy on dissemination of Federal information--including Federal STI. OMB policy had been interpreted (whether intended or not) as discouraging Federal agencies from using electronic dissemination to facilitate public access to agency information. OMB was especially adamant that Federal agencies not disseminate so-called "value-added" information, that is, anything beyond the raw data such as indexing or search and retrieval capability. OMB viewed electronic dissemination of Federal information as primarily a private sector rather than governmental function. In Informing the Nation, OTA pointed out that OMB policy appeared to be inconsistent with agency information programs and missions established by statute as well as with general statutory principles of open government.[1] Restricting the Federal science agencies from providing value-added information, or from providing such information in electronic form, would erode their ability to carry out statutory responsibilities. Such restrictions also would prevent the science agencies from passing on to STI users the value-added benefits of electronic technologies included in agency R&D and automation programs (and paid for with taxpayer dollars).

OMB policy direction appears to have recently shifted to a more balanced position--one that recognizes the legitimate role of Federal agencies in electronic dissemination as well as the private sector's role in supplementing and complementing agency dissemination. Nonetheless, the history of this policy debate strongly suggests the need for congressional direction. The absence of clear congressional guidance contributed to years of controversy over information dissemination policy, and resulted in significant time and dollar costs to the government and various interested parties in seemingly endless debate over statutory interpretation and legislative intent. Even more importantly, the absence of clear congressional guidance hindered the ability of the government-including Federal science agencies--to fully realize the significant opportunities for cost-effective improvements in overall public access to Federal information. For example, in the case of the National Technical Information Service (NTIS), OMB's insistence on privatization, which was later overruled by Congress, might have resulted in a 2 or 3 year delay in NTIS modernization.

Public access to Federal STI has been further complicated by the ongoing debate about the need for restrictions on STI to protect national security, promote international competitiveness, or encourage domestic innovation. How can or should these needs be reconciled with the basic commitment in the United States to the free flow of STI, especially STI that has been developed or collected at taxpayer expense? Finally, public access to Federal STI has been caught in the middle of the debate over the roles of individual Federal science agencies and governmentwide agencies such as NTIS and the Government Printing Office (GPO) in information dissemination. For example, while many concur in the need for a governmentwide directory to Federal STI, an implementation plan has not yet been developed and agreed to.

An overall strategy on improving access to Federal STI needs to address at least the following areas: basic principles of STI dissemination; basic policy on the free flow of STI; technical standards and directories for ST I dissemination; and respective roles of the individual science agencies and governmentwide dissemination and archival agencies. (Other aspects of an overall strategy are discussed in chapter 4 on interagency coordination.)

1U. S. OTA, Informing the Nation, op. cit., ch. 11.

Principles of STI dissemination. OMB and its directives on information dissemination take on great importance in the absence of governmentwide policy for STI. The OMB role was strengthened through enactment of the Paperwork Reduction Act of 1980,[2] which established an Office of Information and Regulatory Affairs (OIRA) within OMB. The Act was amended in 1986 to include information dissemination within its scope.[3] However, Congress did not provide statutory guidance on the shape, direction, or even basic philosophy of information dissemination that might be promulgated by OIRA.

OMB's efforts during the 1980s to promulgate information dissemination policy have proved to be very controversial.[4] Much of the controversy has focused on the role of the private sector in and user charges for Federal information dissemination. Both the draft and final 1985 versions of OMB Circular A-130 on "Management of Federal information Resources" emphasize that Federal agencies place "maximum feasible reliance" on the private sector for information dissemination, and that costs be recovered through user charges where appropriate.[5]

This OMB policy direction could have accelerated if A-130 went unchanged and Federal agencies issued their own departmental regulations to implement A-130. The Department of Commerce is a case in point, and is particularly important since several Commerce agencies have major STI functions (e.g., NTIS, NOAA, National institute of Standards and Technology (NIST), and the Patent and Trademark Office).

The basic thrust of the August 1988 draft Commerce policy was that "[operating units will use private sector firms to develop, manage, and operate electronic dissemination activities to the maximum extent possible, " and that, "before initiating electronic information dissemination, operating units will conduct a privatization analysis." The proposed policy placed the burden of proof on the agency to "justify any proposed direct Federal role in disseminating electronic information in terms of overriding public need, law, and/or program mission." The burden was particularly heavy with respect to the development and dissemination of value-added electronic information products and services, and in general the marketing and distribution of agency information–all functions which the Department felt should be carried out primarily by the private sector. The Department, in its own highlights sheet, noted that, as a standard of performance, Commerce's electronic dissemination activities should "[o]ffer no value-added features." Likewise, the draft policy placed the burden of proof on the agency to justify why fees to recover the actual costs of dissemination should not be applied.[6]

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2 P. L. 96-511, December 11, 1980.

3 P. L. 99-500, October 18, 1986, and P.L. 99-591, October 30, 1986.

4 See, for example, McClure and Hernon, U.S. Scientific and Technical Information, op. cit.; C.R. McClure, P. Hernon, and H. Relyea, eds., United States Government Information Policies: Views and Perspectives (Norwood, N.J.: Ablex Publishing Corp., 1989); statement of Harold B. Shill, Associate Professor, West Virginia University, on behalf of the West Virginia Library Association and West Virginia University Libraries, before a May 23, 1989, hearing of the House Government Operations Subcommittee on Government Information, Justice, and Agriculture; statement of Harold B. Shill, on behalf of the American Library Association, Legislative Assembly, before a July 14, 1987, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research and Technology; U.S. OTA, Informing the Nation, op. cit., ch. 11; and H.C. Relyea, J. Bortnick, and R.C. Ehlke, Management of Federal Information Resources: A General Critique of the March 1985 OMB Draft Circular (Washington, D.C.: Congressional Research Service, Library of Congress, July 5, 1985). Also see "Librarians Fight Government Plan," New York Times, Feb. 21, 1989, p. A17; J. Markoff, "Giving Public U.S. Data: private Purveyors Say No," New York Times, March 4, 1989, pp. A1, 47; J. Markoff, "Policy Shift on Access to U.S. Data," New York Times, April 10, 1989, pp. D1, D8; D. Sherwood, "Data Wars," Government Executive, April 1989, pp. 24 ff; and C. Webb, "Government Databases: Competing with Private Services?" Presstime, April 1989, pp. 18-20.

5 U. S. Office of Management and Budget, draft, "Management of Federal Information Resources," Federal Register, Vol. 50, No. 51, March 15, 1985, pp. 10734-10747; U.S. Office of Management and budget, Circular A-130, "Management of Federal Information Resources," Vol. 50, December 24, 1985, pp. 52730-52751.

Overall, the proposed policy placed so many substantive and procedural hurdles in the path of agency electronic dissemination activities that innovation and creativity could have been seriously impaired. Even though the policy stipulated procedures by which agency components could have justified government electronic dissemination and/or fee waivers, the procedural burden appeared to be high enough to discourage agency initiatives.

In January 1989, OMB issued an "Advance Notice of Further Policy" that was interpreted by many respondents as favoring private sector over government dissemination of Federal information, limiting agency dissemination to basic and not value-added electronic information, and requiring user fees to recover the costs of dissemination, absent compelling reasons to the contrary.[7] The public comment on the January OMB notice was overwhelmingly critical. OMB concluded that the January draft did not accurately communicate OMB's policy views and had further confused and polarized the debate. As a consequence, on June 15, 1969, OMB issued a "Second Advance Notice of Further Policy Development on Dissemination of Information" that formally withdrew the January 4 notice, summarized the comments received, and presented OMB's reactions and preliminary conelusions.[8] On June 16, OIRA Administrator Jay Plager announced the withdrawal in testimony before the Senate Committee on Governmental Affairs, Subcommittee on Government Information and Regulation.[9] Commerce Department officials subsequently indicated that the draft departmental policy, mentioned earlier, has been placed on indefinite hold and would be subject to further modification and public comment if and when the policy process continues.

The essence and significance of the June OMB notice is captured in the following quotation:

> OMB wishes to make clear that its fundamental philosophy is that government information is a public asset; that is, with the exception of national security matters and such other areas as may be prescribed by law, it is the obligation of the government to make such information readily available to the public on equal terms to all citizens; that to the extent the flow of information from the government to the public can be enhanced by the participation of the private sector, such participation should be encouraged; and that participation by the private sector supplements but does not replace the obligations of government. These principles apply whatever the form, printed, electronic, or other in which the information has been collected or stored. OMB did not intend that either OMB Circular A-130 or the January 1989 notice should have the effect of dissuading agencies from carrying out activities they believe are necessary for the proper performance of agency functions...or that Federal agencies or the public should be made to rely primarily on the private sector for the dissemination of government information.

6U. S. Department of Commerce, Draft Department Administrative Order on "Electronic Information Dissemination," August 5, 1988, published in part as "Draft Policy of the U.S. Department of Commerce on the Dissemination of Information in Electronic Format," *Government Information Quarterly*, Vol. 6., No. 1, 1989, pp. 89-96.

7U. S. Office of Management and Budget, "Advance Notice of Further Policy Development on Dissemination of Information," *Federal Register* Vol. 54, No. 2, January 4, 1989, pp. 214-220.

8See summary of comments in U.S. Office of Management and Budget, "Second Advance Notice of Further Policy Development on Dissemination of Information," *Federal Register*, Vol. 54, No. 114, June 15, 1989, pp. 25554-25559; also see J. Markoff, "O.M.B. Proposes Switch in Information Policy," *New York Times*, June 10, 1989, p. A-28.

9Testimony of Jay Plager, Administrator, OMB Office of Information and Regulatory Affairs, before a June 16, 1989, hearing of the Senate Committee on Governmental Affairs, Subcommittee on Government Information and Regulation. Also see testimony of Jay Plager before a June 28, 1989, hearing of the House Committee on Administration, Subcommittee on Procurement and Printing.

10U. S. OMB, "Second Advance Notice," op. cit., p. 25557.

OMB intends to prepare a new draft policy consistent with the discussion in the June 15 notice. At the same time, various congressional committees are developing legislative proposals to provide OMB with specific statutory guidance on information dissemination. OMB policy and related legislation can be expected to have a significant impact on Federal STI dissemination. These initiatives deserve careful scrutiny to ensure that governmentwide dissemination principles are consistent with those appropriate for STI, and, if not, to make sure that separate guidance is provided for STI. Several key principles need attention:

- **strengthening public access to Federal science agency STI;**
- **providing enhanced or value-added Federal STI products and services when appropriate to agency missions and user needs;**
- **taking advantage of opportunities to improve the cost-effectiveness of Federal agency STI dissemination;**
- **encouraging the diversity of avenues for dissemination of Federal STI;**
- **involving potential users, providers, and contractors in agency planning for STI dissemination;**
- **determining when and how user charges are applied to Federal STI dissemination;**
- **defining when and how intellectual property rights extend to Federal STI;**
- **enhancing the role of the private sector (e.g., libraries, vendors) in Federal STI dissemination; and**
- **ensuring equitable competitive conditions for contractors and vendors involved in Federal STI.**

Policy on the free flow of STI. The Federal role in the U.S. scientific and technical enterprise is premised on the free flow of Federal STI. Until recently, this basic premise of openness has been

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11 For related discussion, see U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, *Electronic Collection and Dissemination of Information by Federal Agencies: A Policy Overview*, House Report 99-560, 99th Congress, 2nd sess. (Washington, D.C. : U.S. Government Printing Office, April 29, 1986. Also see U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information and Individual Rights, *Government Provision of Information Services in Competition With the Private Sector*, Hearing, 97th Congress, 2nd Sess. (Washington, D.C. : U.S. Government Printing Office, February 25, 1982); Rep. Glenn English, "Electronic Filing of Documents With the Government: New Technology Presents New Problems," *Congressional Record-House*, Mar. 14, 1984, H1614-1615; U.S. Congress, House, Subcommittee on Government Information, Justice, and Agriculture, *Electronic Collection and Dissemination of Information by Federal Agencies*, Hearings, April 29, June 26, and October 18, 99th Congress, 1st Sess. (Washington, D.C.: U.S. Government Printing Office, 1986); U.S. Congress, House, H.R. 2600, "Securities and Exchange Commission Authorization Act of 1987," 100th Congress, 1st Sess., June 4, 1987; and U.S. Congress, House, Committee on Energy and Commerce, *Securities and Exchange Commission Authorization Act*, Report to accompany H.R. 2600, 100th Congress, 1st sess., Rep. No. 100-296 (Washington, D. C.: U.S. Government Printing Office, Sept. 9, 1987). For recent discussion, see J.J. Berman, *The Right to Know: Public Access to Electronic Information*, Report prepared for the Markle Foundation, in P.R. Newberg, ed., *New Directions in Telecommunications Policy*, Vol. 2, Information Policy and Economic Policy (Durham, N. C.: Duke University Press, 1989), pp. 39-69; G. Bass and D. Plocher, *Strengthening Federal Information Policy: Opportunities and Realities at OMB*, Benton Foundation Project on Communications and Information Policy Option (Washington, D. C.: The Benton Foundation, 1989); statements of Nancy Kranich, Director of Public and Administrative Services, New York University Libraries, on behalf of the American Library Association, and D. Kaye Gapen, Dean of Libraries, University of Wisconsin, on behalf of the Association of Research Libraries, before a May 23, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture; statement of Alan F. Westin, President, Reference Point Foundation, and Professor of Public Law and Government, Columbia University, before an April 18, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture; H.H. Perritt, Jr., *Electronic Acquisition and Release of Federal Agency Information*, Report to the Administrative Conference of the United States, October 1, 1988; Administrative Conference of the United States, Recommendation 88-10 on "Federal Agency Use of Computers in Acquiring and Releasing Information," adopted December 8-9, 1988; and statement of K.B. Allen, Senior Vice President for Government Relations, Information Industry Association, before an April 18, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture.

modified only in narrowly defined areas of STI relating primarily to national security. However, over the last decade or two, several trends have converged to greatly complicate questions of free versus restricted flow of Federal STI.

First, the U.S. no longer has a commanding lead in many areas of science and technology. The across-the-board U.S. advantage that existed in the immediate post-World War II years, perhaps through the 1950s and 1960s, no longer exists. Second, the global economy is now much more competitive, with foreign countries and companies offering a strong challenge to traditional U.S. dominance in numerous industries and economic sectors. For example, the percentage of foreign-owned U.S. companies, foreign students in U.S. graduate programs, and foreign ownership of U.S. patents has increased dramatically since the 1960s. Third, the U.S. military advantage, while still significant, is under pressure in part as a result of intensified technical and economic competition from foreign powers. Fourth, electronic technologies vastly speed up the collection, storage, and dissemination of STI and thus accelerate the rate of information transfer within the scientific and technical community on a national and global scale.

It is not surprising, then, that the 1980s have seen numerous efforts to further restrict access to Federal STI for economic or security reasons. As examined in several prior OTA reports, the primary grounds for access restrictions are national security, foreign policy, and international competitiveness.[12] National security restrictions have the longest history. DOD generally recognizes the need for open exchange of basic research information to the maximum extent possible, in order to promote the scientific progress on which the defense technology base ultimately depends. However, various DOD components (e.g., especially the Air Force and National Security Agency (NSA)) favor a restrictive approach on access to applied research and technical information. This restrictive approach culminated in proposals to give NSA the lead governmentwide role in computer security and to extend the NSA role to so-called "sensitive but unclassified" Federal information.[13] This category was to include information that, while unclassified by itself, becomes sensitive to the national security when, for example, aggregated in electronic form and available over online databases. Strong opposition to these proposals by the commercial information industry, academia, scientific and library associations, civil liberties groups, and Congress contributed to enactment of the Computer Security Act of 1987. This act assigned the National Bureau of Standards (now the National Institute of Standards and Technology (NIST)) - rather than NSA -- the lead role for civilian computer security, and limited the role of DOD with regard to unclassified, civilian Federal information. information industry and civil liberties representatives, among others, remain concerned about the NSA role in civilian information systems, and the need to ensure the free flow of unclassified Federal information.[14]

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12 U.S., Office of Technology Assessment, *Federal Government Information Technology: Management, Security, and Congressional Oversight*, OTA-CIT-297 (Washington, D.C.: U.S. Government Printing Office, February 1986); *The Regulatory Environment of Science*, OTA-TM-SET-34 (Washington, D.C.: U.S. Government Printing Office, February 1986); *International Competition in Services*, OTA-ITE-328 (Washington, D.C.: U.S. Government Printing Office, July 1987); *Defending Secrets, Sharing Data*, OTA-CIT-310 (Washington, D.C.: U.S. Government Printing Office, October 1987); *Science, Technology and the First Amendment*, OTA-CIT-369 (Washington, D.C.: U.S. Government Printing Office, January 1988); and *Holding the Edge: Maintaining the Defense Technology Base*, OTA-ISC-420 (Washington, D.C.: U.S. Government Printing Office, April 1989).

13 U.S., OTA, *Defending Secrets*, op. cit., chaps. 1,6, 7; also see U. R. Blados, "Controlling Unclassified Scientific and Technical Information," *Information Management Review*, Vol. 2, No. 4, 1987, pp. 49-60.

14 P.L. 100-235, the "Computer Security Act of 1987," January 8, 1988. Also see testimony of Kenneth Allen, Senior Vice President, Information Industry Association, and Marc Rotenberg, Director, Washington Office, Computer Professionals for Social Responsibility, before a May 4, 1989, hearing of the House Committee on Government Operations, Subcommittee on Legislation and National Security.

Policy debates over limits on STI availability involve the balancing of competing interests.[15] In the realm of international science and technology, Congress is requiring a balanced approach designed to ensure that U.S. "access to research and development opportunities and facilities, and the flow of scientific and technological information, are, to the maximum extent practicable, equitable and reciprocal."[16] In negotiating and overseeing international scientific agreements and activities, the Secretary of State is directed to consider:[17]

- scientific merit;
- equity of access by U.S. public and private entities to public (and publicly supported private) research and development opportunities and facilities in each country which is a major trading partner of the Us.;
- possible commercial or trade linkages with the U.S. which may flow from the agreement or activity;
- national security concerns; and
- any other factors deemed appropriate.

Likewise, concern over international competitiveness has led to various actions to encourage the transfer of technology and related technical data resulting from government conducted or funded R&D to the private sector. The "Stevenson-Wydler Technology Innovation Act of 1980"[18] and the "Federal Technology Transfer Act of 1986"[19] together established a variety of mechanisms to facilitate transfer of technology from Federal laboratories to the private sector. These acts authorized Federal laboratories to enter into cooperative R&D agreements with other governmental (Federal, State, local) entities and with the private sector (including universities and commercial firms), and to license, transfer, or waive patent rights resulting from such R&D. A major dilemma for dissemination of Federal STI comes with proposals to extend technology transfer policies from the technology itself to the technical data about the technology. The transfer of rights in technical data from government to the private sector could restrict access to a significant portion of unclassified Federal STI.

A 1987 executive order directs agencies to develop policies that, in effect, transfer technical data by enabling Federal contractors and grantees to retain rights in computer software, engineering drawings, and other technical data generated under Federal contract or grant.[20] This executive order and related proposals by the Office of Federal Procurement Policy[21] have led to a vigorous debate about how to balance the desire for domestic technology transfer with other important governmental objectives. Agencies such as DOE and NASA recognize the open exchange of technical information as a fundamental component of their research missions. A blanket transfer of rights in technical data could seriously impair the conduct of research in fields such as energy and space that generate the very technologies which some desire to be transferred. In other words, too much emphasis on short-term commercialization of technology and related technical data could actually impair the U.S. long-term competitive posture.[22]

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15 See, for example, H.C. Relyea, Striking A Balance: National Security and Scientific Freedom (Washington, D.C.: American Association for the Advancement of Science, 1985); U.S., OTA, First Amendment, op. cit., ch. 4; and National Academy of Science, Panel on the Impact of National Security Controls on International Technology Transfer, Balancing the National Interest: U.S. National Security Export Controls and Global Economic Competition (Washington, D.C.: National Academy Press, 1987).

16 P. L. 100-418, the "Omnibus Trade and Competitiveness Act of 1988," August 23, 1988, Part II -- Symmetrical Access to Technological Research, Sec. 5171 (a).

17 Ibid., Sec. 5171 (d).

18 P. L. 96-480, Oct. 21, 1980.

19 P. L. 99-502, Oct. 20, 1986.

20 E O. 12591, April 10, 1987.

21 U. S. Office of Federal Procurement Policy, "Intellectual Property Rights Policy," draft, February 1989.

22 See, for example, the special issue, "Symposium on the Impact of Competitiveness," Government Information Quarterly, Vol. 6, No. 1, 1989.

A further complicating factor is that, in many fields of science and technology, STI developed by other countries is increasingly important. Policies that severely restrict public access to unclassified Federal STI could lead to reciprocal policies in other countries, with the net result that the international exchange of STI would decline. For example, in the area of energy research, the thrust of DOE policy is to Increase--not decrease--the exchange of international energy STI. The DOE Office of Scientific and Technical Information manages a two and one-half year old Energy Technology Data Exchange (ETDE) under the auspices of the international Energy Agency and with the participation of Canada, Denmark, Finland, Federal Republic of Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, and United Kingdom in addition to the United States.[23]

The participating countries transmit summaries of energy-related STI to DOE on a monthly or biweekly basis, where the summaries are consolidated and provided (on magnetic tape) to participating countries for dissemination to researchers and policymakers. The ETDE includes about 7,500 biweekly updated STI entries and over 2 million entries in the retrospective file. The latter is available via online commercial vendors to research organizations, universities, and libraries within the participating countries. Online usage is divided roughly as follows: industry (71 percent); academia (15 percent); and government (14 percent).[24]

The role of commercial online vendors in the ETDB highlights another implication of overly restrictive policies on STI dissemination. Numerous vendors sell or resell Federal STI databases, or larger databases that include significant Federal STI, to both domestic and international customers. One selling point is the completeness of a particular database, or ensemble of databases, with respect to STI in any particular subject area. A significant erosion in availability of Federal STI to commercial vendors (and for that matter, not-for-profit vendors as well), coupled with possible reciprocal restrictions by other countries, would likely impair the viability and certainly the utility of these databases.

A major challenge, then, is to develop an STI dissemination policy that:

1. encourages U.S. researchers to employ electronic means, where appropriate, to facilitate access to and use of domestic and foreign STI; but at the same time
2. protects U.S. national security interests by controlling access to classified or narrowly defined militarily-sensitive STI; and
3. encourages U.S. international competitiveness through
   a. the open, reciprocal international exchange of STI,
   b. domestic transfer of Federally-funded technology from the Federal government to the private sector where appropriate,
   c. protection of private sector proprietary rights in technology and data (to the extent nonFederal funds are used), and
   d. domestic transfer of rights in technical data developed by or for the Federal Government (with Federal funding) to the private sector in narrowly defined areas where the benefits substantially outweigh the costs.[25]

Congress needs to reconcile differing philosophies about the free flow of STI in developing guidance for the Federal science agencies. This

23 International Energy Agency, Energy Technology Data Exchange, 1988 Annual Report, ETDE/OA-10 (Oak Ridge, TN: U.S. Department of Energy, Office of Scientific and Technical Information, 1988); International Energy Agency, Introducing ETDE: An IEA Multilateral Information Program, ETDE/OA-06 (Oak Ridge, TN: U.S. Department of Energy, Office of Scientific and Technical Information, June 1988).

24 Ibid.

25 For some proposed policy statements, see "Changing Federal Relationships in Intellectual Property," February 1989 draft, provided to OTA by CENDI, and "Policy Directions [in New Regulations on Patents and Copyrights]," May 1989 draft, provided to OTA by NASA.

balancing should take into account proposed legislation that emphasizes the open, unrestricted flow of Federal information as well as legislation that focuses on the transfer of Federally-supported technology and information to the private sector.[27] This balancing also needs to consider existing statutes that promote information access (such as the Freedom of Information Act[28]) and those statutes that limit access in some ways. For example, the Defense Authorization Act of 1984 granted DOD authority to withhold from public disclosure certain unclassified but militarily-sensitive and export-controlled scientific and technical information developed by or for DOD that would otherwise be accessible under fold.=

Technical standards and directories for STI dissemmination. Appropriate technical standards are essential if the government wishes to realize cost-effectiveness and productivity improvements and to facilitate private sector use of Federal STI. Technical standards can accomodate flexibility among different formats so that once the information is input to the system, it can be processed, edited, revised, stored, and disseminated in electronic, paper, or microfiche formats. Standards developed for Federal STI should becompatible, to the extent possible, with those adopted by the private sector. Priority areas for standards-setting include:

- STI indexing and cataloging (standard formats are needed, so that NTIS, GPO, and mission agencies are using compatible approaches);
- STI quality control (especiaily for preventing or minimizing errors in collecting data and creating documents, and for maintaining data and document integrity throughout the information life cycle);
- STI security (technical and administrative standards for preventing unauthorized use or alteration of Federal STI);
- text markup and page/document description languages (e.g., Standard Generalized Markup language, which has been issued as an international standard and as a Federal Information Processing Standard (FIPS));
- optical disks (there has been significant progress on CD-ROM standards, e.g., for mastering, formatting, and reading, but not

26 U.S. Congress, House, H.R. 2381, the "Information Policy Act of 1988," 101st Congress, 1st Session, May 16, 1989; also see U.S. Congress, House, H. R. 2773, the "Freedom of Information Public Improvements Act of 1989," 101st Congress, 1st Session, on, June 28, 1989, that would redefine government records for FOIA purposes to cover all "computerized, digitized and electronic information." Also, draft bills to reauthorize the Paperwork Reduction Act and amend the printing chapters of 44 USC emphasize the free flow of Federal information.

27 See U.S. Congress, Senate, S. 550, the "Department of Energy National Laboratory Cooperative Research and Technology Competitiveness Act of 1989," 101st Congress, 1st Session, March 9, 1989, as amended August 4, 1989, and included as Part C of S. 1352, the "National Defense Authorization Act for Fiscal Years 1990 and 1991," August 4, 1989. Also see U.S. Congress, Senate, Committee on Armed Services, National Defense Authorization Act for Fiseal Years 1990 and 1991, Report No. 101-81, 101st Congress, 1st Session (Washington, D.C.: U.S. Government Printing Office, July 19, 1989); and U.S. Congress, Senate, Committee on Energy-and Naturual Resources, Department of Energy National Laboratory Cooperative Research and Technology Competitiveness Act of 1989, Report No. 101-108, 101st Congress, 1st Session (Washington, D.C.: U.S. Government Printing Office, August 4, 1989).

28 For a detailed discussion of issues concerning an electronic FOIA, see J. Grodsky, "The Freedom of Information Act in an Electronic Age," in U.S. OTA, Informing the Nation, op.cit., pp. 207-236; also see J.J. Berman, The Right to Know: Public Access to Electronic Information, op.cit.; H.H. Perritt, Jr., Electronic Acquisition and Release of Federal Agency Information, op.cit.; and Thomas L. Susman, Chairman, American Bar Association, Committee on Government Information and Privacy, "Access to Electronic Information Under the Freedom of Information Act," draft report, February 28, 1989. Also see statements of Ronald Plesser, Esq., Piper & Marbury, and Patti A. Goldman, Esq., Public Citizen, Inc., before a July 11, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture.

29 U.S. Congress, P.L. 98-94, "Department of Defense Authorization Act of 1984," September 24, 1983; also see W. Blades, "Controlling Unclassified Information," op.cit.

yet for search and retrieval software; standards for WORM, Erasable, and CD-1 disks are in earlier stages of development); and

- electronic data interchange, Including the open systems interface (OSI) concept (e.g., an OSI procurement standard has been issued as a FIPS).

Most STI managers, users, and private vendors agree to the need for interoperability among the various systems and equipment. The Federal Government can accelerate the development and adoption of the necessary standards. An overall Federal STI strategy could reinforce the role of the National Institute of Standards and Technology in standards setting, working with GPO, NTIS, and the Federal science agencies.

The large STI databases-such as in the geographic, space, and earth sciences-must have technical standards for data archiving and exchange, if these resources are to be managed and used effectively. For example, geographic information systems (G IS) will permit much greater data exchange among the Federal science agencies. GIS require the integration of multiple data sets - frequently originating from several different agencies. Most Federal agencies with GIS applications are using major data sets from one, or typically, several other agencies.[30] GIS must have standards to ensure interoperability among users in difference agencies. Most agencies using GIS have not yet developed standard definitions and/or classifications for the major thematic data categories used in GIS applications and do not have an operational program to collect and maria e standardized data for use in GIS applications.[31] The formally chartered (by OMB) Federal Interagency Coordinating Committee on Digital Cartography (chaired by USGS) has made progress in developing a standard format for Federal geographic information storage and exchange.[32]

With regard to space science data, NASA is active in the standards arena. The Science Data Systems Standards Office (at NASA's National Space Science Data Center (NSSDC)) is responsible for supporting standards development, working with the national and international standards organizations, validating standards, and disseminating information about standards. NASA recognizes the importance of technical standards to space science data collection, storage, and dissemination. The NSSDC has developed a generic data storage standard, known as the Common Data Format that is being beta-tested by NASA laboratories, other government agencies, universities, corporations, and foreign institutions.[33]

In the area of earth science data, the standards-setting effort is being led by the Interagency Working Group on Data Management for Global Change, whose members include NASA, NOAA, NSF, USGS, the U.S. Navy, and the Departments of Energy, Agriculture, and State. The working group has emphasized the importance of technical standards to facilitate the exchange of data directory information and the actual data sets. Standards are needed to assist scientists and others to access and use earth sciences data on a variety of computers and over a range of electronic

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30U. S. Interagency Coordinating Committee on Digital Cartograpbn, Reports Working Group, A Summary of GIS Activities in the Federal Government, August 1988, pp. 16-18.

31Ibid. , pp. 13-15.

32See, for example, U. S . Federal Interagency Coordinating Committee on Digital Cartography, Standards Working Group, Federal Geographic Exchange Format: A Standard Format or the Exchange of Spatial Data Among Federal Agencies, December 15, 1986, and U.S. Interagency Coordinating Committee, Coordination of Digital Cartographic Activities in the Federal Government, Third Annual Report to the OMB Director, 1988. For discussion of the need for a directory to GIS activities and improved Federal /State/local cooperation on GIS, see Lisa Warnecke, "Geographic/Land Information Development Coordination Clearinghouse and Network," Syracuse University, School of Information Studies, January 1989, and "Geographic Information Coordination in the States: Past Efforts, Lessons Learned, and Future Opportunities," in Piecing the Puzzle Togegher: A Conference on Integrated Data for Decisionmaking, proceedings, National Governors Association, Center for Policy Research, May 27-29, 1987.

33U. S. National Aeronautics and Space Administration. Goddard Space Flight Center. National Space Science Data Center, NSSDC Data Listings, NSDDC-88-01, January 1988.

networks. This includes the need for standards on data quality. The working group has enlisted the National Institute of Standards and Technology (NIST) in its standards-setting activities. Likewise, the National Research Council's Numerical Data Advisory Board is emphasizing the role of NIST in developing governmentwide standards for large-scale scientific and technical databases of all types.

Directories to Federal STI are also essential, to help users find the information they seek. Proposed OMB policy and legislation[34] would mandate an improved directory or index (or several directories or indices) to Federal information, presumably including STI. There is concern that a directory or index might be used by OMB to thwart rather than facilitate agency information dissemination. OMB has proposed that it not use the directories for review and approval purposes, and, indeed, that agency directories not even be submitted to OMB but to a designated governmentwide agency (OMB suggests NTIS) for consolidation and dissemination.[35] A logical approach would be for NTIS and GPO to collaborate on preparation of a governmentwide directory, and start by collecting and consolidating available agency-specific directories.

Directories to large scale scientific databases as well as STI documents should be included in such efforts. For example, the proliferation of space science electronic databases -- offline and online -- reinforces the importance of directories to help users locate the desired information. NASA's Master Directory provides online access to a directory of NASA and other space and earth science data sets and related information systems. For each data set, the directory includes a descriptive title, abstract, references, contact persons, archival information, storage media, and technical details (e.g., parameters measured, scientific discipline, spatial coverage, time period). The directory also allows connection to other information systems, or database directories, such as those maintained by NOAA or USGS.[36] The NASA directory concept may be applicable to other Federal science agencies, and could be made available to the Federal depository libraries and other Federal information dissemination facilities. In addition to the directory, NASA is developing expert systems software to help users rapidly search, access, manipulate, and display data.

The Interagency Working Group on Data Management for Global change is committed to the development and adaptation of NASA's master directory into an "interoperable directory" that will provide access to information about global change data. Earth sciences data will be maintained by each agency on a decentralized basis, along with detailed catalogs or inventories of these agency data sets. Summary descriptions of the data sets will be included in a central directory that can route inquiries to the appropriate detailed catalogs located at individual data centers and can also transfer data among the various data centers and users. Both online and offline electronic services will be available.[37]

The operational version of the directory will include the following Federal earth sciences data centers or systems: NASA (National Space Science Data Center including the NASA Climate, Ocean, and Land Data Systems); NOAA (National Oceanographic Data Center, National Geophysical Data Center, National Climatic Data Center); and USGS (Earth Science Information Center, Earth Resources Observing Satellite [Eros] Data Center, National Water Data Exchange [NAWDEX], and

34U. S. OMB, "Second Advance Notice of Policy Development," June 15, 1989, op. cit., p. 25555; and U.S. Congress, House, H. R. 2381, op. cit., Sec. 2(i) (3).

35U. S. OMB, "Second Advance Notice," op. cit., p. 25556.

36U. S. National Aeronautics and Space Administration, Goddard Space Flight Center, The National Space Science Data Center, NSSDC-88-26, January 1989, pp. 5-6.

37U. S. National Aeronautics and Space Administration, Goddard Space Flight Center, National Space Science Data Center, "Report on the Third Catalog Interoperability Workshop, November 16-18, 1988," James R. Thieman, Mary E. James, and Patricia A. Bailey, eds., March 1989.

Earth Science Data Directory, among others).[38] In order to further test the directory concept on a smaller scale, the working group and participating Federal agencies are supporting the development of an Arctic environmental data directory.

Arctic climate is thought to be a particularly sensitive indicator of global change, and thus the arctic data directory should have direct utility to the global change research program as well as serving as a prototype for a larger earth sciences data directory. CD-ROM will be considered as a medium for dissemination of both the Arctic data directory and selected data sets.[39] CD-ROMs are also planned for reference and bibliographic materials relevant to polar regions (e.g., one CD-ROM for the 83,000 references in libraries with major polar collections).

Role of governmentwide dissemination and archival agencies. Another important aspect of STI dissemination strategy is the role for governmentwide dissemination and archival agencies and their relationship to the Federal science agencies. Defining and balancing these roles is complicated by the transition from paper (and to a lesser extent microfiche) to electronic formats now underway. This is especially true for scientific and technical information, a significant percentage of which is already in digital form and frequently only usable in electronic formats.

The major governmentwide agencies include: the Government Printing Office (GPO) which is responsible for printing and sales of selected documents by the Superintendent of Documents (SupDocs), and distribution of documents through the Depository Library Program; the National Technical Information Service (NTIS) for the clearinghouse and sales of technical documents; and the National Archives and Records Administration (NARA) with regard to archiving and long-term preservation of documents. All of these agencies play major roles today for STI in paper and microfiche document formats, but less so for STI in electronic formats and databases. The implications of electronic information for these agencies are discussed in OTA's Informing the Nation[40] (which considered GPO, SupDocs, DLP, and NTIS) and the National Academy of Public Administration's The Effects of Electronic Recordkeeping on the Historical Record of the U.S. Government (which focussed on NARA).[41] Both reports discussed a number of alternatives and emphasized the importance of sound strategic planning for electronic formats.

A key question concerns the degree of centralization versus decentralization for the storage and dissemination of Federal STI. When considering electronic STI, it is clear that the creation, storage, and dissemination of STI is fundamentally and inherently decentralized within the science agencies.

There are several reasons for the decentralized nature of STI. First, the volume of STI is vast, and many agencies have difficulty in managing their own STI, much less another agency's data. The notion of centralizing all STI in one data bank is neither cost-effective nor technically feasible at this time. Second, the technical systems for creating, storing, and disseminating STI are typically closely tied to agency automation programs. Centralizing STI dissemination systems, even if technically feasible, could fore-

38 See, for example, U.S. Interagency Working Group on Data Management for Global Change, "Interagency Session on Data Management for Global Change," minutes of meeting dated September 18, 1987.

39 See August 8, 1988, memo from Thomas L. Laughlin, Coordinator, Arctic Environmental Data Workshop, NOAA, to Arctic Environmental Data Directory Working Group; Douglas R. Posson, "Arctic Environmental Data System: Results from the Boulder, Colorado Workshop," Arctic Research of the United States, Fall 1988, Vol. 2; and February 3, 1989, memo from Douglas R. Posson, Chairman, Arctic Environmental Data Directory Working Group, USGS, to Working Group Members.

40 U.S. OTA, Informing the Nation, op. cit., see esp. ch. 4-7, and 12.

41 National Academy of Public Administration, The Effects of Electronic Recordkeeping on the Historical Record of the U.S. Government (Washington, D.C.: National Archives and Records Administration, January 1989). Also see, Committee on the Records of Government, Report (Washington, D.C.: Council on Library Resources, March 1985).

close innovation and opportunities for improving productivity in the agencies. Third, the diversity of STI needs and users among the Federal science agencies spans a wide spectrum of disciplines and research areas. A decentralized approach brings agency STI officials and the scientists and researchers who create and use the STI closer together. Fourth, the economies-of-scale for electronic formats are achieved at lower levels of demand than for ink-on-paper printing. For example, copies of floppy diskettes or CD-ROMs can be produced cost-effectively at volumes of only tens to a few hundreds, while many conventional press runs require volumes in the thousands to capture economies-of-scale.

Several agencies have data centers that are responsible for collection, archiving, and dissemination of databases, and much of these data are already in electronic formats. The major data centers include: the National Space Science Data Center, National Climatic Data Center, National Oceanic Data Center, National Geophysical Data Center, Earth Science information Center, and Earth Resources Observing Satellite Data Center, among others. On the bibliographic and document side of STI, several of the science agencies have their own central STI office (e.g., at NASA and DOE[42]), and most have a significant infrastructure for STI, although the actual structure and administration varies widely among the agencies (e.g., in terms of resources, staffing, visibility).

A key challenge is to preserve and possibly strengthen the ability of the governmentwide agencies to carry out their information responsibilities within a decentralized, increasingly electronic environment. A range of alternatives was considered by OTA in informing the Nation,* by various congressional committees in hearings on NTIS, GPO, and the DLP,[44] and at a recent NARA conference on electronic recordkeeping.[45] The NARA conference identified a combination of roles and responsibilities that seems to be balanced and especially well-suited to STI.

Under this scenario, the Federal science agencies retain primary responsibility for the storage and dissemination of STI collected or developed by each agency. The science agencies would operate pursuant to: OMB guidance promulgated under the Paperwork Reduction Act (chapter 35 of Title 44 of the U.S. Code, as possibly further amended to provide congressional statutory guidance on overall dissemination policy); GPO (and Joint Committee on Printing) guidance promulgated under the printing chapters of Title 44, as possibly amended, to ensure that the integrity of the GPO printing procurement program, SupDocs sales program, and DLP is maintained; NTIS guidance promulgated under the "National Technical information Service Act of

4? See U.S. National Aeronautics and Space Administration, The NASA Scientific and Technical Information System and How to Use It, NASA SP-7073, Washington, D.C., 1989; and U.S. Department of Energy, The Role of the Office of Scientific and Technical Information in DOE's Scientific and Technical Information Program, November 1988.

43U.S. OTA, Informing the Nation, op. cit.

44See, for example, U.S. Congress, House, Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology, National Technical Information Service, Hearing, 100th Congress, 2nd Session (Washington, D. C.: U.S. Government Printing Office, Feb. 24, 1988); U.S. Congress, House Committee on Science, Space, and Technology, National Bureau of Standards Authorization Act for Fiscal Year 1989, Report 100-673, Part 1, 100th Congress, 2nd Session (Washington, D.C.: U.S. Government Printing Office, June 3, 1988); U.S. Congress, House, Committee on Energy and Commerce, National Bureau of Standards Authorization Act for Fiscal Year 1989, Report 100-673, Part 2, 100th Congress, 2nd Session (Washington, D.C.: U.S. Government Printing Office, July 8, 1988); U.S. Congress, House, Committee on Administration, Subcommittee on Procurement and Printing, hearings on "Review of the Printing Chapters of Title 44 of the U.S. Code Due to the Changes in Electronic Information Format, Distribution, and Technology During the Last Decade," May 23-24 and June 28-29, 1989; U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, hearings on "Federal Information Dissemination Policies and Practices," April 18, May 23, and July 11, 1989.

45U.S. National Archives and Records Administration, "Electronic Records: A Strategic Plan for the 1990s," Conference Summary and Recommendations, June 21-23, 1989, see especially the recommendations of the working group on information collection and dissemination.

1988"[46] to insure that the integrity of the NTIS clearinghouse is maintained; and NARA guidance promulgated under the archival chapters of Title 44, as possibly amended, to insure long-term preservation and access to STI. This is predicated on the assumption that OMB, GPO, NTIS, and NARA guidance would be consistent and compatible.

A possible division of responsibilities between the mission agencies and governmentwide agencies is highlighted below with respect to an illustrative hypothetical electronic product-USGS hydrology information (e.g., trends in stream flows and reservoir and lake levels) issued on CD-ROM:

- USGS would notify GPO, NTIS, and NARA in advance of production and supply product information (e. g., size of the hydrology database, type of search and retrieval software, estimated cost and demand).
- GPO would decide whether the CD-ROM should be included in the SupDocs sales program, based on an estimate of demand beyond that being met by USGS direct sales. USGS could opt to use SupDocs as the primary sales outlet if the CD-ROM qualified.
- GPO also would determine whether the CD-ROM should be offered to depository libraries, and if so, how many libraries desired a copy of the CD-ROM.
- NTIS would decide whether the CD-ROM should be included in the NTIS clearinghouse and sales program.
- GPO and NTIS would, on a coordinated basis, make sure that the CD-ROM is cataloged and listed in appropriate governmentwide directories and bibliographic databases.
- NARA would review the CD-ROM to determine long-term archival needs.
- GPO and NTIS would, again on a coordinated basis, advise USGS of their need for copies of the CD-ROM (to meet estimated SupDocs sales, depository library distribution, and NTIS sales needs).
- USGS would obtain CD-ROM production services in the manner that best meets its cost, quality, and turnaround requirements. This could be through an agency contractor, GPO contractor, GPO itself (if an inhouse service is offered), or NTIS contractor (if NTIS offers CD-ROM services).
- Wherever the USGS CD-ROM is produced, GPO and NTIS would ride the order for the number of additional copies required.

The division of responsibilities outlined should be generally applicable to all offline electronic products, including optical disks, magnetic tapes and cassettes, and diskettes (hard and floppy). For online electronic STI databases, the large scale databases would be maintained by the agency data centers. But online directories and possibly small subsets of data might be handled in the same way as the CD-ROM illustration above. Some directories also could be disseminated on CD-ROM or other offline electronic formats.

The roles of NARA and the DLP need special attention. For example, NARA might find that agency data centers can meet archival needs for many STI databases, in which case NARA need not retain physical archival control. However, even when an agency or data center serves as the archive, NARA would help ensure that the archival arrangement is cost-effective and meets data management and technology standards (e. g., regarding longevity of storage media, conversion from one storage medium to another, and portability among different media and equipment), Also, NARA would ensure that when an agency data center determines that certain STI could no longer be retained inhouse, STI scheduled for permanent archival would be transferred to a NARA archive. Machine-readable materials are included within the legal definition of "record."[47] And NARA has an active program for archiving electronic records, which is now being extended to Federal STI. Potentially permanent electronic records identified by NARA include, for example:[48]

46 See U.S. Congress, P.L. 100-519, Subtitle B -- National Technical Information Service, codified at 15 USC 3701 et. seq.

47 44 USC 3301.

- **unique and important scientific and technical data resulting from observations of natural events or phenomena or from controlled laboratory or field experiments;**
- **natural resources data related to land, water, minerals, or wildlife; and**
- **geographic data used to map the surface of the earth.**

To accomplish this mission, NARA will need to appraise the vast store of geographic, space, and earth sciences data with respect to archival needs and requirements, a task that becomes even more challenging with the rapid evolution of electronic storage and retrieval technologies.

As for the Depository Library Program, there appears to be a consensus that electronic formats should be included, although there are differences of opinion over implementation.[49] The continuing debate is focused primarily on questions about: (1) online dissemination (CD-ROM seems fairly well accepted inprinciple); (2) financing, including a possible mix of appropriated DLP funds, cost sharing with agencies and/or depository libraries, user charges, and bulk-rate or off-peak contracts with private vendors; and (3) longer-term reorganization of the DLP in light of electronic alternatives. Several electronic pilot projects are being implemented.[50] For further discussion of depository library alternatives, see Informing the

48U.S. National Archives and Records Administration, Managing Electronic Records: An Instructional Guide, draft, no date, pp. 15-17; also see Michael L. Miller, "Appraisal and Disposition of Electronic Records," U.S. National Archives and Records Administration, March 1988 draft; and June 13, 1989, cooperative agreement between NARA and NOAA.

49For the range of viewpoints on the DLP, see: statement of Joseph E. Jenifer, Acting Public Printer, Government Printing Office, before a May 23 hearing of the Committee on House Administration, Subcommittee on Procurement and Printing; Memorandum from GPO General Counsel to Acting Public Printer, "GPO Dissemination of Federal Agency Publications in Electronic Format,'* May 22, 1989; U.S. Congress, Joint Committee on Printing, resolutions dated April 8, 1987, June 17, 1987, and June 29, 1988, regarding GPO, depository libraries, and electronic formats; Honorable Frank Annunzio, Chairman, Joint Committee on Printing, letter to Honorable Ralph E. Kennickell, Jr., Public Printer, March 25, 1988; U.S. Congress, Committee on Appropriations, Legislative Appropriations Bill, 1989, Report to accompany H.R. 4487, Report No. 100-621, 100th Congress, 2nd Session (Washington, D.C.: U.S. Government Printing Office, 1988); statement of Honorable Viz Fazio, Chairman, House Committee on Appropriations, Subcommittee on the Legislative Branch, before a June 28, 1989, hearing of the House Committee on Administration, Subcommittee on Printing and Procurement; statements of D. Kaye Gapen, Dean of Libraries, University of Wisconsin (on behalf of the Association of Research Libraries), Sandra McAnich, Head, Government Documents, University of Kentucky Libraries (on behalf of the Government Documents Roundtable, American Library Association), and Kenneth B. Allen, Senior Vice President, Government Relations, Information Industry Association, accompanied by Peyton R. Neal, Jr., Chair, 11A Government Printing Office Committee, before a May 24, 1989, hearing of the House Committee on Administration, Subcommittee on Procurement and Printing. Also see a somewhat more critical statement of Paul P. Massa, President, Congressional Information Services, Inc., before a July 13, 1989, hearing of the National Commission on Libraries and Information Science. One private vendor, Legi-Slate, Inc., has offered to provide electronic online dissemination of selected congressional information to depository libraries at bulk rate discounted prices, based in part on the results of a successful 5 1/2 month pilot test with 51 depository libraries. The same concept could be used by other vendors with respect to other types of Federal information, including STI. See Legi-Slate, "Pilot Project Evaluation Preliminary Summary," January 8, 1989.

50The GAO is conducting an evaluation of the research methodology of the electronic pilot projects. See Donald E. Fossedal, Assistant Public Printer, U.S. Government Printing Office, letter to Richard Fogel, Assistant Comptroller General, U.S. General Accounting Office, May 8, 1989. For background on the pilot projects, see U.S. Congress, Joint Committee on Printing, Provision of Federal Government Publications in Electronic Format to Depository Libraries, Report of the Ad Hoc Committee-on Depository Library Access to Federal Automated Databases (Washington, D.C.: U.S. Government Printing Office, 1984); U.S. Congress, Joint Committee on Printing, An Open Forum on the Provision of Electronic Federal information to Depository Libraries, 99th Congress, 1st Sess. (Washington, D.C.: U.S. Government Printing Office, 1985); and U.S. Congress, OTA, Informing the Nation, op.cit., ch. 6.

Nation[51] **and Technology and U.S. Government Information Policies: Catalysts for New Partnerships.**[52]

51U. S. OTA, *Informing the Nation,* op. cit., ch. 7.

52Association of Research Libraries, *Technology and U.S. Government Information Policies: Catalysts for New Partnerships,* ARL, Washington, D. C., October 1987. Also see statements of Vicki W. Phillips, Chair, Depository Library Council to the Public Printer, Patricia Glass Schuman, President, Neal-Schuman Publishers, Inc. (on behalf of the American Library Association), and Bruce M. Kennedy, Head, Reference Department, Georgetown University Law Center (on behalf of the American Association of Law Libraries) before a July 13, 1989, hearing of the National Commission on Libraries and Information Science.

4. IMPROVING INTERAGENCY LEADERSHIP AND COORDINATION ON FEDERAL STI

Question 4.

Question 4. **What changes could be made, both in internal agency organization and in interagency coordination, to enhance public access to STI?**

An important prerequisite to developing and implementing a governmentwide strategy for STI dissemination is leadership--leadership from the science and technology community, Congress, Federal science agencies, and the Executive Office of the President, including OMB and the Office of Science and Technology Policy (OSTP). The focus here is on the Federal science agencies and OSTP (OMB was discussed earlier). Institutional leadership is especially important to realize improvements in interagency coordination and internal agency organization, as well as the other elements of an STI strategy. Changes that could be made, as part of an overall strategy, to improve in these areas include: strengthening the OSTP role; establishing an OSTP advisory committee and an interagency coordinating committee on Federal STI; and upgrading STI dissemination functions within agency R&D and Information Resources Management programs.

Strengthening the OSTP role. OSTP is a logical focal point for executive branch STI leadership. The "National Science and Technology Policy, Organization, and Priorities Act of 1976,"[1] OSTP's organic statute, addresses STI in the declaration of congressional policy. The act lists "effective management and dissemination of scientific and technological information" as part of the U.S. science and technology base, and states that "Federal departments, agencies, and instrumentalities should establish procedures to insure among them the systematic interchange of scientific data and technological findings developed under their programs."[2] But the statute does not assign STI functions specifically to OSTP. The stated functions of OSTP are broad enough to include STI, and STI is mentioned in the charter of a President's Committee on Science and Technology that was to consider, among other things, "improvements in existing systems for handling scientific and technical information on a Government-wide basis, including consideration of the appropriate role to be played by the private sector in the dissemination of such information."[3] However, this provision of the law has not been implemented.

OSTP has in the past provided some staff attention to STI matters, and has supported activities of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). This council, established under Title IV of the act, is composed of the OSTP Director, who serves as chairman, and representatives of the major Federal science and technology agencies. The Council created the Committee on Earth Sciences, which in turn has endorsed the work of the Interagency Working Group on Data Management for Global Change. This working group is addressing some of the key STI technical and policy issues, at least as they relate to earth sciences and global change data. FCCSET also has supported work in the areas of high performance computing and networking, which also relate to STI dis-

1 U.S. Congress, P.L. 94-282, May 11, 1976.

2 P. L. 94-282, Sec. 102(a)(5)(c) and Sec. 102(C)(10).

3 P. L. 94-282, Sec. 303 (a) (2).

semination.[4] In contrast, neither OSTP nor the FCCSET has given significant attention to dissemination of STI documents or bibliographic databases, to issues involving agencies like NTIS and GPO that are responsible for disseminating such materials, or to governmentwide information dissemination issues that are relevant to STI.

in general, the relatively low profile of OSTP with respect to governmentwide STI policy has, in effect, ceded the dominant executive branch policy role to the Office of Management and Budget. To the extent STI is included within the scope of governmentwide information dissemination policy, then the activities of OMB could have a profound impact on STI dissemination.

A strengthened OSTP role seems desirable to insure that the special needs and problems of STI are fully considered, and that the contribution of STI to broader national goals is identified and realized. A stronger role should also help improve interagency coordination on STI. The new OSTP director may, on his own initiative, give a higher priority to STI matters. This could involve the assignment of OSTP staff to the STI area, and the formal recognition of STI functions within each of the major OSTP programmatic areas. But even so, Congress may wish to amend the law to provide stronger congressional guidance. This could be done by adding STI as an explicit, required area of OSTP responsibility. STI also could be added as an explicit, required function of the FCCSET.

OSTP could prepare and issue a strategic plan on STI, with the advice and assistance of advisory committees and agency officials, as was done for high performance computing. This recently issued plan[5] articulates the goals, rationale, action steps, responsibilities, and budget for initial implementation of the U.S. high performance computing and networking program. Program leadership is assigned to OSTP, assisted by a FCCSET Committee on Computer Research and Applications and an advisory panel selected by and reporting to the OSTP Director. The FCCSET Committee will be responsible for interagency planning and coordination, technology assessment, and preparation of policy recommendations and annual progress reports to OSTP. The advisory panel will include scientific, academic, and industry experts, and will provide the OSTP Director and FCCSET with independent assessments of program progress, relevance, and balance. A similar organizational approach could be used for "the Federal STI Program."

<u>Establishing advisory committees on STI</u>. Many STI analysts cite the experience of the Committee on Scientific and Technical Information (COSATI) as evidence of the potential effectiveness of a high level advisory body. COSATI was formed in 1963 by the old Office of Science and Technology (created in 1962 by executive order) and its President's Science Advisory Committee (PSAC). For several years, COSATI and PSAC provided high-level executive branch leadership on STI.[6] With a change in administrations, COSATI was transferred from the Office of Science and Technology to NSF in 1971 and abolished in 1972. The Office of Science and Technology itself was abolished in 1973.[7] Even

4 See U.S. Office of Science and Technology Policy, Executive Office of the President, *A Research and Development Strategy for High Performance Computing*, Committee on Computer Research and Applications, Federal Coordinating Council on Science, Engineering, and Technology (Washington, D.C.: Executive Office of the President, November 20, 1987); and U.S. Office of Science and Technology Policy, Executive Office of the President, *The Federal High Performance Computing Program* (Washington, D.C.: Executive Office of the President, Sept. 8, 1989).

5 U.S. OSTP, *High Performance Computing Program*, 1989, op. cit.

6 See, for example, President Science Advisory Committee, *Science, Government, and Information: The Responsibilities of the Technical Community and the Government in the Transfer of Information* (Washington, D.C.: U.S. Government Printing Office, Jan. 10, 1963).

7 Thomas E. Pinelli, "Chronology of Selected Reports, Related Studies, and Significant Events Concerning Scientific and Technical Information in the United States," May 1989 draft. For other historical overviews, see A. Bishop and M. O. Fellows, "Descriptive Analysis of Major Federal Scientific and Technical Information Policy Studies," in McClure and Hernon, *United States Scientific and Technical Information Policies*, op. cit., pp. 3-55; and A.A. Aines, "A Visit to the Wasteland of Federal Scientific and Information

though OSTP was reestablished (with the "P" for policy added to the statutory name) by statute in 1976, COSATI and PSAC have not yet been revived. The new OSTP Director has announced plans to establish a President's Council of Advisors on Science and Technology--the equivalent of PSAC--under the President's statutory authority. Functions of the new President's Council of Advisors could be extended to STI and the creation of advisory subgroups such as COSATI.

Two STI advisory bodies could be justified. For example, a COSATI composed of a mix of outside advisors and experts could report to the OSTP Director. This group could include representatives from major segments of the science and technology community concerned with STI: scientists, scholars, information specialists, large and small business leaders, librarians, State/local government officials, consumer and labor leaders, and the like. A second advisory body comprised entirely of agency STI officials could be established under FCCSET. This group could include representatives from a cross-section of Federal science agencies, including the major Federal science data centers and document clearinghouses, and the governmentwide dissemination and archival agencies.

The absence of the equivalent of COSATI, or a formal FCCSET advisory body on STI, in part led to the creation of CENDI (Commerce, Energy, NASA, NLM, Defense Information). CENDI is an interagency group established by several Federal science agencies (NTIS, DOE, NASA, DTIC, and NLM) to address problems and opportunities relevant to STI. A strengthened CENDI may be needed, whether as a formal FCCSET body or as a separate but complementary activity.

CENDI could be upgraded in several ways. One, its scope could be expanded to include the data side of STI as well as the bibliographic and document side which it now concentrates on. Two, CENDI's membership could be expanded to include other Federal agencies with major STI functions (e.g., USGS, NOAA, and EPA). Three, CENDI's staff support and funding could be expanded to meet added responsibilities. Fourth, CENDI could establish or strengthen formal working relationships with other interagency groups. Fifth, CENDI could exert active and visible leadership in educating government executives on the importance of STI dissemination and a governmentwide STI strategy.

Whatever the mechanism, improved coordination is needed among those interagency groups involved in Federal STI, including:

- CENDI;
- Interagency Working Group on Data Management for Global Change;
- Interagency Coordinating Committee on Digital Cartography;
- Special Interest Group on CD-ROM Applications and Technology;
- Federal Publishers Committee;
- Interagency Panel on Numerical Data;
- Interagency Advisory Council on Printing and Publishing; and
- Federal Library and Information Center Committee.

Upgrading agency STI management. Agency management of STI needs to be strengthened.[8] First, information dissemination should have a higher priority within agency Information Resources Management (IRM) programs. Most agency IRM offices give scant attention to dissemination, even though dissemination was included in the original IRM concept, and is referred to throughout the Paperwork Reduction Act (as amended in 1986). IRM officials and

Policy," Journal of the American Society of Information Science, Vol. 35, May 1984, pp. 179-184.

8For a general critique of agency information management as it relates to STI, see C.R. McClure, A. Bishop, and P. Doty, "Federal Scientific and Technical Information (STI) Policies and the Management of Information Technology for the Dissemination of STI," in Information Technology: Planning for the Second 50 Years, Proceedings of the 51st Annual Meeting of the American Society for Information Science, Christine L. Borgman and Edward Y. H. Pai, eds. (Medford, NJ: Learned Information Press, 1988), in press. Also see U.S. OTA, Informing the Nation, op. cit., esp. ch. 11.

activities are mostly occupied with computers, telecommunications, management information systems, and procurement activities. Job definitions, career paths, and training programs for information dissemination professionals and IRM officials could be revised and strengthened.[9] Second, STI dissemination should have higher priority within agency R&D programs. STI is the primary product of R&D and is central to agency R&D missions. Several possible actions to upgrade STI deserve consideration:

- the direct participation of STI staff in agency R&D planning and decision-making;
- the separation of dissemination as a line item within agency R&D budgets;
- the allocation of at least some minimum percentage of R&D grants, contracts, and operating budgets to STI dissemination, data management, and related areas;
- the participation of R&D program officials in selected interagency STI groups and activities;
- the participation of R&D grantees, contractors, and the like in agency innovation centers designed to share new information about STI dissemination, among other topics;
- the involvement of R&D and STI managers in focus group discussions with and surveys of STI users; and
- the joint sponsorship of independent research on STI dissemination and use.

Other examples of the need for interagency leadership and coordination. Improved interagency leadership and coordination are needed to deal with a variety of other issues that should be part of an overall strategy on STI dissemination. These issues include, for example, user charges for STI, international cooperation on STI, private sector involvement in STI dissemination, and education and training of STI users.

The transition to new forms of offline and online electronic storage and dissemination creates a need to review STI cost and pricing structures. For example, the Interagency Working Group on Data Management for Global Change found a range of pricing policies in the earth science agencies--from no or partial fees to full marginal costs of more.[10]

The proliferation of networks and programs for exchange of STI means that more international cooperation is needed. The working group recognized from the outset that earth sciences data must be collected and disseminated globally to foster research on global change. The Federal earth science agencies have dozens of international agreements for information exchange, and these could be the basis for an international data network, if adjustments are made to ensure compatibility among the individual data systems. The working group is coordinating with other national and international scientific organizations on earth sciences data management, including the:

- National Research Council Space Science Board, Committee on Data Management and Computation;
- National Research Council, Numerical Data Advisory Board;
- National Research Council, Committee on Geophysical Data;
- International Geosphere/Biosphere Program, Data Management Working Group;
- International Council of Scientific Unions, Panel on World Data Centers;
- Committee on Earth Observation Satellites, Working Group on Data;
- Committee on Data for Science and Technology (CODATA); and
- World Climate Data Program.

Commercial and not-for-profit vendors and the library community play a major role in the dissemination of Federal STI. This role could be expanded with better coordination and cooperation between the Federal science agencies

9 See U.S. OTA, *Informing the Nation,* op. cit., esp. ch. 11.

10 U.S. Interagency Working Group on Data Management for Global Change, draft statement, April 14, 1989.

and the private sector. Increased availability of Federal STI in electronic formats could stimulate and strengthen the private sector role in STI dissemination. This has been the case with online and CD-ROM formats. The collection and creation of the Federal STI databases and documents are paid for by the taxpayer. The development cost of many of these databases is beyond what most private organizations could afford or would risk on such a venture. These databases are a shared national resource. New electronic technologies help the Federal science agencies to prepare and maintain these databases and distribute them to the public--including the private sector. Private vendors, among others, thus are assisted by the government in their business of redisseminating, repackaging, and enhancing Federal STI and converting it into marketable products and services.

Representatives of the Information Industry Association (IIA) support government use of electronic technology for improving the efficiency and effectiveness of information dissemination activities. The IIA envisions a partnership role for the private sector in complementing government dissemination, and suggests four basic principles to ensure access to public information:'

1. The government shall provide access to public information in whatever media it is available.
2. In disseminating information, the agency should ensure that no party, public or private, has the ability to exercise monopolistic control over the information.
3. Government information available to the public must be available to ail members of the public on an equal basis at costs not to exceed the marginal cost of dissemination.
4. Federal agencies must not assert copyright, or implement copyright-like provisions, over their information products absent clear statutory authorization.

Electronic Federal STI should also benefit commercial telecommunication companies. if electronic Federal STI is accepted by users and demand for online services increases, the use of telecommunication gateway services should likewise increase. Market stimulation should extend to the Bell operating companies, long distance telephone carriers, commercial value-added networks, and also not-for-profit networks. The latter include the Online Computer Library Center (OCLC), Research Libraries Information Network (RLIN), Western Library Network (WLN), and Reference Point, Inc. (the latter intended to serve citizen organizations). These and other not-for-profit organizations offer Federal information in their portfolio of services, which could be extended to Federal STI dissemination.

The role of libraries as STI intermediaries also could be enhanced with STI in electronic formats. University research libraries, specialized science and technology libraries, libraries in Federal (and some State/local) science agencies, and a few of the larger public libraries already make extensive use of Federal STI on paper or microfiche. Electronic STI is now limited to a few bibliographic databases available online and/or on CD-ROM from Federal science agencies and/or private vendors. Many of these libraries are preparing for when more Federal STI will be available electronically. Other libraries, including elementary and secondary school libraries, could use electronic Federal STI to help train students and the public in using electronic information services.

Prior OTA studies have examined the U.S. system for educating scientists and engineers, and identified several opportunities that relate directly to STI dissemination. '2

11 See statements of Kenneth B. Allen, Senior Vice President for Government Relations, Information Industry Association, before an April 18, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, and before a July 13, 1989, hearing of the National Commission on Libraries and Information Science.

12 See 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); Power On? New Tools for Teaching and

For example, OTA found that "hands-on" computer-based science learning could increase student interest in the subject matter and enhance student learning. OTA also noted the growing role of computer-based science in science museums, centers, and fairs around the country. Overall, availability of Federal STI in low-cost, user-friendly electronic formats could add a new and important dimension to computer-based mathematics, science, and engineering education. School libraries could serve as a focal point for teacher and student training in the basics of online and CD-ROM use, and could provide a shared computer resource available to support the science curriculum. This could be an extension of the role already performed by library staff at many college and university libraries and at some of the larger and better-funded public libraries.[13]

Integrating electronic STI access, retrieval and use into science education at ail levels should significantly improve the research skills and productivity of U.S. scientists and engineers in the long term. Various studies have highlighted the "inadequate information gathering/management skills of the R&D community" and the lack of skills and/or motivation to use available bibliographic tools, especially with respect to foreign STI.[14] Electronic Federal STI dissemination could play an important part in solving this problem. Leadership from OSTP and a strong and well-coordinated interagency initiative could help make this a reality.

Learning, OTA-SET-379 (Washington, D. C. : U.S. Government Printing Office, September 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).

13For a detailed discussion of opportunities for computer-based mathematics education, see National Research Council, Mathematical Sciences Education Board, Committee on the Mathematical Sciences in the Year 2000, Everybody Counts: A Report to the Nation on the Future of Mathematics Education (Washington, D.C. : National Academy Press, 1989); and National Council of Teachers of Mathematics, Commission on Standards for School Mathematics, Curriculum and Evaluation Standards for School Mathematics (Washington, D.C: National Council of Teachers of Mathematics, March 1989).

14See C.R. McClure, "Increasing Access to U.S. Scientific and Technological Information: Policy Implications," ch. 12 in McClure and Hernon, Scientific and Technical Information, op. cit. pp. 319-354. Also see S. Ballard, C .R. McClure, T. 1. Adams, M.D. Levine, L. Ellison, T. E. James, Jr., L .L. Malysa, and, M. Meo, Improving the Transfer and Use of Scientific and Technical Information: The Federal Role (Norman, OK: Science and Public Policy Program, University of Oklahoma, 1986, available from NTIS, PB 87-142923); and U.S. Congress, House, Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology, Scientific and Technical Information: Policy and Organization in the Federal Government, Hearings on H.R. 2159 and H.R. 1615, 100th Congress, 1st Session (Washington, D. C.: U.S. Government Printing Office, 1987). Also see National Research Council, Numerical Data Advisory Board, Improving the Treatment of Scientific and Engineering Data Through Education (Washington, D.C: National Academy Press, 1986), and Towards a National S&T Data Policy proceedings of an April 14, 1983, workshop cosponsored by the Numerical Data Advisory Board, Congressional Research Service, and House Committee on Science and Technology.