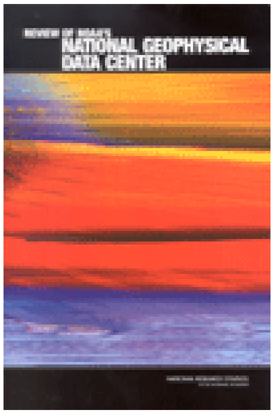

Review of NOAA's National Geophysical Data Center

Committee to Review NOAA's National Geophysical Data Center, Committee on Geophysical and Environmental Data, National Research Council

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REVIEW OF NOAA’S NATIONAL GEOPHYSICAL DATA CENTER

Committee to Review NOAA’s National Geophysical Data Center

Committee on Geophysical and Environmental Data
Board on Earth Sciences and Resources
Division on Earth and Life Studies

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This report has been reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

Dwain Butler, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi
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Although the individuals listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions and recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Fred N. Spiess, emeritus, Scripps Institution of Oceanography, La Jolla, California. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Preface

The National Oceanic and Atmospheric Administration's (NOAA's) National Geophysical Data Center (NGDC) collects, disseminates, and archives marine, solar-terrestrial, and solid earth data on behalf of NOAA and the environmental science community. This report focuses on how well the center is performing these functions, serving its user communities, and supporting NOAA's mission. In particular, the report addresses the questions posed by Gregory Withee, assistant administrator for satellite and information services, responsible for the National Environmental Satellite, Data, and Information Service (NESDIS) (see Appendix B). At Dr. Withee's request the committee did not review the National Snow and Ice Data Center, which receives funding through NGDC but is not part of the center.

To prepare for the review the committee modified criteria that had been developed by its parent Committee on Geophysical and Environmental Data, which has been reviewing data centers since 1967. The review committee added criteria to address issues of leadership, vision, and mission, which are more prominent in this review compared with previous data center reviews. Ten-year trends were emphasized because NGDC has not been assessed by the external user community since 1993. The criteria for review were used to evaluate NGDC at a November 13-15, 2002, site visit in Boulder, Colorado. The committee also gathered information at an August 13-14, 2002, meeting with NESDIS managers and in teleconferences, e-mail questionnaires, and meetings with managers from other parts of NOAA. These include the Forecast System Laboratory, National Climatic Data Center, National Geodetic Survey, National Oceanographic Data

Center, Office of Coast Survey, and the Space Environment Center. The committee met on February 6-7, 2003, to prepare its report.

The review took place at a time of transition at NGDC. The director, Michael Loughridge, retired in December 2002, and Christopher Fox from NOAA's Pacific Marine Environmental Laboratory was named interim director. As a result the review presents a snapshot of NGDC as it existed in 2002. The committee hopes that its findings will help the new director guide the center in the future.

The committee would like to acknowledge the individuals who briefed the committee or provided input to the study, including Charles Challstrom, David Clark, Mai Edwards, David Epp, Christopher Fox, Mary Glackin, Ernest Hildner, Allen Hittelman, Tom Karl, Maureen Kinney, John Kinsfather, Herbert Kroehl, Michael Loughridge, Alexander MacDonald, Kurt Schnebele, George Sharman, Gregory Withee, and Charles Wooldridge. Thanks also go to the NGDC staff, who prepared the background material and figures requested by the committee, spoke openly with the committee during the site visit, and answered numerous questions during the committee's writing phase. Their hard work and cooperation greatly facilitated this review. Finally, the committee thanks the study director, Anne Linn, for her efficient organization of the study process and her outstanding performance in producing this report.

Ferris Webster, *Chair*
Bernard Minster, *Vice-chair*

Contents

Executive Summary

An objective of the National Oceanic and Atmospheric Administration (NOAA) is to understand and predict changes in the Earth's environment. The data needed to conduct integrated studies of natural systems are necessarily diverse and must be drawn from regions ranging from the center of the Earth to the solar surface. Acquiring these data, assuring their quality, and making them available to users is the job of the National Environmental Satellite, Data, and Information Service (NESDIS) and its three national data centers for climate, oceanography, and geophysics. The National Geophysical Data Center (NGDC) is responsible for archiving and disseminating data related to marine geology and geophysics, solid earth geophysics, and solar-terrestrial physics.

Although NOAA's environmental objectives are broad, the agency has traditionally focused on the ocean and atmosphere, raising questions about the role of NGDC—a geophysical and solar-terrestrial center—within NOAA. At the request of NESDIS the Committee to Review NOAA's National Geophysical Data Center was established to answer the following questions:

1. Is the NGDC mission well articulated and understood by its staff and its users?
2. Is NGDC organized, staffed, equipped, and supported to fulfill its mission?
3. Is NGDC appropriately aligned to support the mission, vision, strategic goals, and themes of NOAA and NESDIS?

4. Are NGDC's performance measures appropriate for tracking progress in achieving results and for judging center funding?
5. How well does NGDC collect the data and information it needs to effectively conduct its activities?
6. How effectively does NGDC measure customer satisfaction?

The committee undertook the review from the perspective of the scientific user community. The following recommendations were based on analysis of background material prepared by NGDC, a site visit, discussions with NOAA managers and staff, and assessment of previous reviews of NGDC and other national data centers.

NGDC AT A GLANCE

NGDC was created in Boulder, Colorado, from disparate data programs within NOAA and predecessor organizations in 1965. This history is reflected in the center's organizational structure, which is divided into four semi-autonomous divisions—marine geology and geophysics, solid earth geophysics, solar-terrestrial physics, and information services. Over the years the center's holdings have grown and changed. For example, there is now less emphasis on seismology and more emphasis on ecosystems and natural hazards than there was at the center's inception.

The center now holds 38 terabytes of data and serves tens of thousands of users. The base funding of $4.3 million is not sufficient to cover the payroll of both the permanent and contract staff and carry out the center's responsibilities of acquiring data from agency programs and principal investigators; ensuring that the data are properly documented and assessed for quality; disseminating data, metadata, and information products to users; and archiving them for future generations of users. Budget shortfalls are made up through reimbursable work, mostly to NOAA and other government agencies.

MISSION AND VISION

Over the last decade NGDC's base funding has remained flat while the number of users and the volume of data holdings have increased exponentially. During the same interval, base funding of the other NOAA data centers has increased, suggesting that NGDC has not effectively conveyed its mission and vision to NOAA. The problem is twofold. First, NGDC's

[1] The National Geophysical and Solar-Terrestrial Data Center [a previous name for NGDC] acquires, processes, archives, analyzes, and disseminates solid Earth and marine geophysical

formal mission statement[1] is out of date and no longer fully describes the scope of the center, its connections to NOAA, or its potential for future growth. Second, the center's vision—to be the preeminent stewards of geophysical and relevant environmental data—is not closely aligned with NOAA's priorities, even though long-term data archival is a formal NOAA responsibility.

However, NOAA's new strategic plan for fiscal year (FY) 2003 to FY 2008 contains priorities that are more favorable to NGDC than previous strategic plans. Of particular importance is NOAA's new priority for integrated environmental approaches, an area in which NGDC has some experience and could play an important role. Moving in this direction will require a new vision for the center, a restatement of its mission, and less emphasis on the traditional disciplinary boundaries of marine geology and geophysics, solid earth geophysics, and solar-terrestrial physics. The latter would be facilitated by reorganizing the center so that a common set of services and functions serves all NGDC disciplines.

Recommendation: NOAA, NESDIS, and NGDC should jointly participate in a rearticulation of NGDC's mission in support of NOAA's environmental responsibilities as defined in the NOAA draft strategic plan for 2003.

Recommendation: NGDC should develop an integrated approach to the stewardship of environmental data and operate in such a way that shareable services and functions (e.g., database management, software development) serve all NGDC disciplines.

DATA CENTER PERFORMANCE

User Interactions

The purpose of any data center is to serve its users. To do this well the center must be able to identify its users and assess their satisfaction. NGDC's users include scientists from academia, government laboratories, and the private sector, as well as the general public in the United States and abroad. More detailed information on users is not available because users now overwhelmingly use the Web to find data instead of contacting a staff member at the center. The Web site was not designed to capture much information about users, and the Paperwork Reduction Act of 1995 forbids

data as well as ionospheric, solar, and other space environment data; develops analytical, climatological, and descriptive products to meet user requirements; and provides facilities for World Data Center-A (Solid Earth Geophysics, Solar Terrestrial Physics, and Glaciology).

nonrigorous user surveys, such as those that the center used to conduct. NESDIS has recently obtained Office of Management and Budget approval for a one-time user survey of its data centers, so better information on customer satisfaction is forthcoming. Finally, the center has not had an external user advisory committee since 1993. External guidance is especially important now that mechanisms for obtaining meaningful user feedback are more difficult to put in place.

Recommendation: NGDC should take steps to obtain effective feedback from its users by establishing an independent external advisory group, conducting statistically valid user surveys, and making better use of its Web site to characterize users and to define their interests and level of expertise.

Previous data center reviews suggest that the best data centers are integrated into the scientific community. There are many ways to increase scientific involvement with the center, including having scientific expertise among the center staff. A number of center staff have scientific credentials and publish papers about NGDC data, but the center might also consider appointing a chief scientist who would interact with all the divisions to energize the science. Links with the external scientific community could be strengthened by increasing the number of collaborative projects with outside scientists, re-establishing the scientific advisory committee, and/or populating the visiting scientist program with active scientists from outside the Boulder area.

Recommendation: NGDC should improve scientific involvement of center personnel with the datasets by recruiting scientists to work with the data, establishing a vigorous program of external visiting scientists, and/or creating strong partnerships with other agencies, industry, and academia to supplement staff expertise.

It is inferred from Internet domain names that a significant fraction of NGDC's users are not scientists. Serving the educational needs of these lay users is difficult, requires specialized skills, and is given a lower priority in practice by NGDC. Indeed, NGDC's performance measures call for only 0.25 full-time equivalents (FTEs) and associated resources to be devoted to outreach activities. However, this level of effort is significantly lower than that of other agencies and has not led to a coherent education and outreach program.

Recommendation: For NGDC to have an effective education and outreach program, it should first develop a strategy that can be implemented for all disciplines, and the program should be given resources commensurate with that strategy.

Data Collection and Distribution

Through its entrepreneurial staff the center has been able to obtain many datasets of value to the community and is well positioned scientifically to acquire important new data streams in the future (e.g., geodetic data from NOAA's network of continuously operating reference stations, solar-terrestrial elements of the National Polar-Orbiting Operational Environmental Satellite System). NGDC will have to continue working with data collection programs and with principal investigators to ensure that relevant data and metadata are obtained and archived properly. All data related to marine geology and geophysics, solid earth geophysics, and solar-terrestrial physics need not be archived at NGDC. Indeed, there are financial, scientific, and data safety reasons for having multiple archives. However, NGDC should provide prominent links to guide users to these related archives. Given that the Web is the first place most users go for data, NGDC should place high priority on putting all its digital holdings online or nearline. These steps would help NGDC become the first place users go to find geophysical data.

Recommendation: NGDC should work with organizations that are sponsoring relevant data collection projects (e.g., National Ocean Partnership Program, National Science Foundation) from the outset to ensure that NGDC will receive the resulting data. It should also provide prominent links on its Web site to complementary archives.

Recommendation: NGDC should continue to convert historical analog records to digital form and make all its digital holdings available online or nearline in the near future.

Implementing this recommendation would enhance data availability and preservation.

Staff and Facilities

The staff appear to be well qualified to carry out their tasks. However, claiming budget shortfalls, NGDC has not filled vacancies, and the number of federal FTEs has declined to 51, a 50 percent decrease since 1992. As a result the balance of skills at the center has become skewed. The center has supplemented its technological expertise through grants to the University of Colorado's Cooperative Institute for Research in the Environment. It could do the same to supplement its scientific expertise. The pending retirements will permit the center to hire employees with needed skills and inject new blood into the center.

Recommendation: NGDC should develop a strategy for recruiting and retaining staff that places a high priority on enhancing the scientific vigor of the center and ensures that key technological expertise resides on the permanent staff.

NGDC's hardware infrastructure—built on a network of Linux servers and a modern tape robotic mass storage system—has the capacity to meet the data distribution and archival needs of the center. However, the pace of data migration (10 percent per year) is slower than is generally accepted, potentially jeopardizing the safety of the data. Another concern is that the offsite backup storage facility is not located at a significant distance from Boulder. The proximity of the primary and backup storage locations creates the potential for significant data loss through natural disasters and power outages, and interruptions of data availability from loss of Internet connectivity to the Boulder area.

Recommendation: NGDC should improve its data stewardship, guided by practices at other data centers, to accelerate its data migration schedule and its rate of archive transcription, and should also address the center and backup site disaster vulnerability.

Performance Measures

Performance measures provide a means for evaluating progress. However, many of the performance measures used by NGDC in FY 2002 have more to do with the efficient operation of a federally supported facility than with good data center performance. For example, NGDC's current performance measures include "alternative dispute resolution" but do not include "ease of access to holdings." With the revision of the NOAA and NESDIS strategic plans, NGDC has an opportunity to propose a new approach to defining performance measures—one that begins with determining the characteristics of a good data center (e.g., data are easily found and accessed by users) and then defines performance measures accordingly.

NGDC is at a turning point. Recent and upcoming retirements at NGDC and the change of focus at NOAA present a tremendous opportunity to install new leadership and build NGDC into an integrated science center. In doing so it can take advantage of existing strengths, including a capable staff; some critically important data that are not held elsewhere; a favored location in Boulder, Colorado, which places scientific expertise at their fingertips; and experience creating integrated datasets and tools. With vision and inspired leadership NGDC can improve its effectiveness, fulfill its potential within NOAA, and more effectively contribute to pressing global concerns of understanding and managing our environment.

1

Introduction

The Earth's atmosphere, oceans, land surface, interior, and near-Earth space form an integrated system in which changes in one element of the system may affect the others. Understanding the elements of this system, the way they interact, and how they have changed through time requires the collection and synthesis of a wide variety of scientific data acquired, often continuously, over long periods of time from a wide range of scientific instruments located in different geographic regions and different regions of the near-Earth space environment. These data provide the basis for understanding the causal relationships between physical processes that occur within this complex system. An example is the determination that major geomagnetic storms are initiated by sporadic ejections from the outmost layer of the solar atmosphere propagating through space and affecting the Earth's magnetosphere.[1] Over longer periods of time geophysical data are necessary for detecting and monitoring environmental trends. For example, changes in the Earth's magnetic field over decades to centuries contain a wealth of information on the dynamics of the Earth's deep interior; changes in the composition of seafloor sediments over hundreds of thousands to millions of years are used to reconstruct past climates and to help elucidate the cause and variability of global

[1] Office of the Federal Coordinator for Meteorology, 1995, *National Space Weather Program: Strategic Plan*, FCM-P30-1995, Washington, D.C., <http://www.ofcm.gov/nswp-sp/text/a-cover.htm>.

climate change; and long-term changes in the level of geomagnetic activity are used to infer changes in the Sun's magnetic field and the solar wind, possibly of significance to global change.[2] Long-term, continuous data records are also useful for practical applications, such as planning for geomagnetic-storm-induced power and communications disruptions[3] or for establishing reliable baselines for geomagnetic surveys. Much of the data used in the above applications are archived at the National Oceanic and Atmospheric Administration's (NOAA's) National Geophysical Data Center (NGDC).

Although a number of federal and state government agencies collect environmental data, NOAA is responsible for providing long-term stewardship of environmental data, thereby ensuring their usefulness to current and future generations of scientists.[4] This mission is carried out under the auspices of NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), which operates three environmental data centers: NGDC, the National Climatic Data Center (NCDC), and the National Oceanographic Data Center (NODC). Together, the data centers disseminate and archive over 1 petabyte (10^{15} bytes) of data that are used to study processes operating anywhere from the center of the Earth to the Sun.

NGDC has the smallest base budget of the NOAA data centers (Table 1.1), but its holdings span the most disciplines. NGDC's holdings include information on aurora, cosmic ray, ionospheric, and solar phenomena; bathymetry, topography, and relief; earthquake, volcano, and tsunami hazards; ecosystems; geomagnetism; marine geology; marine trackline geophys-

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[2] J.D. Hays, J. Imbrie, and N.J. Shackleton, 1976, Variations in the Earth's orbit: Pacemaker of the ice ages, *Science*, **194**, 1121-1131; N.J. Shackleton, S.J. Crowhurst, G.P. Weedon, and L.J. Laskar, 1999, Astronomical calibration of Oligocene-Miocene time, *Philosophical Transactions of the Royal Society of London*, Series A, **357**, 1907-1930; C.T. Russell, 1975, On the possibility of deducing interplanetary and solar parameters from geomagnetic records, *Solar Physics*, **42**, 259-269; M. Lockwood, 2001, Long-term variations in the magnetic field of the sun and heliosphere: Their origin, effects and implications, *Journal of Geophysical Research*, **106**, 16,021-16,038.

[3] Use of good geomagnetic storm forecasts could save the U.S. electricity industry $350 million over three years. See NOAA economic statistics, May 2002, <http://www.publicaffairs.noaa.gov/worldsummit/pdfs/economicstats.pdf> and references therein.

[4] At the federal level environmental data are collected by the 10 agencies that participate in the U.S. Global Change Research Program: Departments of Agriculture, Defense, Energy (DOE), and Health and Human Services; Environmental Protection Agency; National Aeronautics and Space Administration; NOAA; National Science Foundation; Smithsonian Institution; and the U.S. Geological Survey (USGS). See Climate Change Science Program and the Subcommittee on Global Change Research, 2002, *Our Changing Planet: The Fiscal Year 2003 U.S. Global Change Research Program and Climate Change Research Initiative*, Washington, D.C., 124 pp. DOE and USGS also have a formal mission to archive environmental data. However, the vast majority of environmental data collected by federal agencies is eventually archived at NOAA.

TABLE 1.1 Vital Statistics of the NOAA Data Centers

Data Center	Number of Staff[a]	FY 2002 Budget Base ($M)	Total ($M)	Base/Total (%)	Base/Staff ($k)	Current Holdings (TB)[b]
NCDC	173	12.0	44.4	27	69	704.7
NODC[c]	56	5.3	7.9	67	95	1.5
NGDC	51	4.3	9.0	48	84	37.6

[a] Full-time equivalents, including only federal workers. NGDC figures include two vacancies.

[b] TB = terabyte. Single copy of data; all the data centers also hold backup copies, which doubles the data volumes shown, to comply with National Archives and Records Administration standards.

[c] Figures exclude the National Coastal Data Development Center and the NOAA library, which are funded through NODC.

ics; land geochemistry, geothermal, and gravity data; and marine well log data (Appendix C). The collocation of this wide array of data and information products provides a number of scientific advantages, such as enhancing opportunities for cross-disciplinary research. However, it also poses management challenges, such as maintaining sufficient expertise in the data to serve users or defining the center's focus to NOAA and the broader community.

This report reviews NGDC's practices in collecting, disseminating, and archiving marine, solar-terrestrial, and geophysical data and assesses how well the center is managing its holdings, serving its users, and supporting NOAA's mission. The formal charge to the committee is given in Box 1.1.

BOX 1.1 Committee Charge

At the request of Gregory Withee, assistant administrator for satellite and information services, the National Research Council Committee to Review NOAA's National Geophysical Data Center was established to review NGDC, with particular emphasis on answering the following questions:

1. Is the NGDC mission well articulated and understood by its staff and its users?
2. Is NGDC organized, staffed, equipped, and supported to fulfill its mission?
3. Is NGDC appropriately aligned to support the mission, vision, strategic goals, and themes of NOAA and NESDIS?
4. Are NGDC's performance measures appropriate for tracking progress in achieving results and for judging center funding?
5. How well does NGDC collect the data and information it needs to effectively conduct its activities?
6. How effectively does NGDC measure customer satisfaction?

HISTORY OF NGDC

NGDC was created in 1965 from existing data programs in the Department of Commerce, particularly the Coast and Geodetic Survey and the Central Radio Propagation Laboratory. Initial holdings included gravity, seismic, tsunami, geodetic, and geomagnetic data. NGDC also operated world data centers (WDCs) for gravity, seismology, and geomagnetism, which archived and disseminated data related to the International Geophysical Year.[5] In 1972 NGDC merged with the Solar-Terrestrial Data Center, and marine geology and geophysics data were transferred from NODC to NGDC over the next few years. By 1975 the three main foci for the center emerged: solid earth geophysics, solar-terrestrial physics, and marine geology and geophysics.[6] World data center activities were organized under the solid earth geophysics and solar-terrestrial physics divisions at that time, and the WDC for Marine Geology and Geophysics was established in 1982.[7] The National Snow and Ice Data Center was also created in 1982 and took over responsibility for the World Data Center for Glaciology. Since then, the holdings of NGDC have grown and diversified, but the only major change in focus came in 1990, when the NOAA paleoclimatology program was created at NGDC. However, responsibility for paleoclimate data was transferred to NCDC in 2002 to "improve the performance of our climate work within NESDIS."[8] Other holdings that have been transferred from NGDC to other agencies in recent years include seismic data (earthquake, strong motion, multichannel) and operational

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[5] The International Geophysical Year of 1957-1958 was intended to allow scientists from around the world to take part in a series of coordinated observations of various geophysical phenomena. These observations were archived and disseminated through world data centers operated under the auspices of the International Council for Scientific Unions and hosted by the United States, Soviet Union, Europe, Asia, and Australia. Since that time, the World Data Center system has broadened into new disciplines and now comprises about 50 centers that collect, archive, and distribute a wide range of solar, geophysical, and environmental data for scientific purposes for no more than the cost of filling a user request. See S. Ruttenberg and H. Rishbeth, 1994, World Data Centers—past, present and future, *Journal of Atmospheric and Terrestrial Physics*, **56**, 865-870; International Council for Scientific Unions, 1996, *World Data Center System Guide*, Boulder, Colo., 109 pp.

[6] The Marine Geology and Geophysics Division was a branch of the Solid Earth Geophysics Division until 1981.

[7] The list of world data centers, including the three operated by NGDC—World Data Center for Marine Geology and Geophysics, World Data Center for Solar Terrestrial Physics, and World Data Center for Solid Earth Geophysics—appears at <http://www.ngdc.noaa.gov/wdc/wdcmain.html>.

[8] Memorandum from Gregory Withee, assistant administrator, satellite and information services, to Michael Loughridge, director, NGDC, April 17, 2002.

activities in geomagnetism, which were transferred to the USGS in 1973.[9] The USGS now operates U.S. seismic and geomagnetic observing stations, although NGDC retains certain archive, dissemination, and international data responsibilities in these areas. Aeromagnetic data were returned to the USGS in 1999 when the agency obtained resources to reanalyze and disseminate them.[10] Despite these changes NGDC remains organized along historical lines, with three scientific divisions—solid earth geophysics, marine geology and geophysics, and solar-terrestrial physics—and an information services division (Figure 1.1).

ORGANIZATION OF THE REPORT

This report considers the purpose, function, and operation of NGDC and the opportunities and challenges it has within NOAA to provide comprehensive access to and stewardship of a wide range of geophysical data. The review was conducted from the perspective of the scientific user community; biographical sketches of the committee members are given in Appendix A. Chapter 2 gives an overview of NGDC data center functions, from data acquisition to customer service to long-term archiving. These data center functions were evaluated using criteria listed in Appendix B. A list of NGDC holdings is given in Appendix C. The remaining chapters are organized to answer the questions posed to the committee. Chapter 3 focuses on ways to improve the effectiveness of NGDC in the areas of data collection, customer satisfaction, and data management. It also deals with management issues such as organization, resources, and performance measures. NGDC's performance measures for fiscal year 2002 are given in Appendix E. Chapter 4 examines NGDC's mission and vision and its role within NESDIS and NOAA. The missions, themes, and strategic objectives of NGDC, NESDIS, and NOAA are given in Appendix D. Chapter 5 contains the conclusions of the report. Finally, a list of acronyms is given in Appendix F.

[9] Background material prepared by NGDC for the August 13-14, 2002, committee meeting. A memorandum of agreement between the Department of Commerce and the Department of Interior transferred the major federal seismologic operational research and service programs, and later the World Data Center for Seismology, from NOAA to the USGS.

[10] Personal communication from Mai Edwards, data administrator, NGDC, March 10, 2003.

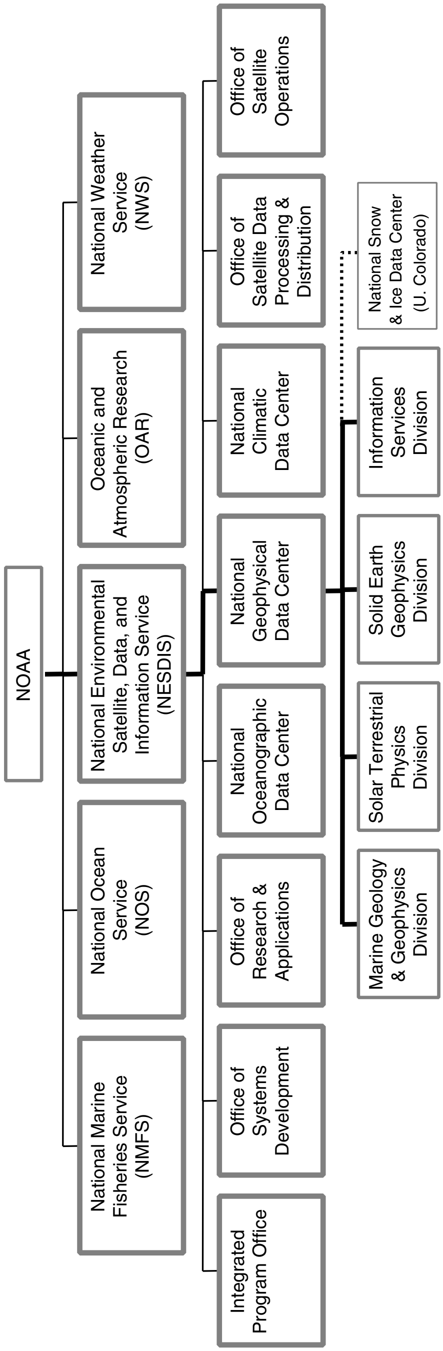

FIGURE 1.1 Organization chart showing the divisions of NOAA, NESDIS, and NGDC.

2

Overview of NGDC

The purpose of data centers is to serve users not only now but also in future generations. Doing this well requires that data centers participate in all the major stages in the life cycle of a dataset:

1. *Data collection and product generation*. Data centers can seek to clarify both the information being captured and the inputs or parameters imported from other sources and to facilitate the process of recording them.
2. *Management of active datasets*. Data centers can strive to understand the data needs of their users; prepare guide information to assist users in evaluating the relevance of the data to their purposes; develop data-handling tools and services to help users find and work with the data; contact experts on behalf of users with complex scientific queries; and reprocess data in response to scientific demands.
3. *Long-term archive*. Data centers can assemble and present useful information about datasets to ensure a greater likelihood that the data will remain useful beyond the period when a high volume of exchange, access, and manipulation takes place.[1]

This chapter describes the National Geophysical Data Center's (NGDC's) activities in the data life cycle. This description is based on

[1] National Research Council, 1998, *Review of NASA's Distributed Active Archive Centers*, National Academy Press, Washington, D.C., pp. 41-43.

information gathered from meetings, interviews with NGDC staff, and background material related to the committee's review criteria (Appendix B). An analysis of these issues is given in Chapter 3.

HOLDINGS

Overview

NGDC holdings include seafloor and lakefloor analyses, descriptions, and sample inventories; trackline geophysical measurements; hydrographic sounding surveys; multibeam bathymetry tracks and surveys; sidescan sonar and multichannel seismic profiles; hazards information; ecosystems data and assessments; and solar, magnetospheric, ionospheric, geomagnetic, and cosmic ray data (Appendix C). Data are collected from a variety of platforms—ship, submarine, aircraft, ground and seafloor stations, and satellites. Satellite data held by NGDC include particles and fields, spacecraft anomalies, solar imagery, and solar radiation data from the National Oceanic and Atmospheric Administration's (NOAA's) geostationary and polar-orbiting satellites and the Air Force's Defense Meteorological Satellite Program (DMSP). The DMSP holdings make up 97 percent of the total data volume at NGDC (Figure 2.1) and account for most of the growth in data volume at NGDC in the late 1990s (Figure 2.2). The archive will continue to grow at a rapid rate if NGDC acquires other large datasets currently under discussion (see "Data Acquisition and Transfer Strategy" below).

Although almost all of the newer datasets are in digital form, the center also maintains substantial holdings of paper, film, and microfilm records, as well as slide sets and posters (see Appendix C for a list of datasets). About 25 percent of the total volume of all NGDC data are online.[2] Of the digital data holdings, 51 percent of solid earth geophysics (SEG) datasets, 62 percent of solar-terrestrial physics (STP) datasets, and 84 percent of marine geology and geophysics (MGG) datasets are online.[3] In general, analog datasets are more difficult for staff to manage than digital datasets because the relevant metadata often do not reside with the analog records, which makes it harder to assemble useful datasets. Similarly, small, unique

[2] Presentation to the committee by Michael Loughridge, director, National Geophysical Data Center, August 13, 2002.

[3] Based on averages of the percent online of datasets for each division listed in Appendix A. Datasets vary in size, and the datasets given in Appendix A are highly aggregated, so these figures differ from the total amount of NGDC data online. Nevertheless, they provide an indication of where each division stands in making its data available online.

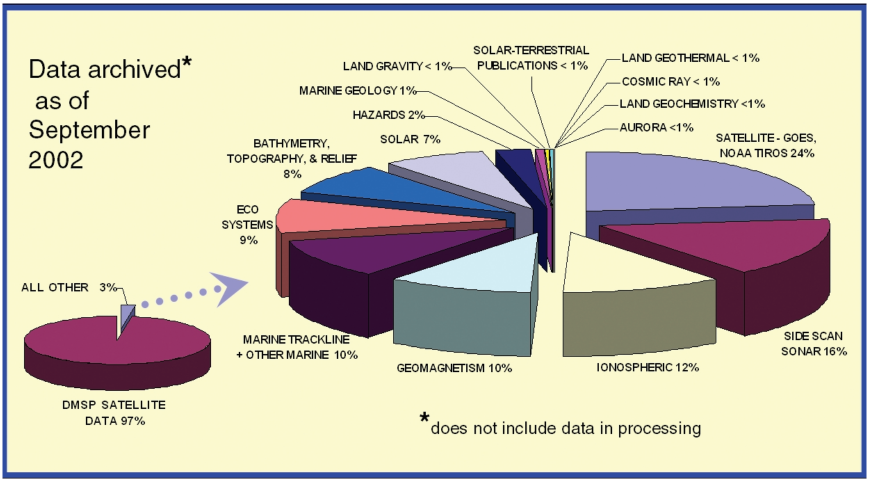

FIGURE 2.1 Digital data holdings archived as of September 2002, showing the relative volumes of different data types. DMSP data make up 97 percent of the volume of digital holdings. SOURCE: National Geophysical Data Center.

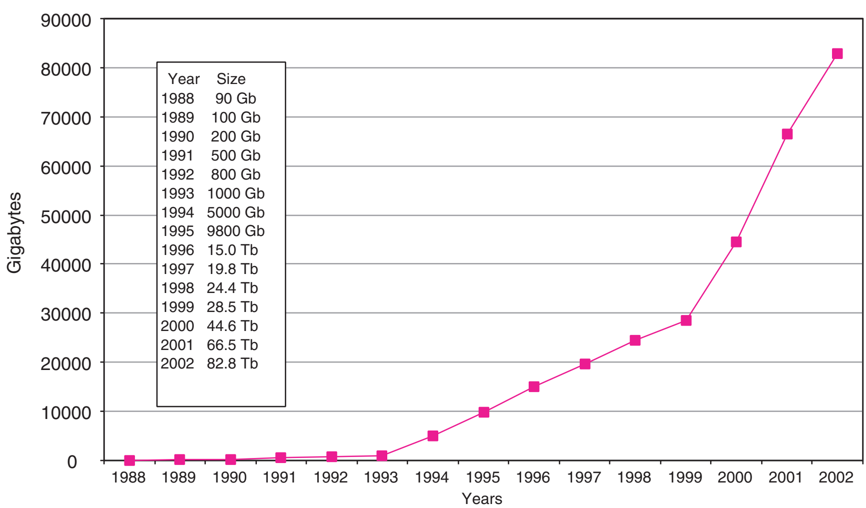

FIGURE 2.2 Growth in NGDC holdings from 1988 to 2002. Data volumes include backup copies. The changes in slope reflect the addition of two major data streams: DMSP in 1993 and film scans of DMSP and new bathymetry data in 1999. SOURCE: National Geophysical Data Center.

datasets are often more difficult to manage than large datasets such as DMSP because of the diversity of formats and metadata.

Most datasets are updated or added to regularly. About 50 percent of the datasets have been updated within the last two years (2001 and 2002) and 80 percent have been updated within the last 10 years (Appendix C).

Data Acquisition and Transfer Strategy

NGDC is required to archive certain data to fulfill its mission (Appendix D) or to support agreements with other agencies. For example, in some disciplines principal investigators funded by the National Science Foundation and the Office of Naval Research are required to deposit their data in a national archive, such as NGDC, although this requirement is not always enforced and resources for data conditioning and archiving are rarely forthcoming.[4] NGDC division chiefs also actively seek relevant datasets and consider requests to take responsibility for data from external organizations, including other divisions of NOAA (e.g., the National Ocean Service, Office of Oceanic and Atmospheric Research), universities, federal agencies (e.g., National Imagery and Mapping Agency, Air Force Weather Agency, U.S. Geological Survey [USGS]), international organizations (e.g., International Hydrographic Organization, Intergovernmental Oceanographic Commission, Ocean Drilling Program), and industry.[5] Potential future sources of data include the Solar X-ray Imager (SXI) on GOES-12, a network of continuously operating Global Positioning System reference stations, high-resolution sidescan sonar imagery, and shallow-water multibeam bathymetry.[6] In addition, NOAA in coordination with the Department of Defense and the National Aeronautics and Space Administration is preparing the National Polar-Orbiting Operational Environmental Satellite System (NPOESS). The satellites will carry a space environment sensor suite that is similar to the suite carried on the DMSP spacecraft and could be managed by NGDC. NGDC's reported criteria for acquiring or rejecting new data are given in Box 2.1.

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[4] NSF's Ocean Sciences Division is considering modifying its data archival requirements. Under the proposed new guidelines principal investigators (PIs) will be able to send data to any scientific data repository as long as that repository has an agreement to eventually transfer the data to a national archive for permanent stewardship. In their final grant reports PIs will have to demonstrate that the archive requirement has been satisfied. Personal communication from David Epp, program director, NSF Marine Geology and Geophysics program, March 12, 2003.

[5] Background material prepared by NGDC for the August 13-14, 2002, committee meeting.

[6] Since the review took place, NGDC has begun receiving GOES SXI data, high-resolution sidescan sonar imagery, and data from Continuously Operating Reference Stations.

Box 2.1 NGDC Criteria for Acquiring Data

- relevance to the NGDC, NESDIS, and NOAA missions
- current or potential scientific significance of the data
- ability of NGDC to provide a useful service for the data
- demand for the data
- immediate and long-term availability of the data elsewhere
- resources required for acquisition, archive, stewardship, and dissemination
- ability of NGDC to acquire required resources
- existing requirement to archive data of that type

NOTE: The criteria do not appear in order of priority.

SOURCE: Background material prepared by NGDC for the November 13-15, 2002, committee meeting.

Over the years, NGDC has worked with thousands of data providers, some of whom use NGDC as their primary distribution avenue. Examples include digital bathymetry data from NOAA's National Ocean Service, unclassified and unrestricted geophysical maps from the Naval Oceanographic Office Geomagnetic Data Library,[7] and solar data from the Solar Optical Observation Network. In addition, NGDC holds global and regional datasets compiled from organizations around the world. About 60 percent of NGDC datasets by data type partially or completely replicate data from other sources (Appendix C); their distribution through NGDC is a benefit to users since many of these replicated datasets are not easily accessible from the original source.

In addition to acquiring data, NGDC transfers data to other organizations (see Chapter 1, "History of NGDC"). Most of the transferred data were managed by the Solid Earth Geophysics Division, which now includes ecological datasets and has a considerably more environmental focus than it has had historically.

DATA USERS

NGDC users include scientific, technical, and lay users in government agencies, universities, and private companies in the United States and abroad.[8] Users are categorized by Web visitors and customers who purchase data. The latter are well defined; Web users are categorized by Internet

[7] <http://www.ngdc.noaa.gov/seg/potfld/gdl/map_dds.html>.
[8] *NOAA Organizational Handbook*, <http://www.rdc.noaa.gov/~ohb/E/EH0000.html>.

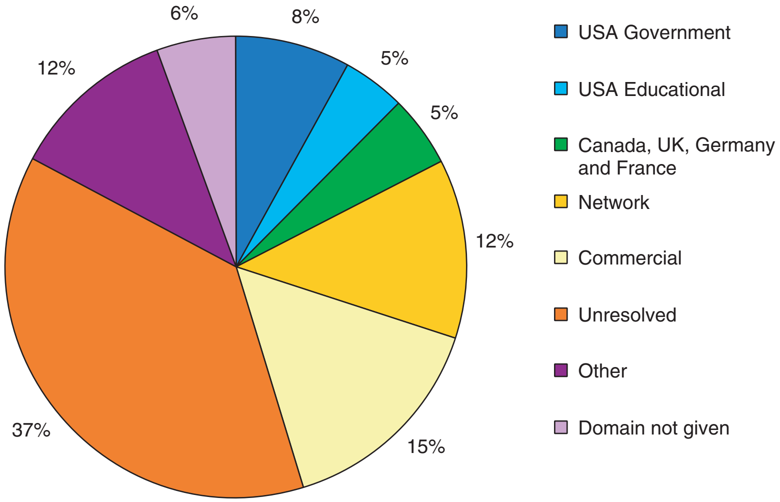

FIGURE 2.3 Profile of the top domains accessing the NGDC Web site in FY 2002. Apart from the U.S. government and educational communities, users (87 percent) are difficult to characterize by domain name. SOURCE: Data from the National Geophysical Data Center.

domain names, including NOAA and other government agencies (dot-gov); universities and other educational institutions (dot-edu); foreign government, industry, and academia (country-specific domain name); private industry and publishing (dot-com, dot-org, and dot-net), and the general public (dot-com, dot-org, and dot-net). However, a substantial fraction of users (37 percent) cannot be classified by even these broad user categories. NGDC infers that scientists are no longer the dominant users of NGDC data because dot-com users far exceed dot-edu users (Figure 2.3).

NOAA has no formal priorities for responding to requests from different user groups, although internal users are apparently given the highest priority. Staff in the National Weather Service and the Office of Oceanic and Atmospheric Research, for example, are considered the most important users of satellite data.[9] Similarly, NGDC reports that it does not give priority to any user group,[10] but NGDC staff told the committee that the center tries to meet the needs of its sophisticated users (i.e., scientists,

[9] Presentation to the committee by Charles Wooldridge, chief of staff, NOAA's National Environmental Satellite, Data, and Information Service, November 13, 2002.

[10] Background material prepared by NGDC for the November 13-15, 2002, committee meeting.

government agencies). Whether the center addresses the needs of unskilled users depends on the ease of filling the data request.

DATA ACCESS

Users obtain data from NGDC in three ways: (1) by downloading data from the NGDC Web site, (2) by ordering data from NGDC's online store, and (3) by requesting data from NGDC staff directly. Data downloaded from the NGDC Web site or FTP servers are free of charge, whereas information ordered from the online store may have a charge. In no case does NGDC charge more than the cost of preparing a product for dissemination and distributing it to the public (incremental cost).[11] This practice complies with the guidelines set forth in Office of Management and Budget Circular A-130.[12]

With the rapid growth of Internet usage the total number of distinct hosts served online has increased exponentially over the past decade, with a doubling interval of about 29 months (Figure 2.4a). In 2002 nearly 800,000 distinct hosts were served. Trends in online access by particular user groups were not available because of inconsistencies in year-to-year tracking, but trends in offline user groups are shown in Figure 2.4b. The fraction of users requesting offline data dropped dramatically from fiscal year (FY) 1998 to FY 2002, with the fraction of foreign and general public users decreasing the most (Figure 2.4b).

NGDC's network connectivity appears to be sufficient to enable users to download the data volumes of interest. An OC-12 line was installed in August 2002, and the center has a 1,000-Mbps connection to organizations in Boulder (e.g., National Center for Atmospheric Research, National Institute of Standards and Technology, University of Colorado) and beyond. Several servers can be directed to fill user requests, a lesson NGDC learned when a National Public Radio interview led users to overwhelm the center's Web server in 1995.[13]

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[11] Presentation to the committee by Mary Glackin, deputy assistant administrator for satellite and information services, August 13, 2002.

[12] Federal data policy is set forth in the Paperwork Reduction Act (as amended in 1995) and specific guidelines to agencies are given in OMB Circular A-130, Management of Federal Information Resources (1994). Federal information is disseminated to the public on an unrestricted basis for no more than the incremental cost. See 44 U.S.C. § 3506(b)(1)(c) and <http://www.whitehouse.gov/omb/circulars/a130/a130.html>.

[13] Personal communication from David Clark, assistant director, NGDC, February 28, 2003. The activity required to bring down the NGDC server at that time (2,563 hosts, 58,550 files, 1,071,826,408 bytes transferred) was trivial compared with the routine activity of NGDC servers today.

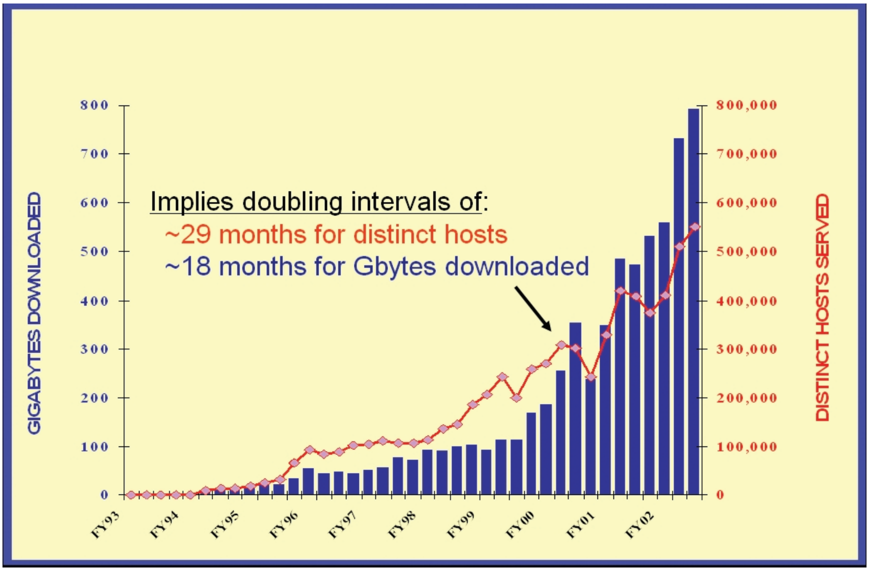

FIGURE 2.4a Quarterly online user statistics. From FY 1993 to FY 2003, the number of distinct hosts (blue bars) grew to 800,000. SOURCE: National Geophysical Data Center.

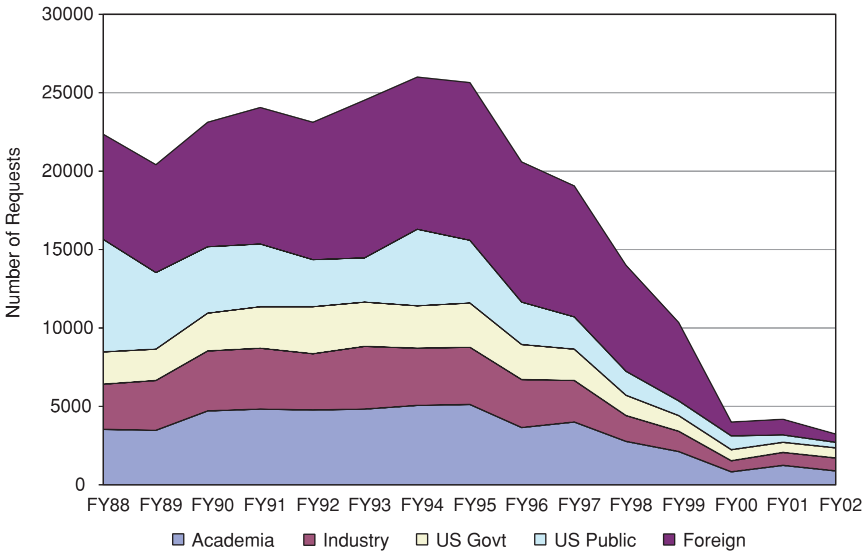

FIGURE 2.4b Decrease in offline (e.g., phone calls, faxes) data and information requests from FY 1988 to FY 2002. The NGDC Web site was established in FY 1995. The figures for FY 1999 through FY 2002 are for data requests only. SOURCE: National Geophysical Data Center.

SERVICES

NGDC reports that providing services is its main function.[14] This is a commendable priority for any data center. NGDC services include ensuring data quality, developing tools for working with the data, providing background information for interpreting the data, answering questions from data users, and linking the center's Web site to relevant holdings that reside elsewhere. Some services are provided to all users at no cost; others are designed for specific clients and are undertaken on a reimbursable basis.

Each division has its own customer service group that is responsible for helping individual users find the data they need. The customer service staff members the committee talked with at the site visit seemed enthusiastic and dedicated, but they told the committee that their job was getting harder as the number of unsophisticated users increases and number of customer service staff members decreases (see "Management" below). Contact information for customer service is easily found on the NGDC Web site.

The divisions are also responsible for providing background material to help users—especially less sophisticated users—learn about the data. There is no education and outreach program as such. Instead the three scientific divisions determine which general information, tutorials, or other resources to provide, which meetings to attend, which schools to visit, etc. For example, the MGG division offers a few educational resources (e.g., a description of the data types found in each subdiscipline, a tutorial on why seafloor data are important) and direct links to tutorials prepared by other organizations (e.g., "volcano expedition" by the Scripps Institution of Oceanography).[15] The natural hazards datasets managed by the SEG division include an education section aimed at young students. The STP division offers background information on most subjects at about the middle school or possibly high-school level, but it does not have links to other educational resources. Many subject areas (e.g., geomagnetism, marine geophysics) also have a set of frequently asked questions. Finally, NGDC has two representatives on the NESDIS Outreach and Education Team.

Some services are provided by NGDC staff in partnership with private vendors. Examples include interactive map and other geospatial services, which are being developed in partnership with ESRI, and a Web interface to the Blue Angel commercial metadata software package, which facilitates metadata updates.

Metadata are key to understanding data quality, and NGDC reports that it complies with Federal Geographic Data Committee metadata standards, which document data quality, among other things. Assessing the

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[14] Background material prepared by NGDC for the August 13-14, 2002, committee meeting.
[15] <http://www.ngdc.noaa.gov/mgg/education.html>.

quality of the data, working with data providers to correct errors, and creating metadata for each dataset is the responsibility of the NGDC staff member assigned to the dataset. Creating appropriate metadata is a difficult task, especially when there are many different sources of data. NGDC recognizes the importance of metadata and requests but does not always receive fully documented data. Data that are not sufficiently documented or quality controlled may be flagged or not placed into the database.[16] Such data may be made available in the future, but NGDC is not anxious to acquire more undocumented datasets because of the cost and difficulty of managing such data.

NGDC also participates in developing standards with other agencies (e.g., many of NGDC's datasets are formatted for and made accessible through the Global Change Master Directory), professional societies, and international organizations. For example, NGDC developed a NESDIS-wide tool for relating metadata to international standards.

Finally, NGDC staff members provide services to other organizations, mostly other divisions of NOAA or other government agencies. Such services range from distributing gravity data on behalf of the National Geodetic Survey to providing the archive for nonnavigational charts for the Office of Coast Survey[17] to digitizing and distributing geomagnetic data for the National Imagery and Mapping Agency.[18] Some of these activities are carried out on a reimbursable basis.

ARCHIVE AND STEWARDSHIP

The NGDC computer and storage facility employs a configuration of rack-mounted servers with high-bandwidth networks within NGDC, to other agencies in Boulder, and to the Internet. The computers functioning as Web servers and managing the storage and archiving facilities are running the Linux operating system and employ both disks and tape (robots) for storage. NGDC is currently migrating data from 8-mm tape and IBM 3480 cartridges to an IBM 3590 tape robot system. Another robotic system uses Linear Tape Open (LTO) tapes for backing up every computer in the center. NGDC provides data to Web users from data stored online (on disk) and nearline (on the tape robots). The use of multiple small computers as Web servers provides backup and also facilitates scaling to growing needs. All data users are served from the NGDC Boulder site—there are no mirrored sites for Internet

[16] Presentation by NGDC staff at the November 13-15, 2002, committee meeting.
[17] Committee teleconference with Charles Challstrom, director of NOAA's National Geodetic Survey, and Maureen Kinney, deputy chief of NOAA's Office of Coast Survey, November 15, 2002.
[18] Background material prepared by NGDC for the August 13-14, 2002, committee meeting.

service, although NGDC's Space Physics Interactive Data Resource services are mirrored in five countries. Copies of the digital data are kept at a backup facility approximately five miles away. NGDC staff told the committee that data are stored in National Archives and Records Administration-approved climate-controlled environments at both sites.

About 10 percent of the archive tapes are randomly tested each year, as specified in NGDC's performance measures (Appendix E).[19] The test compares the volume of data recovered with the volume of data originally written to the tape. The oldest tapes in the 3480 archive are 10 years old.

MANAGEMENT

Budget

NGDC receives three types of funding: (1) base funding, which is allocated from the National Environmental Satellite, Data, and Information Service (NESDIS); (2) funding from other parts of NOAA, particularly the NOAA-wide Environmental Services Data and Information Management Program; and (3) reimbursable work and data sales (e.g., datasets, custom data products, posters, slide sets). Base funding accounted for 47 percent ($4.3 million) of the NGDC budget in FY 2002, other NOAA sources were 29 percent ($2.6 million), and reimbursable projects were 15 percent ($1.3 million). In addition, the center received $0.79 million for one-time, nonrecurring expenses, such as hardware and software. Corrected for inflation, NGDC's base funding has remained relatively flat for the last 10 years, and the total NGDC budget, which has risen and fallen, is now about at the same level that it was in 1992 (Figure 2.5). Some NGDC staff members believe budgets are flat because NOAA does not consider the center to address "mainstream" NOAA issues.[20]

The budget picture by division is more variable (Figure 2.6). The budgets for the MGG and SEG divisions peaked in 1995—driven by reimbursable work (MGG) and by funding from other NOAA sources (SEG)—and have declined since then. In contrast, the budgets for STP and the Information Services Division (ISD) have generally grown over the last decade. Base funding is allocated to the divisions by the NGDC director. NGDC staff told the committee that the Office of the Director[21] and ISD are funded

[19] Background material prepared by NGDC for the November 13-15, 2002, committee meeting.

[20] Interviews with NGDC staff members, November 14, 2003.

[21] Funding for the Office of the Director includes the director's staff salaries and center-wide expenses, including performance bonuses, mailing, rent, utilities, phone, network, meeting exhibits, supplies, maintenance, National Snow and Ice Data Center (NSIDC) allocation, and travel.

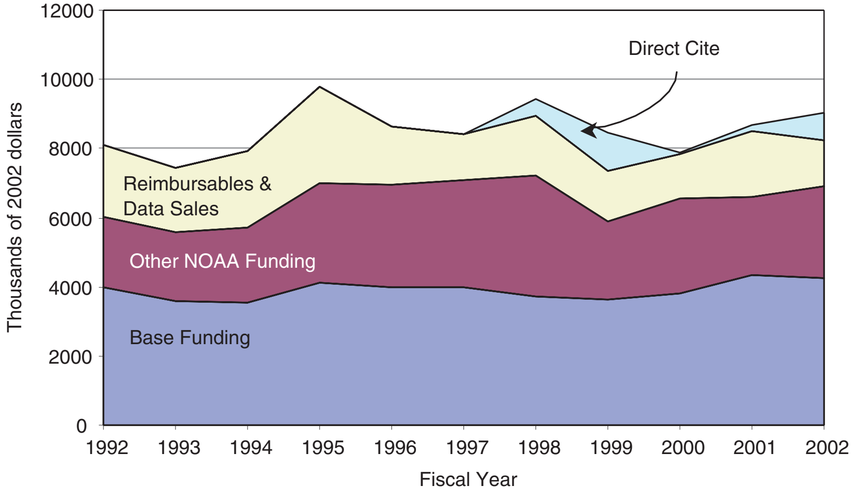


FIGURE 2.5 Ten-year budget history (FY 1992-FY 2002), corrected for inflation, for NGDC. From bottom to top, base funding is shown in violet, funding from non-NESDIS parts of NOAA is shown in maroon, funding from reimbursable work and data sales is shown in yellow, and direct cite funding (one-time, nonrecurring expenses, such as hardware and software) is shown in aqua. SOURCE: Calculated from data provided by the National Geophysical Data Center.

first, and the remaining resources are allocated among the three science divisions based on a fixed percentage of the federal salaries of the division. Base funding has been insufficient to cover base operations over the past 10 years.[22] The divisions make up budget shortfalls or expand into new areas by seeking reimbursable and other NOAA funding.

Staffing

NGDC has 85 full- and part-time staff members (not counting vacancies), including 43 federal employees, 3 contractors, 2 NOAA Corps officers, 1 National Ocean Service (NOS) detailee, 22 University of Colorado Cooperative Institute for Research in Environmental Science (CIRES) employees, and 14 visiting scientists. In addition, there are 15 work-study students and interns. The federal workforce consists of 49 full-time equivalents (FTEs), although there are 51 authorized positions at the center. Each division has roughly the same number of FTEs, but the CIRES staff mem-

[22] Base operations include labor, rent, utilities, and the NSIDC allocation. From budget information prepared by NGDC for the November 13-15, 2002, committee meeting.

bers are concentrated in the solid earth geophysics and solar-terrestrial physics divisions. Funding to pay for the contractors, CIRES employees, work-study students, and to some extent the federal employees comes from reimbursable projects. The visiting scientists—most of whom have retired from NGDC or from federal agencies in the Boulder area—NOAA Corps officers and the NOS detailee are not on the payroll.

The average age of the federal employees is in the 50s and the average age of the total workforce is mid-40s.[23] More than half the federal employees are eligible for some sort of retirement, including 16 percent eligible now and 48 percent eligible under discontinued service provisions. The aging of the workforce, which increases costs, coupled with flat budgets, have led to a decrease in the staff level at NGDC. The number of federal FTEs has dropped by 50 percent since 1992, while the volume of datasets and the number of Web accesses has grown exponentially (Figures 2.2 and 2.4a). Of course, an exponential growth in Web accesses does not translate into an exponential growth in the level of effort needed to manage the data.

Seventy-five percent of the staff members have a bachelor's degree or higher and 10 percent have a PhD degree. Most of the staff (mainly federal employees) managing the datasets or working with customers have a degree in physical science. Nearly all the scientific programming and a small fraction of the network and database administration is provided by CIRES employees. Most of these have engineering, physical science, or computer science backgrounds. Nevertheless, NGDC staff members told the committee that the center does not have the scientific expertise to manage all the diverse holdings. The center supplements its expertise with individuals in other NOAA laboratories (e.g., the Pacific Marine Environmental Laboratory provides expertise in hazards), the University of Colorado, and with visiting scientists.

Organization

As noted in Chapter 1 the organizational structure of NGDC is historical. The MGG and information services divisions have existed for about 20 years, and the SEG and STP divisions have existed since the creation of NGDC. A number of the staff members the committee interviewed identified problems with this organizational structure:

- Some activities are carried out in parallel by more than one division, leading to inefficiencies.

[23] Presentation to the committee by Michael Loughridge, director, National Geophysical Data Center, August 13, 2002.

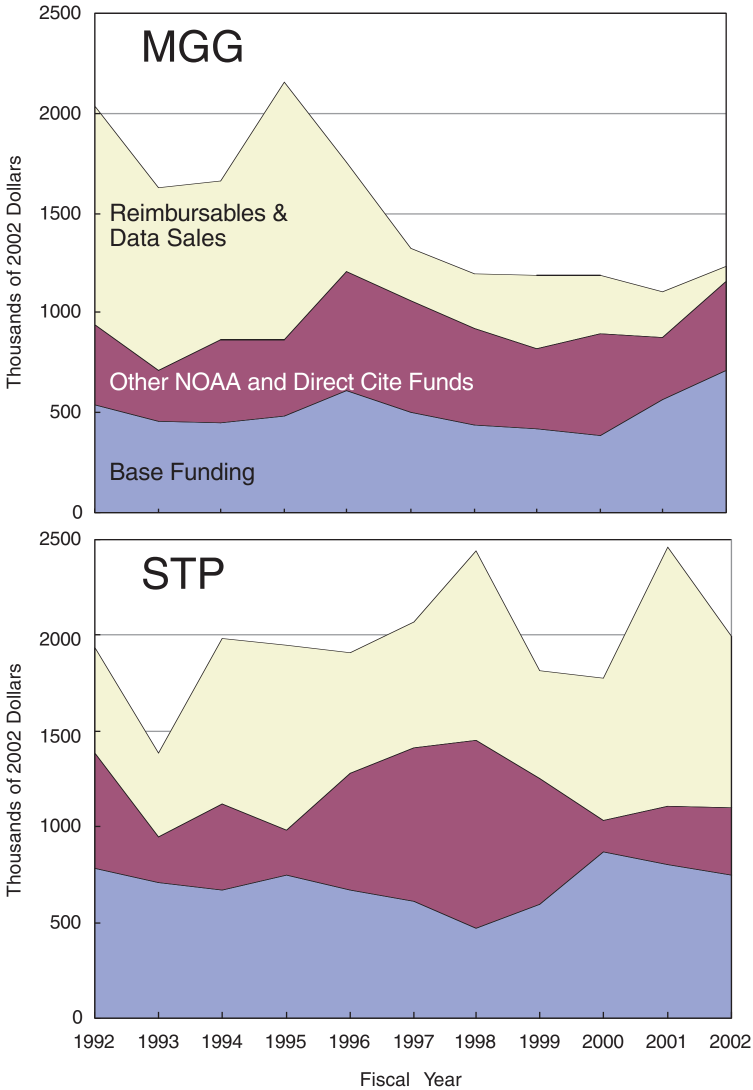
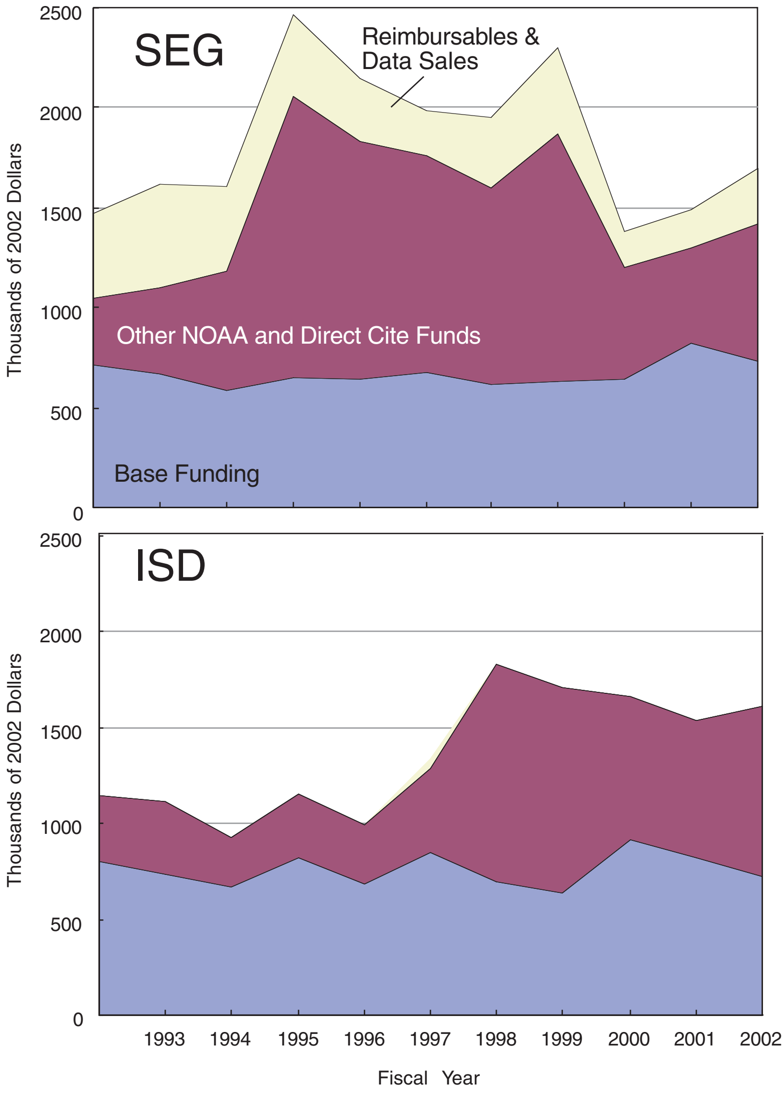


FIGURE 2.6 Ten-year budget history (FY 1992-2002), corrected for inflation, for the four NGDC divisions: Marine Geology and Geophysics (MGG), Solid Earth Geophysics (SEG), Solar-Terrestrial Physics (STP), and Information Services (ISD). Base funding is shown in violet, other NOAA funding (including direct cite) is



shown in maroon; and funding from reimbursable work and data sales is shown in yellow. SOURCE: Calculated from data provided by the National Geophysical Data Center.

- The division heads are able to act autonomously without considering the consequences of their actions on the budget. As a result the budget is not necessarily aligned with the core activities of the center.
- Turf battles between the divisions are common, generating morale problems.[24]

Breaking down the walls between the divisions was seen by some NGDC staff members as one of the most important steps the center should take.

[24] Interviews with NGDC staff members, November 14, 2003.

3

Improving the Effectiveness of NGDC

This chapter reviews the four tasks that relate to improving the effectiveness of the National Geophysical Data Center (NGDC).

Task 5. How well does NGDC collect the data and information it needs to effectively conduct its activities?

Task 6. How effectively does NGDC measure customer satisfaction?

Task 2. Is NGDC organized, staffed, equipped, and supported to fulfill its mission?

Task 4. Are NGDC's performance measures appropriate for tracking progress in achieving results and for judging center funding?

DATA AND INFORMATION COLLECTION

One of NGDC's missions is to acquire solid earth, marine geophysical, ionospheric, solar, and other space environment data. Examination of the holdings shows that data collection is rarely comprehensive and is even spotty in some cases. Examples of "missing" data include bathymetry data collected by individual investigators, marine seismic data collected by organizations around the world, historical ocean-bottom photography data, and popular geomagnetic indexes. Reasons why the data may be incomplete include:

- NGDC is one of many archives in marine geology and geophysics, solid earth geophysics, and solar-terrestrial physics.

- NGDC staff members are given great latitude in what data to acquire, and they are most likely to seek data with which they are familiar.
- Funding limitations require the center to be opportunistic about what data are acquired or rescued (i.e., mission relevance and available funding appear to be the primary criteria for acquiring data; see Box 2.1).
- Principal investigator requirements to deposit data in some disciplines are commonly not enforced by funding agencies (e.g., National Science Foundation [NSF], National Aeronautics and Space Administration [NASA], Department of Defense). As a result many important research programs do not contribute data regularly to NGDC.

NGDC has established a number of effective partnerships for acquiring data from other parts of the National Oceanic and Atmospheric Administration (NOAA). The fact that the center is taking on more responsibility for archiving and distributing gravity and geodetic data, for example, attests to its ability to perform these functions well. However, NGDC has not had equal success with the National Environmental Satellite, Data, and Information Service (NESDIS) or with data collection programs outside NOAA. For instance, NESDIS has not assigned responsibility for the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) space environment dataset to NGDC, even though staff expertise in developing and distributing such products would ensure better continuity between the Defense Meteorological Satellite Program and NPOESS products, enabling them to be used for studies spanning the two satellite eras. Moreover, some communities are considering whether to archive all their data at NGDC. For example, a recent workshop sponsored by the NSF and the Office of Naval Research recommended the establishment of a distributed system of discipline-specific archives, rather than a central repository for marine geology and geophysics data.[1] NGDC will have to convince organizations that hold relevant data that they are best handled by NGDC and should eventually be archived at the center.

The "national" in NGDC implies that the center is a primary place to find a wide range of geophysical data. To be an effective national center NGDC need not have comprehensive holdings, but it should provide comprehensive access to geophysical data on its Web site by pointing to organizations that hold complementary data. Such organizations include the seismic reflection archive at the University of Texas; GLORIA sidescan sonar images and interpretive geographic information system layers at the U.S. Geological Survey (USGS); offshore seismic data at the Minerals Manage-

[1] *Data Management for Marine Geology and Geophysics: Tools for Archiving, Analysis, and Visualization*, Report of a Workshop, La Jolla, Calif., May 14-16, 2001, 28 pp.

ment Service; seismic data from the Incorporated Research Institutions for Seismology (IRIS) Data Management Center, USGS, Southern California Earthquake Center, International Seismological Centre, and the University of California, Berkeley; geodetic data from the UNAVCO Facility; elevation and land cover data from the EROS Data Center; geomagnetic data from the Canadian Auroral Network for the OPEN Program Unified Study (Canopus) at the Canadian Space Agency; magnetograms from the International Monitor for Auroral Geomagnetic Effects (IMAGE) program in northern Europe and Russia; ground-based magnetic records curated by the space physics group at the University of California, Los Angeles; magnetometer data from Magnetometer Array for Cusp and Cleft Studies (MACCS) at Boston University and Augsburg College; and geomagnetic data from the Polar Orbiting Geophysical Observatory (POGO) and Magsat at NASA, from the Orsted satellite at the Danish Meteorological Institute, and from the Gravity and Magnetic Field Mission (CHAMP) at GeoForschungsZentrum.[2] None of these are prominently found on NGDC's Web site or are simply listed without explanation under "related web sites."[3] Yet such pointers are a valuable service to users, especially those conducting studies that require data from multiple sources (e.g., see Figure 3.1). Negotiating reciprocal courtesy pointers with other relevant archives would greatly benefit the geophysical and environmental science community.

In the committee's view NGDC should be an authority that is knowledgeable about the existence of all significant geophysical and complementary data relevant to its mission. NGDC should thus (1) acquire relevant data and metadata for its own databases and (2) provide information on these holdings on the NGDC Web site and links to the data and metadata either at NGDC or the other organization's Web site.

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[2] <http://wedge.ig.utexas.edu/Web/main_html/intro.htm>, <http://kai.er.usgs.gov>, <http://www.gomr.mms.gov/ homepg/pubinfo/repcat/arcinfo/index.html>, <http://www.iris.edu/data/data.htm>, <http://neic.usgs.gov/>, <http://www.scec.org/resources/data/>, <http://www.isc.ac.uk/>, <http://quake.geo.berkeley.edu/ncedc/access.html>, <http://edc.usgs.gov/>, <http://www.unavco.ucar.edu/data_support/data/data.html>, <http://www.dan.sp-agency.ca/www/sub_data.htm>, <http://www.geo.fmi.fi/image/>, <http://www-ssc.igpp.ucla.edu/uclamag/>, <http://space.augsburg.edu/space/index.html>, <http://denali.gsfc.nasa.gov/personal_pages/purucker/pogo.html>, <http://nssdc.gsfc.nasa.gov/space/space_phys/nmagsat.html>, <http://web.dmi.dk/fsweb/projects/oersted/>, <http://op.gfz-potsdam.de/champ/>.

[3] For example, page links to the Lamont Doherty Earth Observatory (LDEO) core repository, the LDEO/RIDGE multibeam database, and the ODP Janus database would be more easily found and useful if they were moved to the appropriate section of the NGDC Web site and accompanied by adequate data descriptions.

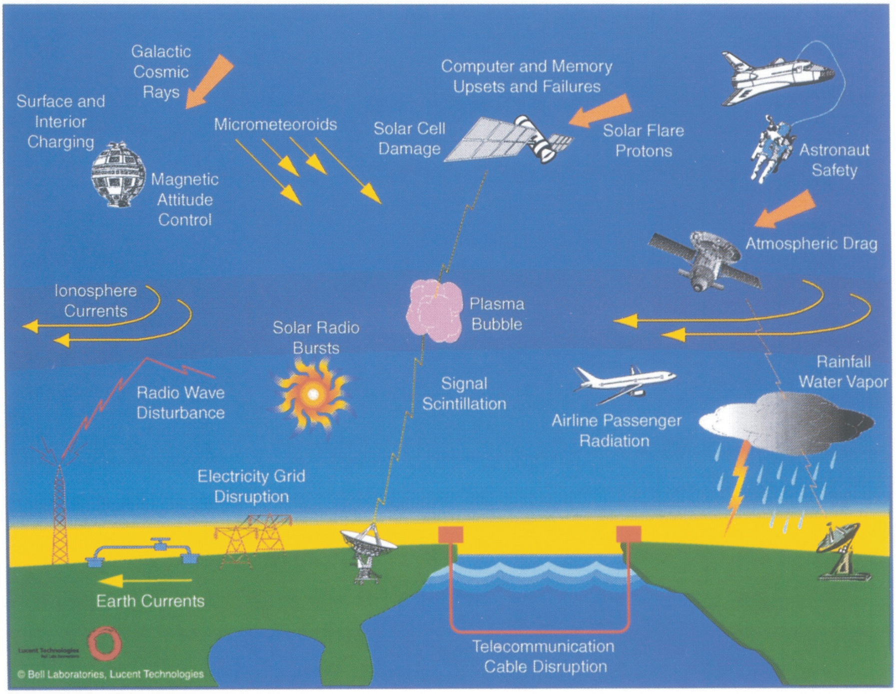

FIGURE 3.1 Some of the effects of space weather on technical systems deployed on and above the Earth's surface and on signal propagation. Space weather refers to conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and upper atmosphere that influence the performance and reliability of technological systems in space and on the ground or endanger human health. Adverse conditions in the space environment can disrupt satellite operations, interrupt various communication channels, degrade navigation capabilities, lead to the rerouting of transpolar flights, and cause the shutdown of electric power distribution grids. Research in this area is coordinated by the National Space Weather Program and is sponsored by a number of federal agencies, including NSF, NOAA, U.S. Air Force, NASA, USGS, Coast Guard, Navy, Army, Federal Aviation Administration, and the Department of Energy. The principal space weather forecast group is NOAA's Space Environment Center in Boulder, Colorado. The principal archive of space weather records is maintained by NGDC. SOURCE: L. Lanzerotti, 2001, Space weather effects on technologies, in *Space Weather*, Geophysical Monograph 125, American Geophysical Union, Washington D.C., pp. 11-22. Reproduced by permission of American Geophysical Union.

Recommendation: NGDC should work with organizations that are sponsoring relevant data collection projects (e.g., National Ocean Partnership Program, National Science Foundation) from the outset to ensure that NGDC will receive the resulting data. It should also provide prominent links on its Web site to complementary archives.

To be most useful, Web links to other organizations should be organized and/or described in a way that helps users navigate through the maze of relevant resources.

CUSTOMER SATISFACTION

NGDC received a Department of Commerce customer service award in 1997 for its work in data distribution, archive and collection, and its focus on customer satisfaction.[4] However, the question of whether NGDC's users are satisfied cannot be answered with available data. The large and growing population of users, which far exceeds the number of scientists and operational users for which the system was designed,[5] suggests that many users are getting what they need from NGDC. On the other hand, anecdotal evidence suggests that at least some users visit the center but never return.

Measuring Customer Satisfaction

To assess customer satisfaction it is first necessary to determine who the users are. A detailed knowledge of its user profile is one of the most difficult challenges faced by any data center. In general, data centers track data requests and supplement that information with user surveys, direct feedback from users and visiting scientists, phone contacts, and interactions with their advisory committee to learn about their users' preferences and satisfaction with the center. However, several of these avenues are not available to or have not been fully utilized by NGDC.

- **With the shift to online access the center is losing direct contact with its users.** Before the advent of the Internet the normal procedure for obtaining

[4] Department of Commerce *Excellence in Customer Service Award*, National Geophysical Data Center, 1997.

[5] The membership of the American Geophysical Union (AGU) may serve as a proxy for the size of the geophysics community. AGU members represent the fields of atmospheric, hydrologic, ocean, planetary, and solid earth sciences; biogeosciences; geodesy; geomagnetism and paleomagnetism; and space physics and aeronomy. In 2002 there were 38,000 members from 117 countries. See <http://www.agu.org>.

data from NGDC generally involved telephone calls, letters, or even personal visits. With Web-based data distribution, users have become anonymous. NGDC staff no longer know who most of their users are, what they need, or if they are satisfied with the data products. Online users are categorized by domain name, but such categories are misleading, as NGDC recognizes. A scientist working from home may have a dot-com e-mail address, and it is impossible to differentiate user groups from foreign countries or from U.S. e-mail addresses with dot-org, dot-net, or dot-com extensions. Even the number of online users is difficult to determine. NGDC counts hits (a browser request for any one item, such as a page or graphical image), which are likely to be several orders of magnitude greater than the actual number of users.[6] It also tracks distinct hosts by Internet Protocol (IP) address for the center as a whole. This measure overestimates the number of users, because the same user may access the Web site from several different computers (e.g., home and work), but it provides the best estimate of unique users with currently available software. Finally, NGDC does not have a means of distinguishing actual users from casual browsers of its Web site. Actual users could be differentiated from casual browsers by tracking the volume of scientifically useful information actually transferred to users from the Web site.

- **The Web site is not used to follow user patterns**. Through creative Web page design, NGDC can learn more about the interests of its users, even if it cannot obtain detailed information about who the users are.[7] By following the steps of users on the Web site it is at least possible to find out what parts of the system are most used. Which pages were viewed, the order in which they were viewed, and the average number of visits by distinct users can be monitored with any number of sophisticated log-file analyzer programs available at little or no cost.
- **The Paperwork Reduction Act (PRA) of 1995 makes it difficult for the center to survey its users**. Before the PRA (Box 3.1) was implemented NGDC conducted quarterly surveys of users who received products shipped by NGDC (e.g., posters, CD-ROMs). An analysis of NGDC's quarterly surveys from 1994 to 1999[8] shows that these users were overwhelmingly

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[6] D. Lohrmann, 2002, Is your site effective? The right metrics can tell, *Government Computer News*, **21**, May 6, <http://www.gcn.com/21_10/tech-report/18546-1.html>. At the IRIS Data Management Center the number of hits exceeds the number of pages viewed by a factor of 8 and exceeds the number of visits by a factor of 25.

[7] D. Lohrmann, 2002, Is your site effective? The right metrics can tell, *Government Computer News*, **21**, May 6, <http://www.gcn.com/21_10/tech-report/18546-1.html>.

[8] Respondents were asked to rank the center on a scale of 1 to 6 on the following questions: (1) timeliness of response, (2) condition of package, (3) helpfulness of staff, (4) knowledge of staff, (5) data quality, (6) application to your use, (7) accessibility of data, (8) data format, (9) documentation quality, and (10) data were as described. Users were also invited to provide written comments and suggestions.

BOX 3.1 Paperwork Reduction Act

One of the goals of the Paperwork Reduction Act of 1995 is to "ensure the greatest possible public benefit from and maximize the utility of information created, collected, maintained, used, shared and disseminated by or for the federal government." Federal agency responsibilities relating to user surveys are outlined in section 3506.

(c) With respect to the collection of information and the control of paperwork, each agency shall—

(1) establish a process within the office headed by the official designated under subsection (a),that is sufficiently independent of program responsibility to evaluate fairly whether proposed collections of information should be approved under this chapter, to—

(A) review each collection of information before submission to the Director for review under this chapter, including—

(i) an evaluation of the need for the collection of information;
(ii) a functional description of the information to be collected;
(iii) a plan for the collection of the information;
(iv) a specific, objectively supported estimate of burden;
(v) a test of the collection of information through a pilot program, if appropriate; and
(vi) a plan for the efficient and effective management and use of the information to be collected, including necessary resources;

. . .

(3) certify (and provide a record supporting such certification, including public comments received by the agency) that each collection of information submitted to the Director for review under section 3507—

(A) is necessary for the proper performance of the functions of the agency, including that the information has practical utility;

. . .

(H) has been developed by an office that has planned and allocated resources for the efficient and effective management and use of the information to be collected, including the processing of the information in a manner which shall enhance, where appropriate, the utility of the information to agencies and the public;

(I) uses effective and efficient statistical survey methodology appropriate to the purpose for which the information is to be collected; and

. . .

(e) With respect to statistical policy and coordination, each agency shall—

(1) ensure the relevance, accuracy, timeliness, integrity, and objectivity of information collected or created for statistical purposes;

(2) inform respondents fully and accurately about the sponsors, purposes, and uses of statistical surveys and studies;

(3) protect respondents' privacy and ensure that disclosure policies fully honor pledges of confidentiality;

(4) observe Federal standards and practices for data collection, analysis, documentation, sharing, and dissemination of information;

(5) ensure the timely publication of the results of statistical surveys and studies, including information about the quality and limitations of the surveys and studies; and

(6) make data available to statistical agencies and readily accessible to the public.

SOURCE: Public Law 104-13, See 44 U.S.C. §3507.

positive about the center. On average more than 85 percent of responses were favorable, with the most positive responses concerning the questions "condition of package," "helpfulness of staff," and "data were as described." The most negative responses concerned the questions on data format and documentation quality. Although this information is useful to NGDC, it is important to note that the number of respondents was a tiny fraction of the center's total users. Respondents declined from about 250 per quarter in 1994 and 1995 to less than 100 per quarter by 1999. In that same interval the number of offline requests dropped from about 25,000 to 10,000 (Figure 2.4b), and the number of online users grew to about 100,000 (Figure 2.4a). By either measure the respondents do not represent a valid statistical sample. And as pointed out above, the respondents were not a representative sample of users because the surveys sampled only offline users who received data.

The Paperwork Reduction Act contains provisions to prevent government agencies from conducting nonrigorous surveys (Box 3.1). Before NGDC can conduct a survey the Office of Management and Budget (OMB) must approve the survey questions and the methodology for analyzing the results. NDGC staff members told the committee that this includes identifying the survey recipients and proving that the survey would yield a 65 to 75 percent response rate. If such a response rate cannot be guaranteed, the center must contract with professional statisticians to develop a statistical analysis plan for dealing with the survey responses. NOAA's Chief Information Office acknowledges that conducting statistically valid surveys is nontrivial and that OMB approves very few surveys proposed by NOAA. OMB has recently approved a one-time survey of customers who have used data from any of the NESDIS data centers in the past year, although it will only be valid if a 75 percent response rate is achieved.[9]

The committee feels strongly that user surveys are essential for data centers to gauge user satisfaction with existing products and services and to determine which new products and services are needed. Nonrigorous sur-

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[9] See <http://www.rdc.noaa.gov/~pra/customer.htm>. The one-time NESDIS survey is posted at <www.ncdc.noaa.gov/survey.html>. Survey questions are similar to but more comprehensive than the questions used by NGDC: (1) quality of service received, (2) quality of product(s) received, (8) timeliness of response, (3) cost of product/service received, (4) degree that product(s) met your needs, (5) format of data received, (6) documentation of data received, (13) description of data in catalogs and directories, (7) accessibility of data, (9) overall satisfaction with service, (10) overall satisfaction compared with services/data obtained from private sector, (11) overall satisfaction compared with services/data obtained from other federal agencies, (12) type of product obtained, (13) primary use of the product(s) received, (14) user affiliation, (15) frequency of product requests, (16) ways in which the data benefited the user or the user's company, (17) online system used to order data, (18) ease of finding data on the Web site, and (19) data center that shipped the data.

veys yield some information about customers, but the best analysis of customer satisfaction will derive from a properly designed survey with a suitable response rate. The questionnaire being used by NOAA is a reasonable start for learning about users, although additional questions might be useful to better characterize the general public. This survey and the process to obtain OMB approval would be useful guides to other federally supported data centers.

- **NGDC has not had an external committee of users since 1993.** External advisory committees provide valuable insight into the needs and satisfaction of different communities with the center.[10] The last NGDC external review committee met yearly from 1990 to 1993. In the 10 years that followed, the center has had no formal external advice. The lack of external guidance at the same time that the Web-based system no longer provides user feedback is especially hard to justify. An independent, external advisory committee with rotating membership (1) can provide a fresh view from at least some of the users of the center; (2) could stimulate the center to take useful actions that it might otherwise hesitate to embark on; and (3) can provide input by which NGDC can judge customer satisfaction.

Recommendation: NGDC should take steps to obtain effective feedback from its users by establishing an independent external advisory group, conducting statistically valid user surveys, and making better use of its Web site to characterize users and to define their interests and level of expertise.

Education and Outreach

As noted in Chapter 2 many NGDC users are not scientists in academia or government laboratories, and meeting their needs in practice is given lower priority by NGDC staff. Such an attitude is understandable given funding limitations, NOAA's apparent user priorities, and the shortage of skills among NGDC staff for serving lay users. According to NGDC's performance measures, only 0.25 FTE and associated resources must be devoted to outreach (Appendix E). Nonscientists, however, are a growing fraction of NGDC users, and the center will have to devote more attention to this group if it wants them to continue using the center. Currently the center does not make a coordinated effort to educate users about the holdings. For example, at the committee's site visit one staff member complained about the need to explain basic electromagnetic theory to callers wanting to know how to use their Global Positioning System (GPS) device. The staff member referred callers to the frequently asked questions posted

[10] For this reason NASA requires that each of its distributed active archives centers support a user working group.

on Web sites of other entities. Presumably users could then call NGDC back and get more detailed answers to questions that were incompletely addressed on these sites. In the committee's view education of the user community (including lay users and scientists working outside of their discipline) about matters directly related to NGDC holdings is an issue that should be addressed by the center. However, NGDC's effort in education and outreach is not substantial, especially compared with the resources devoted by other agencies.[11] Education and outreach activities in some federal agencies are becoming more rigorous, and the ad hoc approach of NGDC has not kept up with the times. If NGDC is to meet its stated goal of serving the broader user community,[12] it will have to develop a formal education and outreach program, integrated through all the data and information of the center, and spanning the different education levels of the user community.

Recommendation: For NGDC to have an effective education and outreach program, it should first develop a strategy that can be implemented for all disciplines, and the program should be given resources commensurate with that strategy.

ORGANIZATION AND RESOURCES

Intellectual Assets

The Boulder location is an asset to NGDC because of the nearby complementary intellectual and technical capital (e.g., NOAA laboratories, University of Colorado's Cooperative Institute for Research in Environmental Science [CIRES], USGS, National Center for Atmospheric Research [NCAR]). These resources provide a greater pool of scientific expertise than could be garnered by NGDC alone and could be used by the center to better answer questions users have about the data. The CIRES link is used to the

[11] NASA's Office of Space Science requires that 1 to 2 percent of the budgets of flight projects be spent on education activities (see National Aeronautics and Space Administration, 1996, *Implementing the Office of Space Science Education/Public Outreach Strategy*, Washington, D.C., 69 pp.). NASA's Earth Science Enterprise (ESE) does not have an education requirement, although 0.5 percent of the budget of Earth System Science Pathfinder projects and about 2 percent of the ESE budget overall is devoted to education (personal communication from Blanche Meeson, assistant director for education, outreach, and applications, NASA Goddard Space Flight Center, April 2003). The NSF science and technology centers typically contribute 15 to 20 percent of their budgets to education (personal communication from Bruce Umminger, senior scientist for office of integrative activities, NSF, April 2003).

[12] Background material prepared by NGDC for the November 13-15, 2002, committee meeting.

center's advantage, particularly with regard to technology. However, the committee was surprised to find that links to the academic staff at the University of Colorado are weak, especially compared with the links forged by the National Snow and Ice Data Center.[13]

Experience based on previous reviews suggests that data centers work best when their staff members understand the data and interact with scientific users. Centers that have robust interaction with the scientific community usually have a high level of customer satisfaction and a highly supportive user advisory committee.[14] Metadata, calibration, and data quality all require involvement of the science community. There are several ways to accomplish this. One is to select center staff with scientific qualifications, expertise, and continuing interest in the science. A number of NGDC staff members have scientific credentials and publish regularly. From 1992 to 2002 NGDC staff members authored or coauthored 98 articles in scientific journals and books, conference and workshop proceedings, and organization publications.[15] About 75 percent of the publications were peer reviewed. Nearly 40 percent of the staff appear on these publications, with one staff member contributing to one-third of them.

The center could also consider appointing a chief scientist, who would interact with all the divisions to energize the science and lead strategic planning for the scientific activities of the center. The right person—a scientist with a broad range of interests in NGDC disciplines and with an abiding interest in scientific data management and dissemination—would nurture interactions with NGDC's natural constituency. A chief scientist also tends to attract data from and collaboration with external scientific institutions, which can enhance scientific involvement throughout the center.

Another way to obtain scientific stimulus is to have strong links with the science community. This can be achieved through (1) coauthorship of papers with scientists from outside the center, (2) a scientific advisory

[13] National Research Council, 1998, *Review of NASA's Distributed Active Archive Centers*, National Academy Press, Washington, D.C., pp. 154-155.

[14] See, for example, National Research Council, 1984, *Solar-Terrestrial Data Access, Distribution, and Archiving*, National Academy Press, Washington, D.C., 31 pp.; National Research Council, 1993, *1992 Review of the World Data Center-A for Rockets and Satellites and the National Space Science Data Center*, National Academy Press, Washington, D.C., 80 pp.; National Research Council, 1994, *1993 Review of the World Data Center-A for Meteorology and the National Climatic Data Center*, National Academy Press, Washington, D.C., 29 pp.; National Research Council, 1998, *Review of NASA's Distributed Active Archive Centers*, National Academy Press, Washington, D.C., 233 pp.; National Research Council, 2001, *Enhancing NASA's Contribution to Polar Science*, National Academy Press, Washington, D.C., 124 pp.

[15] Compiled from background material prepared by NGDC for the August 13-14, 2002, committee meeting.

BOX 3.2 Halley's Comet: A Personal Experience with NGDC
By Christopher Russell

In 1986 when Halley last passed through the inner solar system, I came to realize that earlier in 1910 the geometry of Halley's passage was such that the Earth passed through Halley's ion tail. Observers at the time noted this occurrence but were unaware of the existence of the solar wind and the nature of a cometary tail. By the mid-1980s computer simulations had been run using the then understood properties of the solar wind to model the cometary ion and surrounding magnetic tail. We could now interpret ground-based magnetic records that had mystified the observers of 1910. I contacted NGDC and asked if it had records for this period of time. NGDC had ready access to hourly averages recorded as tables of numbers in station logs and requested the original paper records or microfilm recordings of these paper records from various record centers. Eventually sufficient data were acquired for the study to begin. The magnetic records were consistent with the Earth entering a large magnetic tail, surrounding a sheet of flowing heavy ions, and consistent with our modern understanding of the comet. The resulting paper was published, coauthored with two members of the NGDC staff.[1] I was very pleased with the interest of the NGDC staff in my problem and the great lengths to which they went to acquire the data.

[1] C.T. Russell, J.L. Phillips, J.A. Fedder, J.H. Allen, L. Morris, and R.A. Craig, 1987, Effect of possible passage through Halley's magnetic tail on geomagnetic activity, *Journal of Geophysical Research*, **92**, 11,195-11,200.

committee, and/or (3) a visiting scientist program. NGDC is carrying out the first: About 60 percent of the peer-reviewed papers mentioned above were coauthored by scientists outside the center. Indeed, one of the committee members has published with NGDC staff (see Box 3.2). However, NGDC has no scientific advisory committee and although it has a number of visitors, it has no real visiting scientist program. NGDC's advisory committee recommended establishing a visiting scientist program in 1990, 1992, and 1993.[16] Most of the visiting scientists on the NGDC roster are retired NGDC employees, who are contributing positively to the center. However, to realize the true

[16] Report of the Science Advisory Panel for the National Geophysical Data Center, Boulder, Colo., November 28-30, 1990, 6 pp.; Report of the Science Advisory Panel for the National Geophysical Data Center, Boulder, Colo., August 12-13, 1992, 6 pp.; Report of the Science Advisory Panel for the National Geophysical Data Center, Boulder, Colo., November 15-17, 1993, 11 pp.

benefits of a visiting scientist program the retired staff should be supplemented by routine visits by scientists from outside organizations.

Recommendation: NGDC should improve scientific involvement of center personnel with the datasets by recruiting scientists to work with the data, establishing a vigorous program of external visiting scientists, and/or creating strong partnerships with other agencies, industry, and academia to supplement staff expertise.

Implementing this recommendation would require a culture change and incentives for working with the data.

Staff

NGDC staff is aging and has been dwindling in number for several years, although the number of managers has remained the same. Yet the center has done little recruiting to fill in after retirements or departures and is thus losing the benefit of younger staff with fresh ideas. Not filling vacancies also sends the implicit message that particular tasks are not important. If the center does not replace a departing seismologist, for example, the implication is that one was not needed. Other staff members may wonder if that applies to their tasks as well.

Not filling vacancies also skews the balance of skills, especially since NGDC appears to devote little effort to retraining staff to fill new jobs needed by the center. For example, the committee noted apparent shortages of skills in the areas of technological support and education and outreach. The senior Oracle database administrator, the network administrator, and Linux/Unix computer systems administrator are drawn from CIRES. CIRES also provides the only staff member with experience in teaching grade school.

Although CIRES positions compensate in part for NGDC's inability to hire, they are not permanent and CIRES staff members are intended to conduct research, not operations. The upcoming round of retirements provides an unprecedented opportunity for the center to adjust the balance of permanent expertise and inject new blood into the center. The center should plan for this shift in personnel by developing a staffing strategy that outlines the skills needed and how to recruit qualified staff, including external searches to fill critical leadership vacancies.

Recommendation: NGDC should develop a strategy for recruiting and retaining staff that places a high priority on enhancing the scientific vigor of the center and ensures that key technological expertise resides on the permanent staff.

Organization

In the early years of NGDC there were a number of reasons for operating three parallel science elements: (1) scientific expertise in the holdings could be concentrated, making it easier for staff to work on multiple related projects; (2) an additional layer of management facilitated dealing with a large staff; and (3) the techniques for handling data were different in the different disciplines. With the shrinking staff and generalization of data management techniques, an internal organization along disciplinary lines may no longer be justified. Indeed, such a structure has two important disadvantages: (1) many data management functions are duplicated, which is not affordable in an era of flat budgets; (2) the divisions are isolated scientifically and managerially; and (3) the divisions often compete with one another, rather than collaborate. Keeping scientific expertise with the holdings is important for managing data and serving users well, but walling off the component disciplines inhibits cross-fertilization within NGDC, as well with other centers. A recent example is the transfer of the paleoclimate division to another NOAA data center, which was facilitated by its separation from the other NGDC divisions.

Organizing NGDC so that a common set of services and functions serves all disciplines would reduce duplication of effort. NGDC already has an information services division that handles systems administration and computer maintenance for the entire center. Other crosscutting services and functions include software engineering, relational database management, geographic information systems, and documentation and publication. On the other hand, maintaining expertise in the data is a service that probably cannot be shared across the disciplines. Whatever organizational structure NGDC adopts has to be flexible enough to handle the projected growth in holdings and number of users, as well as the change in scope as NOAA priorities change.

Environmental issues, such as those within NOAA's purview, tend to require input from a wide range of disciplines and approaches. Addressing such multidisciplinary problems is a challenge that often requires seamless access to many types and sources of data. Examples of integrated science that rely in part on geophysical data are given in Box 3.3. Participating in these programs will require NGDC to manage its holdings and services within a broader context and take a more integrated view of its geophysical data and services. Operating as an integrated science organization instead of three competing discipline divisions would also allow the center to respond more easily to new scientific and technological approaches.

Recommendation: NGDC should develop an integrated approach to the stewardship of environmental data and operate in such a way that share-

BOX 3.3 Examples of Integrative Science

Examples of emerging science projects that require a multidisciplinary approach and the types of data held by NGDC include the following:

- Coupling land and seafloor relief data to develop the best global terrain models for characterizing the effects of dynamic Earth processes.
- Contributing seafloor observatory data (i.e., temperature, pressure, water chemistry, currents, seafloor maps and images, hydroacoustic, seismic) to systematic studies of climate research.[1]
- Integrating marine datasets by geographic location to characterize and monitor the changing seafloor and water column environment.
- Modeling static and time-varying magnetic fields from core, crust, ionosphere, and magnetosphere. These comprehensive geomagnetic field models require data from satellites, permanent magnetic observatories, and surveys.
- Integrating GPS data from NOAA's network of continuously operating reference stations into other networks (e.g., International GPS Service and the proposed Plate Boundary Observatory and International Global Geodetic Observing System) to obtain precise geodetic observations of the planet.

Implementing these projects will require collaboration within NGDC, among the NOAA data centers, and between NGDC and other organizations in the United States and abroad.

[1] The seafloor observatory program and its role in the Global Observing System are discussed in National Research Council, 2000, *Illuminating the Hidden Planet: The Future of Seafloor Observatory Science*, National Academy Press, Washington, D.C., 135 pp.

able services and functions (e.g., database management, software development) serve all NGDC disciplines.

Implementation of this recommendation would also allow greater cost efficiency and flexibility for future growth. The challenge is to maintain the current disciplinary strengths while evolving into a more integrated operation.

Budget

Insufficient funding was a theme that ran throughout the site review. When the committee asked why something was not being done that should be done (e.g., put more data online), the answer was invariably "lack of sufficient funds." There is certainly an appearance of a funding crisis in the center as indicated by the lack of recruitment and the increased workload of the staff.

To meet salary requirements NGDC divisions have been energetic in securing reimbursable work. Indeed, these entrepreneurial activities are necessary to pay for some core data center functions, such as archiving. (Data acquisition and special projects might be appropriate reimbursable activities.) This "follow-the-money" strategy makes it hard for NGDC to maintain and present a coordinated focus to NOAA and the broader community. It also distracts staff from carrying out the center's primary mission.[17] Furthermore, those staff members who are able to obtain reimbursable funding are de facto penalized by having their base support reduced.[18] The formula for allocating the center's base funding (see Chapter 2) does not appear to be closely tied to identifiable center priorities and may not be an efficient use of these funds. Interestingly, in interviews with individual staff members, a few dissented from the view of a funding crisis, stating their belief that more efficient management could stretch the existing resources.

The committee feels that NGDC has substantial resources and with the right focus a great deal can be accomplished with the existing staff and budget. Increases in the size and scope of data holdings and user populations, expanded efforts in education and outreach, and new scientific initiatives at the center may necessitate concomitant growth in the budget. However, most effective use of resources first requires a clarification of the NGDC mission and a vision for the center's future evolution. These issues are discussed in Chapter 4.

DATA MANAGEMENT

Data Dissemination

In the Internet era, users have come to expect rapid online access to data, but three factors potentially limit such access.

1. The data are not all in digital form. NGDC has a substantial patrimony of analog data (e.g., paper records; see Appendix C), much of which will have to be converted to digital form to increase accessibility and to prevent deterioration. NOAA places a high priority on this type of data rescue and provides special funding for this purpose.[19]

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[17] This observation was also made in NOAA, 2001, *The Nation's Environmental Data: Treasures at Risk*, Report to Congress on the Status and Challenges for NOAA's Environmental Data Systems, Washington, D.C., 138 pp.

[18] Interviews with NGDC staff members, November 14, 2003.

[19] For example, the Climate Database Modernization Program is currently providing funds for rescuing analog data. See background material prepared by NGDC for the November 13-15, 2002, committee meeting.

2. Metadata are often insufficient for users to discover both online and offline data. When users search for data on the Internet, they tend to rely more on the metadata and less on personal contacts with a data center or original data collector to learn about the data. It appears to the committee that NGDC captures pertinent metadata where available, although NGDC acknowledges that it does not always have the scientific expertise to maintain the quality of the data or sufficient staff to ensure that metadata are kept up to date.[20] In addition, it is sometimes quite difficult to produce comprehensive and accurate metadata for analog data.

3. The Web site can be difficult to navigate. The effectiveness of a data center's Web site is an important ingredient in ongoing efforts to keep online customers satisfied. The center has not evaluated user satisfaction with its Web site, so the following discussion is based on the experience of committee members and their colleagues. Committee members searched for data in their own discipline and were generally able to find what they were looking for, although not always directly. They found that users seeking geophysical data using a search engine on the Web are likely to arrive first at NGDC. The NGDC Web site has been arranged in such a way that it pops up with high frequency in Web searches. This is a very positive characteristic of the center, one that few centers achieve. Having arrived there, however, some users may be frustrated because in some cases NGDC does not have substantial holdings in the searched-for discipline. Examples include upper-atmosphere data, which are held mainly at NCAR, and volcano data, which are held mainly at the USGS and the Smithsonian Institution. In both cases a search engine lists NGDC first, and NGDC even lists upper-atmosphere data on the front page of its Web site, but the center holds little relevant data.[21] The frustration these users feel may be compounded by the fact that the center does not always have links to external organizations where relevant data may be held, including data that have been transferred from NGDC. In the case of upper-atmosphere and volcano data, for instance, the center has no links to the CEDAR database at NCAR or to the USGS, although a link to the Smithsonian Institution is prominently displayed.

A possible area of improvement in NGDC's Web site is the internal search tools. The committee found it easier to find the Web page of interest by using a Web search engine than by searching within the NGDC Web site. For instance, the Space Physics Interactive Data Resource (SPIDR), which allows users to retrieve datasets interactively, needs better documentation and user instructions.[22] Such systems should be transparent to al-

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[20] Background material prepared by NGDC for the November 13-15, 2002, committee meeting.

[21] NGDC volcano data focus on hazards.

[22] <http://spidr.ngdc.noaa.gov/spidr/>.

most anyone who uses the Web site. Finally, significant portions of NGDC data are not online or in useful forms (Appendix C). Even the digital holdings are not all online or nearline, an observation that surprised the committee. Making digital data available online would greatly increase the accessibility of the holdings and would reduce the staff overhead. It would also make it easier for researchers to locate data quickly and incorporate them into research projects.[23]

Recommendation: NGDC should continue to convert historical analog records to digital form and make all its digital holdings available online or nearline in the near future.

Researchers working outside of their disciplines or users looking for general information may find the Web site hard to use because there is no site map and relatively few introductory pages, tutorials, or other educational materials. Those that exist are often buried where only the most ardent user will find them. Moreover, the home page of the NGDC Web site may be confusing for inexperienced users because of the jargon of the disciplines. The committee notes the importance of continuing to tune the Web site to meet the needs of a wide spectrum of users.

Archive and Stewardship

The committee found the hardware infrastructure to be modern and to have the capability to meet NGDC needs. The move toward inexpensive ($10,000 to $15,000 per node) Linux servers is reasonable and follows trends in other parts of government and in industry. The network of about 100 servers is economical and affords some protection against failure of a single primary node, although it places an additional burden on an already busy staff. The center has made a significant investment in a modern tape robotic mass storage system that will simplify future data migration tasks. However, outside organizations (e.g., NCAR, NASA) were not consulted before the equipment was purchased and benchmarks were not run to see if it was appropriate. Although the robotic mass storage system will likely meet the needs of NGDC for years to come, the center should revamp its equipment acquisition process to permit more analysis of the problem to be solved before equipment is acquired.

The management and long-term storage of data are also of concern. NGDC's intention is to move data to modern media, but the pace of doing

[23] Technologies such as data grids and data webs that make it easier to use remotely archived data are discussed in National Research Council, 2003, *Government Data Centers: Meeting Increasing Demands*, National Academies Press, Washington, D.C., 56 pp.

so seems much too slow to assure the integrity of the data. Moreover, the data transcription policy at NGDC does not seem to be applied consistently to the data holdings. In fact, the committee was alarmed to learn that 10-year-old data are waiting to be migrated to 3590 cartridges and stored in the robotic library system and that some of these data only reside on 8-mm media. The general rule of thumb for archives is that data should be retranscribed every four to five years[24] and that copies of data should be made on at least two types of media with independent hardware devices capable of reading them. NGDC staff told the committee that this plan is followed only as resources allow, suggesting that periodic transcription of data to new media and new technologies is not the highest priority for the center.

Copies of most data exist at another location, but offsite storage is not nearline (robotically accessible), making the NGDC vulnerable to a single point of failure if the primary mass storage system encounters problems. For instance, if the Internet connection into the NGDC building were to suffer a catastrophic failure, there would be no backups to provide access to the data holdings. The official archive consists of an onsite and an offsite copy of the data. Both copies are on the same media type. Another concern is that the offsite backup storage is not located at a significant distance from Boulder. Although the Boulder area is not particularly vulnerable to natural disasters other than a regional power-grid failure caused by a space weather or other severe weather storm, the proximity of the primary and backup storage locations creates the potential for significant interruption of access to data. Plans should be put into place to maintain an NGDC Web presence in the event of natural disasters, power outages, loss of Internet connectivity to the Boulder facility, or other eventualities. At a minimum the NOAA data centers could back up each other to ensure a continuous Web presence.

NGDC has devoted significant resources to ensuring that Internet connections to the center are secure and that they properly address the vulnerabilities that any data center of this size and prominence has. The committee believes that adequate Internet security and practice are in place.

The committee was pleased to see the move toward commercial off-the-shelf software for managing and presenting information. In-house development of infrastructure software should be avoided as much as possible, permitting the center to focus on writing or customizing software for accessing, retrieving, and visualizing data. The partnerships forged between

[24] With the rapid pace of technological change, data migration may have to begin every two to three years. See NOAA, 2001, *The Nation's Environmental Data: Treasures at Risk*, Report to Congress on the Status and Challenges for NOAA's Environmental Data Systems, Washington, D.C., 138 pp.

NGDC and such commercial concerns as ESRI are mutually beneficial, and the center has created many useful data handling tools on its own. Providing such tools is an important role for data centers, although it entails a long-term commitment for supporting them.

Recommendation: NGDC should improve its data stewardship, guided by practices at other data centers, to accelerate its data migration schedule and its rate of archive transcription and should also address the center and backup site disaster vulnerability.

PERFORMANCE MEASURES

As part of NESDIS oversight of the center NGDC must write a management contract with performance measures each year.[25] At the time of the review NGDC had two sets of performance measures: one developed by NESDIS and applied to NGDC and one developed by NGDC (Appendix E). In addition, the center had proposed to add three more performance measures (Table 3.1) in response to a fiscal year (FY) 2002 quarterly review. The NOAA strategic plan is being revised, however, and it will contain new performance measures and milestones. Once the plan is complete NESDIS and NGDC will revise their own strategic plans and performance measures accordingly. Given the substantive changes to the NOAA strategic plan it cannot be assumed that the NGDC performance measures provided to the committee will be used in FY 2003 and beyond. Nevertheless, the committee hopes that its comments on the FY 2002 performance measures will be useful in developing the new ones.

The committee found that many of NGDC's FY 2002 performance measures and milestones (Appendix E) are bureaucratic and do not address the issue of how well the center is progressing. For example, measures such as "ensure a safe workplace" and "alternate dispute resolution" are aimed at operating a federally supported facility well but are only marginally relevant to the success of a science-oriented data center. On the other hand, measures of the completeness of the data holdings and the ease of accessibility are quite germane to the effectiveness of a data center.

Rather than defining performance measures at the outset, a better approach is to develop a list of characteristics that define a good data center (Box 3.4). Performance measures that gauge how well the center is achieving these characteristics could then be developed. Such performance measures should be supplemented with regular reviews by an independent advisory committee.

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[25] Presentation to the committee by Gregory Withee, NOAA assistant administrator for satellite and information services, August 13, 2002.

TABLE 3.1 Proposed Additional Performance Measures and Milestones for FY 2003

Performance Measure	Milestone
Build authoritative long-term archives	Establish a data quality committee to review and document the information quality of NGDC products and services
	Expand use of metadata records to include more data quality information in our directory systems; populate these fields
Acquire valuable emerging data streams	Establish a preliminary operational mirror site for the National Geodetic Survey's Continuously Operating Reference Stations (CORS) data processing and services
Contribute to significant scientific research	Complete the external review
	Develop implementation plan for recommendations

BOX 3.4 What Makes a Good Data Center?

- integrated within the scientific community
- knows its users and their needs
- community perception of the center as "the place to go"
- regular, external, independent feedback
- provides good stewardship
- spirit of innovation
- has qualified personnel who understand the discipline they are serving
- has staff members who work with the data
- data are easily found and accessed by users
- leverage activities with resources from other institutions
- good communication and a shared sense of direction
- thinks strategically

SOURCE: Modified from National Research Council, 1998, *Review of NASA's Distributed Active Archive Centers*, National Academy Press, Washington, D.C., 233 pp.

SUMMARY

The answers to four of the questions posed to the committee are summarized below.

How well does NGDC collect the data and information it needs to effectively conduct its activities? The answer is mixed. NGDC has had a long, successful history of partnering with other organizations to acquire, disseminate, and archive data from around the world. Much of the credit goes to the center staff members, who seek out relevant data and maintain good relations with data collection agencies. However, the center is opportunistic about acquiring data, basing decisions largely on affordability. Moreover, agency requirements that principal investigators deposit data at NGDC are often not enforced. As a result the holdings are spotty and new data acquired are not always those of the highest priority. NGDC need not archive all data related to its mission, but it should have prominent links to related archives on its Web site to guide users to data of interest.

How effectively does NGDC measure customer satisfaction? At the present time NGDC does not measure customer satisfaction effectively. To measure customer satisfaction it is first necessary to identify the users. NGDC has lost direct contact with the bulk of its users, because users overwhelmingly use the Web to find data instead of contacting a staff member at the center. Moreover, other mechanisms for capturing information about users (e.g., Web-log analysis, external user advisory committee) are not fully utilized. Determining customer satisfaction is hindered by new federal laws that forbid nonrigorous surveys, such as those employed by the center in the past. A data center that cannot survey its users cannot meet their needs. However, NESDIS has obtained OMB approval for a one-time user survey of its data centers, and the results will provide important feedback on customer satisfaction.

Is NGDC organized, staffed, equipped, and supported to fulfill its mission? The committee believes that the current organizational structure hinders NGDC from fulfilling its mission. NGDC's historical structure has led to duplication of data management functions and scientific isolation of the divisions. It would be more efficient to reorganize the center, allowing for shared functions across different divisions and more integrated scientific activities. Having greater functional and scientific integration instead of three relatively autonomous divisions would allow the center to respond more easily to multidisciplinary scientific approaches.

NGDC is appropriately equipped to fulfill its mission. NGDC's hardware infrastructure has the capacity to meet the needs of the center, although the data migration schedule should be accelerated to ensure data safety. There is a core of competent and dedicated staff, although vacancies are a problem and the median age is high. The upcoming round of retirements will present an opportunity to hire employees with needed skills, such as technical support. Supplemental scientific expertise is readily available from universities and government laboratories in the Boulder area. A strong scientific connection—either by having scientific expertise among the center staff members, by collaborating with outside scientists, or by encouraging visits from outside scientists to work with the data—is needed to ensure the quality of the data and metadata.

NGDC's base funding is insufficient to cover all of its activities. In response staff members seek reimbursable work, which dilutes the focus of NGDC and distracts staff members from the primary mission. It is possible that by pruning activities not central to NGDC's mission, reorganizing the center structure, and reducing staff numbers the center could rely less on reimbursable funding. Such a decision has to be made within the context of the NGDC mission, which is discussed in Chapter 4.

Are NGDC's performance measures appropriate for tracking progress in achieving results and for judging center funding? Many of the performance measures used by NGDC in FY 2002 are bureaucratic and miss their mark. With the revision of the NOAA and NESDIS strategic plans and performance measures, NGDC has an opportunity to propose a new approach to defining performance measures—one that begins by determining the characteristics of a good data center and then defining suitable performance measures.

4

NGDC Mission and Vision

This chapter deals with the two tasks that relate to the National Geophysical Data Center's (NGDC's) mission.

Task 3. Is NGDC appropriately aligned to support the mission, vision, strategic goals, and themes of the National Oceanic and Atmospheric Administration (NOAA) and the National Environmental Satellite, Data, and Information Service (NESDIS)?

Task 1. Is the NGDC mission well articulated and understood by its staff and its users?

NOAA AND NESDIS MISSIONS

NGDC performs two functions that are directly relevant to NOAA's mission: long-term archiving and dissemination of environmental data. NOAA's mission is to "understand and predict changes in the Earth's environment," where "environment" includes the land, sea, atmosphere, and space.[1] All of these environmental fields are within the domain of NGDC. Moreover, NOAA has been formally responsible for archiving environmental data since the agency was created in 1970.[2] Thus, regardless

[1] Department of Commerce, 2003, *New Priorities for the 21st Century: NOAA's Strategic Plan for FY 2003 - FY 2008 and Beyond*, National Oceanic and Atmospheric Administration, January 16, 2003 draft, <www.osp.noaa.gov/ docs/publicdraft.pdf>.

[2] Data management functions were acquired from the Environmental Science Services

of which environmental sciences are being emphasized NGDC's data management function is appropriate for NOAA. For these two reasons NGDC is appropriately housed at NOAA and should be supported.

To carry out its mission NOAA has laid out four mission goals and six crosscutting priorities (Appendix D). NGDC data are needed to achieve most of the mission goals: bathymetry data support maritime transportation, marine sediment data provide insight on climate variability and change, and geomagnetic data are required to predict space weather. All of NOAA's crosscutting priorities (Appendix D) are relevant to NGDC. NGDC forms a part of NOAA's infrastructure and its data support scientific research and education about the environment, as well as practical applications, such as predicting geomagnetic-storm-induced communications disruptions. In addition, NGDC cooperates with international programs to acquire data and operates three world data centers to disseminate data to scientists all over the world. Finally, NGDC has an obvious role in an integrated environmental observation and data management system. This is a particularly important theme to NGDC, because NOAA has traditionally stressed ocean and atmosphere, areas in which NGDC has a lesser role.

The NESDIS mission and strategic objectives focus on the data aspects of NOAA and are even more relevant to NGDC. The NESDIS mission is to provide "timely access to global environmental data and information services from satellites and other sources."[3] All NGDC activities are aimed at supporting that mission and the accompanying strategic objectives, with the exception of resource management (Appendix D). However, NGDC has only three satellite data streams (data for monitoring the space environment from the Defense Meteorological Satellite Program, Geostationary Operational Environmental Satellites, and Television Infrared Observation Satellite). Some NGDC staff felt that NESDIS gave the center lower priority on that account.[4]

Both the NOAA and NESDIS strategic plans emphasize ocean and atmosphere, whereas NGDC emphasizes the Earth and near-Earth space. Nevertheless, many NOAA and NESDIS missions, objectives, and priorities could not be accomplished without NGDC. NGDC staff members recognize their importance to NOAA and NESDIS, but several told the commit-

Administration and its predecessor organizations in 1970. See Presidential Reorganization Plan Number Four of 1970, 84 Stat. 2090, and Presidential Reorganization Plan Number Two of 1965, 79 Stat. 1318-20.

[3] Department of Commerce, 2001, *A Strategic Plan for NOAA's National Environmental Satellite, Data, and Information Service (NESDIS)*, National Oceanic and Atmospheric Administration, Silver Spring, Md., 28 pp.

[4] Interviews with NGDC staff members, November 14, 2003.

tee that NOAA did not give high priority to the fields of research and operations supported by NGDC.

Both NGDC and NESDIS would benefit from a stronger shared agreement on NGDC priorities and future. In fact, NGDC staff would respond positively to a clear affirmation from NESDIS that their activities were relevant to the NOAA mission. These issues are discussed below.

NGDC MISSION

The committee found several different formulations of the NGDC mission (see Appendix D). The formal mission statement describes NGDC's functions and the types of data it holds, but it is out of date. It refers to the center by its previous name (the National Geophysical and Solar-Terrestrial Data Center) and includes data and components the center is no longer responsible for (e.g., seismic data, World Data Center for Glaciology).[5] In addition, it does not reflect the growth in the number of lay users.

Visitors to the NGDC Web site see a different mission statement: "NGDC's mission is data management in the broadest sense. We play an integral role in NOAA's environmental research and stewardship, and provide data services to users worldwide."[6] This statement does not describe the kinds of data dealt with and probably does not distinguish NGDC from any environmental data center. NGDC's functional statement, which appears in the NOAA organizational handbook, is a better description of the center's activities.[7] The functional statement describes the types of data and services provided by the center, identifies user groups, and summarizes the center's interactions with national and international organizations.

These mission formulations are different from but consistent with one another. Nevertheless, the fact that there are different formulations and that the formal statement is out of date indicates that NGDC's mission is not well stated. During the site visit NGDC staff members offered a number of other ideas about what the center should do, and users that see the vague mission statement on NGDC's home page are unlikely to have a clear idea about the mission of the center. NGDC would benefit from a restatement of its mission, one that describes its current activities and potential for future growth and that has a common thread tying the center to NOAA. The mission statement should also identify which NGDC holdings are relevant for addressing the priorities of NOAA and NESDIS. Indeed, defining its focus to NESDIS is one of NGDC's performance measures (Appendix E).

[5] 15 CFR Ch IX (1-1-97 edition) §950.5.
[6] <www.ngdc.noaa.gov/ngdcinfo/aboutngdc.html>.
[7] *NOAA Organizational Handbook*, <http://www.rdc.noaa.gov/~ohb/E/EH0000.html>.

Recommendation: NOAA, NESDIS, and NGDC should jointly participate in a rearticulation of NGDC's mission in support of NOAA's environmental responsibilities as defined in the NOAA draft strategic plan for 2003.

This exercise should be done every three years or so to keep current with agency priorities and with ongoing scientific advances. Rearticulating the mission would increase the understanding of NGDC's mission by its staff and users, and would also help alleviate NGDC staff member worries about the future of the center within NOAA.

VISION FOR NGDC

Most of the problems facing the center come down to vision and leadership. NGDC's vision is "to be the preeminent national stewards of geophysical and relevant environmental data and to transform these data, using pioneering scientific thought and cutting-edge technology, into effective information necessary to secure a sustainable, flourishing future for our nation and world" (Appendix D). However, the follow-the-money strategy and autonomy of the divisions are not helpful in achieving this shared vision. Moreover, although NGDC's vision is consistent with the NESDIS vision of being the source of the world's most comprehensive environmental information (Appendix D), NESDIS has apparently not accepted any vision presented so far by NGDC as being sufficiently compelling to support at a higher level.

Being good stewards of geophysical and environmental data is a worthy goal and is essential for ensuring that the holdings are useful to current and future generations of users, but NGDC has the potential to be much more. The center could become the first place users go for geophysical data on the terrestrial and space environment. This is not the case today and making this happen would require a vigorous effort to put existing datasets online, add to the archive, and link to other data collections. NGDC could also become a focus within NOAA for integrated environmental science. The center has some experience creating integrated datasets and tools, but building on this experience would require breaking down the walls between the divisions and focusing more on cross-disciplinary activities.

NGDC needs a vision more than other data centers because of its unusually broad span of disparate disciplines. It also needs a strategy for achieving its vision that shows how each of the disciplines fulfills NOAA's mission and priority on integrated environmental science. An NGDC vision understood by the staff and NOAA could allow NGDC to play its natural role in terrestrial and space environment science. The committee believes this is a strong argument for keeping NGDC intact within NOAA, rather than distributing the different elements of the center among other specialized data centers.

Recommendation: NGDC should articulate a vision for the future that integrates the disciplines across its broad environmental roles and develop a strategy to pursue its vision.

SUMMARY

The answers to the tasks related to NGDC's mission are summarized below.

Is NGDC appropriately aligned to support the mission, vision, strategic goals, and themes of NOAA and NESDIS? Yes. NGDC's activities support the mission and strategic goals of both NOAA and NESDIS. Indeed, NOAA's new strategic plan contains priorities that are more aligned with and favorable to NGDC than previous plans. Of particular importance is NOAA's new priority on integrated environmental approaches, an area in which NGDC has some experience and could play an important role. Moving in this direction will require a new vision for the center and less emphasis on traditional disciplinary boundaries.

Is the NGDC mission well articulated and understood by its staff and its users? No. NGDC's formal mission statement is out of date and no longer fully describes the scope of the center, its connections to NOAA, or its potential for future improvement. A number of different mission statements can be found, and NGDC staff members are able to formulate others. Users are unlikely to understand the center's mission from the vague statement posted on the NGDC home page. A mission statement that reflects new NGDC capabilities and new NOAA priorities should be developed cooperatively by NGDC, NESDIS, and NOAA and communicated to the NGDC staff and users of the center.

5

Conclusions

The committee believes that the National Geophysical Data Center (NGDC) has a critical role to play within the National Oceanic and Atmospheric Administration (NOAA) and the broader geophysical and environmental community. NGDC is the natural place within NOAA for stewardship and dissemination of geophysical data related to the terrestrial and space environment. To fulfill its potential, however, the center must first overcome six solvable problems:

1. The center has lost touch with its users. With the switch to Web-based access and the passage of the Paperwork Reduction Act, the center has to establish new mechanisms for determining who its users are, whether they are satisfied with current services, and what products and services they will want in the future. Fulfilling user needs is the primary role of any data center, and it is essential that NGDC obtain and use a statistically valid user survey and improve its methods for evaluating usage of its Web site.
2. NGDC's organizational structure fosters inefficiency and scientific isolation within the center. Organizing the center so that a common set of services and functions serves all NGDC disciplines would reduce costs by eliminating parallel activities. It would facilitate cross-disciplinary activities within the center, make it easier to concentrate staff and funding resources in high-priority areas, and provide a stronger base for developing new, integrated scientific objectives.
3. There is insufficient involvement of scientists with the center. NGDC's holdings are scientific in nature and scientists are required to

provide data, assure them for quality, answer questions about the data, and work with the holdings to ensure their usefulness. NGDC can strengthen relationships with scientific data providers by working with them from the beginning of data collection projects to ensure that NGDC will receive the resulting data. Relationships with scientific users could be strengthened by reestablishing the NGDC advisory committee, recruiting scientists to work with the data, or establishing a vigorous program of visiting scientists from outside the Boulder area.

4. NGDC has had difficulty presenting a compelling mission and vision to NOAA and the National Environmental Satellite, Data, and Information Service (NESDIS). Historically, NOAA has focused on ocean and atmosphere and NESDIS has focused on satellite data, none of which are among NGDC's strong points. The absence of a strong connection between NGDC and NOAA may be responsible for NGDC having insufficient base funding for essential services and staff. However, with NOAA's new emphasis on integrated environmental approaches NGDC should have an important new role within NOAA. To take advantage of this opportunity NGDC should work with NOAA and NESDIS to reframe its mission statement accordingly.

5. Greater attention should be paid to improving the safety and accessibility of the holdings by accelerating the data migration schedule (currently 10 years) and addressing the center's vulnerability to disasters.

6. The utility of the holdings could be improved by the center becoming an authority on the existence of all geophysical and complementary data relevant to NGDC's and NOAA missions. Doing so will require NGDC to continue to work with data collection programs to acquire relevant data for its own databases and begin to provide prominent links to the holdings of complementary archives. The center can also make its own holdings more accessible by placing digital holdings online or nearline and by converting historical analog records to digital form.

Most of these problems can be overcome with the assets the center has on hand:

1. a capable, enthusiastic staff
2. holdings that are critically important for a wide variety of scientific and operational purposes
3. a favored location in a science city, which places scientific and technological expertise at the center's fingertips
4. experience creating integrated datasets and tools
5. substantial although not necessarily sufficient funding for meeting key obligations

The recent and upcoming retirements at NGDC and change in priorities at NOAA present an opportunity to foster new leadership and build NGDC into an integrated science center. With vision and leadership NGDC can become an essential element of NOAA for understanding and managing our environment.

Appendixes

Appendix A

Biographical Sketches of Committee Members

Ferris Webster is a professor in the College of Marine Sciences at the University of Delaware. His research interests concern the data and information needs of global environmental research programs and the role of the ocean in climate change. Dr. Webster served as assistant administrator for research and development at the National Oceanic and Atmospheric Administration from 1978 to 1982. He has served in leadership positions on numerous committees and organizations dealing with environmental data, including the National Research Council's Committee on Geophysical and Environmental Data, Intergovernmental Oceanographic Commission, and Global Climate Observing System. Perhaps no other scientist in the world has as much experience with data center reviews. He currently chairs the International Council for Science's Panel on World Data Centers and Ad Hoc Group on Data and Information.

J.-Bernard H. Minster is a professor at the Scripps Institution of Oceanography and director of the Institute of Geophysics and Planetary Physics for the University of California system. His research interests are in seismology, geodesy, and the acquisition, declassification, and exchange of geophysics data and information. He has served on several data center reviews, including the recent National Research Council review of seven distributed active archive centers operated by the National Aeronautics and Space Administration. Dr. Minster currently chairs the Committee on Geophysical and Environmental Data and has served on numerous committees related to solid earth geophysics, including the Board on Earth Sciences and Resources and its Committee on Geodesy.

Timothy K. Ahern is the program manager of the National Science Foundation-funded Incorporated Research Institutions for Seismology data management system. A geophysicist by training, he is responsible for all national and international nodes of the data management system and oversees all aspects of the data center, including development and operation of information systems, budgets, and personnel. Dr. Ahern is a regular contributor to the scientific literature, and his recent publications have focused on providing easy access to terabytes of seismological information and managing data from distributed networks.

Claudia J. Alexander is a project scientist for the U.S. Rosetta project at the Jet Propulsion Laboratory. She is also an adjunct professor at Prairie View A&M University. Her current duties include serving as a science coordinator for two instruments onboard the Galileo spacecraft. Dr. Alexander's research interests are in magnetospheric physics and the solar wind, and she is currently exploring sources for the atmosphere of Jupiter's moon Ganymede. She also has community interests and contributes to a NASA-sponsored, Web-based, public science-learning tool entitled "Windows to the Universe" and cosponsors an education program for African American middle school boys in Richmond, California.

Jeremy Bloxham is a professor of geophysics and chair of the Department of Earth and Planetary Sciences at Harvard University. His research interests are in observational and theoretical geomagnetism and the application of high-performance computing and visualization to problems in geophysics. Dr. Bloxham chairs the International Association of Geomagnetism and Aeronomy's Working Group on the Theory of Planetary Mean Fields and Geomagnetic Secular Variation. He has received many awards for his contributions to the field of geomagnetics, including the Macelwane Medal of the American Geophysical Union and the Chapman Medal of the Royal Astronomical Society.

David S. Goldberg is a Doherty senior research scientist at Columbia University's Lamont-Doherty Earth Observatory and director of its Borehole Research Group. His research interests are in natural gas hydrates, carbon sequestration, and borehole instrument development. He has participated in 15 oceanographic cruises and 9 continental programs to collect geophysical data. He is responsible for all aspects of borehole logging for the Ocean Drilling Program, including data acquisition, processing, and dissemination. This information is routinely archived at the National Geophysical Data Center.

Raymond A. Greenwald is a group supervisor at the Applied Physics Laboratory at Johns Hopkins University. He designs and operates ground-based auroral zone radars and also uses space-based observations. His research focuses on transients in the high-latitude ionosphere convection patterns. Dr. Greenwald has served on National Research Council committees related to solar-terrestrial physics, including the Committee on Solar and Space Physics.

Patrick E. Mantey is Jack Baskin Professor of Computer Engineering and was the founding dean of the School of Engineering at the University of California, Santa Cruz. Prior to joining that faculty he spent 17 years at IBM. Dr. Mantey's research interests include image processing, storage, and retrieval; electronic libraries; database applications; and user-machine interaction. He is the lead investigator on the REINAS project, which has developed a system to support real-time observations in environmental science, concentrating on the oceanography and meteorology of the Monterey Bay region.

Christopher T. Russell is a professor in the Department of Earth and Space Sciences and the Institute of Geophysics and Planetary Physics at the University of California, Los Angeles. His research interests concern the energy flow from the Sun through the solar wind and into the terrestrial and planetary magnetospheres. He has been an investigator on a number of NASA missions related to magnetic fields and the solar wind. Dr. Russell has served on numerous National Research Council advisory committees, including the Committee on the Long-Term Retention of Scientific and Technical Records of the Federal Government and the Decadal Study of Sun-Earth Connections, of which he currently chairs the Panel on Solar Wind-Magnetosphere Interactions. He also served on the science advisory panel to the National Geophysical Data Center from 1990 to 1995. He is a recipient of the Space Science Award of the International Council for Science's Committee on Space Research and the Macelwane Award of the American Geophysical Union.

Deborah K. Smith is a senior scientist at the Woods Hole Oceanographic Institution. Her research focuses on the dynamics of submarine volcanic rift zones and involves geological and geophysical mapping of the seafloor using a variety of instruments. A data collector, she has strong interests in data quality and preservation and has organized workshops about these topics. She also has interests in education and outreach and has written for popular magazines and designed Web sites permitting school children and the public to participate in a virtual research expedition. Dr. Smith has served on two advisory committees: the U.S. Science Advisory Committee and its executive committee, and currently the RIDGE 2000 executive committee.

NRC STAFF

Anne M. Linn is a senior program officer with the Board on Earth Sciences and Resources of the National Academies. She has been with the board since 1993, directing the USA World Data Center Coordination Office and staffing a wide variety of geophysical and data policy studies. In addition, she is the secretary of the International Council for Science's (ICSU's) Panel on World Data Centers and a member of the ICSU Ad Hoc Committee on Data. Prior to joining the staff of the National Academies, Dr. Linn was a visiting scientist at the Carnegie Institution of Washington and a postdoctoral geochemist at the University of California, Berkeley. She received a Ph.D. in geology from the University of California, Los Angeles.

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Appendix B

Criteria for Review

RELATIONSHIP WITH NOAA AND NESDIS MISSION

- Maintaining or enhancing position as an authoritative source of geophysical data and information
- Being ready for new data streams
- Establishing and maintaining a working relationship with providers of data products, algorithms, and ancillary information
- Fitting within the NESDIS strategic plan
- Relevance to the NOAA and Department of Commerce missions and discipline themes

DATA AND HOLDINGS

- Providing easy and timely access to data, data products, and information of high integrity and quality (data discovery, online visualization, online data delivery, facilitating access to data from other data centers)
- Fostering the quality of holdings
    - ➢ issuing data update notices
    - ➢ notifying users of errors
    - ➢ engaging scientific community in quality control
- Ensuring that data and data products are properly documented and that all appropriate ancillary information is readily accessible
- Ensuring that data and associated metadata are secure
- Establishing and maintaining a data acquisition strategy
- Transcribing, rescuing, and preserving data

USERS

- Characterizing the user community (e.g., who are they?)
- Responding to the needs of different user communities (e.g., scientific, commercial, public, education)
- Educating and reaching out to users about the application and significance of data and information holdings

TECHNOLOGY, FACILITIES, AND WORKFORCE

- Implementing an information technology strategy that includes
  - ➢ usability
  - ➢ performance
  - ➢ access
  - ➢ security
  - ➢ migration (data and software)
  - ➢ technology tracking
- Maintaining in-house expertise to acquire and/or develop appropriate hardware and software
- Knowledge and use of appropriate national and international data standards

MANAGEMENT

- Maintaining the science capability to judge the quality of the data/integrity of the holdings
- Encouraging user feedback
- Promoting local innovation and initiative
- Interacting and cooperating with other NOAA units to address common issues and avoid duplication of effort
- Possessing a vision for NGDC
- Having sufficient resources to carry out the NGDC mission
- Quality of the workforce
- Receiving regular input from and responding to an independent user advisory group
- Maintaining a program of active visiting scientists/having a superscientist on staff
- Leveraging NGDC activities with resources from other institutions

Appendix C

NGDC Holdings

Appendix C—NGDC Holdings

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Aurora Data					
All-sky camera films	STP	D&A		16,000 paper, 6,200 microfilm	0
Auroral radar, spectral line data, visual	STP	A	358	1,020 microfilm, paper	2
Auroras and other lights viewed from space and Auroras Australis slides	STP	A		72 slides	0
Airglow	STP	D&A	4.56	3,340 pages, UAG-1	80
Bathymetry, Topography, and Relief					
Bathymetry of the Gulf of Mexico on CD-ROM	MGG	D	600		0
Bathymetry/relief posters and slides	MGG	A		11 posters, 40 slides	0
Bathymetry/topography gridded data	MGG	D	0.2		0
Coastal relief models	MGG	D	30,000		50
Coastal relief model U.S./northeast Atlantic on CD-ROM	MGG	D	15,000		50
Coastal relief model U.S./Southeast Atlantic on CD-ROM	MGG	D	15,000		50
Coastal relief model Florida/eastern Gulf of Mexico	MGG	D	3,000		50
Coastal relief western Gulf of Mexico	MGG	D	1,200		50
Coastal relief model central Gulf of Mexico	MGG	D	1,200		50
Coastlines/shorelines digital	MGG	D			100
Estimated and measured seafloor topography	MGG	D			0
ETOPO2 2-minute gridded global elevations	MGG	D	600		50

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
		1,783				
			1967	M, R	global	P
	55	405	1968	M, R	global	P
	46		1998	S	Air Force, Australia	P
	1	1,378	1967	M, R	global	P
		5,230,673				
100	22		2000	CD	NGDC, NOS	N
100	10,352		2000	P, S	NGDC	N
100			2001	D	global	P
100	12	124,220	2002	D	NGDC, NOS	N
100	223		2001	CD	NGDC, NOS	N
100	215		2001	CD	NGDC, NOS	N
100	125		2002	CD	NGDC, NOS	N
100	89		2002	CD	NGDC, NOS	N
100	97		2002	CD	NGDC, NOS	N
100	0	453,709	2001	O	multiple	Y
100		68,586			NSF, NOAA	Y
100	308	2,092,507	2000	CD	NSF, NOAA, Navy	P

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
ETOPO5 5-minute gridded world elevations	MGG	D	328		100
Global relief images on CD-ROM	MGG	D	600		100
GLOBE 30" global topography	SEG	D	1,727		100
Great Lakes bathymetry posters	MGG	A		8 posters	0
Great Lakes bathymetry digitized at NGDC	MGG	D	189		50
Lake Ontario bathymetry CD-ROM	MGG	D	600		50
Lake Erie bathymetry CD-ROM	MGG	D	600		50
Lake Michigan bathymetry CD-ROM	MGG	D	600		50
Multibeam bathymetry, NOS, coastal U.S.	MGG	D	10,698		0
Multibeam bathymetry from U.S. and international sources, worldwide	MGG	D	36,444		0
Multibeam bathymetry from east coast of the U.S. on CD-ROM	MGG	D	600		0
NOS hydrographic data digital	MGG	D	7,964		100
NOS hydrographic survey data on CD-ROM	MGG	D	1,200		100
NOS bathymetry/fishing maps scanned and paper	MGG	D&A	9,000	455 maps	0
TerrainBase 5-minute global topography/bathymetry	SEG	D	1,934		100

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
100	1,449	158,873	1993	CD, O	Navy	Y
100	57	55,641	2000	CD, D, O	NGDC	N
100	676	1,261,122	2000	CD, D, O, P		N
100	2,159		2000	P	NGDC, GLERL, CHS, NOS	N
100	262	216,919	2002	D	NGDC, GLERL, CHS, NOS	N
100			1996	CD	NGDC, GLERL, CHS, NOS	N
100	86		1998	CD	NGDC, GLERL, CHS, NOS	N
100	58		1996	CD	NGDC, GLERL, CHS, NOS	N
100	681		2002	D	NOS	Y
100	977		2002	D	global	Y
100	20	16,958	1999	CD	multiple	Y
100		12,984	2001	D, O	NOS	P
100	213		2001	CD	NOS	N
100	3,326	24,518	2001	CD, M	NOS	P
100	1,491	192,570	1994	CD, O		N

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Topography U.S. state images	SEG	D	31		100
Topography miscellaneous old archive	SEG	D	88		0
Cosmic Ray Data					
Cosmic ray neutron monitor data	STP	D&A	378	29,400 paper	80
Ionization chamber, mesons, balloon data	STP	A		4,654 paper	0
Ecosystems					
Global ecosystems	SEG	D&A	8,577	19 charts	100
Africa ecosystems	SEG	D	446		0
Vegetation index	SEG	D	106,464		20
Regional assessments	SEG	D	786		50
Coastal ecosystems	SEG	D	304		50
Geomagnetism					
Geomagnetic components D, H, and Z or X, Y, and Z at 10 sec, 1-min, 2.5-min, and hourly intervals	STP	D&A	34,575	1,655,153 paper, 6,308 microfilm	100
Geomagnetic indices aa, Kp, Ap, Kn, Ks, Km, Cp, C9, AE, AL, AO, AU, Dst, PC	STP	D&A	394	376,960 paper	100
Geomagnetic principal magnetic storms and sudden commencements	STP	D	4		100
Main magnetic field observations[b]	SEG	D&A	17,312	360,600 paper, reports, charts, microform	20
Magnetic repeat station data	SEG	D&A	11,542	25,000 pages	5
Main field models and services	SEG	D	96	50 charts	100
Paleomagnetic data	SEG	D	51		95

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
100	1	552,066	1999	D, O		Y
0	8	0	1989	D		P
		47,525				
	25	47,525	2002	CD, D, O, R	global	Y
	0	0	2001	R	global	Y
		3,149,445				
100	213	3,146,353	2000	CD, D, O	global	P
0	0	0	1998	D	U.S. govt	P
100	452	143	1997	D, O	U.S. govt	P
50	82	2,947	1998	D, G, O, R	regional	P
50	119	2		D, O, R	regional	P
		2,517,223				
	2,175	263,115	2002	CD, D, MF, O, R	global	Y
	1,452	38,715	2002	CD, D, O, R	various	Y
		3,733	2002	O R	global	Y
20	245	43,487	2001	CD, D, O, MF, P, R	global	P
40		13,892	1999	R	global	P
100	136	1,630,675	2000	CD, D, M, O, R	global	P
95	33	287,832	2002	D, O	global	P

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Aeromagnetic data, non-U.S.	SEG	D&A	8,547	200 microfilm	20
Aeromagnetic data, U.S.	SEG	D	51,217		20
Main field geomagnetic data from satellites	SEG	D	1,523		5
Hazards					
Earthquake seismicity data[i]	SEG	D&A	2,919	60,000 pages, microfilm	95
Earthquake strong motion[j]	SEG	D&A	4,396	10,000 pages	
World stress and fault mechanism data	SEG	D	5		100
Volcano data[k]	SEG	D&A	.9	29 reports, posters	100
Tsunami data	SEG	D&A	3	6,008 reports, microfilm, charts	80
Hazards photos	SEG	D&A	21,992	5,520 photos, slides	40
Ionospheric Data					
Ionospheric digital database	STP	D&A	107,053	224,000 paper	97
Ionospheric catalogs, models, and programs	STP	D	31		100
Analog ionograms and reduced characteristics	STP	D&A	30,982	2,527,905 paper, 147,260 microfilm	10
Ionospheric total electron content	STP	D&A	1,089	12,500 paper	0
Ionospheric predicted numerical coefficients[l]	STP	D	3		0
Ionospheric absorption	STP	D&A	7	530,281 UAG-34 paper	0

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
95	108	8,003	1998	CD, D, O, M, MF	international	N
70	533	224,843	2000	CD, D, O, M	U.S. state govt, industry	P
100	36	2,938	1993	CD, D	NASA, DOD	Y
		9,159,118				
	3,479	2,822	2002	CD, D, G, MF, OS, R	global	P
	429	991	1996	CD, D, O, OS	global	Y
100	3	1,389	1991	D, G, O	global	Y
50	1,246	398	2001	G, O, P, R, S	global	P
95	564	1,686	2002	D, G, MF, O, OS, R	global	N
100	5,249	7,395	2002	D, G, O, P, S	global	P
		191,859				
	172	180,200	2002	CD, D, O, R	global	P
	37	10,986	2002	CD, D, O	global	P
	22		2002	CD, D, MF, O, R	global	P
	16		~1980	D, R	global	
	140		1999	D, R	global	
	5		1965	D, R	global	P

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Miscellaneous: oblique incidence (satellite), POGS (satellite), drifts, back/forward scatter, incoherent scatter (now at NCAR)	STP	A	184	50,000 paper	0
Sudden ionospheric disturbances	STP	D	26	10,300 paper	100
Land Geochemistry					
Geochemical and petrological data	SEG	D	463		0
Land Geothermal					
U.S. thermal springs	SEG	D&A	17	125 maps	80
Geothermal world heat flow data	SEG	D	0.3		100
Land Gravity					
Gravity point data	SEG	D&A	1,880	4,525 paper, microfilm	0
Gravity grid data	SEG	D	425		20
Gravity satellite data	SEG	D	1,112		0
Marine Geology Data					
Index to marine and lacustrine geological samples	MGG	D	136		100
Core data from ODP legs 101-129	MGG	D	208		100
Core data from DSDP	MGG	D	1,739		100
PETROS analyses of igneous rocks	MGG	D	54		100
CLIMAP 18K bp sediment data files	MGG	D	10		100
NGDC marine sediment grain size database	MGG	D	54		100

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
			1977	D, R	global	
		673	2002	CD, D, O, R	global	N
		219				
0	20	219	1990	D	global	P
		16,866				
80	153	15,645	1982	D, M, O, R	state, federal govt	P
100	1	1,221	2000	O	Intl. Heat Flow Comm.	Y
		946,087				
70	1,553	595,030	1999	CD, D, O, R, M, MF, P	global	P
90	660	256,639	1997	CD, D, O, R, M, P	global	P
80	243	94,418	1993	CD, D, O, R, M, P	global	P
		5,659,356				
100	40	41,162	2002	G, O	partners	N
100	452	1,215,909[m]		CD, O	ODP	Y
100	194	4,285,391[m]		CD, O	DSDP	Y
100	16	5,526	1980	D, O	Washington State Univ.	N
100	7	1,973	1984	D, O	Brown Univ.	Y
100	1	7,430	2001	D, O	multiple	N

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
SIO geochemistry of FeMn nodules from the seafloor	MGG	D	37		100
SIO Southeast Asia sediment description	MGG	D	25		100
SIO polymetallic seafloor nodule description file	MGG	D	10		100
CNEXO polymetallic seafloor nodule geochemistry	MGG	D	7		100
USGS U.S. east coast CONMAR sediment data	MGG	D	4		100
CLIMAP 120K bp sediment data	MGG	D	1		100
LDEO carbon-14 data	MGG	D	.01		100
SPECMAP archive 1, downcore and core-top data	MGG	D	2		100
LDEO carbonate data	MGG	D	3		100
Brown University carbonate data	MGG	D	3		100
LDEO foraminiferal data	MGG	D	3		100
Digital sediment thickness database	MGG	D	56		100
JODC seafloor sediment data	MGG	D	.2		100
Deck41 surficial sediment description file	MGG	D	5		100
NOAA and MMS marine minerals CD-ROM	MGG	D	613		100
Geotechnical properties of sediment	MGG	D	2		100
GEOLIN inventory of NGDC marine geology data	MGG	D	39		100
Marine geology data reports scanned and paper	MGG	D	3,621	70,106 pages, 110 microfilm, 1 poster	100

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
100	1	2,089	1981	CD, O, D	SIO	N
100	7	1,167	1979	D, O	SIO	N
100		1,366	1977	D, O	SIO	N
100	1	1,293	1979	CD, D, O	BGRM	Y
100	3	2,150	1977	D, O	USGS	Y
100	17	1,340	1990	D, O	LDEO	Y
100	1	2,820	1990	D, O	LDEO	Y
100	12	3,189	1990	D, O	Brown Univ.	Y
100	12	1,826	1991	D, O	LDEO	Y
100	2	1,825	1991	D, O	Brown Univ.	Y
100	4	1,762	1992	D, O	LDEO	Y
100	11	6,544	2002	D	NGDC	N
100		1,121	1979	D, O	JODC	Y
100		4,968	1975	D, G, O	NGDC	N
100	73	2,043	1992	CD, O	global	N
100		33	1992	D, O	multiple	N
100	80	22,209	2002	G, O	NGDC	N
100	1,057	44,220	2002	MF, O, P, R	global	P

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Marine Trackline Geophysics					
Undersea feature names	MGG	D			100
Worldwide marine geophysical data: bathymetry, magnetics, gravity, seismic shot navigation from U.S. and international sources	MGG	D	40,820		100
Marine geophysical data from GEODAS on CD-ROM	MGG	D	600		100
NGDC worldwide marine geophysical data inventory for GEODAS database management system	MGG	D			100
Marine geophysics seismic reflection	MGG	D	26,752		0
Digital seismic reflection navigation	MGG	D	1,800		0
Southern oceans geophysical data on CD-ROM	MGG	D	600		0
Miscellaneous digital geophysical data files	MGG	D	245		0
Multichannel seismic reflection data on CD-ROM	MGG	D	600		0
SCAR seismic reflection data on CD-ROM	MGG	D	32,977		0
LDEO digitized seismic reflection negatives	MGG	D	20,192		0
Trackline geophysical data, analog	MGG	A		3,300 film, 566 pages, 7,000 negatives, 2,406 sections	0
Marine Well Log Data					
Digital DSDP and ODP downhole logs	MGG	D	3,873		0

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
		39,425				
100		826	2001	O	IOC/IHO	Y
100	1,072	38,599	2002	D	global	P
100	192		2002	CD	global	N
100	8		2002	CD, O	NGDC	N
100	7		2001	D	global	Y
100			2001	D	global	P
100	24		1994	CD	NSF, NOAA, Navy	Y
100	1			D	global	P
100			1998	CD	global	Y
100	35		1998	CD	SCAR	Y
100	27		1991	D	LDEO	Y
90	279	0	2002	MF, OS, R	global	P
		1,304				
100	22	652	2002	D	DSDP	Y

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Well log data from the U.S. outer continental shelf	MGG	D&A	484	190 reels of film	0
Satellite Data: GOES, NOAA TIROS					
GOES Space Environment Monitor (electrons, protons, alpha particles, X-rays, magnetometer)	STP	D&A	38,400	1,606 microfilm	63
GOES Solar X-ray Imager	STP	D	200,000	98,719 images	100
NOAA/TIROS satellites (electrons, protons, and alpha particles)	STP	D	44,100		0
Satellite anomalies causing spacecraft failures	STP	D	1		100
Satellite Data: DMSP					
DMSP film scans data rescue	STP	D&A	4,800,000	1,500,000 film strips	10
DMSP operational linescan system visible and infrared imager	STP	D	28,745,309		27
DMSP space sensors SSIES in situ plasma monitor, DM plasma drift meter, SSJ/4 precipitating plasma monitor	STP	D	1,976,979		24
DMSP SSM/I microwave imager, SSM/T2 microwave water vapor profiler, SSM/T microwave temperature sounder	STP	D	3,791,713		24
DMSP slides of hurricanes and typhoons, 13 slide sets	STP	A		slides	0
6 DMSP posters and 1995 Atlantic hurricanes, 1996, 1997, 1998 most intense tropical storms, nighttime lights of the U.S. and the world, Icosohedron 2000	STP	A		posters	0
DMSP nighttime lights of the world	STP	D	10,600	CD-ROM, jpeg	100

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
100		652	1990	D, MF	multiple	Y
		128,751				
	374	126,860	2002	CD, D, MF, O, R, D	NOAA	N
	0	862	2001	O	NOAA	N
	1	399	2002	O	NOAA	N
	66	630	1993	CD, D, O, R	global	N
		2,922,201				
0.10	15	5	1987	O (FTP)	NOAA	N
100	165	2,832,905	2002	O (FTP) 11.6 Gbytes/day	Air Force	N
50			2002	O (FTP)	Air Force	N
94			2002	O (FTP)	Air Force	N
	98		1998	S	NGDC	N
	5,289		2000	P	NGDC	N
100	350	52,166	1997	CD, O	Air Force	N

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
U.S. lights, road density, population density, land cover (22 layers)	STP	D	1,270		100
DMSP fire product	STP	D			
Solar Data					
Relative sunspot numbers	STP	D&A	36	58,000 paper files, slides	90
Regions of solar activity	STP	D	678		90
Solar radio flux, bursts, spectral data	STP	D&A	77,006	426 boxes, 50,460 paper, 604 microfilm	8
Solar flares in hydrogen-alpha (includes SOON data)	STP	D&A	9,043		10
Solar longitudinal magnetic field	STP	D&A	46	13,550 paper	10
Solar H-alpha faculae, prominences, and filaments	STP	D&A	17	7,578 microfilm UAB-100	2
Solar calcium K line	STP	D&A	19	12,000 paper	10
Solar maps, prominences, filaments	STP	D&A	3,046	26,740 paper	80
Optical observations of solar corona	STP	D&A	27	6,580 paper	80
Solar ultraviolet data from satellites	STP	D&A	10	448 microfilm	100
Observations of interplanetary scintillations or solar wind speed	STP	A		604 paper	0
Total solar irradiation	STP	D&A	33	18 paper	100
Solar-Terrestrial Publications					
Solar geophysical data publications	STP	D&A	1,456	311,040 pages	6
Solar Indices Bulletin	STP	D&A	0.5	1 report per month	0

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
100	75	12	2001	CD, O	various	P
	2	37,113	2002		NGDC	N
		689,525				
	152	120,180	2002	D, O, R, S	global	P
	13	49,522	2002	CD, D, O, R	global	P
	1,551	50,340	2002	CD, MF, O, R	global	P
	67	44,180	2002	CD, D, O, R	global	P
		8,894	2002	O, R	various	Y
		1,806	2002	CD, D, MF, O, R	global	Y
	7	2,363	2002	CD, D, O, R	various	P
		34,022	2002	O, R	various	P
	1	4,822	2002	O, R	various	Y
	1	2,072	2002	MF, O, R	various	Y
	2		2001	R	various	Y
	30	11,812	2002	O, R	various	Y
		87,038				
	3,241	71,761	2002	O, R	NGDC	N
	2,100		2002	O, R	NGDC	N

(continued)

Appendix C—NGDC Holdings *Continued*

Dataset/Category Name	Type[a]	Digital (D) or Analog (A)	Volume (Mbytes)	Analog Size	% Online
Geomagnetic Indices Bulletin	STP	D&A	0.5	1 report per month	0
UAG reports	STP	D&A	1	105 reports	10
Solar variability affecting Earth (NGDC-05/01) CD-ROM	STP	D	600		spidr

[a] MGG = Marine Geology and Geophysics; SEG = Solid Earth Geophysics; STP = Solar-Terrestrial Physics.

[b] Fraction of the dataset being actively used.

[c] The number of accesses in discipline header bars may differ from the sum of accesses by dataset, because accesses are sometimes unable to be differentiated by dataset.

[d] Year that data were last added to the dataset.

[e] CD = CD-ROM; D = digital offline; FTP = file transfer protocol; G = geographic information system; M = map; MF = microform; O = online; OS = oversize chart; P = poster; R = report; S = slide.

[f] BGRM = Bureau de Recherches Geologiques et Minieres; CHS = Canadian Hydrographic Service; CONMAR = Continental Margin (USGS); DMSP = Defense Meteorological Satellite Program; DOD = Department of Defense; DSDP = Deep Sea Drilling Program; GEODAS = geophysical data management system; GEOLIN = marine geology inventory system; GLERL = Great Lakes Environmental Research Laboratory (NOAA); GOES = Geostationary Satellites; IHO = International Hydrographic Organization; IOC = Intergovernmental Oceanographic Commission; JODC = Japan Oceanographic Data Center; LDEO = Lamont Doherty Earth Observatory; MMS = Minerals Management Service; NASA = National Aeronau-

% Used[b]	Number of Offline Users (10 years)	Number of Online Users (FY 2002)[c]	Last Available Year[d]	Form Distributed[e]	Data Source[f]	Replicated[g]
	1,120		2002	O, R	NGDC	N
	360	15,277	1998	O, R	NGDC	N
	17		1996	CD, O, R	global	Y

tics and Space Administration; NCAR = National Center for Atmospheric Research; NOS = National Ocean Service (NOAA); NSF = National Science Foundation; ODP = Ocean Drilling Program; POGS = Polar Orbiting Geomagnetic Satellite; SCAR = Scientific Committee on Antarctic Research; SIO = Scripps Institution of Oceanography; SOON = Solar Observing Optical Network; TIROS = Television Infrared Observation Satellite; UAG = Upper Atmosphere Geophysics Report Series; USGS = U.S. Geological Survey.

[g] N = not replicated; P = partially replicated; Y = fully replicated.

[h] 80 percent of archive is available nearline.

[i] Now limited to significant events.

[j] No longer active archive.

[k] NGDC now refers requests for digital data to the Smithsonian.

[l] No longer available.

[m] Excess accesses due to large number of files in set; the same is true for many directories in all disciplines.

Appendix D

NOAA, NESDIS, and NGDC Missions, Visions, and Strategic Objectives

NGDC MISSION AND VISION

NGDC Formal Mission Statement

The National Geophysical and Solar-Terrestrial Data Center[1] acquires, processes, archives, analyzes, and disseminates solid Earth and marine geophysical data as well as ionospheric, solar, and other space environment data; develops analytical, climatological, and descriptive products to meet user requirements; and provides facilities for World Data Center-A (Solid Earth Geophysics, Solar Terrestrial Physics, and Glaciology).

(a) Geophysical and solar-terrestrial data available from NGSDC include:

(1) *Marine geology and geophysics*. Bathymetric measurement; seismic reflection profiles; gravimetric measurements; geomagnetic total field measurements; and geological data, including data on heat flow, cores, samples, and sediments.

(2) *Solar-Terrestrial physics*. Ionosphere data, including ionograms, frequency plots, riometer and field-strength strip charts, and tabulations; solar activity data; geomagnetic variation data, including magnetograms; auroral data; cosmic ray data; and airglow data.

[1] NGDC was named the National Geophysical and Solar-Terrestrial Data Center from 1972 to 1982.

(3) *Seismology*. Seismograms; accelerograms; digitized strong-motion accelerograms; earthquake data list (events since January 1900); earthquake data service with updates on a monthly basis.

(4) *Geomagnetic main field*. Magnetic survey data and secular-change data tables.[2]

NGDC Web Site Statement

The National Geophysical Data Center's mission is data management in the broadest sense. We play an integral role in NOAA's environmental research and stewardship, and provide data services to users worldwide.[3]

NGDC Functional Statement

The National Geophysical Data Center conducts a data and data-information service in all scientific and technical areas involving solid earth geophysics, marine geology and geophysics, glaciology (snow and ice), the space environment, solar activity and the other areas of solar-terrestrial physics. The scientific specialties treated include seismology, geomagnetism, topography, bathymetry, paleoclimatology, gravimetry, earth tides, crustal movement, geothermics, glaciology, ionospheric phenomena, solar activity and related areas. The services are provided for scientific, technical, and lay users in governmental agencies, universities and the private sector in the U.S. and their counterparts in foreign countries. The Center prepares systematic and special data products and performs data-related research studies to enhance the utility of the service to the users. It performs all functions related to data acquisition, archiving, retrieval, indexing, quality assessments, evaluation, synthesis, dissemination, and publication. The Center operates World Data Center-A for the respective scientific areas listed above under the auspices of the National Academy of Sciences. It performs necessary liaison with other NOAA components and with national and foreign contributors and users of data and information about data. The Center coordinates with other NESDIS data centers and with data centers outside of NOAA in areas of related scientific and technical concern to achieve a useful degree of homogeneity in the data services in the environmental sciences and to avoid duplication of effort. It takes part in jointly planning national and international scientific programs to assure that data collection and management needs are adequately considered.[4]

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[2] 15 CFR Ch IX (1-1-97 edition) §950.5.

[3] <www.ngdc.noaa.gov/ngdcinfo/aboutngdc.html>.

[4] *NOAA Organizational Handbook*, <http://www.rdc.noaa.gov/~ohb/E/EH0000.html>.

NGDC Vision

To be the preeminent national stewards of geophysical and relevant environmental data, and to transform these data, using pioneering scientific thought and cutting-edge technology, into effective information necessary to secure a sustainable, flourishing future for our nation and world.

This vision requires:

- Building authoritative long-term archives
- Acquiring satellite and other emerging data streams
- Providing unrivaled data access analysis and integration
- Contributing to significant scientific research
- Forging new partnerships
- Energizing outreach efforts
- Creating an invigorated environment in which our talented workforce can excel[5]

NESDIS MISSION, VISION, AND STRATEGIC OBJECTIVES

NESDIS Mission

To provide and ensure timely access to global environmental data and information services from satellites and other sources to promote, protect, and enhance the nation's economy, security, environment, and quality of life.[6]

NESDIS Vision

To be the source for the world's most comprehensive and easily accessible satellite products, environmental information, and assessments of the environment.[7]

NESDIS Strategic Objectives

1. Enhancing operational satellite sensing systems
2. Promoting critical environmental data and information services

[5] Presentation to the committee by Michael Loughridge, director, NGDC, August 13, 2002.

[6] Department of Commerce, 2001, *A Strategic Plan for NOAA's National Environmental Satellite, Data, and Information Service (NESDIS)*, National Oceanic and Atmospheric Administration, Silver Spring, Md., p. 4.

[7] *Ibid.*, p. 5.

3. Ensuring a world-class workforce
4. Executing sound and strategic resource management
5. Improving understanding through outreach
6. Improving weather products and services
7. Extending climate services
8. Improving coastal services
9. Providing operational ocean services
10. Saving lives and property through hazards support.[8]

NOAA MISSION, MISSION STRATEGIES, AND VISION

NOAA Mission

To understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet the Nation's economic, social, and environmental needs.[9]

NOAA Mission Goals

1. Protect, restore and manage the use of coastal and ocean resources through ecosystem management approaches.
2. Understand climate variability and change to enhance society's ability to plan and respond
3. Serve society's needs for weather and water information
4. Support the nation's commerce with information for safe and efficient transportation.[10]

NOAA's Crosscutting Priorities

- Integrated global environmental observation and data management system
- Environmental literacy, outreach, and education
- Sound, reliable state-of-the-art research
- International cooperation and collaboration
- Homeland security

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[8] *Ibid.*, pp. 14-26.
[9] Department of Commerce, 2003, *New Priorities for the 21st Century: NOAA's Strategic Plan for FY 2003 - FY 2008 and Beyond*, National Oceanic and Atmospheric Administration, January 16, 2003 draft, p. 1, <www.osp.noaa.gov/docs/publicdraft.pdf>.
[10] *Ibid.*, p. 2.

- Organizational excellence: facilities, infrastructure, security, human capital and administrative services.[11]

NOAA Vision

To move NOAA into the 21st Century scientifically and operationally, in the same interrelated manner as the environment that we observe and forecast, while recognizing the link between our global economy and our planet's environment.[12]

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[11] *Ibid.*, pp. 11-15.
[12] *Ibid.*, p. 1.

Appendix E

NGDC Performance Measures and Milestones

PERFORMANCE MEASURES AND MILESTONES FROM THE FY 2002 NESDIS ANNUAL OPERATING PLAN

Performance Measure	Milestone
Environmental data archived	90% of scientifically significant data archived under NARA-recommended standards
Environmental data made readily accessible	55% of scientifically significant archived data made readily accessible
Archived environmental data sets that are systematically quality controlled using scientifically-based standards	20% of quantity archived data sets having quality control processes in place
Environmental assessments produced that respond to priority national policy or environmental monitoring needs	One assessment per year per data center
Customer services satisfaction level	A customer satisfaction index of at least 75% across all of our services as measured by our customer service survey
Increase number of signed/approved individual development plans for NESDIS by 20% per year	Establish IDPs for all interested current employees and for all new employees

(continued)

Continued

Performance Measure	Milestone
100% of NESDIS supervisors receive required training	Ensure new supervisors have taken, or are scheduled for, training
Yearly, all hands have face to face communications with NESDIS assistant administrator and deputy assistant administrator	Conduct annual "all hands" meeting with senior management at all NESDIS locations
Ensure a safe workplace	Implement the "safety first" program at NGDC
Produce a new state of the environment product	State of the space-weather normals available on the Web
Increase collaborative and participatory activities which support coastal issues	Complete coastal relief model for the U.S. west coast
Establish and provide mechanism for multi-agency collaborative projects in hazards support involving key stakeholders	Complete conterminous U.S. coastal relief model, integrating USGS topography with NOS hydrography for a base layer to hazard modeling such as flooding, storm surge, and tsunami

NOTE: IDP = individual development plan; NARA = National Archives and Records Administration; NESDIS = National Environmental Satellite, Data, and Information Service; NGDC = National Geophysical Data Center; USGS = U.S. Geological Survey.

PERFORMANCE MEASURES AND MILESTONES FROM THE NGDC FY 2002 ANNUAL MANAGEMENT CONTRACT

Performance Measure	Milestone
Increase user access to NOAA/non-NOAA data sources for coastal data	Assume role of primary long-term archive of full-resolution digital NOS hydrographic sounding data
	Refine design of long term archive of NOS shallow water multibeam bathymetry, digital side scan sonar and associated acoustic backscatter data
Increase collaborative and participatory activities which support coastal issues	Collaborate with NMFS to provide NESDIS assistance on needed environmental information technologies, methods and data
	Complete coastal relief model for the U.S. west coast
NESDIS will annually review and update 20% of existing metadata records per year	Report to NESDIS the number of metadata records updated
NESDIS will migrate 10% of its digital data to current accepted archive media every year in accordance with best business practices	Data centers will develop a tape migration plan and will report percentage of media migrated
The availability of on-line NESDIS data sets and products will increase by 10% each year	NESDIS will report annually its achievements and shortfalls in providing online access to high priority environmental data
	Report status of customer demand as measured by requests for data and information
	Report on data delivered online
	Ingest, assess data quality and archive space weather data from global network of ionosondes, solar telescopes, magnetic variation observatories and cosmic ray observatories, ~3 MB per day
	Develop, using COTS, a map server, to support mapping NVDS/NNDC data using the standards-based Open GIS Consortium viewers. This effort will be expanded to support other data

(continued)

Continued

Performance Measure	Milestone
Develop new products to describe the state of the environment	Develop new climate, ocean, and space environment baseline indices
Establish and provide mechanism for multi-agency collaborative projects in hazards support involving key stakeholders	Complete conterminous U.S. coastal relief model, integrating USGS topography with NOS hydrography for a base layer to hazard modeling such as flooding, storm surge, and tsunami
Increased utilization of retrospective data for multi-hazard risk management	Expand hazard brochure into a web-based product, complete with internal NESDIS links
Operationalize web search, subset, and custom CD-ROM capability	Capability implemented for GLOBE elevation, DMSP night-lights, marine survey data, and ecosystems data
New NGDC focus clearly defined in report to NGDC staff and NESDIS	Identify new program thrusts supporting NESDIS or NOAA missions
	Identify current programs which have been discontinued or transferred
Reposition Paleoclimate Program into NGDC's fiscal structure	Identify funding level and support for paleoclimatology
Participate in current or new NOAA or NESDIS data rescue programs as appropriate	Ingest and archive of 250 GB of DMSP film scan data from NESDIS' CDMP
Produce a new state of the environment product	State of the space-weather normals available on the Web
	Develop a sea ice index prototype
Consolidate existing global relief models into one for use as framework data set	Global digital elevation model in GIS compatible format available on appropriate media
Provide NGDC staff to support the NOAA efforts in alternate dispute resolution	Requested mediations performed
Percent of operational satellite products assimilated into user systems	Identify JCSDA tasks needed to optimize satellite data usage in space weather models and applications

Continued

Performance Measure	Milestone
	Ingest and archive all space environment monitoring data from NOAA POES and GOES satellites (~30 MB/day)
	Ingest and archive all raw data records and designated products from the DMSP satellites (~20 GB/day)
	From the SXI sensor operating at full capacity: archive 8640 images/day totaling 2.3 GB per day
100% of NESDIS office/center identifying 0.25 FTE and associated resources committed to outreach	Identify office/center contact person for outreach activity
	Establish office/center space for storage of outreach materials
Increase website accesses NESDIS-wide by 10% per year	Identify main office/center and program web pages
	Develop corporate (NESDIS identifier) web look and incorporate NESDIS web look on main office/center pages
100% of office and center director's use the annual resource plan form to document their program requirements throughout the program and budget development cycle	Prepare the initial FY 2002 annual resource plans for each office and center director for signature approval by the AA and the office and center directors
	Prepare the FY 2003 annual resource plans for each office and center director for the FY 2003 President's budget
	Prepare the FY 2004 annual resource plans for each office and center director for the FY 2004 DOC budget submission
Allow on-line access to satellite reference data sets and spectral demo sets to 100 users at any given time and improve this capacity by 25% each year	Develop a plan to establish on-line access to reference datasets that describe the near-Earth space environment
Increase number of signed/approved IDP's for NESDIS employees by 20% per year	Establish IDP for all interested current employees, and for all new employees

(continued)

Continued

Performance Measure	Milestone
100% of NESDIS supervisors receive required training	All supervisors will have supervisory training within one year of appointment
Implement alternate work schedule program	Implement alternate work schedule program
Support NOAA's second survey feedback action program	Achieve at least 80% employee participation in survey feedback action program
	Complete at least 50% of the action plans
Yearly, all-hands have face-to-face communications with AA and DAA. More frequent meetings with office directors, division chiefs	Conduct annual "all hands" meeting with senior management
	Create and sustain an effective internal organizational communications process
Define a safety plan for NGDC	Implement the "safety first" program at NGDC

NOTE: AA = NESDIS assistant administrator; CDMP = Climate Database Modernization Program; COTS = commercial off-the-shelf; DAA = NESDIS deputy assistant administrator; DMSP = Defense Meteorological Satellite Program; DOC = Department of Commerce; FTE = full-time equivalent; GIS = geographic information system; GLOBE = Global Learning and Observations to Benefit the Environment Program; GOES = Geostationary Satellites; IDP = individual development plan; JCSDA = Joint Center for Satellite Data Assimilation; NESDIS = National Environmental Satellite, Data, and Information Service; NGDC = National Geophysical Data Center; NMFS = National Marine Fisheries Service; NNDC = NOAA national data centers; NOAA = National Oceanic and Atmospheric Administration; NOS = National Ocean Service; NVDS = National Virtual Data System; POES = Polar Orbiting Satellites; SXI = Solar X-ray Imager; USGS = U.S. Geological Survey.

Appendix F

Acronyms

AGU	American Geophysical Union
CIRES	Cooperative Institute for Research in Environmental Science
CORS	Continuously Operating Reference Stations
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
DOE	Department of Energy
FTE	full-time equivalent
FY	fiscal year
GPS	Global Positioning System
ISD	Information Services Division
LDEO	Lamont Doherty Earth Observatory
MGG	Marine Geology and Geophysics
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NESDIS	National Environmental Satellite, Data, and Information Service
NGDC	National Geophysical Data Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOS	National Ocean Service
NPOESS	National Polar-Orbiting Operational Environmental Satellite System

NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
OMB	Office of Management and Budget
PI	principal investigator
PRA	Paperwork Reduction Act of 1995
SEG	Solid Earth Geophysics
STP	Solar-Terrestrial Physics
USGS	U.S. Geological Survey
WDC	World Data Center