Twenty Years of Support for Seismological Research

The IRIS Consortium

1984 – 2004

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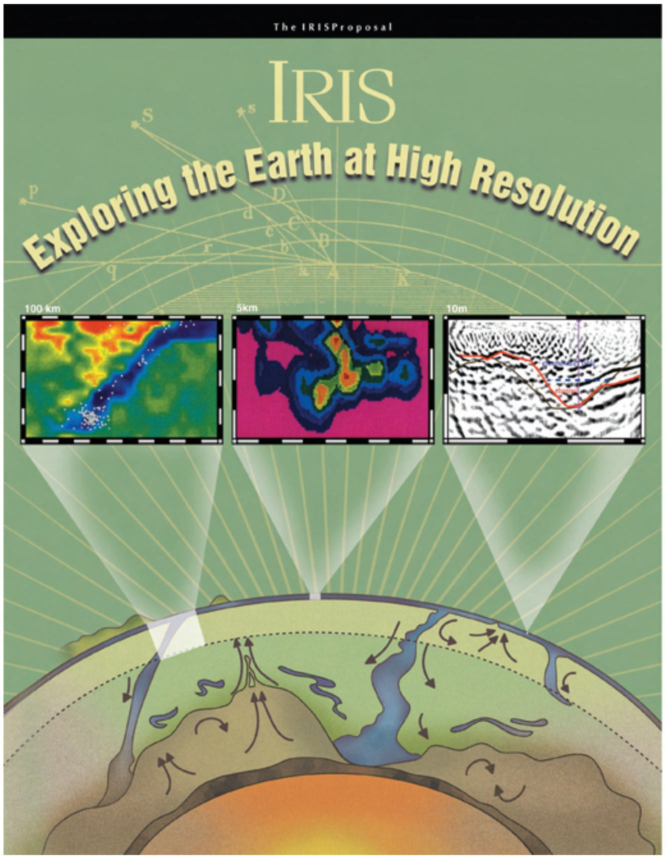

A facilities program to support Research and Education in the Earth Sciences through the collection and distribution of seismological data for studies of:

- Earthquakes
- Earth Structure
- Earth Dynamics
- Verification of the Comprehensive Nuclear Test-Ban Treaty

IRIS NSF

Cover of the proposal that formed the basis for the 2001- 2006 Cooperative Agreement between IRIS and the National Science Foundation.

The IRIS Consortium
June, 2004

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Introduction

This report was prepared in February, 2004 as part of a review being carried out mid-way through the third year of the fourth five-year Cooperative Agreement (2001-2006) between the National Science Foundation (NSF) and the Incorporated Research Institutions for Seismology (IRIS). As stated in the request for the review, its purpose is "to assess the quality and effectiveness of IRIS management and leadership."

This report is intended to complement other materials and mechanisms through which NSF carries out ongoing review of IRIS and its programs. These include:

- **Five-Year Proposals**: The IRIS programs for development and operation of facilities for seismological research have been funded through five-year Cooperative Agreements with NSF. Each of these has been based on a comprehensive proposal that presents the scientific rationale for IRIS core programs; the proposed evolution of the facility; budgets for capital improvements, operations and maintenance; and the governance, organizational and management structure under which the consortium and facilities will be operated. The review process for each of these proposals has included extensive mail review by 10-30 external reviewers, followed by review and site visits by both the regular panel of the Instrumentation and Facilities Program of the Earth Science Division and a Special Emphasis Panel convened especially to review the IRIS proposal. In addition to a detailed description of the IRIS facilities, these proposals have included a lengthy section of "one-pagers" that presents the results of numerous investigations documenting recent scientific results based on the use of IRIS data and resources.

- **Annual Program Plans and Budgets**: As part of the procedures specified in the Cooperative Agreement, every year IRIS is required to provide NSF with an Annual Report, Program Plan and Budget that describes the activities and expenditures for the past year and the proposed activities and budget for the following year. This proposed plan is developed by IRIS, within the context of the five-year plan, based on input from the program Standing Committees and approval by the Executive Committee of the IRIS Board of Directors. Approval by NSF is the basis for incremental funding of IRIS programs on an annual basis.

In addition to the annual and five-year reviews by NSF, the IRIS programs undergo continual evaluation and evolution through input from the university research community and Consortium members. This community review and oversight takes place through the IRIS committee structure, and member participation at Annual Workshops and special meetings. The activities of the Consortium and the state of the IRIS facilities are communicated to the membership through the IRIS web site, an Annual Report and print and electronic newsletters.

In this review, emphasis is placed on the history and evolution of the Consortium and its programs, and the structure for involvement of the membership and broader research community in the governance and management of IRIS. This document does not contain detailed descriptions of either the technical aspects of the facilities or the scientific results that have emerged from their use. For those interested in more information on these topics, the IRIS web site, www.iris.edu (see Appendix III), contains extensive information on the status and use of the facilities, and the publications and bibliography listed in Appendix IV document the scientific rationale and results.

IRIS Articles of Incorporation
May 8, 1984

Purposes:

- to promote and conduct geophysical investigation of the earth's interior using seismic and other geophysical methods;
- to promote the exchange of information and knowledge and to create, foster, and encourage cooperative efforts between the members of the Corporation and other organizations, research workers, students and other institutions involved in the area of the study of earth sciences;
- to solicit, raise and receive funds for the advancement and furtherance of the foregoing purposes; and
- to do any other acts that may further the general purposes of the Corporation as set forth herein.

IRIS – Then and Now

Formation and Incorporation

The idea for the IRIS Consortium grew from the merging of two independent interests identified by the academic seismology community in the early 1980s. One group was interested in an upgraded global digital seismic network that would expand and modernize the aging and under-funded World Wide Standard Seismographic Network (WWSSN). The other group was interested in developing a new generation of portable seismic instruments for seismological studies of the continental lithosphere. Both of these initiatives were guided by reports from a series of important studies carried out by the National Academy of Sciences and its Committee on Seismology on future instrumentation and data needs in seismology and the Earth sciences (Figure 1). Additional encouragement came from a key report from the Committee on Science, Engineering and Public Policy in 1983 that identified "five research areas in which significant dividends can be expected as a result of incremental federal investment in FY1985" including "seismic investigations of the continental crust" and "a global digital seismic array."

Figure 1. A series of important studies by the National Academy of Sciences and its Committee on Seismology in the late 1970s and early 1980s culminated in reports that provided the scientific and technical basis for new observational and data facilities in seismology and Earth sciences.

After a year of intense activity that included numerous workshops and planning meetings, the US seismology community joined together in 1984 to form a new consortium to develop and implement plans for an ambitious new set of facilities to support a wide range of seismological research. The IRIS Consortium was formally created as a not-for-profit corporation in the State of Delaware on May 8, 1984 with a broad mandate, as stated in the Articles of Incorporation, to pursue the development of new resources to support seismological and geophysical investigations (see box on opposite page).

One of the first activities of the corporation was to develop a ten-year proposal that laid out the seismology community's vision. In December 1984, IRIS submitted to the National Science Foundation the "Rainbow Proposal" entitled *Imaging the Earth's Interior: Detailed Studies of the Earth and of the Seismic Source with New Global and Transportable Arrays* (Figure 2). This proposal requested $107 M for the initial five years, and $281 M for the full ten years of activities, which included the development of a Global Digital Seismic Array, a Mobile Array for continental lithosphere studies, Central Data Management and Distribution Facilities, and a Major Computational Facility (see box on page 4).

IRIS Today

Twenty years later, in 2004, IRIS has grown from its 26 original members to a consortium of 101 Members, two US Affiliates, more than 40 International Affiliates and four Educational Affiliates (Figure 3). Three of the initial four major national facilities outlined in the 1984 Rainbow Proposal have been nurtured by IRIS and the community. The rapid evolution of supercomputer facilities obviated the need for a dedicated seismological computational facility, and IRIS data resources

IRIS Proposal to NSF, 1984

Imaging the Earth's Interior

Executive Summary

Our Earth's interior remains one of man's major scientific frontiers. Inaccessible for direct observation beneath a 10-15 km drilling range, Earth's lower crust, mantle and core are seen primarily through illumination by seismic waves.

In a major departure from the traditional single investigator approach to research support, the seismological community has, in 1984, created a consortium of research institutions for the purpose of implementing critically needed national facilities necessary to support seismological research on Earth's interior in the coming decades. IRIS, the Incorporated Research Institutions for Seismology, a non-profit Delaware corporation, was founded May 8, 1984. By the first meeting of the Board of Directors on May 13 there were twenty-six members of the Corporation. As this proposal is submitted, membership includes forty universities, a representation of nearly all U.S. universities with seismological research programs.

A universities consortium of such size and degree of participation represents a unique and remarkably unified commitment to the common research goals addressed by IRIS. A list of member institutions and representatives is given in the Foreword.

This proposal is for support of the ten-year IRIS program for the implementation of four major national facilities for seismology,

- A Global Digital Seismic Array, featuring real-time satellite telemetry from one hundred modern seismographic observatories
- A Mobile Array comprised of one thousand portable digital seismographs to be used for studies of the continental lithosphere
- Central Data Management and Distribution Facilities to provide rapid and convenient access to the data sets for the entire research community
- A Major Computational Facility, capable of supporting the analyses of these new data

The IRIS program is set out in Table 1.1 in a ten-year plan, with budget estimates assuming major capital equipment acquisition in the initial five years. Steady-state operation of the four IRIS elements is estimated to require a minimum of some $17M per year in facilities maintenance and operation, plus $7M annually in equipment acquisition, and a $8M yearly increment in funds for associated research support to individual investigators. The estimated ten-year cumulative cost to bring the IRIS initiative into full operation is $281M, of which nearly 30% represents capital equipment.

Actual expenditures may well exceed this estimate. For example, a fully supported computational facility with Class VI or greater capabilities can alone cost $15M per year. Other NSF programs and other agencies will very likely support major enhancements to the basic IRIS plan.

The IRIS plan offers an NSF response to two of the five research areas identified by the Foundation's Research Briefing Panel on the Solid Earth Sciences initiatives, "...in which significant dividends can be expected as a result of incremental federal investment in FY1985." IRIS represents a consortium made up of an overwhelming majority of the research universities in seismology supporting new initiatives in these areas.

IRIS was created to implement major new national facilities which will provide the tools of earth scientists into the next century, and to develop an effective management for this collective use by the research community. This proposal represents the positive response of the seismological community to clearly-defined needs, and it offers NSF an action plan to develop these exciting areas of the solid earth sciences.

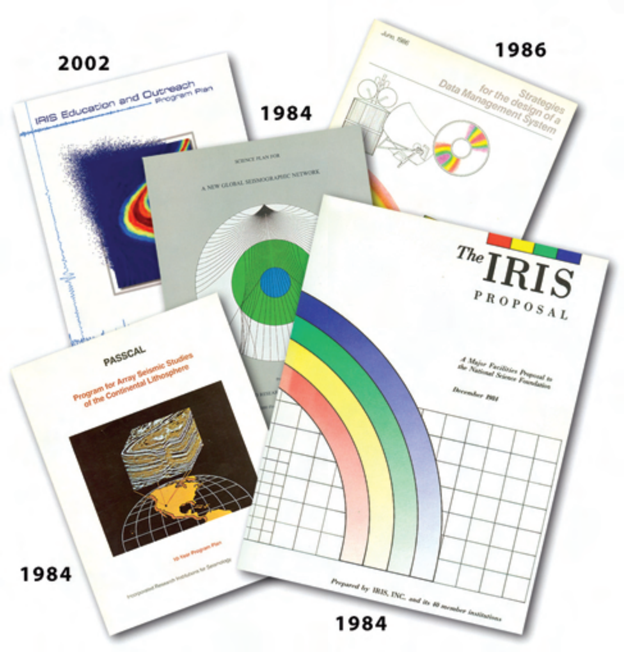


Figure 2. The 1984 "Rainbow Proposal" from the IRIS Consortium to the National Science Foundation built on intensive workshop and Program Plans developed in 1983-84 related to the development of a new Global Seismographic Network and a complementary Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL). Preliminary plans for data management were included in the 1984 proposal and expanded in the 1986 Program Plan for the IRIS Data Management System. Education and Outreach was added as a core IRIS program in 1998 and further defined in the 2002 Program Plan.

focused on centralized data management. With the addition of the Education and Outreach Program in 1998, the IRIS core programs currently consist of:

1. **Global Seismographic Network (GSN)**: A permanent worldwide network of over 130 broadband seismological observatories.
2. **Program for the Array Seismic Studies of the Continental Lithosphere (PASSCAL)**: A program of portable instruments and arrays for use by individual scientists for high-resolution experiments in focused areas,
3. **Data Management System (DMS)**: A data system for collecting, archiving and distributing data from IRIS facilities, as well as a number of other national and international networks and agencies.
4. **Education and Outreach Program (E&O)**: A program designed to integrate research and education by making our data and science accessible to non-seismologists through a variety of innovative programs.

The GSN and PASSCAL are complementary programs and the primary tools for acquisition of new data. The GSN, along with other cooperating networks, provides a baseline resolution of approximately 1000 to 2000 km on the continents and oceanic islands worldwide. Denser deployments of the PASSCAL instruments allow investigations of focused targets with resolution on the order of hundreds of kilometers down to the sub-meter scale. The DMS and E&O are also complementary programs and the primary means of distributing data for research and education. By combining and distributing data from different sources, the DMS allows individual investigators to assemble data products tailored to their research objectives. The DMS also serves as a forum to coordinate international cooperation, set data and software standards, and promote data exchange.

As these core facilities have grown, so has the demand from the seismological community for the services and products that they provide. IRIS facilities, products and services are now essential for the progress of a large proportion of seismological research funded by the NSF, USGS, DoD, and other US government agencies with programs in the Earth sciences and nuclear monitoring. IRIS facilities and data are also making new styles of scientific investigation possible. A constant goal of IRIS is to improve operation and efficiency of the existing core IRIS facilities.

From the beginning, IRIS facilities and products have also been used for educational purposes. Educators use seismograms or earthquake data obtained from the DMS in the classroom, construct public displays of "live" seismological

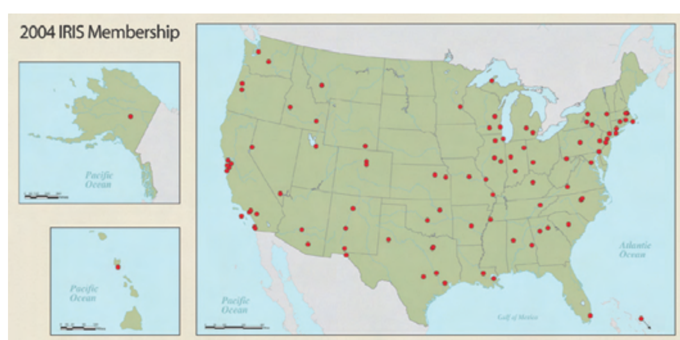


Figure 3. The 101 full members of the IRIS Consortium now represent most universities in the United States with "major commitment to research in seismology and related fields." A full list of the institutional members and their representatives on the IRIS Board is included in Appendix I.

data from the GSN, and introduce students to field work and research through participation in PASSCAL deployments. Following the advice of reviewers of the 1996 IRIS proposal, and recognizing the opportunity that IRIS has to facilitate the use of many types of seismological data for educators, in 1998 IRIS established the Education and Outreach (E&O) Program to better address this the need for educational materials and services. The E&O Program integrates seismological data with educational programs and public outreach, making IRIS data available and usable, not only for research seismologists, but also for educational institutions and the interested public. The E&O Program also plays an important role in translating scientific results on Earth structure and dynamics into terms meaningful and accessible to the general public.

IRIS and EarthScope

The role of the IRIS Consortium in the broader seismological and geophysical research communities in the United States has continued to expand. IRIS has become an organization that successfully facilitates collaboration and cooperation among seismologists and other Earth scientists. As a consortium of universities, IRIS has been able to develop, present and promote initiatives that have broad support in the academic Earth science community. To that end, IRIS has joined with a broad sector of the Earth science community in the development of EarthScope, a major new NSF-funded initiative that includes a new generation of facilities for seismology and geodesy. EarthScope will combine enhanced geodetic observations in the western United States (Plate Boundary Observatory, PBO), a continental scale seismic array (USArray) and *in situ* studies of an active fault zone (San Andreas Fault Observatory at Depth, SAFOD) to provide fundamental new insights into earthquake processes and the structure, evolution and deformation of North America. The IRIS Consortium has joined with UNAVCO, Inc., Stanford University and the US Geological Survey to implement the observational systems that form the foundation of EarthScope.

The USArray component of EarthScope consists of continental-scale, portable seismic arrays that will map the structure and composition of the North American continent and the underlying mantle at high resolution. Through its three elements—the Transportable Array, the Flexible Array, and the Backbone Network—USArray will be able to capture images that span the continuous range of scales from global, through lithospheric and crustal, and from regional to local, complementing and extending the reach of the GSN and PASSCAL facilities. USArray will be implemented through extensions to the existing four IRIS core programs, and represents an approximate doubling of the current IRIS infrastructure in terms of number of instruments and data volume. An exciting aspect of USArray is that virtually every educational institution in the United States will have the opportunity to take an active role in the investigation.

Consortium Activities and Support

As a Consortium, IRIS serves as a forum for exchanging ideas, setting community priorities and fostering cooperation. To enhance this role, IRIS engages the broader community through workshops, publications (Figure 4) and the Web. The Annual IRIS Workshop, usually held in June with an attendance of approximately 200, is a forum to review the IRIS facilities and to assess the state of key areas within the science. Seismological and interdisciplinary topics are included in science talks and poster sessions. Many of these sessions have focused on regions of current PASSCAL and GSN studies, with a special emphasis on linking the seismological studies with other geoscience disciplines. Other science sessions have proposed new directions for the evolution of IRIS programs or the development of new initiatives. For example, sessions on USArray and the Plate Boundary Observatory at Annual Workshops in 1995 and 1998 (followed by IRIS Newsletter articles in 1998) were part of the early stages in the development of EarthScope. The Workshops also include program reviews, tutorials, demonstrations and "Special Interest Groups" (SIGs) to provide IRIS staff and committee members the opportunity to present program activities and explore new directions. Some workshops have been preceded by one-day short courses on data management, instrumentation, software and teacher training. In addition to the Annual Workshop, special topical workshops are supported on an *ad hoc* basis.

The IRIS Newsletter, published two to three times per year from 1990 to 2000, and the DMS Electronic Newsletter, which began in 1999, report on the activities of IRIS and related organizations and present articles on recent developments in seismology (find both at www.iris.edu/about/publications.htm).

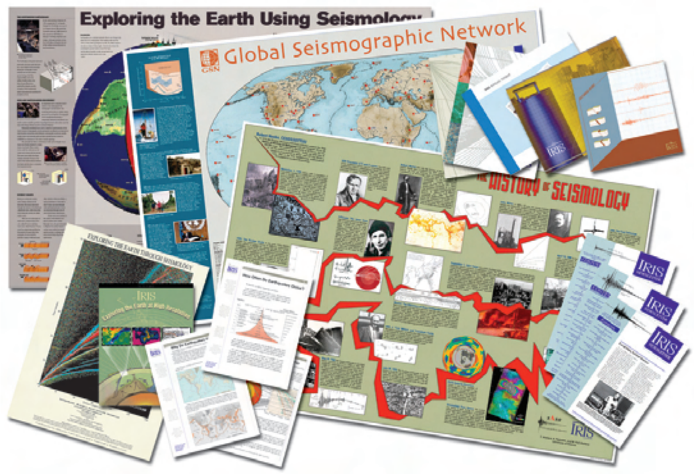


Figure 4. IRIS publications include the Newsletter, Annual Reports, educational "one pagers" and posters, proposals and reports. High-resolution versions of the educational materials are available on the IRIS web site and printed copies are provided free of charge to teachers.

The IRIS Annual Report, with a distribution of 2000, summarizes each year's activities for Consortium members, funding agencies and the public. The Education and Outreach Program publishes a variety of supplementary curriculum materials for use by teachers, including posters and topical one-pagers (both English and Spanish versions are available, www.iris.edu/edu/onepagers.htm). Even the IRIS five-year proposals, in addition to their role in the NSF review process, have been used as a way to engage the community in setting priorities and reviewing recent accomplishments in seismology and the geosciences. The extensive collections of one-page science summaries in the past two proposals have been used in classrooms and graduate seminars as broad summaries of current research in seismology. The IRIS web site (see Appendix III) serves multiple purposes: acting as a portal to IRIS data and services; providing links to other resources and organizations in seismology; and outlining the activities of the Consortium. An IRIS bulkmail service is used to keep registered users informed of IRIS activities, employment opportunities and items of special interest to the seismological community.

There have also been ways in which IRIS, through the breadth of the Consortium membership and the reach of its global programs, has been influential in impacting areas of seismological research that extend beyond its core facilities:

- **Standards for instrumentation and data formats**: In the early stages of the IRIS programs, careful consideration went into the specification of design goals for seismometers and data loggers and standard formats for data exchange. Instruments from a number of manufacturers, produced to meet the specifications of the IRIS GSN and PASSCAL design goals, have become the *de facto* standard for broadband equipment worldwide. This has greatly increased the quality of global seismological information and facilitated the exchange of data. IRIS involvement in the establishment and on-going activities of the international Federation of Digital Seismograph Networks (FDSN) has also facilitated the exchange of global data.

- **Nuclear test monitoring**: Working with the Natural Resources Defense Council, UC San Diego and the USGS, IRIS played a major role in establishing agreements with the Soviet Academy of Sciences to allow the installation of modern seismic stations, as part of the GSN, throughout the Soviet Union in the late 1980s. For the first time, seismic data were available from large parts of Eurasia that had been previously closed to foreign scientists. IRIS has continued to play an important role in calling for open release of data from international treaty monitoring networks and there is growing collaboration between the GSN and the International Monitoring System being established for the Comprehensive Nuclear Test Ban Treaty.

- **Re-use of undersea cables**: The GSN has been a pioneer in the use of retired commercial telecommunication cables for scientific observations on the seafloor. The H2O observatory has been established on the seafloor, mid way between Hawaii and California, using a cable donated by AT&T to IRIS Ocean Cable, Inc. As new technologies evolve, additional commercial cables are becoming available and there is increasing interest throughout the marine sciences community in the possible exploitation of these resources.

Facility Operation and Maintenance

As it celebrated its 50th anniversary in 2002, the National Science Foundation identified "People, Ideas, Tools" as the cornerstones of its new Strategic Plan. The inclusion of an explicit commitment to facilities as an underpinning of NSF-supported research is echoed in the Geoscience Directorate's *NSF Geo-*

sciences Beyond 2000 and *Geo Facilities Long-Range Plan*. These documents reflect a growing awareness, especially in the Earth and environmental sciences, of the need for the Foundation to balance its support of basic research with a commitment to establish and maintain the observational and data-management tools required to stimulate and support research and exploration. At the same time, by including "People" as a key element in its Strategic Plan, NSF underscores its commitment to the educational process and makes explicit the obligation to maintain the highest quality scientific workforce and present our data, results and experience to the public in ways that are stimulating and approachable.

Under Cooperative Agreement with NSF, the IRIS Consortium has established core facilities—the tools of seismology—that have become an essential part of the fabric of domestic and international research in seismology and the Earth sciences. Through careful planning and constant re-evaluation, these tools have evolved and grown in response to the changing needs of the research community. The IRIS facilities were established with a commitment to high-performance in quality of instrumentation, data resources and user services. IRIS continues that tradition of excellence, extending the facilities to higher resolution; establishing a pathway to an enduring, long-term commitment to global observations and preservation of data resources; and encouraging public and educational involvement in the excitement of seismological discovery.

A substantial investment has been made in IRIS facilities, in both hardware and software. Less tangible, but equally important, has been the investment in the human resources that make IRIS an effective and efficient organization. One of the most significant activities of the mature IRIS organization is the operation and maintenance of the capital investments that have been made in establishing its facilities. A significant challenge for IRIS and the seismology community in the future will be to maintain the support required to continue operation of the full facility (both *tools* and *people*) to support the exploration of new *ideas* essential for a healthy future of research in seismology and the Earth sciences.

With support from NSF, other US agencies and numerous national and international partners, IRIS has built a successful facility that in many ways directly realizes the vision that was articulated twenty years ago in the original IRIS proposal. IRIS, in partnership with the USGS, operates a Global Seismographic Network that in terms of geographical station distribution comes close to the network originally planned. Instrument acquisition for PASSCAL continues, bringing it close to meeting the original goals, and in many ways PASSCAL program has also exceeded its initial expectations in terms of being able to support a large variety of field experiments. The DMS has evolved into an archiving and data distribution center for IRIS and other seismological and geophysical data, with a capacity that far exceeds that originally planned.

When IRIS was established, only a half-dozen research institutions in the US could support the facilities required for cutting-edge observational seismology. The technical requirements for maintaining instruments, fielding experiments, and handling large data sets prohibited all but a fortunate few from having access to high-quality data sets and state-of-the-art instrumentation. Today, a new generation of scientists has been empowered by IRIS. Every scientist and student with a connection to the Internet now has access to data from global, regional, and local networks around the world. Any individual investigator can now propose an experiment without the burden of establishing an in-house technical capability. The past infrastructure barriers to seismology have been torn down—making our science and data available to new audiences of researchers and educators.

Consortium Structure and Governance

Structure and Roles

The IRIS governance and management structure is an interface between the scientific community, funding agencies and the programs of IRIS. The structure is designed to ensure close involvement of the research community in the development of IRIS facilities, to focus scientific talent on common objectives, to encourage broad participation, and to effectively manage IRIS programs. Community involvement in the governance and management of IRIS has been a key to the success of the Consortium. Each year, over 50 scientists from more than 30 research institutions participate in the management of IRIS through its eight regular committees, plus *ad hoc* advisory groups. These scientists work with a professional staff led by the President, Director of Planning, Director of Operations, Director of Finance and Administration, and four Program Managers to administer IRIS programs.

As a **consortium of research universities**, IRIS looks to its members to provide advice and direction on IRIS activities. Through on-going interactions with scientists at member institutions and through formal structures such as workshops, annual meetings, symposia and newsletters, the research community interacts with IRIS and, through the Consortium, expresses its evolving needs to funding agencies. From the enthusiasm and experience of its members, IRIS derives excitement and vision to guide the role that IRIS can play in supporting Earth science and encouraging forefront research.

As a **major facilities program** for NSF, IRIS works closely with the NSF Division of Earth Sciences to develop a program focused on the support of facilities on which NSF-funded seismological research is based. Through a series of Cooperative Agreements, NSF has provided funding with which IRIS, on behalf of the research community, operates and manages the core programs of GSN, PASSCAL, DMS and E&O. Since many operational aspects of the IRIS programs are closely integrated with activities at the US Geological Survey and other federal and international programs, joint IRIS/NSF coordination with these activities is also essential to maintaining an effective program.

As a **corporation**, IRIS provides the legal and fiscal structure through which NSF can interact with IRIS for the stable operation of its facilities, and a mechanism for developing programs and bringing the wishes of it members to fruition. Through its professional staff, committees and sub-awardees, IRIS provides continuity in institutional and personnel resources for operational and developmental activities.

Consortium Membership

IRIS is a 501 (c) (3) not-for-profit corporation, incorporated under the laws of the State of Delaware in 1984. The Consortium is governed by a Board of Directors consisting of representatives appointed by each of the 101 member institutions. As specified in the IRIS By-Laws, educational and not-for-profit institutions chartered in the U.S., with a major commitment to research in seismology and related fields, may become Members of IRIS. Two- and four-year colleges and universities with a commitment to teaching undergraduate Earth science, including seismology, may become Educational Affiliates. Research institutions and other not-for-profit organizations both inside and outside the US engaged in seismological research and development, which do not otherwise qualify for IRIS membership, may be elected Affiliates or Foreign Affiliates. The Board of Directors meets at least once per year, to receive a report of annual activities, elect members to the Executive Committee and transact other activities that require Board action, such as revision of the By-Laws. The Annual Meeting takes place in December during the American Geophysical Meeting in San Francisco. The By-Laws allow for special meetings of the Board to be called as required. Consortium activities also take place at the IRIS Annual Workshop, usually held in June, and partial travel support is provided to encourage participation by representatives from member institutions. Appendix I contains a list of the current 101 institutional members of the Consortium, along with their representatives on the Board of Directors, as well as the current Affiliates, Foreign Affiliates and Educational Affiliates.

Committee Structure

It is the seven-member **Executive Committee**, acting on behalf of the Board of Directors, that serves as the major decision-making forum for IRIS. It sets goals and policies, reviews and approves program plans and budgets, appoints members to advisory committees and directs the activities of the President and staff. The Chair, Vice-Chair and Secretary of the Executive Committee, along with the President and the Treasurer, serve as Officers of the Corporation. Members of the Executive Committee must be Board members and are elected for rotating three-year terms by the full Board of Directors. The Executive Committee has created three sub-committees drawn from Executive Committee membership—Budget and Finance, Membership and Legal Affairs—that are responsible for coordination of key Executive Committee functions. ExCom also appoints membership to the Nominations Committee to prepare a slate for the annual election and a Workshop and Publications Committee. The Executive Committee appoints and receives information and advice from four Program Standing Committees, a Planning Committee and a Program Coordination Committee. Appendix I shows the organization of these committees and lists current and past membership. It also includes the formal charge to each committee, as approved by the Executive Committee. The **Planning Committee** develops new initiatives and coordinates IRIS research activities with related programs in fields such as earthquake hazard mitigation and nuclear monitoring. The **Program Coordination Committee** integrates activities that cross-cut the individual programs and is charged with developing a coordinated program budget each year for presentation to the Executive Committee. A special **Instrumentation Committee** was recently created to report to the Coordination Committee on pan-IRIS instrumentation issues. Four separate **Standing Committees** provide detailed oversight of the four core programs: the Global Seismographic Network (GSN), the Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL), the Data Management System (DMS), and the Education and Outreach Program (E&O). Chairs of the Standing Committees participate in Executive Committee meetings on a non-voting basis. In addition, the President and the Executive Committee appoint special advisory committees and *ad hoc* working groups for specific tasks. It is the role of all appointed committees to develop recommendations for the Executive Committee, which in turn, evaluates and acts upon such recommendations on behalf of the Board of Directors.

The Executive Committee meets three or more times per year to review the status of IRIS programs, to approve annual budgets and to develop long-term program directions. Each of the four Standing Committees meets twice per year to review program-specific activities and makes recommendations for improvements and future developments. The Coordination Committee meets prior to the Executive Committee's spring budget meeting to coordinate presentation of the next year's plan and budgets for approval by the Executive Committee. Each year, IRIS committee meetings are also combined with site review visits to the various program facilities, specifically: the Data Management Center in Seattle, Washington; the PASSCAL Instrument Center in Socorro, New Mexico; the GSN facility at the University of California, San Diego; the USGS partnership facility at the USGS Albuquerque Seismological Laboratory in Albuquerque, NM; and the IRIS headquarters office in Washington.

One of the greatest strengths of IRIS continues to be the strong engagement of a broad sector of the scientific community in the governance and management of the Consortium and facilities. Appendix I shows the IRIS committee structure and the breadth of community involvement over the past 20 years. Membership on the Board of Directors and Executive Committee is restricted to individuals from Consortium member institutions, but the Standing Committees, other committees and working groups can draw from any institution and a number of scientists from government agencies and labs participate, enriching the input to the committees and enhancing interagency collaboration. More than 160 individuals have served on IRIS committees since 1984, with more than 50 engaged in active, *pro bono* service each year. Tables in Appendix I show how the membership on each committee has evolved over time. While a number of committed individuals have been exemplary in their dedication through continued service over the years, often on multiple committees, there has also been an explicit effort to engage new committee members, especially younger scientists. Most members of the Executive Committee are elected after initial participation on one of the Program Standing Committees, providing them with an in-depth knowledge of the way in which the facilities are operated. The constant feedback and advice from a community of active scientists has been essential to the success and evolution of the programs and facilities operated by IRIS.

Program Planning and Review

The primary instrument for IRIS support has been a series of five-year cooperative agreements between IRIS and the National Science Foundation. These awards are based on proposals which review the current state of the facility and outline the goals for activities for the next five years. Both the IRIS proposal and the annual program plans and budgets are developed through a systematic process designed to distill the collective scientific interests and priorities of 100 research institutions.

The mode of NSF funding for the IRIS facilities—five-year Cooperative Agreements with Annual Program Plans and Budgets—has provided a level of both stability and flexibility that has allowed the facility resources to evolve in response to changing scientific needs and technical developments. For example, the PASSCAL program has continuously worked with its Standing Committee to assess the balance of different types of instrumentation (short-period vs. broadband) based on community input and the demands of an evolving portfolio of NSF funded research projects. Over the past 20 years, PASSCAL has also increased the level of professional support provided for field programs and data management, in response to requests from PI's. The GSN has been able to remain flexible in the installation of key stations, using Standing Committee recommendations on the balance of continent vs. island based stations; or borehole vs. vault installations; and responding to political opportunities and logistic challenges. The Data Management System has had to evaluate the balance between software development, user services and maintenance of the archive. The IRIS programs have also made on-going adjustments to respond to international developments. As hardware and data procedures established by IRIS have become *de facto* standards, there have been increasing opportunities for international collaboration in areas such as station installation, data exchange and field experiments. In all of these areas, decisions to adjust priorities in the evolution of the facilities have been directed by the Program Standing Committees and Executive Committee, based on consideration of their scientific and technical merits.

In addition to the five-year cycle of reviews carried out as part of the NSF proposal process, the structure of IRIS management, and the organization within specific programs, have also received periodic review and evaluation by internal and external committees. For example, a review of the IRIS management structure by an *ad hoc* committee of former Executive Committee chairs in 1997 led to the formation of the IRIS Planning and Program Coordination Committees as a means of encouraging long-term strategic planning and interactions among programs. A competition for the IRIS Data Management Center resulted in the Center being moved from an interim location at the University of Texas to its current location at the University of Washington in 1991. A competition for the PASSCAL instrument center lead to the consolidation of the previous two centers at Stanford and Lamont to a single new location at New Mexico Institute of Mining and Technology. The DMS Standing Committee recently conducted a self-study to review the current structure and activities and presented a strategic plan to guide the development of future DMS functions. The GSN was reviewed in 1998 when the White House Office of Science and Technology Policy appointed a special panel of the National Science and Technology Council to evaluate the GSN in the context of other global networks. A special NSF-mandated external review of the GSN in 2003 resulted in improvements in GSN operations and started a process to provide standardization of GSN equipment.

Collaborations and Partnerships

IRIS has entered into partnerships with both national and international agencies and groups whose scientific goals overlap those of IRIS. These partnerships range from formal documents and MOU's to "a handshake," illustrating the flexibility with which IRIS can act in serving and furthering its scientific programs. In addition to various modes of interaction with Consortium member institutions, some of the principal organizations with which IRIS interacts in the US include: the United States Geological Survey (USGS), the Southern California Earthquake Center (SCEC), the Advanced National Seismic System (and many of the associated regional networks), UNAVCO, Inc, the UNIDATA program center of the University Consortium for Atmospheric Research (UCAR), the Digital Library for Earth Science Education, the Association of State Geologists, NASA/JPL, DOE and its labs, and AFTAC.

Among its US partners, IRIS has formed its strongest ties with the USGS. The USGS presence and stability have proven to be of great importance throughout the IRIS programs. The USGS (through it Albuquerque Seismological Laboratory, ASL) has been a partner with IRIS in the GSN since its inception. The ASL group is responsible for operation of more than 60% of the GSN stations. Under long-standing arrangements, re-confirmed in a recent GSN Annex to a Memorandum of Understanding between NSF and USGS, IRIS provides the capital investment for the station instrumentation at joint stations and the USGS funds the operations and maintenance. Data collection and quality control are carried out jointly with all data from the entire GSN available through the IRIS Data Management Center. There has also been close collaboration between IRIS and the USGS Advanced National Seismic System (ANSS), primarily though the USGS group in Golden, CO, related to development of the national Backbone network and data distribution. Numerous experiments involving USGS scientists, often in partnership with university PIs, have made use of PASSCAL instruments in crustal studies in the US and abroad. These have included a number of significant investigations of basin structure in urban areas in the western US related to seismic hazard evaluation. The USGS and the IRIS Education and Outreach Program have also collaborated on the development of a very successful museum display and outreach program.

In the international sphere, collaborations with many organizations have been essential to the health of the GSN as a global observing program. The map of GSN stations and the list of GSN partners in the following section indicates the scope these collaborations. Each of the more than 100 GSN stations outside the US represents some level of formal international partnership developed by IRIS, USGS and UCSD. These range from large and complex agreements with China, Russia and many of the states of the former Soviet Union, to arrangements with national universities or Geological Surveys, to operating agreements with private organizations and individuals. A significant program with Japan has resulted in joint installation of stations at remote islands in the Pacific, including real-time satellite telemetry. Exchanges with the Central Asian republics of the former Soviet Union have been especially fruitful. Collaborative projects, many of them initiated by IRIS, have made it possible to install modern seismic stations and gather first-class data from regions of the world that were inaccessible to seismologists twenty years ago. GSN stations play an important role in the International Monitoring System for the Comprehensive Test Ban Treaty Organization and arrangements for shared satellite communication with that organization are greatly improving the real-time access to some GSN stations. These and other partnerships provide an extremely cost-effective mechanism to operate a global facility like the GSN, and provide an avenue for US researchers to work in regions of the world that would be difficult to access. Many PASSCAL experiments have been able to build on contacts that have emerged though IRIS interactions with foreign institutions. Conversely, many of the IRIS Foreign Affiliates listed in Appendix I have resulted from interest in IRIS and its programs developed though contacts made during GSN installations or PASSCAL-supported experiments.

The IRIS Data Management System has also been a vehicle and stimulant for international collaboration, especially in the area of data exchange. Through the international Federation of Digital Seismograph Networks, many national and regional networks exchange data and contribute to the FDSN archive at the IRIS DMC. A number of national data centers have adopted IRIS-developed formats and procedures for data management, greatly facilitating data exchange. The IRIS DMS has lead an effort to develop the concept of networked data centers (NetDC) that is being used to share resources and data among major centers in the US, Europe, Japan and China.

While these international and domestic partnerships play a significant role in efficient operation of the IRIS facilities, the stability and strength of these relationships is grounded in the role that IRIS plays as a university-based Consortium encouraging international scientific exchanges and collaboration in Earth science research.

IRIS Programs

Data Management System

The Rainbow Proposal submitted by IRIS to NSF in 1984 sought funding to develop, in parallel with the seismological equipment facilities, “Central Data Management and Distribution Facilities” to provide community access to the data collected, and a “Major Computational Facility” to support analyses of these data. The proposal stressed the development of a central node called the IRIS Data Management Center (DMC). The anticipated requirements were to manage about 500 gigabytes of new data per year and service a few hundred data requests per year. Currently, the DMC, which is located at the University of Washington, is adding over 16 terabytes of waveform data to the archive each year and servicing over 50,000 requests annually. These numbers will increase significantly when USArray data start flowing.

The fundamental goals of the initial DMS were to coordinate the routine aspects of data gathering and organization and shift these tasks to a central facility accessible to all researchers. The DMS would enable seismologists to focus on their research instead of the more mundane aspects of collecting and assembling the required data sets prior to beginning research.

Two initial studies guided the development of the IRIS DMC. “Strategies for the Design of the IRIS Data Management Center” developed for IRIS by the Science Horizons Corporation (Minster and Goff, 1986) and the TASC report (TASC, 1987) identified several guiding principles for a successful DMC.

Initially the concept of a large, self-contained DMC was pursued with the understanding that

- the task before it was formidable
- the budget for such a system would be greater than $10,000,000 per annum
- existing technologies within the reach of the university community could not manage the envisioned amount of data.

Over time, the structure of data management within IRIS has changed from the original centralized system that was envisioned to a hybrid system that takes advantage of both centralized and distributed components. While the IRIS DMC is still the largest component of the DMS, roughly one-third of the financial assets of the DMS are provided to facilities outside the DMC. In the case of the permanent data from the Global

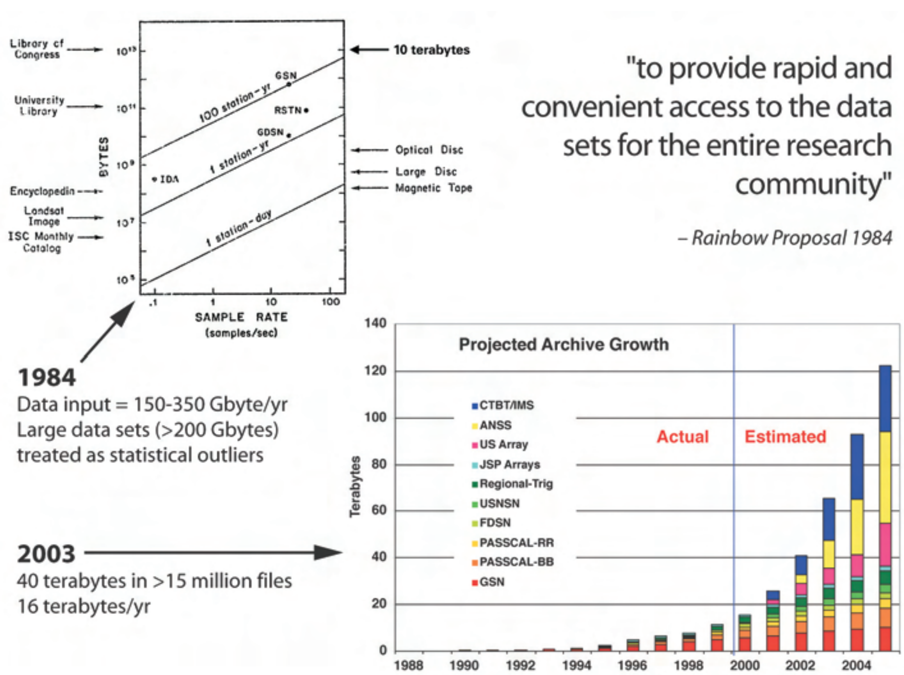


Figure 5. Data Management System—Then and Now. The 1983 report on “Effective Use of Earthquake Data” considered large data sets of more than 200 Gbytes to be “statistical outliers” beyond the capabilities of mass store systems available to the seismological research community. Today the archive at the IRIS Data Management Center contains almost 50 terabytes of data and its mass storage system has the capacity to expand to more than a petabyte.

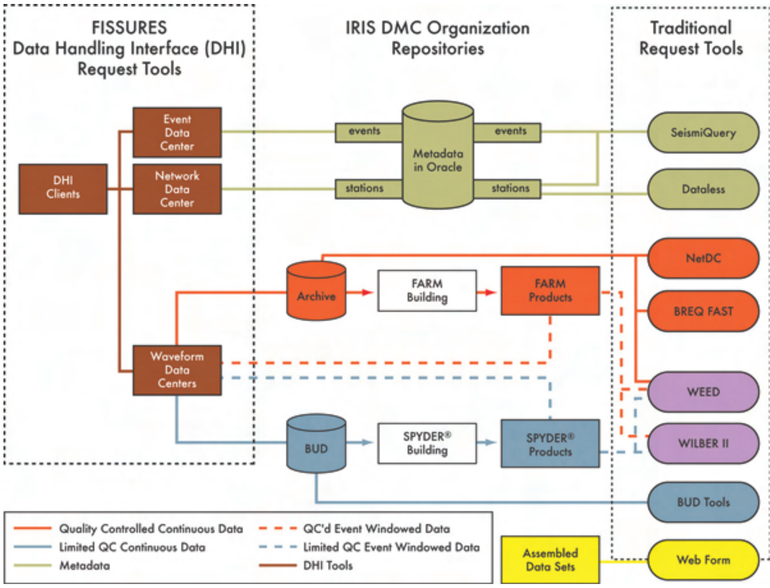


Figure 6. This figure shows the four data repositories (Archive, BUD, FARM, and SPYDER®) that exist at the IRIS DMC. Continuous data are held in the Archive and the BUD; event-segmented products are in the FARM and SPYDER® systems. Data in the Archive and the FARM are quality controlled whereas BUD and SPYDER® data are real-time data with little or no quality control. The standard data request tools supported at the IRIS DMC are shown on the right and the evolving Data Handling Interface is shown on the left.

Seismic Network (GSN), two Data Collection Centers (DCCs) are co-located with the Network Operations facilities in San Diego and in Albuquerque. This allows technical staff familiar with the details of the recording systems and their installation to be readily accessible to the technicians dealing with data and metadata issues. These three centers—IRIS DMC, ASL DCC and IDA DCC—form the heart of the DMS. The capabilities of these three centers are augmented via smaller and carefully monitored activities at U.S. universities and in some cases, international data centers. Data quality assurance for data generated by the portable deployments of seismometers of the Program for Array Seismic Studies (PASSCAL) is funded directly by the IRIS PASSCAL program but strong and effective interfaces (people and computers) have been forged between the DMS and the PASSCAL programs.

IRIS is inherently an international organization due to the geographic distribution of seismic sensors it operates. The IRIS DMS has worked with international operators of a variety of networks to develop standardized data formats, data request methods, data distribution techniques and documentation. IRIS involvement in the Federation of Digital Seismographic Networks (FDSN) has resulted in data exchange with other nations, including Canada, China, France, Germany, Italy, Japan, Netherlands, Switzerland, and Taiwan. In most instances, these data meet the standards set for data from the IRIS GSN. Our international partners consult with IRIS on data management and data distribution methods. Seismological networks around the world are using applications developed by the DMS to archive, distribute and quality control their seismological data. In cooperation with U.S. Geological Survey, the DMS has encouraged the exchange of data between other U.S.-supported networks. Many regional networks now contribute data to the DMC and cooperate with the DMS in the development of new techniques for interactions between data centers.

Data Distribution and Archiving

The primary goal of the DMS is to provide users with a complete and continuous archive of quality-controlled information (waveforms and associated metadata) from all IRIS installations (Figure 6). In developing this complete archive, two pathways have evolved to serve the most common requests:

- **Event Windowed vs. Continuous.** Many seismological investigations are based on analysis of all available data from specific events (earthquakes or explosions). Once the origin information (location and time) of an event is known, simple tools can be used to extract the time windows of interest for waves arriving at any seismic station. Since these data segments represent a small fraction of the total archive, they can be stored in on-line disks for rapid access. At the IRIS DMC, these on-line resources have been called FARM (Fast

Access Recovery Method), for quality controlled data from the archive) and SPYDER® (for access to near-real-time data from events, before complete quality control). Since it takes time (minutes to weeks) to create event catalogs and collect data from all stations, these on-line data resources grow with time following an event. This is especially true for the FARM archive, which depends on the completion of quality control procedures.

- **Immediate vs. Quality Controlled.** In general, most research experiments look for the highest quality, most complete data available. In the case of the DMC, the resource of choice is the permanent archive of continuous data, or the FARM for event-windowed data. There are applications, however, especially in earthquake monitoring and education, where immediate access is more important than completeness or final quality control. To service these types of requests, the IRIS DMC, in collaboration with the USGS, has developed a variety of user tools that collect event-related waveforms immediately following notification of an event by the National Earthquake Information Center (NEIC). The core of this system is SPYDER®, which uses the NEIC location information to determine the appropriate time segments and gathers waveforms from stations that are available on-line via the Internet.

Waveform data entering the DMC are handled using well-established international standards for formats and metadata (SEED and miniSEED). Procedures are in place to exchange metadata information with network operators to update needed information related to station configuration. The waveforms are stored for several months in an on-line disk-based RAID system and the metadata are managed in an Oracle Database Management System. Passive-source PASSCAL data are stored in a manner analogous to the way GSN data are archived. Data that are acquired from active-source experiments are received and stored in SEG-Y format and distributed as special volumes of "assembled data sets." The discovery and access tools have recently been significantly enhanced in order to ease the task researchers have in gaining access to these valuable data sets.

A Brief History of Mass Storage at the DMC

In 1988 an Interim DMC was established at the University of Texas, Austin. While at this center, the preliminary techniques for managing the data from the GSN were developed. While in Austin the DMC used the mass storage capabilities at the Center for High Performance Computing. The system developed around SUN Microsystems servers and SUN workstations, and today the DMC still is structured around high-end SUN and UNIX-based systems. In 1991 the DMC acquired its first mass storage system. A Metrum RSS-600 running AMASS software was capable of storing 6 terabytes of information. This system served the DMC very well for nearly five years. Unfortunately it was the primary storage system for six years. The technology required to read the media became nearly impossible to maintain. The DMC learned the importance of insuring that data are routinely transcribed to newer technology storage systems roughly every four years, which is consistent with practice at other major data centers such as NCAR. It is not the life of the media that proved important; it is the ability to support the recording devices that truly controls the viability of an archiving system. In 1997 the IRIS DMC acquired a StorageTek Wolfcreek robot with helical scan Redwood tape drives and capable of storing 50 terabytes of data. In 2001 the DMC upgraded its storage robot to a 6000-slot capable Powderhorn robot with T9940 tape drives. This system was capable of storing 360 terabytes of data. As the technology in tape drives evolved the DMC began transcribing data to higher capacity 9940B tape technology in 2004 and the robot's capacity grew to more than 1 petabyte (1×10^{15} bytes).

The DMC data holdings in 2003 came primarily from five different sources. The IRIS GSN data holdings total 13.8 terabytes, the IRIS PASSCAL program holdings total 13.9 terabytes, regional networks within the US total 13.5 terabytes, networks from the FDSN have contributed 4.3 terabytes and other data sources have contributed roughly 2.2 terabytes to the DMC archive. As of February 2004 the archive contained roughly 48 terabytes of data. The archive is stored in two sort orders, once by time and once by station that allows user requests to be serviced with high efficiency depending on the nature of the request. Each of the time and station sort orders are stored twice in the Powderhorn and the time sorted data are also stored on DLT tape in a secondary library. These DLT copies are transferred routinely to UNAVCO in Colorado for out-of-state safekeeping of all data holdings.

Staffing

At the beginning of 2004, the staff of the IRIS DMC numbers 15, the ASL DCC has 8 staff and the IDA DCC has 3.5 staff. Staff at the IRIS DMC and IDA DCC is fully funded from annual support from the NSF to IRIS. Financial resources from the U.S. Geological Survey (USGS) are used to pay for the staff at the ASL DCC but most major equipment used in the data collection activities at the ASL DCC are funded through IRIS.

DMC staff is divided into three primary groups. The operations group consists of four people who are responsible for archiving data and servicing requests for data from the user community. The software engineering group consists of seven people whose responsibilities include the development and maintenance of all software used within the routine operations of the DMC, development of new user access tools, and development of new methods of serving data to the research community. The software group possesses strong computing skills that include relational database management systems, object-oriented software development, and CORBA distributed computing techniques. The final group of five people includes the DMS Program Manager, the Web-master, the DMC Office Manager and two UNIX Systems administrators.

The IRIS DMC is considered to be the place most researchers go to obtain the data necessary to perform their seismological research. Twenty years after the formation of IRIS, most of the original goals of data management within IRIS have been met or exceeded. Data volumes exceed the earlier projections by more than an order of magnitude (Figure 7), use of the system as measured by individual requests for data exceed expectations by more than two orders of magnitude (Figure 8), and data from hundreds of recording systems are available in seconds to a few tens of minutes after real time. This was accomplished for a variety of reasons, not least among them that the seismological community retained tight control of the overall direction of the DMS and yet allowed a professional staff to take advantage of technological advances, achieving greater efficiencies than were imagined.

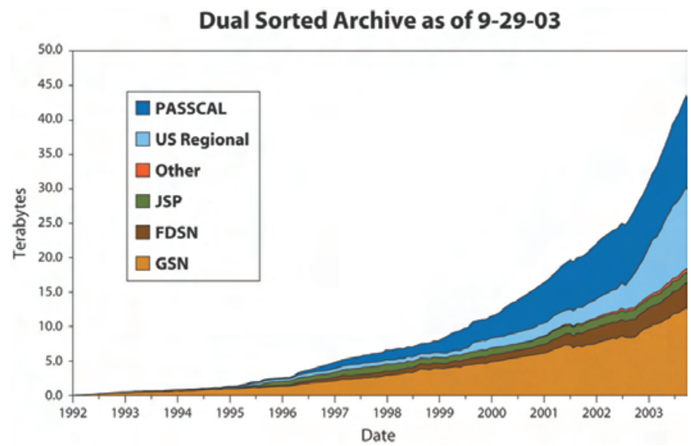


Figure 7. The archive of station and time-sorted data has grown exponentially with time. As of 2004 there were almost 50 terabytes of data in the archive. The GSN (red) and PASSCAL (purple) components form the heart of the archive. The FDSN (yellow), International networks (green) and US regional networks (blue) components provide roughly one-third of the data available.

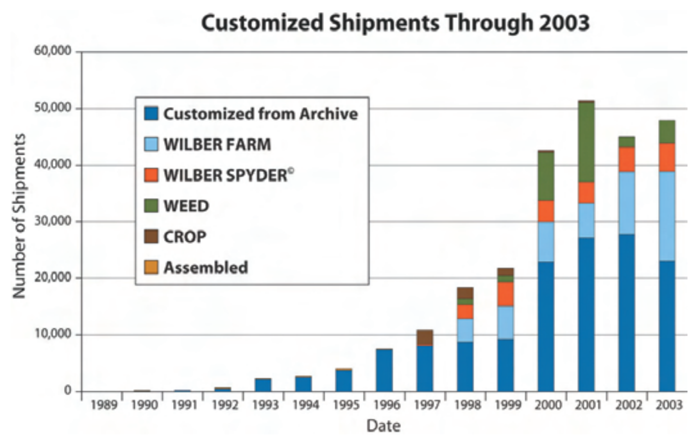


Figure 8. Customized data products from the IRS DMC are produced in response to specialized orders for data that users can make using various request tools. An even larger quantity of data is distributed to users through direct access to on-line standardized data sets.

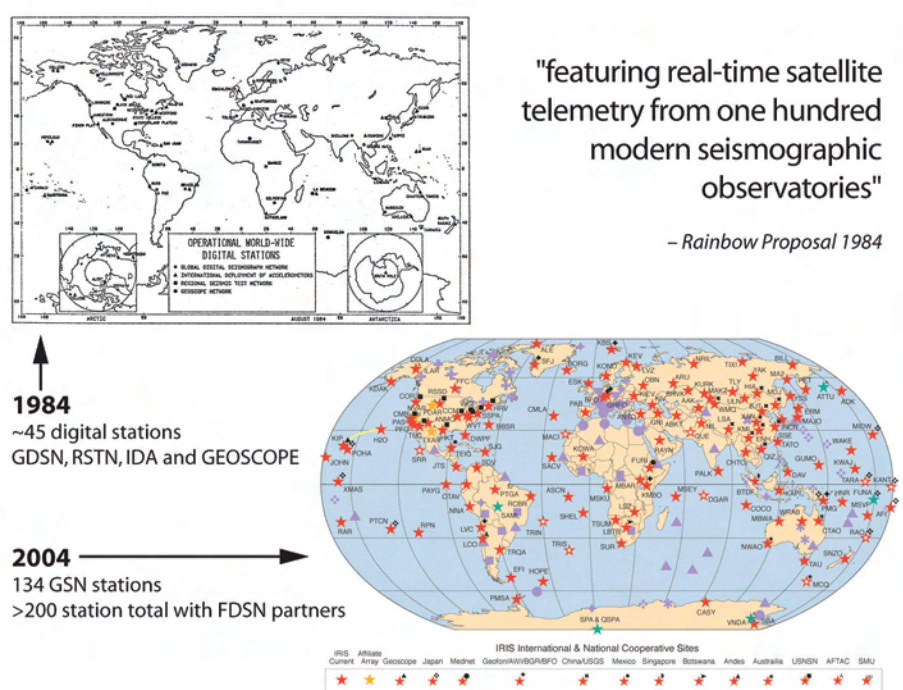
Global Seismographic Network

The Global Seismographic Network (GSN) is a cooperative partnership of U.S. universities and government agencies, coordinated with the international community, to install and operate a global, multi-use scientific facility as a resource for environmental monitoring, research, and education. The GSN is also a state-of-the-art digital network of scientific instrumentation and is part of a century-long tradition in seismology of global cooperation in the study of Earth. GSN instrumentation is capable of measuring and recording with high fidelity all of Earth's vibrations from high-frequency, strong ground motions near an earthquake to its slowest free oscillations. Sensors are accurately calibrated, and timing is based on satellite clocks. The primary focus in creating the GSN has been seismology, but the infrastructure is inherently multi-use, and can be extended to other disciplines of Earth science.

The seeds of the GSN were planted in the late 1970s when modern seismometers with feedback electronics became available with very-broad bandwidth (from ~12-hour tidal periods to frequencies of tens of Hz), high-dynamic range, and linearity for recording the largest earthquake signals, and instrumental noise below the lowest natural seismic background noise. Computer costs were declining while processing speeds and recording capacities were increasing exponentially. Global telecommunications were being put in place. This strong technological foundation came at a time when the science of seismology had advanced theoretically beyond its observational capacity. The questions being posed by the science could not be answered with the limited data available. Furthermore, existing seismic stations were unevenly distributed about the planet and strongly biased in coverage—enormous areas of the oceans and large sections of continents were not instrumented at all. The southern hemisphere was particularly poorly monitored. At the same time, scientists' view of Earth as a system was coming into focus. Seismology with its unique vantage into the planet was called to image Earth's interior and provide fundamental physical data for other branches of the geosciences. Finally, the deaths of several hundred thousand people in a single earthquake in Tangshan, China in 1976 and the billions of dollars lost world wide in earthquake damage accentuated the need to understand better the dynamics of earthquakes in order to mitigate their hazards.

With the seismology community's scientific needs, and concurrent rapidly developing technologies, as a backdrop, the IRIS Consortium initiated the GSN in 1986 with funding from the

Figure 9. The growth of global seismic networks 1984-2004. Data from less than 40 digital stations were openly available when IRIS was formed and the global distribution was uneven. Today more than 130 standardized, broadband stations form the core of the IRIS/USGS Global Seismographic Network, most of them available in real time, with many more regional and national stations available through the Federation of Digital Seismographic Networks.



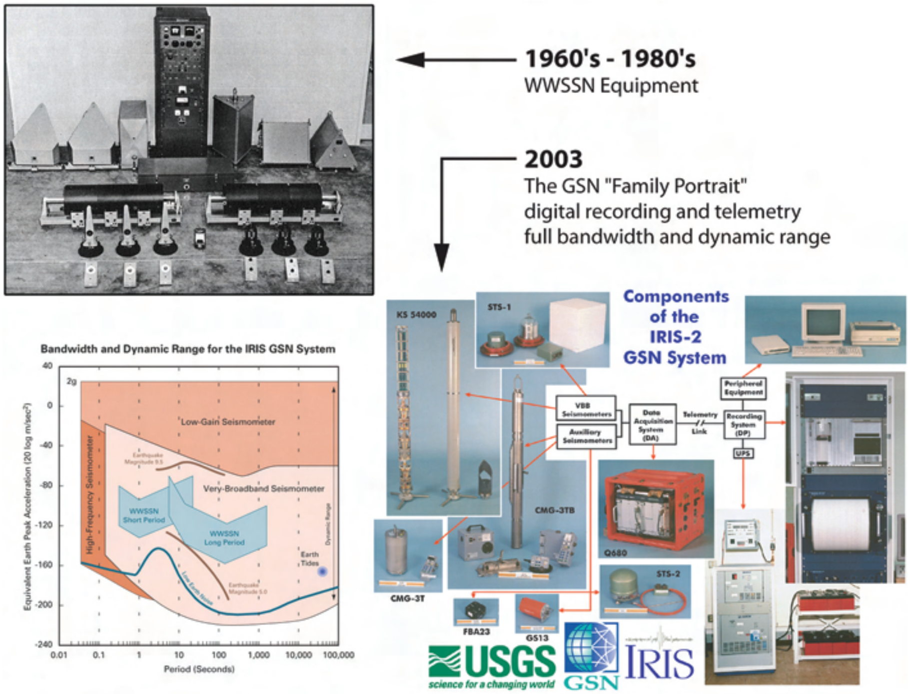


Figure 10. The evolution of seismic instrumentation from the 1960s to today. The narrow band seismometers and photographic recorders of the World Wide Standardized Seismographic System (WWSSN) had limited dynamic range and bandwidth. Today's GSN instrumentation covers the entire range of amplitudes and frequencies required to study regional and teleseismic earthquakes.

National Science Foundation, and in cooperation with the U.S. Geological Survey. The GSN built upon the foundation infrastructure of the USGS's analog World Wide Standard Seismograph Network (WWSSN) and the digital Seismic Research Observatories (SRO) stations and the UCSD International Deployment of Accelerometers (IDA) stations, and extended them to create new and more uniform coverage of Earth. The GSN evolved with technological advances, and added telephone, Internet, and satellite communications with its stations toward its design goal of global real-time telemetry.

Growing slowly at first, then accelerating with funding from the nuclear verification community in anticipation of the Comprehensive Nuclear Test Ban Treaty (CTBT), the GSN is now a state-of-the-art digital network with terabytes of multi-use data from its 134 stations. Nine more sites are in various stages of implementation. The GSN is also responsible for the Hawaii-2 Observatory, the first real-time seafloor station, and for the QSPA station at SPRESSO in the Quiet Sector at the South Pole.

Over 80% of the GSN has available real-time communication either through satellite links or the Internet. Of the satellite links, the GSN is directly responsible for two VSATs in Africa and four in South America under our Houston Hub, and five VSATs in the Pacific under our Oahu Hub in cooperation with the Pacific Tsunami Warning Center and the National Weather Service. The GSN coordinates its satellite infrastructure with USNSN at seven sites in the United States, and at 11 sites in China with the NCDSN. The GSN has successfully developed the sharing concept with the CTBTO Global Communications Infrastructure, and coordinates with GCI in telemetry sharing at nine sites currently with new sites being added monthly. The GSN manages the Internet infrastructure to seven sites in Siberia, and coordinates with NSF Polar Programs for Iridium circuits to northernmost Canada. Established for seismology, the GSN infrastructure now serves as host for the world's largest microbarograph infrasound network, one of the largest global GPS networks, as well as for geomagnetic and weather sensors.

Through IRIS, the GSN is a founding member of the Federation of Broadband Digital Seismographic Networks (FDSN), which has served to help coordinate siting of global stations among member networks and to establish an international data exchange format for seismic data (SEED). The GSN cooperates internationally through its individual relationships with 105 organizations that host GSN stations in 62 nations around the world. These cooperative efforts result in the contribution of seismic equipment, telemetry, and other in-kind support that has enhanced GSN stations above and beyond the funding from the United States.

Instrumentation

The basic GSN instrumentation design goal is to record with full fidelity all seismic signals above Earth's background noise. This has been accomplished using a combination of high-quality seismometers and data acquisition systems deployed in ways to minimize background noise. The bandwidth of the GSN system meets the diverse requirements of the scientific community, national/regional/local earthquake monitoring, tsunami warning networks, strong-ground-motion engineering community, and the International Monitoring System for the Comprehensive Nuclear Test Ban Treaty.

To achieve this full coverage, several state-of-the-art seismometers are used in combination. Data acquisition systems are computers with analog-to-digital encoders and accurate clocks. The GSN uses state-of-the-art 24-bit digitizers for the very-broadband channels, and 16-bit digitizers selectively on other channels. The computer systems time-stamp the data from a GPS reference standard, provide an interface for operator functions, format data, manage the communications interface, and store all data to a local recording medium. All GSN data are locally recorded for trans-shipment to a Data Collection Center, serving as back-up when a real-time telemetry link exists.

GSN stations are deployed to provide uniform Earth coverage. Local noise conditions vary dramatically. Sites are chosen to achieve the best possible low-noise noise conditions, while balancing cost and logistical considerations. Many GSN stations are deployed in a split configuration where a local radio link exists between a remote seismometer/digitizer, deployed for low noise conditions, and the computer system located at a local host organization where local personnel are directly involved in the operation and maintenance of the system.

The GSN Network Operators—USGS Albuquerque Seismological Laboratory (ASL) and the UCSD Scripps Institution of Oceanography (IGPP) IRIS/IDA group—have coordinated and conducted a variety of tests in many environments to determine the best siting modes. In general, underground siting is best—getting away from wind-generated and diurnal tem-

GSN management includes a far-reaching international component of direct relationships with:

- Russian National Network
- Chinese Seismological Bureau
- Geoscience Australia
- Geological Survey of Canada
- University of Brazil
- Germany's GeoForschungsZentrum and Geological Survey
- Mexican National Seismic Network
- British Geological and Antarctic Surveys
- Japan Marine Science and Technology Center (JAMSTEC)
- National Research Institute for Earth Science and Disaster Prevention of Japan
- University of Tokyo Earthquake Research Institute
- France's Institut de Physique du Globe de Paris
- Dipartement Analyse et Surveillance de l'Environnement
- New Zealand Geological and Nuclear Sciences
- Comprehensive Test Ban Treaty Organization International Monitoring System
- International Ocean Network
- Federation Digital Seismic Network

National partnerships include:

- National Science Foundation (Earth, Oceans Atmospheres and Polar Programs)
- USGS (Albuquerque, Reston, Golden and Menlo Park)
- National Weather Service
- Pacific Tsunami Warning Center
- NASA/JPL
- AFTAC
- Defense Threat Reduction Agency
- US State Department Verification Monitoring Task Force
- UNAVCO
- Various University Partners

perature influence—if one can avoid groundwater and noisy pumps. Hard rock provides for the best coupling of the sensor to the Earth. Sediment sites tend to trap high noise into the layer, and also have spurious local resonances. Boreholes work effectively to reduce long-period (>20 sec) horizontal noise on both the continents and larger islands, and also reduce high-frequency noise (>3 Hz) though not as dramatically. However, ocean-loading effects on very small islands and atolls produces additional long-period noise that is not mitigated by a borehole deployment. Noise level in the "microseism" band from about 2 Hz to 20 sec is generated by the oceans and is not mitigated by installation depth. Here the distance from the sea is the determining factor, with the best sites being within the continental interiors.

Geophysical Observatories

The GSN has pursued a steady course toward expanding the use of its infrastructure for broader scientific observatory measurements. Some additional sensors are specifically useful in a seismological context. The GSN operates LaCoste-Romberg gravimeters at some of its locations. Microbarographs are in the process of being deployed throughout the network to augment seismic data with acoustic wavefield data. Such pressure data are useful for monitoring atmospheric events, such as volcanic explosions, and for understanding pressure-related noise processes at the seismic station.

With funding from the National Imaging and Mapping Agency (NIMA), the GSN has served as a vehicle for establishing GPS sites co-located at eight GSN stations in Russia. The GSN is also collaborating with JPL/UNAVCO to establish GPS at GSN stations in Gabon, Uganda, the Galapagos, and the Seychelles. Some basic surface meteorological measurements (pressure, temperature, and humidity) greatly increase GPS data's scientific usefulness. The GSN has installed meteorological sensor packages at Russian GPS sites, in coordination with its JPL/UNAVCO installations. These new GPS+Met sites have been registered with SuomiNet, a nascent, national real-time GPS network for atmospheric research in the United States (see http://www.unidata.ucar.edu/SuomiNet/).

Operations and Maintenance

The GSN's single most important task is network Operations and Maintenance (O&M). O&M is the annual investment that the seismological community must make to insure a healthy return of high-quality data from the installed base of state-of-the-art GSN stations. O&M requires people, equipment, supplies, travel and cooperation with our station hosts. Average station uptime in 2003 was 85% for the network. As the GSN moves from its installation phase toward a focus on operations and maintenance, and with emphasis on standardization of equipment and improvements in data quality and data return, it is expected that Network uptime will improve toward the 90% uptime goal established at the initiation of the GSN.

O&M includes not only activities in support of the network stations, but also the flow and quality assurance of the data from the stations. The GSN has two primary Network Operators. The USGS Albuquerque Seismological Laboratory (ASL) operates 83 IRIS/USGS stations, and the University of California San Diego operates 38 IRIS/IDA stations. Additionally, 13 GSN stations are operated as part of individual University Networks or as GSN Affiliates. Under a Memorandum of Understanding with IRIS and NSF, the USGS provides O&M support for ASL. NSF provides O&M support for the IRIS/IDA element of the GSN, for the amortization of all GSN equipment at 5% per year, and for recurring telemetry costs to bring GSN data to the US in real-time. The basic O&M support of the IRIS/IDA element of the GSN includes personnel, O&M travel, station supplies and stipends, repairs and overhead.

Funding for routine O&M support of the IRIS/USGS component of the GSN by ASL is provided separately by the USGS. IRIS, NSF and USGS coordinate and cooperate in their roles and responsibilities for the GSN under the NSF-USGS Memorandum of Understanding Annex on the Global Seismographic Network (2002).

PASSCAL

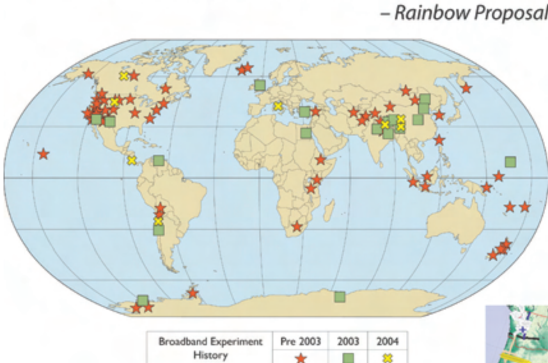
Background

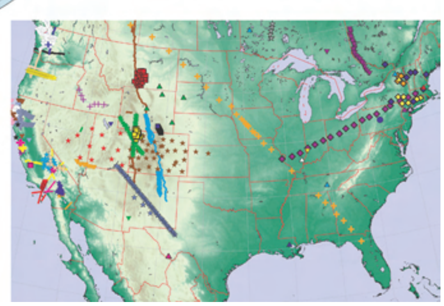
IRIS launched the Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) in the mid-1980s to develop, acquire, and maintain a new generation of portable instruments for seismic studies of the crust and lithosphere. PASSCAL formed the flexible complement (the “Mobile Array” in the original Rainbow Proposal) to the permanent observatories of the Global Seismographic Network. During the first cooperative agreement between IRIS and NSF (1985-1990) the primary emphasis was on the careful specification of design goals and the development and testing of what became the initial 6-channel PASSCAL instruments. While not the direct result of PASSCAL efforts, three other technological breakthroughs in the 1985-1990 time period were critical for the success of portable array seismology: the development of a low-power portable broadband force-feedback sensor; the availability of a highly accurate GPS absolute time base; and the advent of compact high-capacity hard disks. An initial 35 seismic systems incorporating these advances were delivered in 1989 and maintained through the first PASSCAL Instrument Center at Lamont-Doherty Geological Observatory of Columbia University. During the second cooperative agreement (1990-1995), the Lamont facility, which focused on the use of broadband sensors used primarily in support of passive source experiments, grew to more than 100 instruments. Starting in 1991, a second Instrument Center was established at Stanford University to concentrate on support of a newer, 3-channel instrument designed for use in active source and rapid deployment earthquake aftershock experiments. By 1995, almost 300 of these instruments were available.

The core facility for support and maintenance of the PASSCAL instruments has now been established at a combined PASSCAL Instrument Center (PIC) located at New Mexico Tech in Socorro, NM. This facility, established in 1998 following proposal solicitations and exhaustive review, served to consolidate experiment-support efforts, improve efficiency, and lower the operational costs associated with previously maintaining two instrument centers. The Center is housed in a new building with 7500 sq. ft. of lab space and 15000 sq. ft. of warehouse space. The building was designed by the PASSCAL technical staff to optimize Center operations. The centralization of the facility has allowed us to provide improved services while maintaining the same number of outstanding employees even as the number of instruments and experiments grows.

"A Mobile Array comprised of one thousand portable digital seismographs to be used for studies of the continental lithosphere"

– Rainbow Proposal 1984





2004 PASSCAL Inventory

6 channel recorders	210
3 channel recorders	330
Single channel recorders	440 (UTEP)
	400 (IRIS)
60 channel instruments	4

Figure 11. PASSCAL instruments have been used to support more than 400 experiments since 1989. The world map shows locations of deployments of broadband experiments. The US map shows both broadband deployments for passive investigations and short-period profiles for active source experiments.

The Instrument Center, which is operated under subaward from IRIS to New Mexico Tech, has a staff of 14 including the Center Director, four Software Engineers, six Hardware Engineers, an Office Manager and Administrative Assistant. The IRIS PASSCAL Program Manager and Deputy Program Manager are also stationed in Socorro.

Currently, PASSCAL has a stable of more than 700 portable, digital seismic recording systems, comprised of approximately 330 3-channel recorders, 210 6-channel recorders, 400 small, light-weight, single-channel "Texan" instruments, and four 60-channel reflection/refraction systems. In addition to the instruments owned by IRIS, PASSCAL provides maintenance support for 440 "Texan" instruments owned by the University of Texas-El Paso.

While one basic metric used to measure PASSCAL's progress has been the number and capability of instruments available for use in experiments, the scope of the facility extends well beyond hardware alone. Underlying the hardware pool, PASSCAL maintains an extensive support structure for instrument design, maintenance, and testing; field support; software development and documentation; and user training. PASSCAL operates as a resource for the research community, in effect serving as a "lending library" for specialized seismological equipment, but also providing technical support and user training.

Scientific Impact

Images of the Earth's interior provided by both active- and passive-source seismic experiments are of fundamental importance in the study of the structure and evolution of the solid Earth and the dynamic processes that shape it. Since the first active- and passive-source PASSCAL experiments in 1986 and 1988, respectively, the breadth of new information about Earth structure and dynamics developed through PI-driven PASSCAL experiments is astounding. In just the past 10 years, over 400 large- and small-scale PASSCAL arrays have been deployed to image many of the planet's major plate boundaries, cratons, orogenic systems, rifts, faults, and magmatic systems. Key tectonic provinces worldwide serve as natural laboratories to study a wide range of structures and processes (e.g., Himalyan collisional belt and Tibetan Plateau, Rocky Mountain Front, Andean and Cascadia subduction zones, Yellowstone, Iceland and Hawaiian hotspots, the Rio Grande, Baikal and East-African Rifts, Basin and Range Province, Canadian Cordillera, Abitibi Greenstone Belt, Tanzanian, Kaapvaal and Zimbabwe Cratons, southern Sierra Nevada, Tien Shan, Antarctic Mountains, Archean-Proterozoic Cheyenne Belt suture, etc.).

The advances made possible by PASSCAL are driven by the creativity of scientists using the PASSCAL facilities, by the technology that PASSCAL makes available, and by the flexibility of the instrument pool to foster innovative research. While we sometimes measure the success of the PASSCAL's program by the number of instruments available and the number of experiments conducted, the real measure of success of the program lies in the diversity of important science that has been accomplished. In addition to the types of studies typical of PASSCAL-supported experiments over the past decade, new opportunities exist for forging broad partnerships and interdisciplinary research collaborations.

Instrumentation

In the original 1984 Rainbow Proposal, it was estimated that about 1000 instruments with 6000 recording channels would be needed to support the experimental requirement for field programs in seismology. The size and composition of the PASSCAL inventory has evolved through a continuing reassessment of the balance between technical and scientific pressures. While standardization of equipment, data formats and operational procedures is an essential ingredient in the success of all IRIS programs, PASSCAL must handle special challenges in the trade-offs between standardization, specialization and optimization. The wide variety of experimental configurations supported by PASSCAL, and the need for performance optimization under extreme field conditions, have led to the development of a number of "standardized" field systems. On the technical side, desires to keep the equipment "state-of-the-art" are balanced by issues of reliability, portability, simplicity and cost. In a facility that provides equipment for use by operators with a wide range of technical skills and training, there are advantages in minimizing the number of different types of instruments. Nevertheless, the wide range of field conditions and scientific problems to be addressed requires an appropriate variety of instrument characteristics. On the scientific side, the PASSCAL Standing Committee, with input and oversight from other IRIS committees and staff, continually addresses the balance of resources provided to support the special needs of different sectors of the research community. The facility now encompasses a full spectrum of instruments: telemetered broadband arrays; high-resolution, multi-channel instruments; single-channel reflection/refraction instruments; and advanced short-period and broadband instruments for portable array seismology to address the range of research needs. PASSCAL systems have become *de facto* standards for portable seismic instrumentation worldwide.

Telemetered Arrays. The PASSCAL Broadband Array is based on the same data acquisition systems used in the 3- and 6-channel recorders. Instead of on-site recording to disk, data are telemetered to a central site and merged in real time. The broadband telemetered array was developed in the early 1990s in collaboration with the University of California, San Diego, under the IRIS Joint Seismic Program (JSP) for deployment in the former Soviet Union for nuclear test-ban verification calibration tests. When the JSP program was completed, the equipment and expertise necessary to operate the array were transferred to PASSCAL. Developmental work on array technology continues to be supported at UCSD. The original PASSCAL Broadband Array consisted of 32 broadband sensors and digitizers that telemeter the data via spread-spectrum radios to a concentrator site located up to 80 km away. PASSCAL currently has the acquisition systems, seismometer communications, and central recording equipment to field two 30-station broadband arrays.

Multi-Channel Instruments. PASSCAL maintains four multichannel recording systems. The equipment, each of which records 60 channels on a single recorder, has been used very effectively for crustal imaging and a number of shallow studies of fault zones, aquifers, and hazardous-waste sites, as well as training and education in undergraduate classrooms and field labs. The number of experiments supported by this pool of instruments is now on the order of 20 per year, with many experiments utilizing multiple systems. The multi-channel equipment is intended to supplement similar systems already in the research community. In most of the major experiments, the PASSCAL equipment is augmented with similar equipment owned by the PI or the USGS.

Active-Source Experiments ("Texans"). These experiments are designed to observe artificial sources such as explosions, air guns and vibrators. The primary data requirements are for high frequency recording at high sample rates, and precision timing. The typical experimental mode is to record specific timed segments, synchronized with the timing of the artificial sources. The instruments are moved often to occupy many sites. PASSCAL's single-channel "Texan" is currently used for most active-source experiments as it is small, lightweight and easy to use. PASSCAL currently has 400 Texan instruments and supports another 440 Texan instruments in the PASSCAL instrument center through a cooperative agreement with the University of Texas, El Paso (UTEP). The UTEP-owned systems are used for PASSCAL experiments effectively in the same fashion as the IRIS instruments.

Long-Term Passive Deployments (Broadband). Much of PASSCAL's effort centers around the fielding of long-term deployments of arrays of up to 50 or more broadband stations focused on dense spatial sampling of the teleseismic, regional, and local seismic wavefield. These large, densely sampled experiments are designed by individual NSF funded investigators to target deep structure of the Earth from lithosphere to the inner core. In addition, they have been used to study earthquake-aftershocks, fault-zone-properties, and active volcanoes. The PASSCAL instruments used for passive experiments are either 6-channel or 3-channel REFTEKS, typically coupled with intermediate-period sensors whose long-period response extends to below 30 seconds. With at least 300 broadband instruments in the field at all times, many in long-term deployments, PASSCAL is supporting a combined array approximately twice the size of the GSN. The PASSCAL data policy requires that all data be archived at the DMC (usually within months of their field collection) and made publicly available within two years of the end of the field deployment. The broadband data are archived at the DMC in a manner identical to the GSN data, so that users can make requests combining data from multiple experiments. While each deployment of the portable PASSCAL networks is targeted at a specific research experiment, the combined effect of multiple experiments around the world is to effectively provide temporary, high-resolution augmentation to the permanent coverage provided by the GSN,

RAMP (Rapid Array Mobilization Program). PASSCAL reserves ten instruments for the RAMP instrument pool to enable very rapid response for aftershock-recording following significant earthquakes. PASSCAL instruments were first used in an aftershock study at Loma Prieta, less than one month after the first instruments were delivered in 1989. The pool continues to be used for aftershock studies, but also for special short-term projects that otherwise could not get access to instruments. In the event of a significant earthquake requiring an aftershock response, all RAMP instruments are available for shipping within 24 hours.

PASSCAL and USArray

Maintenance and development of PASSCAL facilities will be coordinated with EarthScope's USArray as it develops over the next five years. Together, these programs will provide unprecedented opportunities for detailed imaging of Earth's crust, mantle and core. With the PASSCAL instrument pool, seismologists can pursue innovative ideas to study scientific problems anywhere in the world. This ability is perhaps the greatest success of the PASSCAL program over the last 20 years. USArray is a natural extension of this success but it is not a replacement for the PASSCAL core program. USArray will function as an integrated experiment focused exclusively on the United States. Instrumentation in large transportable and flexible arrays that make up the seismic component of USArray will be deployed in a coordinated fashion for a twelve-year period. We anticipate that a potential outcome of USArray will be to increase the demand for similar dense deployments elsewhere in the world. IRIS thus plans to maintain and slowly expand the core PASSCAL pool to meet this demand.

Education and Outreach

IRIS members have increasingly recognized the need to communicate the results of scientific research to the public more effectively, to advance science literacy for greater understanding of our rapidly changing and increasingly technological world, and to attract more students to study science. To address these issues, IRIS formed an E&O committee in January 1997 and hired the first E&O program manager in January 1998. Since that time, the program has grown to 2.5 IRIS staff managing a number of subcontract and consultant awards, with significant contributions from members of the IRIS community.

Since its inception, the E&O program has explored the needs of the different audiences it serves and has developed a core program to address those needs. In 1998, the IRIS E&O committee convened a conference with representatives from diverse science and science education disciplines, funding agencies, and other Earth science E&O programs to develop a broad vision of how IRIS could uniquely contribute to science education and outreach. The discussions and collaborations that developed during the conference have guided IRIS' E&O efforts ever since and formed the basis for a program plan published in 2002.

The IRIS E&O course of action is to provide products and programs for a variety of audiences, including the general public, K-12 students and educators, and post-secondary students at our nation's colleges and universities. Programs range from those that impact large numbers of people for brief time periods to those that impact smaller numbers of people through extended interactions. IRIS' E&O program also looks inward to develop the talent within the ranks of IRIS' member institutions so that all may fully participate in building an education program of national scope and prominence.

Our goal is to help create a new generation of Americans with a greater understanding of Earth science and seismology, and to help attract the best and brightest to our discipline. Research shows that creative teachers using innovative lessons can stimulate an early interest in science and increase the likelihood of a student choosing a career in science. To stimulate this interest requires high quality educational resources for teachers in K-12 and for college faculty in undergraduate programs. Providing accurate and efficient professional development and resource materials in Earth science and seismology is especially important for teachers in middle and high school grades who currently teach the bulk of the Earth science concepts that the majority of Americans will ever learn.

IRIS focuses on developing people who can help us make a difference, and developing products that support the efforts of those same people. By engaging the full membership of IRIS in E&O activities, we capitalize on our numbers, geographic diversity, and especially the wealth of creativity and knowledge within our community. While IRIS can make advances in science education through seismology, a concerted effort to link seismology across the scientific disciplines helps achieve an even greater impact. We recognize the need to coordinate with other organizations and seek opportunities to collaborate on education and outreach activities where mutual interests exist.

To date, the following educational activities have been developed and implemented by IRIS E&O:

Museum exhibits. One of the earliest IRIS E&O activities focused on a traveling museum exhibit designed in collaboration with the USGS. This display has been on loan to the Franklin Institute Science Museum for use in their *Powers of Nature*

Figure 12. IRIS/USGS real-time display at the Smithsonian Institution National Museum of Natural History (photo credit: Jason Mallett).

exhibit and has traveled to 10 museums since 1998. Since that time the museum program has expanded to four permanent exhibits as well as the traveling display. Our museum partners include the Smithsonian Institution National Museum of Natural History, the American Museum of Natural History in New York, Carnegie Museum of Natural History in Pittsburgh, and the New Mexico Museum of Natural History and Science in Albuquerque. In the next year, more than 16 million visitors will have the opportunity to view and learn from these exhibits in museums around the US. The exhibits portray earthquakes not as destructive events, but as signals of the geological forces that build our mountains and shape our landscape. The real-time aspect of the displays allow visitors to see the location and size of global and local earthquakes that occur every day and to see the recorded movement of the ground as seismic waves travel around the globe. The success of the program is attributed to: 1) real-time global data streams, 2) state-of-art electronic displays combined with traditional "three-dimensional" mechanical displays (retired drum recorders), 3) on-going evaluations and upgrades, and 4) strong partnerships that allow each exhibit to be sustained and customized to the specific needs of the individual host museum.

Professional development program. The E&O Program continues to refine its highly effective, one-day professional development experience designed to support the background and curricular needs of formal educators. The program for teachers and college faculty began as a one-day workshop at annual meeting of the National Science Teachers Association, and now also includes workshops at the annual meetings of the California Science Teachers Association and the Geological Society of America, as well as one to two other selected venues each year. Some of the workshops are conducted in collaboration with other organizations. Workshops have also been held to train seismologists to run their own teacher-training workshops.

Figure 13. Teachers and college faculty exploring earthquake slip behavior at an IRIS one-day workshop at the Geological Society of America 2003 annual meeting.

Leveraging the expertise of the consortium, IRIS delivers content on topics such as: plate tectonics, propagation of seismic waves, seismographs, earthquake locations, and Earth's interior structure. At the core of the IRIS professional development model is the philosophy that improvements in the level of teacher use of such material can be achieved by increasing teacher comfort in the classroom. Specifically, we seek to increase teacher comfort in the classroom by providing professional development which:

- Increases an educator's knowledge of scientific content,
- Provides educators with a variety of high-quality, scientifically accurate activities to deliver content to students,
- Provides educators with inquiry-based learning experiences,
- Provides direct contact with IRIS research and E&O individuals

The development of a coordinated assessment effort during 2003 has provided critical decision making data and has begun to document the impact the program has on educators. Using this information as a guide IRIS will continue to monitor and alter its curricular resources and implementation style in an effort to maximize this impact.

Web site. The E&O web site provides the primary means of distributing general information and resources, including both timeless information such as answers to frequently asked questions and timely information about recent seismological events. The IRIS E&O web page provides (1) information on the programs, activities, and opportunities of IRIS E&O; (2) tools for the non-specialist to access and manipulate seismological data (earthquake statistics, maps and seismograms); (3) links to E&O efforts in seismology and the Earth sciences at IRIS member institutions and other organizations; (4) background and topical earthquake information; and (5) instructional materials. The IRIS web site represents collaboration between the Data Management System (DMS) and E&O to enhance the profile of IRIS and provide greater access to IRIS resources.

Figure 14. Whitman College student David Fee servicing a seismograph in New Zealand during his IRIS undergraduate internship in 2001.

Summer internship program. IRIS initiated its summer internship program in 1998, which has grown to 10 interns working at 8 different IRIS institutions during the summer of 2003. Through their participation in the program, these students gain experience in and exposure to the field of research science and Earth science as potential career paths. An important and valuable part of the internship is the presentation by the students of the results of their summer research at a national meeting during the following year.

Educational seismographs and the use of seismic data. Collecting and distributing seismic data products to the research community is the mainstay of IRIS. As advances in seismology are frequently data driven, this data is frequently the foundation for making advances in our understanding of Earth. However, sharing those data and the excitement of discovery that they offer with a general audience requires effective tools and an understanding of seismology. People want to know how a seismometer works and how it can detect earthquakes on the other side of the planet. They want to know what each wiggle on a seismogram means. While not all of these questions are easily answered, providing non-specialists tools to begin investigating these questions and illuminate the basic scientific research process is a valuable contribution to society. To address this need, IRIS E&O in collaboration with the DMS and GSN have developed a range of products. The *Seismic Monitor* is a web-based tool that provides a quick global view of recent earthquake locations, with links to the IRIS waveform database. Data access is also provided both through DMS tools on the IRIS web site and through the Global Earthquake Explorer (GEE) software, which has been specially designed for the non-specialist audience. GEE software and associated instructional materials, now in beta testing, have been developed in part via a subaward to the University of South Carolina, and includes built-in teaching modules as well as free exploration options. In 2000, IRIS initiated a program to distribute educational seismographs to schools, including new display software (the AS1 seismograph and AmaSeis software). Over 50 schools now are operating the systems and using educational modules developed for the systems.

Posters and one-page handouts. IRIS produced the first educational poster ("Exploring the Earth Using Seismology") in 1998 and continues to give out thousands of copies of that poster each year. The poster shows how seismic waves from the 1994 Northridge earthquake propagated throughout the Earth, and is used by teachers to illustrate Earth science concepts. IRIS continues to develop new posters such as the recent "History of Seismology" poster that is aimed at high school and college students. The one-page educational handout series covers topics related to our posters and to our museum displays. The series has expanded to six topics and has been translated into Spanish.

Educational Affiliate membership. In 2001, IRIS established a new Educational Affiliate membership category for 2 and 4-year colleges and universities that teach seismology but are not sufficiently involved in seismology research to become full consortium members. The objective of this membership category is to cultivate a base of non-research colleges and universities committed to excellence in undergraduate geoscience education through the co-development of E&O activities designed to address their needs. The first Educational Affiliate members were accepted in 2002 and the initial members are assisting IRIS in developing E&O activities to address their needs.

Distinguished lecturer series. IRIS initiated the IRIS/SSA distinguished lecture series in 2003, in collaboration with the Seismological Society of America, as an additional way to reach the public through informal learning institutions. In the first year of the program, two speakers presented a total of nine lectures at major museums and universities throughout the country to audiences of up to 400 people.

IRIS and USArray

USArray is part of the new EarthScope facility, supported with funds from NSF's MREFC account, to be used in a targeted experiment to image the structure and deformation of Earth beneath the North American continent. USArray, along with existing permanent regional and national networks, will extend uniform coverage to the entire country allowing for a thorough and systematic seismological study of the conterminous United States. The combined resources of EarthScope—the Plate Boundary Observatory, USArray and SAFOD—will initiate a powerful observational framework for research in the Earth sciences at all scales and will be a natural avenue for pursuing education and outreach. Building on the concept of field laboratories, a combination of permanent and transportable observatories will serve as platforms for a diverse suite of studies. The special appeal of this approach is that every part of our nation will be used as a laboratory in some aspect of important and interesting geoscience study. Virtually every educational institution will have the opportunity to take an active role in the investigation and, through coordinated education and outreach efforts, encourage an interest in "real" local geology among K-12 students and the public.

A continent-sized array will be a powerful large-aperture telescope offering an unprecedented window into Earth's interior. The U.S. is an excellent location for such a window because of the ideal source-receiver distance from the intense seismicity of the western Pacific and South America. Broad-scale tomography of the upper mantle beneath North America will benefit greatly from the permanent station spacing on the order of 300 km, while much higher resolution imaging of lithospheric structure will emerge through active and passive source seismic studies, accompanied by an appropriate mix of other geophysical observations, using the portable broadband array. The expanded network of permanent stations, reporting in real time to the USGS, will improve the detection, location, and source characterization of both U.S. and global seismicity.

USArray consists of three major elements: (1) a Transportable Array, (2) a Flexible Array, and (3) a Backbone Network of permanent stations.

1. The core of USArray is the **Transportable Array**, a telemetered array of 400 broadband seismometers, deployed in the United States. The array is designed to provide real-time data from a regular grid with dense and uniform station spacing of ~70 km and an aperture of ~1400 km. The Transportable Array will record local, regional, and teleseismic earthquakes to produce significant new insights into the earthquake process, provide resolution of crustal and upper mantle structure on the order of tens of kilometers, and increase the resolution of structures in the lower mantle and at the core-mantle boundary. The Transportable Array will roll across the country with 18-24 month deployments at each site. Multiple deployments will cover the entire continental United States and Alaska over a period of 10-12 years. When completed, the array will provide unprecedented coverage for 3-D imaging from ~2000 seismograph stations. While the initial focus of USArray is coverage within the United States, extensions of the array into neighboring countries and onto the continental margins in collaboration with scientists from Canada, Mexico, and the ocean sciences community would be natural additions to the initiative.

2. As a complement to the Transportable Array, USArray's **Flexible Array** will include a pool of ~2400 portable instruments (a mix of broadband, short period, and high frequency sensors) that can be deployed using flexible source-receiver geometries. These instruments will permit high-density, shorter-term observations, using both natural and explosive sources, of key geological targets within the footprint of the larger Transportable Array, for example, at the SAFOD site. Many important targets are amenable to investigation with the Flexible Array, including: the depth extent of faults, magma chamber dimensions beneath active volcanoes, the relation between crustal tectonic provinces and mantle structure, the shape of terrane boundaries, the deep structure of sedimentary basins and mountain belts, and the structure and magmatic plumbing of continental rifts. Linked with coordinated geological, geochemical, and geodetic studies through the broader EarthScope initiative, this USArray component can address a wide range of problems in continental geodynamics, tectonics, and earthquake processes. Examples include imaging the continental arc system in the

Cascades from slab to edifice, examining the deep roots of the North American craton and paleotectonics by which the craton was formed, imaging both ancient and modern orogens and rifts to explore variability in continental tectonics, identifying the role of the mantle lithosphere during orogenesis and rifting, and unraveling the relationship between deep processes and surface features.

3. A third element of USArray is the development of a **Backbone Network**, through augmentation of permanent stations of the USGS National Seismic Network (NSN) and the IRIS/USGS Global Seismographic Network (GSN). Relatively dense, high-quality observations from a continental network with uniform spacing of 300-350 km are important for tomographic imaging of deep Earth structure, providing a platform for continuous long-term observations, and establishing fixed reference points for calibration of the Transportable Array. Some stations of the Backbone Network will be equipped with continuous GPS receivers. This permanent component of USArray will be coordinated with the USGS and complements the initiative underway at the USGS to install an Advanced National Seismic System (ANSS).

The successful implementation and execution of USArray will be aided greatly by the existence and vitality of the IRIS core programs. The PASSCAL program has a long record of managing and servicing portable instrumentation, and the PASSCAL facility in Socorro and association with the broadband array program at UCSD will serve as the key operational base for executing the transportable and flexible components of USArray. The USArray contributions to the ANSS Backbone Network will be implemented as a natural extension of the collaboration between IRIS and the USGS in operation of the GSN. Equally importantly, the IRIS DMS program has been able to distribute successfully very large amounts of data to the seismological and geophysical community. Implementing data distribution from USArray through the existing IRIS DMS facility will be effective and economical. Similarly, the significant educational opportunities presented by USArray can be efficiently capitalized on through the IRIS Education and Outreach program.

Program Management and Corporate Structure

Management Structure

IRIS management is based on linked operational structures for the four core programs—the Global Seismographic Network, the PASSCAL program for portable instrumentation, the Data Management System, and Education and Outreach. The central administrative and business functions are carried out through a Headquarters Office in Washington, DC. As described below and shown in Figure 15, the programs are managed through offices or subawards linked to each of the operational centers for the core programs. Overall management is under the direction of a full-time President, appointed by the Executive Committee. Senior staff consists of:

- Dr. David Simpson, President
- Dr. Gregory van der Vink, Director of Planning (until Sept 2003)
- Dr. Shane Ingate, Director of Operations
- Dr. Tim Ahern, DMS Program Manager
- Dr. Rhett Butler, GSN Program Manager
- Dr. Jim Fowler, PASSCAL Program Manager
- Dr. John Taber, E&O Program Manager
- Ms. Candy Shin, Director of Finance and Administration

Although each of the four core programs have a standardized management and oversight structure consisting of a Program Manager and Standing Committee, each program operates through its own unique combination of direct employees, subawards, and partnerships. As indicated in Figure 15, the core facilities programs are widely dispersed: key elements, involving full-time staff devoted to IRIS activities, are located at the Data Management Center in Seattle; the PASSCAL Instrument Center in Socorro; the IDA and Broadband Array groups at UC San Diego, the USGS GSN facility in Albuquerque; and IRIS Headquarters in Washington DC. IRIS has 34 full-time employees on its payroll (not including new employees currently being added for EarthScope activities), and an additional 30 are supported full time through the major IRIS subawards listed above. Including the additional 30 employees supported by the USGS on the staff of the GSN facility at Albuquerque, there are approximately 84 full-time scientists and technicians involved in the operation of the core IRIS facilities and IRIS-related programs. Partial support is also provided through subawards for important IRIS-related programs (see Appendix V) at Harvard University (for GSN data quality review); the University of Washington (as host for the DMC); the Moscow Data Center (for communication services and software support in Russia); the University of Texas, Austin (for support of Texan instruments); and the University of South Carolina (for software development).

The **Global Seismographic Network**, managed by Dr. Rhett Butler, operates through subawards and partnership agreements. Approximately 30% of the GSN is operated through a subaward with the University of California, San Diego. This subaward provides for equipment acquisition, installation, operation and maintenance and data collection for the IRIS/IDA component of the GSN. The IDA staff includes 11 FTEs for GSN station operations and associated data-collection activities. Another 65% of the network is operated through a Memorandum of Understanding with the US Geological Survey's Albuquerque Seismological Laboratory in Albuquerque, New Mexico. The remaining 5% of the network is operated through a suite of partnership agreements with individual universities that host GSN stations and provide operational support for those stations. NSF retains title to all permanent equipment for the GSN; an inventory of over $18M of GSN equipment is maintained by IRIS. Since 1998, the USGS has provided funding for the operation and maintenance of their component of the GSN through a special line item in the Department of Interior budget for GSN operations. IRIS continues to provide support to the USGS for installation of new equipment. From 1988 to 1996, Congress provided a total of more than $60M to IRIS for support of the GSN, first as part of a Joint Seismic Program with the Soviet Academy of Sciences to install GSN stations and arrays in the Soviet Union, and then as part of a program to further capitalize the GSN for multi-purpose applications including contributions to nuclear monitoring. Funds for these activities were provided by Congress through the Department

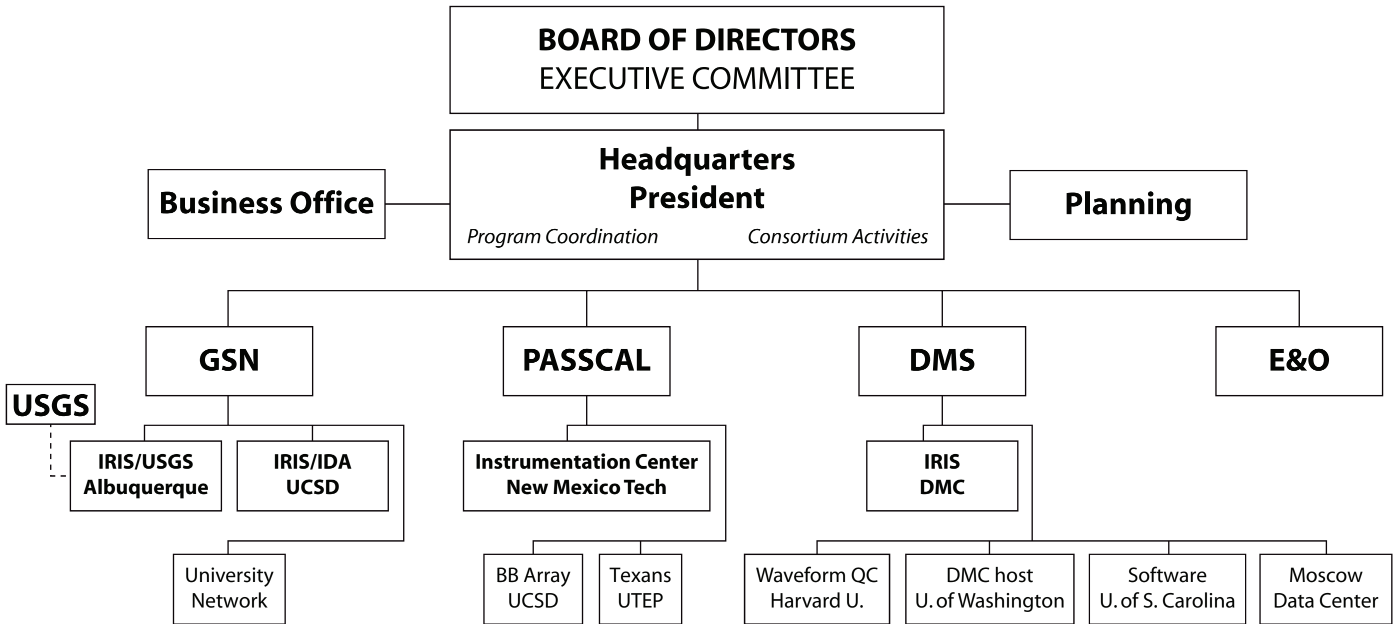


Figure 15. Structure of IRIS operations.

of Defense budget and transferred via interagency agreement with NSF for inclusion in the IRIS Cooperative Agreement. The development of the GSN has benefited from other cost-sharing arrangements as well. An agreement with the Japanese government has provided equipment and communication links for remote island stations in the Pacific. The Pacific Tsunami Warning Center supports part of the communications costs for key stations in the Pacific. The GSN has recently developed the concept of sharing telemetry with the International Monitoring System for the Comprehensive Nuclear Test Ban Treaty to support communications from GSN stations that are part of the IMS.

The **PASSCAL** program, managed by Dr. James Fowler, operates principally through a subaward from IRIS to the New Mexico Institute of Mining and Technology (NMT). This subaward provides support for a staff of 14 NMT employees to operate the PASSCAL Instrument Center in a special office, lab and warehouse facility provided by NMT. The Instrument Center is responsible for the acquisition, assembly and maintenance of all PASSCAL instruments and for training and experiment support for PASSCAL users. Equipment is allocated to users according to a priority system based on funding source and schedule constraints. PASSCAL has recently received support from the Department of Energy for acquisition of a new generation of data systems to replace aging inventory so that NSF- and DOE-funded projects receive highest priority for instrument allocation. Scientists work with the Instrument Center to specify and schedule the equipment needed for each experiment. The Instrument Center prepares equipment for shipment to the experiment site and the PI is then responsible for installation, operation and return of the equipment at the end of the experiment. At the request of the PI, PASSCAL will provide technical assistance in the field for initial set-up of equipment and also help with data collection, quality control and archiving. All permanent equipment for PASSCAL is purchased directly by IRIS with inventory maintained by IRIS. Other elements of the PASSCAL program include a subaward to the University of California San Diego to support development activities related to use of radio communications technology in telemetered broadband arrays; and an award to the University of Texas, El Paso to support maintenance of a pool of 440 UTEP-owned Texan recorders that are made available for use in PASSCAL experiments.

The **Data Management System**, managed by Dr. Tim Ahern, operates through a combined structure of IRIS employees, subawards and partnerships. The Data Management Center, housed in private office space near the University of Washington campus in Seattle, is an IRIS facility and the primary operational node of the DMS. The mass store system and associated computer facilities are located there, along with a staff of 15 IRIS employees for software development, maintenance of the data archive and user support services. The data-request mechanisms developed by the DMS have emphasized automated procedures to minimize the amount of human intervention required to service data requests. Staff are available, however to provide advice and support to users and assist in producing customized requests. The DMS also provides training to US and international groups on topics related to data management and the use of IRIS-developed database systems. Data collection and quality-control functions for GSN data are preformed under DMS direction through a partnership with the US Geological Survey and through a subaward to the IDA group at the University of California, San Diego. Additional DMS subawards include: the University of Washington as host of the DMC; Harvard University for GSN waveform quality control; University of South Carolina for software development and the Moscow Data Center for communication support and software development.

The **Education & Outreach Program** (E&O), managed by Dr. John Taber at the IRIS Headquarters office, is the newest of the IRIS programs, established in 1998. The Program Manger, an Education Specialist and a half-time programmer (shared with DMS) are responsible for the development of print and web-based educational materials; support of the museum program; organization of teacher training workshops; and the scheduling of the summer intern and lecturer programs. The E&O program has managed a series of subawards, including one to the University of South Carolina for development of the Global Earthquake Explorer (GEE) for seismogram display and to other universities for development of educational materials.

Senior Management at **IRIS Headquarters** consists of the President, Director of Planning and Director of Operations. In addition to direct oversight of the IRIS programs and Consortium activities, the President serves as the primary point of contact between IRIS and NSF and with the IRIS Board and Executive Committee. The Director of Planning works with the Planning Committee to explore new program and funding initiatives and improve the visibility of the IRIS program with the public, member institutions, government agencies, and Congress. The Director of Operations works with the Program Coordination Committee and Program Managers to strengthen interactions among the programs and develop cross-program initiatives. Headquarters staff is also responsible for organization of meetings, workshops, publications and other Consortium activities.

The **IRIS Business Office** is responsible for accounting and financial reporting, human resources, contracts and awards, procurement and inventory, insurance, and general office assistance. The goals of the business office are to implement good business practices in all areas such that:

- Business operations are effective and efficient.
- Activities are in compliance with applicable laws, regulations, award terms and conditions, and internal policies and procedures.
- Program personnel receive the appropriate support for their programs.
- Organizational assets are protected.

The business office staff consists of:

- Director of Finance & Administration: plans, organizes, and directs the functions of the business office, and reports to the President.
- Accounting Manager: oversees accounting functions to ensure accurate and reliable data necessary for business operations.
- Staff Accountant I: processes travel vouchers, rebills, and purchase orders.
- Staff Accountant II: processes general accounts payable and records cash receipts.

Funding and Budget Process

The primary source of IRIS funding since its inception has been the National Science Foundation under five-year Cooperative Agreements, which charge IRIS with "establishing, operating, maintaining, and managing the IRIS core programs…," with statements of work that are developed by the NSF Program Officer, in consultation with IRIS, based on the tasks identified in the five-year proposal submissions. The Statement of Work from the current Cooperative Agreement is shown in the box on page 33. In addition to funding from the NSF Earth Sciences Division Instrumentation and Facilities Program (EAR/IF), NSF allows supplements from other NSF programs, other Federal agencies, or other funds, to be provided through amendments to the Cooperative Agreement,

From: NSF-IRIS Cooperative Agreement EAR-0004370
Exploring the Earth at High Resolution: The IRIS 2005 Program Plan

C. STATEMENT OF WORK AND AWARDEE RESPONSIBILITIES

The Incorporated Research Institutions for Seismology shall be responsible for the project in accordance with its proposal EAR-0004370 as modified by the August 1, 2001 cover letter with revised Year 1 budgets. The Awardee shall be responsible for establishing, operating, maintaining, and managing the IRIS core programs, which consist of the Global Seismographic Network (GSN), a pool of portable seismic recording instruments (Program for Array Seismic Studies of the Continental Lithosphere or PASSCAL), the Data Management System (DMS), and Education and Outreach (E&O).

In particular, IRIS shall:

1. Acquire instrumentation for the GSN and install it at GSN station sites in accordance with the NSF-approved Annual Program Plan and Budget.
2. Assume responsibility for the operation and maintenance of all GSN stations designated as IRIS GSN stations in accordance with the approved Annual Program Plan and Budget and work with the U.S. Geological Survey (USGS) to ensure the continued high-quality operation and maintenance of IRIS/USGS GSN stations.
3. Carry out and report to NSF by July 1, 2003, an in-depth study of the operation, personnel and instrument costs, and support of the Global Seismographic Network, in collaboration with NSF, USGS, representatives of the Federation of Digital Seismic Networks (FDSN), and GSN network operators.
4. Acquire PASSCAL instrumentation in accordance with the approved Annual Program Plan and Budget.
5. Maintain the PASSCAL instrument pool at the PASSCAL Instrument Center so that it is available to support high-quality seismic research by the U.S. academic research community in accordance with the approved Annual Program Plan and Budget.
6. Continue to operate the DMS in accordance with the approved Annual Program Plan and Budget.
7. Provide rapid access to all seismic data collected by IRIS programs and help coordinate access to seismic and other Earth science data collected with support from other national and international organizations.
8. Coordinate the siting and instrumentation of the IRIS GSN stations with the international FDSN and its member nations, as well as the USGS and other U.S. agencies so that the common goal of global coverage is achieved as rapidly and efficiently as possible.
9. Coordinate feasibility studies regarding methods of instrumenting and installing ocean-bottom GSN stations with national and international groups so that GSN coverage of the oceans is achieved as rapidly and efficiently as possible.
10. Educate pre-college and college students and the public about seismology, the Earth sciences, and IRIS through museum and school exhibits and other educational programs in accordance with the approved Annual Program Plan and Budget of the Education and Outreach Program.
11. Monitor the scientific, technical, and fiscal performance of all subawards made under the terms of this Agreement, ensuring that all NSF requirements are observed.
12. Execute the scientific, technical, and fiscal responsibilities of IRIS projects supported by Federal agencies other than NSF and approved as part of this Agreement, ensuring that all NSF requirements are observed.
13. Keep NSF informed of all activities carried out under this Agreement and other IRIS activities funded by Federal Agencies other than NSF.
14. Engage in appropriate programs to inform the Earth science community about the potential uses of the IRIS facility and to keep the community informed about its accomplishments.

up to a maximum approved by the National Science Board. IRIS has received external funding from a variety of public and private sources, including the Department of Defense, Department of Energy, National Imagery and Mapping Agency, the Comprehensive Nuclear-Test-Ban Treaty Organization, the Keck Foundation, the W. Alton Jones Foundation, and Japanese organizations. IRIS maintains a separate account of unrestricted funds, built from membership fees, investments and management fees. These monies are used for expenses that are not or cannot be supported by a Federal award. The Executive Committee appoints a three-member Budget & Finance Committee to work with the Director of Finance and Administration and take responsibility for receiving and reviewing monthly budget reports, for oversight of the unrestricted funds, and to initially receive the auditor's reports. The committee identifies and communicates issues in these areas to the Executive Committee for further action when needed.

The funding history for IRIS is shown in Figures 16 and 17. Figure 16 shows the funding source and Figure 17 shows the allocation to individual IRIS programs. The bulk of IRIS core support has come from the Earth Sciences Division, Instrumentation and Facilities Program, but additional funds have been provided through the Cooperative Agreement via interagency transfer from other federal agencies; limited funds have come from private sources. Two significant enhancements to the IRIS support have come from special Congressional appropriations through the Department of Defense (1988-1996, for support of a joint program with the Soviet Academy of Science and for multi-use application of the GSN including nuclear monitoring) and the Department of Energy (2001-2004, for replacement of PASSCAL data loggers).

Under the Cooperative Agreement with NSF, IRIS is required to submit to NSF an Annual Report, Plan and Budget, which summarizes the activities over the past year, outlines the program for the year ahead and presents the budget request for the following year. These annual reports are not proposals (which are submitted every five years) but progress reports to the NSF Program Manager and form the basis for annual funding increments. The details of the annual plan and budget are not constrained by the original proposal, but are expected to follow the general plan presented in the proposal and the nominal levels of annual funding increments specified in the Cooperative Agreement.

Typically in January, the IRIS Executive Committee (ExCom) meets to set overall policy goals and recommend the balance among programs for the next funding year, which begins on July 1. In the early spring, IRIS Standing Committees meet to develop detailed program plans and budgets, review work statements and proposals for subawards, and identify material for the Annual Report and Plan. After the Standing Committee meetings, the IRIS Coordination Committee (CoCom) reviews and reconciles differences between program budgets, develops options for an overall budget plan for presentation to ExCom, and prepares an outline for the Annual Report and Plan. In the late spring, the ExCom meets again to review or modify the overall funding structure, and approves a final draft Budget and Program Plan. IRIS staff then prepares the Annual Report, Program Plan and Budget for submission to NSF based on the guidance from ExCom. The new fiscal year for IRIS, and the usual budget year for the core programs, begins July 1. Throughout the year, Program Managers receive monthly budget reports that show variances between budgeted and actual costs. During the early fall, after the accounting books are reviewed and closed and the annual A-133[1] audit has been completed, final account balances are reported and programs identify funds that were not expended as of June 30. These unspent funds are either:

- approved tasks that have not yet been completed;
- tasks that have been dropped; or
- tasks that cost less than budgeted.

The CoCom meets again in the fall and has the opportunity to review the prior year unspent funds and make adjustments to budgets or activities, with recommendations for ExCom discussion and/or approval, as appropriate.

[1] Annually, a certified public accounting firm hired by IRIS conducts an audit in compliance with OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations," and prepares a report which includes:
a) an opinion on whether the financial statements are presented fairly;
b) a report on internal control, including the results of internal control tests;
c) a report on compliance with (material) laws, regulations, and contract provisions; and
d) a schedule of findings and questioned costs.

Overlain upon the IRIS management structure and budget process is the management oversight provided by the National Science Foundation. The Annual Program Plan and Budget, as proposed through the Executive Committee and approved by the NSF Program Officer, forms the basis for each year's program activities. The Cooperative Agreement sets thresholds under which IRIS can make internal changes in budget allocations and provides mechanisms by which requests for more significant changes in the plan can be presented to NSF for approval. The ongoing interaction among the NSF Program Officer, IRIS management and the community representation on IRIS committees, coupled with the flexible structure of the Cooperative Agreement, has proven to be effective in allowing IRIS to establish and develop its core facilities in response to the evolving needs of the university research community.

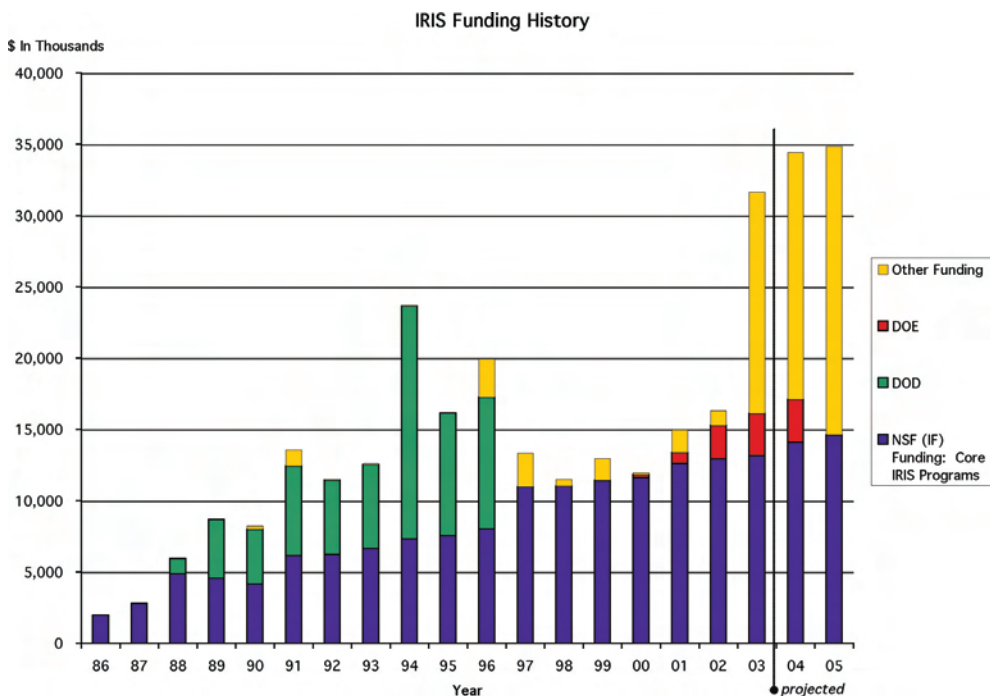


Figure 16. History of support for IRIS showing source of funding. The core support has come from the NSF Earth Science Division, Instrumentation and Facilities Program. Additional support has come from Congressional appropriations to DOD and DOE, transferred to NSF via interagency agreement.

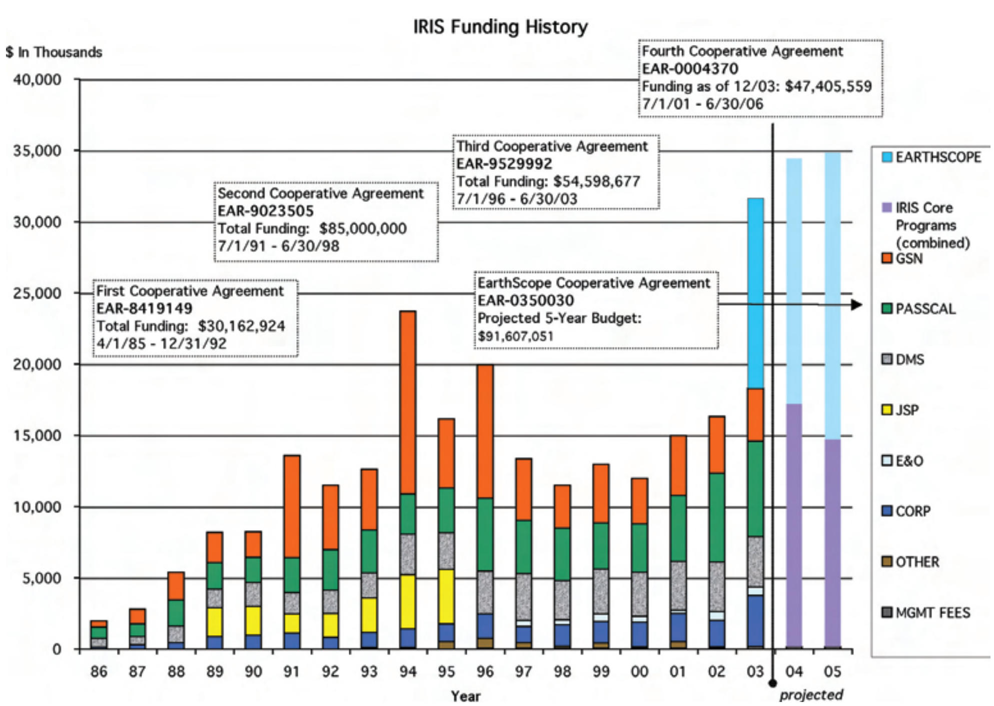
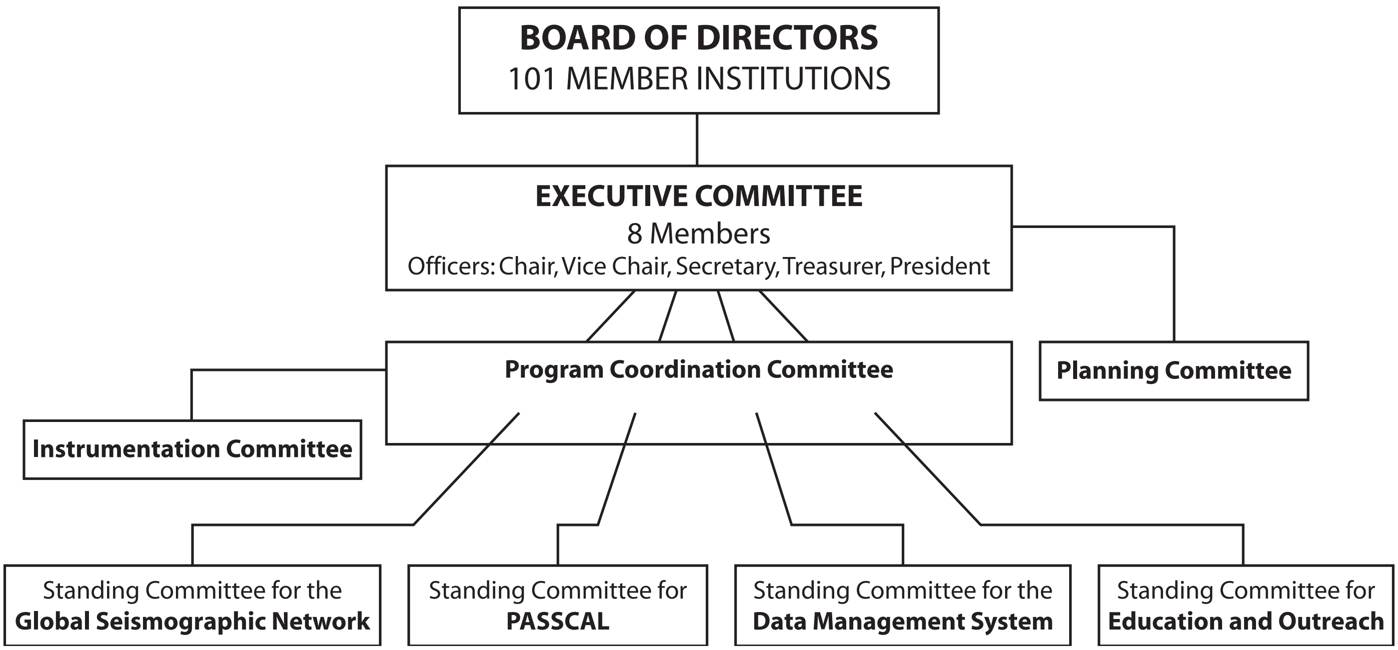


Figure 17. IRIS funding showing annual budgets for each core program. JSP was the Joint Seismic Program with the Soviet Academy of Sciences for support of station installation in Eurasia. Duration and total amounts of funding (NSF plus interagency transfers) during each Cooperative Agreement are shown in the boxes. New EarthScope funding and anticipated support for the remainder of the current Cooperative Agreement are indicated.

Appendix I

IRIS Consortium Membership and Governance Structure



The following pages show the structure, membership and evolution of IRIS Governance.

- **Consortium Member Institutions, Directors and Alternates**
  This table gives the names of the 101 member institutions of the Consortium in 2004 and the names of each institution's representative and alternate on the Board of Directors.
- **IRIS Committee Participants, 1984-2004**
  This table lists the names and institutions of over 160 individuals who have participated in IRIS governance since 1984, along with the name of the committees on which they have served.
- **IRIS Standing Committee Charges**
- **IRIS Committee Membership 2004**
- **History of Executive and Standing Committee Membership, 1984-2004**
  These tables list the membership of each of the Standing Committees from their formation to 2004.

Consortium Member Institutions, Directors and Alternates

IRIS Member Institutions

INSTITUTION	BOARD MEMBER	ALTERNATE
University of Alabama		Dennis L. Harry
University of Alaska	Douglas H. Christensen	Roger Hansen
University of Arizona	Susan Beck	George Zandt
Arizona State University	Matthew J. Fouch	Ed J. Garnero
University of Arkansas at Little Rock	Haydar J. Al-Shukri	Jeffery B. Connelly
Auburn University	Lorraine W. Wolf	
Boise State University	Lee M. Liberty	James P. McNamara
Boston College	John Ebel	Alan Kafka
Boston University	Geoffrey Abers	Rachel E. Abercrombie
Brown University	Karen Fischer	Donald Forsyth
California Institute of Technology	Donald Helmberger	Thomas Heaton
University of California, Berkeley	Barbara Romanowicz	Lane Johnson
University of California, Los Angeles	John Vidale	Paul Davis
University of California, Riverside	Stephen K. Park	David D. Oglesby
University of California, San Diego	Peter Shearer	Jon Berger
University of California, Santa Barbara	Craig Nicholson	Ralph Archuleta
University of California, Santa Cruz	Thorne Lay	Susan Schwartz
Carnegie Institution of Washington	Paul Silver	Selwyn Sacks
Central Washington University	Timothy Melbourne	Charles Rubin
University of Colorado, Boulder	Mike Ritzwoller	Anne Sheehan
Colorado School of Mines	Roel Snieder	Thomas Boyd
Columbia University	Paul G. Richards	Arthur Lerner-Lam
University of Connecticut	Vernon F. Cormier	Lanbo Liu
Cornell University	Muawia Barazangi	Larry Brown
University of Delaware	Susan McGeary	
Duke University	Peter Malin	Eylon Shalev
Florida International University	Dean Whitman	
University of Georgia	Robert Hawman	James Whitney
Georgia Institute of Technology	Leland T. Long	James Gaherty
Harvard University	Göran Ekström	Adam Dziewonski
University of Hawaii at Manoa	Gerard Fryer	Charles Helsley
IGPP/Lawrence Livermore National Laboratory	William Walter	Peter Goldstein
IGPP/Los Alamos National Laboratory	Hans Hartse	Leigh House
Idaho State University	Joseph M. Kruger	
University of Illinois at Urbana Champaign	Wang-Ping Chen	Xiaodong Song
Indiana University	Gary L. Pavlis	Michael Hamburger
Indiana University/Purdue University at Fort Wayne	Dipak Chowdhury	
Kansas State University	Stephen Gao	Charles Oviatt
University of Kansas	Ross A. Black	
University of Kentucky	Edward W. Wollery	Zhenming Wang
Lawrence Berkeley National Laboratory	D.W. Vasco	E.L. Majer
Lehigh University	Anne Meltzer	
Louisiana State University	Juan Lorenzo	Roy Dokka
Macalester College	John P. Craddock	Karl R. Wirth
Massachusetts Institute of Technology	Robert Dirk van der Hilst	Bradford H. Hager
University of Miami	Tim Dixon	Falk Amelung
The University of Memphis	Jer-Ming Chiu	Arch Johnston
University of Michigan	Larry Ruff	
Michigan State University	Kazuya Fujita	David W. Hyndman
Michigan Technological University	Wayne D. Pennington	Jimmy F. Diehl
University of Minnesota		
University of Missouri	Eric Sandvol	Mian Liu
University of Montana	Michael Stickney	Marvin Speece
University of Nevada, Las Vegas	Catherine Snelson	Jim O'Donnell
University of Nevada, Reno	Glenn Biasi	Steve Jaume
University of New Orleans	Abu K.M. Sarwar	

New Mexico Institute of Mining & Technology	Richard C. Aster	Harold Tobin
New Mexico State University	James Ni	Thomas Hearn
State University of New York at Binghamton	Francis T. Wu	Jeff Barker
State University of New York at Stony Brook	William Holt	Daniel Davis
University of North Carolina, Chapel Hill	Jonathan Lees	Jose Rial
Northern Illinois University	Paul Stoddard	Philip Carpenter
Northwestern University	Ray Russo	Seth Stein
The University of Oklahoma	Roger Young	Judson Ahern
University of Oregon	Eugene Humphreys	Doug Toomey
Oregon State University	John Nabelek	Anne Trehu
Pennsylvania State University	Shelton S. Alexander	
Princeton University	Guust Nolet	Robert Phinney
University of Puerto Rico, Mayagüez	Christa von Hillebrandt	Eugenio Asencio
Purdue University	Lawrence W. Braile	Scott King
Rensselaer Polytechnic Institute	Steven Roecker	Robert McCaffrey
Rutgers University	Vadim Levin	Michael J. Carr
Rice University	Alan R. Levander	Dale Sawyer
Saint Louis University	Brian J. Mitchell	Keith Koper
San Diego State University	Robert Mellors	Steven Day
San Jose State University	Donald L. Reed	Richard Sedlock
Southeast Missouri State University		Nicholas H. Tibbs
University of South Carolina	Tom Owens	Pradeep Talwani
University of Southern California	Thomas H. Jordon	Ta-Liang Teng
Southern Methodist University	Eugene T. Herrin	
Stanford University	Gregory C. Beroza	Simon Klemperer
Syracuse University	Douglas K. Nelson	
University of Tennessee	Richard T. Williams	
Texas A&M University	Richard Gibson	Philip D. Rabinowitz
Texas Tech University	Harold Gurrola	Calvin Barnes
University of Texas at Austin	Clifford A. Frohlich	Stephen P. Grand
University of Texas at Dallas	George McMechan	John Ferguson
University of Texas at El Paso	Kate Miller	Randy Keller
University of Tulsa	Christopher L. Liner	Bryan Tapp
University of Utah	Robert B. Smith	Gerald T. Schuster
Virginia Polytechnic Institute	J. Arthur Snoke	John Hole
University of Washington	Steve Malone	Kenneth Creager
Washington University, St. Louis	Douglas Wiens	Michael Wysession
West Virginia University	Thomas H. Wilson	Robert Behling
University of Wisconsin, Madison	Clifford Thurber	William J. Lutter
University of Wisconsin, Milwaukee	Keith A. Sverdrup	Brett Ketter
University of Wisconsin, Oshkosh	Timothy Paulsen	
Woods Hole Oceanographic Institution	Ralph Stephen	Alan Chave
Wright State University	Ernest C. Hauser	Paul J. Wolfe
University of Wyoming	Scott B. Smithson	
Yale University	Jeffrey J. Park	

U.S. Affiliate Member Institutions

INSTITUTION	REPRESENTATIVE
Naval Air Weapons Station, Geothermal Program Office	Francis Monastero
Maryland Geological Survey	Gerald R. Baum

Educational Affiliates

INSTITUTION	REPRESENTATIVE
Arizona Western College	Michael Conway
Diné College	Steven C. Semken
Eckerd College	Laura Reiser Wetzel
Trinity University	Glenn C. Kroeger

Foreign Affiliate Member Institutions

INSTITUTION	REPRESENTATIVE
Academy of Sciences, Seismological Center, Albania	Betim Muco
Australian National University, Australia	Brian Kennett
The University of Queensland, Australia	Peter Mora
Observatório Nacional, Brazil	Jorge Luis de Souza
Universidade de Brasilia, Brazil	Joao Willy Rosa
Universidade de São Paulo, Brazil	Marcelo Assumpção
Ecole Polytechnique, Canada	Marianne Mareschal
Geological Survey of Canada, Continental Geoscience Division	Isa Asudeh
University of British Columbia, Canada	Michael G. Bostock
University of Toronto, Canada	Kin-Yip Chun
Universidad Nacional, Costa Rica	Federico Güendel
Geophysical Institute, Czech Republic	Axel Plesinger
Masaryk University, Czech Republic	Petr Firbas
National Research Institute of Astronomy and Geophysics, Egypt	Amin Ibrahim Hussein
University of Bristol, England	George Hellfrich
University of Cambridge, England	Keith Priestley
The University of Leeds, England	Roger Clark
University of Leicester, United Kingdom	Peter Maguire
Intl. Institute of Earthquake Engineering and Seismology, Iran	Manouchehr Bahavar
Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Mexico	Cecilio J. Rebollar
Institute of Geological & Nuclear Sciences, New Zealand	Mark Peter Chadwick
University of Otago, New Zealand	Helen Anderson
Victoria University, Institute of Geophysics, New Zealand	Martha Kane Savage
University of Bergen, Norway	Eystein S. Husebye
Instituto Geofisico Del Peru, Peru	Edmundo Norabuena
Chinese Academy of Sciences, China	Ai Yinshuang
Institute of Geology, SSB, Beijing, PRC	Qiyuan Liu
Institute of Geophysics, Beijing, PRC	Gongwei Zhou
Peking University, PRC	Shao Xian Zang
University of Hong Kong, PRC	Lung Sang Chan
Institute of Geophysics, Polish Academy of Sciences, Poland	Pawel Wiejacz
Instituto Superior Técnico, Portugal	Joao F.B.D. Fonseca
Universidade do Porto, Faculdade de Engenharia, Portugal	Rui Carneiro-Barros
National Institute for Earth Physics, Romania	Andrei Bala
Kuban State University, Russia	Vladimir Babeshko
Russian Academy of Sciences, Russia	Vitaly V. Adushkin
Hanyang University, Republic of Korea	So Gu Kim
Institute of Geophysics, Switzerland	Domenico Giardini
Academia Sinica, Institute of Earth Sciences, Taiwan	Bor-Shouh Huang
National Central University, Taiwan	Kuo-Gong Ma
Istanbul Technical University, Turkey	Tuncay Taymaz
Kandilli Observatory, Bogazici University, Turkey	Nurcon Ozel
Tubitak-Marmara Research Centre, Turkey	M. Namik Yalcin

IRIS Committee Participants, 1984-2004

Geoffrey	Abers	Boston University	DMS, PASSCAL, GSN
Duncan	Agnew	University of California, San Diego	GSN
Ketti	Aki	University of Southern California	PASSCAL
Shelton	Alexander	Pennsylvania State University	EXCOM, DMS
Marcos	Alvarez	New Mexico Tech	PASSCAL
Charles	Ammon	St. Louis University	GSN
Don	Anderson	California Institute of Technology	Excom
Charles	Archambeau	TRAC	JSP
Richard	Aster	New Mexico Tech	PASSCAL, E&O
Jeffrey	Barker	SUNY, Binghamton	E&O
Susan	Beck	University of Arizona	GSN, Excom
Harley	Benz	USGS, Golden	DMS, GSN
Jonathan	Berger	University of California, San Diego	JSP, GSN
Eric	Bergmann	Global Seismological Services	GSN
Gregory	Beroza	Stanford University	GSN
Gilbert	Bollinger	Virginia Poly Institute and State University	PASSCAL
Harold	Bolton (Obs)	USGS, Albequerque	DMS
Thomas	Boyd	Colorado School of Mines	Excom, E&O
Lawrence	Braile	Purdue University	PASSCAL, Excom, E&O
Thomas	Brocher	USGS, Menlo Park	PASSCAL
Ray	Buland	USGS, Golden	GSN
Alan	Chave	Woods Hole Oceanographic Institution	PASSCAL, GSN
John	Collins	Woods Hole Oceanographic Institution	PASSCAL
Kenneth	Creager	University of Washington	DMS, GSN
Robert	Crosson	University of Washington	DMS
Peter	Davis	University of California, San Diego	DMS, GSN
Robert	Detrich	Woods Hole Oceanographic Institution	DMS
Douglas	Dodge	Lawrence Livermore National Laboratory	DMS
Diane	Doser	University of Texas, El Paso	PASSCAL
Douglas	Dreger	University of California, Berkeley	GSN
Kenneth	Dueker	University of Colorado	PASSCAL
Adam	Dziewonski	Harvard University	GSN, Excom, Planning
Paul	Earle	NEIC, USGS, Golden	GSN
Göran	Ekström	Harvard University	GSN, JSP, DMS, Excom, Planning
Kathy	Ellins	University of Texas, Austin	E&O
William	Ellsworth	USGS, Menlo Park	PASSCAL
Robert	Engdahl	USGS	DMS
John	Filson	USGS, Reston	JSP, GSN
Karen	Fischer	Brown University	GSN
Frederick	Followill	Lawrence Livermore National Laboratory	PASSCAL
Donald	Forsyth	Brown University	GSN
Matthew	Fouch	Arizona State University	PASSCAL
Clifford	Frohlich	University of Texas, Austin	DMS
Kazuya	Fujita	Michigan State University	GSN
James	Gaherty	Georgia Institute of Technology	GSN
Edward	Garnero	Arizona State University	DMS
Lind	Gee	University of California, Berkeley	Excom, E&O
Holly	Given	University of California, San Diego	GSN
Peter	Goldstein	Lawrence Livermore National Laboratory	DMS
Joan	Gomberg	USGS, Memphis	PASSCAL
Stephen	Grand	University of Texas, Austin	GSN
Michelle	Hall-Wallace	University of Arizona	E&O
Michael	Hamburger	Indiana University	E&O
Steven	Harder	University of Texas, El Paso	PASSCAL
Daniel	Harvey	University of Colorado	JSP
Egill	Hauksson	California Institute of Technology	PASSCAL
Thomas	Heaton	California Institute of Technology	GSN
Donald	Helmberger	California Institute of Technology	GSN
Thomas	Henyey	University of Southern California	PASSCAL
John	Hildebrand	University of California, San Diego	GSN

John	Hole	Virginia Polytechnic Institute	PASSCAL
William	Holt	SUNY, Stony Brook	DMS
Heidi	Houston	University of California, Los Angeles	GSN
Eugene	Humphreys	University of Oregon	PASSCAL, Excom
Charles	Hutt	USGS, Albuquerque	DMS, E&O, GSN
Shane	Ingate	University of California, San Diego	DMS
David	James	Carnegie Institution of Washington	PASSCAL
Roy	Johnson	University of Arizona	DMS, GSN, PASSCAL
Arch	Johnston	University of Memphis	JSP, Excom
Thomas	Jordan	University of Southern California	Excom, Planning
Alan	Kafka	Boston College	E&O
Hiroo	Kanamori	California Institute of Technology	GSN, Excom
Randy	Keller	University of Texas, El Paso	Excom
Camilia	Knapp	University of South Carolina	E&O
Monica	Kohler	University of California, Los Angeles	DMS
Glenn	Kroeger	Trinity University	E&O
John	Lahr	USGS, Denver	E&O
Charles	Langston	Pennsylvania State University	JSP, GSN
Kenneth	Larner	Colorado School of Mines	PASSCAL
Gabi	Laske	University of California, San Diego	GSN
Thorne	Lay	University of California, Santa Cruz	Excom, GSN
Jonathan	Lees	University of North Carolina	DMS
Arthur	Lerner-Lam	Columbia University	GSN, JSP, PASSCAL, Planning, Excom
Alan	Levander	Rice University	Excom, DMS, Planning
John	Louis	University of Nevada, Reno	PASSCAL
Peter	Malin	Duke University	DMS
Stephen	Malone	University of Washington	DMS, Excom
Kurt	Marfurt	University of Houston	PASSCAL
Robert	Massé	USGS, Golden	GSN
Guy	Masters	University of California, San Diego	Excom, DMS
Thomas	McEvilly	University of California, Berkeley	GSN, Excom
Susan	McGeary	University of Delaware	Excom
George	McMechan	University of Texas, Dallas	PASSCAL
Daniel	McNamara	USGS, Golden	DMS
Robert	Mellors	San Diego State University	E&O
Anne	Meltzer	Lehigh University	PASSCAL, Excom, Planning
William	Menke	Columbia University	DMS, PASSCAL
Kate	Miller	University of Texas, El Paso	PASSCAL, Excom
Bernard	Minster	University of California, San Diego	DMS
Brian	Mitchell	St Louis University	GSN
Walter	Mooney	USGS, Menlo Park	PASSCAL
John	Nabelek	Oregon State University	DMS, PASSCAL
Keith	Nakanishi	Lawrence Livermore National Laboratory	DMS
Guust	Nolet	Princeton University	Excom, E&O, DMS
Robert	North	Center for Monitoring Research	GSN
Andrew	Nyblade	Pennsylvania State University	Excom
Emile	Okal	Northwestern University	GSN
David	Okaya	University of Southern California	PASSCAL, DMS
John	Orcutt	University of California, San Diego	DMS, Excom, GSN, Planning
Thomas	Owens	University of South Carolina	DMS, PASSCAL, Excom
Jeffrey	Park	Yale University	Excom, JSP, GSN
Gary	Pavlis	Indiana University	JSP, PASSCAL, DMS, Excom
Robert	Phinney	Princeton University	PASSCAL, Excom
Thomas	Pratt	USGS	PASSCAL
Paul	Richards	Columbia University	Excom, JSP, DMS
Michael	Ritzwoller	University of Colorado	JSP, GSN
Steven	Roecker	Rensselaer Polytechnic Institute	PASSCAL
Barbara	Romanowicz	University of California, Berkeley	GSN, Planning
Lawrence	Ruff	University of Michigan	DMS
Martha	Savage	Victoria University	DMS
Susan	Schwartz	University of California, Santa Cruz	DMS, E&O
Steven	Semken	Arizona State University	E&O
Peter	Shearer	University of California, San Diego	Excom

Anne	Sheehan	University of Colorado	GSN, PASSCAL
Paul	Silver	Carnegie Institution of Washington	Excom, JSP, PASSCAL
David	Simpson	Columbia University	JSP, PASSCAL
Stuart	Sipkin	USGS, Denver	GSN, DMS
Kenneth	Smith	University of Nevada, Reno	DMS
Robert	Smith	University of Utah	Excom, PASSCAL, Planning
Stewart	Smith	University of Washington	JSP
Sean	Solomon	Carnegie Institution of Washington	GSN
Seth	Stein	Northwestern University	Excom
William	Stevenson	USGS, Denver	PASSCAL
Brian	Stump	Southern Methodist University	JSP, PASSCAL
Fumiko	Tajima	University of California, Berkeley	DMS
Toshiro	Tanimoto	California Institute of Technology	DMS
Steven	Taylor	Los Alamos National Laboratory	DMS
Ta-liang	Teng	University of Southern California	Excom, GSN
George	Thompson	Stanford University	Excom
Clifford	Thurber	University of Wisconsin, Madison	PASSCAL, Excom
Anne	Trehue	Oregon State University	PASSCAL, Excom, DMS
Jeroen	Tromp	California Institute of Technology	GSN, DMS
Robert	van der Hilst	Massachusetts Institute of Technology	DMS, Excom
Suzan	van der Lee	Northwestern University	E&O
Aaron	Velasco	University of Texas, El Paso	E&O
Frank	Vernon	University of California, San Diego	JSP, PASSCAL
John	Vidale	University of California, Los Angeles	Excom
Lisa	Wald	USGS, Golden	E&O
Terry	Wallace	University of Arizona	JSP, GSN, DMS, Excom, Planning
William	Walter	Lawrence Livermore National Laboratory	PASSCAL
Lianxing	Wen	State University of New York, Stony Brook	GSN
Douglas	Wiens	Washington University, St Louis	DMS, Excom
Richard	Williams	University of Tennessee	PASSCAL
Christian	Winther	University of California, San Diego	GSN
Cecily	Wolfe	University of Hawaii	GSN
John	Woodhouse	University of Oxford	DMS
Robert	Woodward	USGS, Albuquerque	DMS, E&O
Francis	Wu	SUNY, Binghamton	DMS
Michael	Wysessiion	Washington University, St Louis	Excom, Planning
George	Zandt	University of Arizona	PASSCAL
Colin	Zelt	Rice University	PASSCAL

IRIS Standing Committee Charges

Program for Array Seismic Studies of the Continental Lithosphere

The PASSCAL Standing Committee oversees the evolving policies of the portable instrumentation program, addressing issues in hardware development, usage, and the dissemination of data collected by individual field projects.

1) Set standards of instrumentation and software development for PASSCAL, working in concert with the PASSCAL Program Manager to exploit new technology.
2) Set guidelines for the use of the PASSCAL facility. This includes the use of the PASSCAL data acquisition system (DAS), sensors, field computers and instrument center personnel.
3) Set guidelines for archiving data collected in PASSCAL experiments.
4) Aid in scheduling instrument use.
5) Develop and evaluate strategies for the successful procurement of PASSCAL instrumentation (6000 channels) so as to complete the PASSCAL facility by 1996.
6) Develop new initiatives to enhance the effectiveness of the PASSCAL program
7) Advise the Program Manager and the IRIS President on program planning and yearly budgets.

Global Seismographic Network

The GSN Standing Committee develops policies to facilitate a timely and successful installation of the Global Seismic Network, and the rapid dissemination of the data collected by the GSN.

1) Set standards for GSN instrumentation and data collection
2) Develop and maintain a siting plan that ensures the timely deployment of GSN instruments, and accounts for the contributions of other 'equivalent' networks in maximizing the global coverage afforded by the GSN.
3) Set standards/policies to ensure the timely flow of data from the GSN stations to the DCC's
4) Develop and evaluate strategies for the successful procurement and installation of GSN equipment so as to complete the global seismographic network by 1996 (128 'goal' stations).
5) Cooperate with the USGS, the Federation of Digital Broad Band Seismograph Networks (FDSN), and other groups interested in establishing digital stations for global studies, to establish a well-distributed network in an expeditious manner.
6) Develop plans for the long-term maintenance of the GSN.
7) Coordinate with the OSN Steering Committee to facilitate the deployment of ocean bottom stations, so as to reach the GSN goal of uniform global coverage.
8 Develop new initiatives to enhance the effectiveness of the GSN.
9) Advise the Program Manager and the IRIS President on program planning and yearly budgets.

Data Management System

The DMS Standing Committee operates in an oversight capacity to ensure that the IRIS Data Management System (DMS) is effective in archiving and making available data from the GSN and PASSCAL programs, as well as other data.

1) Develop and maintain policies that ensure that data flow into the DMC in a timely fashion from the DCC's (in the case of GSN data) and from individual investigators (in the case of PASSCAL data). These duties will be closely coordinated with the GSN SC and PASSCAL SC respectively.
2) Ensure completeness of the data archive. Develop policies for the archival of non-IRIS data, particularly FDSN data needed to ensure the global recording of teleseismic events by broadband seismometers.
3) Develop, set and maintain data quality standards for GSN, PASSCAL, as well as other data stored by the DMC.

4) Ensure that users have easy and rapid access to the data archive.
5) Advise in the development of software tools for the display and processing of seismic data by users.
6) Provide oversight for the operation of the IRIS DMC, the IRIS/IDA DCC, the IRIS/USGS DCC, and other DMS components as needed.
7) Develop new initiatives to enhance the effectiveness of the DMS.
8) Advise the Program Manager and the IRIS President on program planning and the yearly budgets.

Education and Outreach

The Committee on Education and Outreach will develop recommendations to the IRIS Executive Committee for programs that will foster within the next generation of research scholars, educators, policy-makers, business leaders, and benefactors an appreciation for and an understanding of seismology and related study of the Earth. The E&O Committee , working with the seismological and educational communities, will develop and implement IRIS programs designed to enhance seismology and Earth Science education in K-12 schools, colleges and universities, and in adult education. Implementation of such an ambitious program will require seeking additional funding from appropriate agencies such as NSF/EHR. A major objective will therefore be to make seismology accessible to the broadest possible audience, demonstrating that seismology is intellectually fascinating, and that a background in geoscience is valuable and relevant for a broad range of careers. In keeping with NSF's goal of integrating education with research, the educational committee will also give high priority to identifying mechanisms for IRIS research programs and activities to enhance the educational process at all levels.

Planning Committee

The Planning Committee is charged with thee task of studying strategic problems and opportunities related to the vitality of IRIS and the research community in order to advise the Executive Committee in considering priorities and policies. As part of the process, the Planning Committee should review developments in national program which are expected to have a significant impact on IRIS and the IRIS community and explore prospective new scientific directions, instrumentation, or initiatives. The Planning Committee will develop recommendations for review and action by the Executive Committee.

Program Coordination Committee

The Program Coordination Committee is charged with the task of developing an integrated IRIS budget for review and action by the Executive Committee. As part of this process, the Program Coordination Committee should identify ways to enhance scientific effectiveness, coordination among the core programs, and economies of scale. It is expected that the activities of the Program Coordination Committee will result in improved coordination and cooperation of the core programs and optimized development and use of IRIS resources.

Instrumentation Committee

The Instrumentation Committee should be pan-IRIS Consortium, spanning all four programs. As technology evolves, the Instrumentation Committee should be cognizant of cross-programmatic system requirements, and pursue goals of system design that will satisfy these cross-programmatic needs. The Instrumentation Committee should be proactive, encouraging research and development as appropriate, and seeking new products that could meet current, future, and unexpected needs for sensors, data acquisition systems, communications and data distribution hardware. The Instrumentation Committee should be responsive to specific needs for technical advice, by providing reports and recommendations to the IRIS Coordination Committee and Standing Committees when requested. The Instrumentation Committee should also serve as IRIS liaison to similar bodies for other programs such as ANSS.

IRIS Committee Membership 2004

Executive Committee

Ekstrom, Goran (Chair)	Harvard University	04
Beck, Susan	Univ. of Arizona	04
Beroza, Greg	Stanford University	06
Lerner-Lam, Art	Columbia University	05
Miller, Kate	Univ of Texas, El Paso	05
Nyblade, Andy (Sec)	Pennsylvania State Univ	04
Owens, Tom (VChair)	Univ. of South Carolina	04
Stump, Brian	Southern Methodist Univ.	06
Shin, Candy	Treasurer	
Simpson, David	President	

Global Seismographic Network

Lay, Thorne (Chair)	Univ. of CA, Santa Cruz	05
Leith, William (ex off)	USGS, Reston	
Creager, Ken	Univ of Washington	04
Earle, Paul	NEIC, USGS, Golden	05
Fischer, Karen	Brown University	06
Laske, Gabi	Univ of CA, San Diego	04
Park, Jeffrey	Yale University	05
Ritzwoller, Mike	University of Colorado	06
Tromp, Jeroen	California Inst. of Technology	04
Wen, Lianxing	State Univ. of NY, Stony Brook	05
Davis, Peter (obs)	Univ. of CA, San Diego	
Hutt, Charles R (obs)	USGS, Albuquerque	
Berger, Jon (obs)	Univ. of CA, San Diego	

PASSCAL

James, David (Chair)	Carnegie Inst. of Washington	05
Collins, John	Woods Hole Oceanographic Inst.	04
Fouch, Matthew	Arizona State University	06
Hole, John	Virginia Polytechnical Inst.	05
Knapp, Camelia	University of South Carolina	06
Roecker, Steve	Rensselaer Polytechnic Inst.	04
Sheehan, Anne	Univ. of Colorado, Boulder	04
Stevenson, William	USGS, Denver	06
Walter, William	Lawrence Livermore Nat. Lab	05
Zelt, Colin	Rice University	05
Alvarez, Marcos (obs)	New Mexico Tech	
Aster, Rick (obs)	New Mexico Tech	
Vernon, Frank (obs)	Univ. of CA, San Diego	05

Data Management System

Nolet, Guust (Chair)	Princeton University	05
Dodge, Douglas	Lawrence Livermore Natl. Lab	04
Garnero, Ed	Arizona State Univ	04
McNamara, Daniel	USGS, Golden	05
Okaya, David	Univ. of Southern California	04
Trehue, Anne	University of Oregon	06
van der Lee, Suzan	Northwestern University	06
Wiens, Douglas	Washington Univ., St Louis	05
Bolton, Harold(obs)	USGS, Albequerque	
Davis, Peter(obs)	Univ. of California, San Diego	

Education and Outreach

Aster, Rick (Chair)	New Mexico Tech	04
Ellins, Kathy	University of Texas, Austin	06
Kafka, Alan	Boston College	04
Semken, Steve	Arizona State University	05
Stein, Seth	Northwestern University	06
Wald, Lisa	USGS Golden	05
Aaron Velasco	University of Texas, El Paso	06

Planning Committee

Dziewonski, Adam (chair)	Harvard University	03
Ekstrom, Goran	Harvard University	05
Jordan, Thomas	Univ of Southern California	04
Lerner-Lam, Art	Columbia University	03
Meltzer, Anne	Lehigh University	04
Simpson, David	IRIS	
Wysession, Michael	Washington University	05
Levander, Alan	Rice University	05

Program Coordination Committee

Owens, Thomas (chair)	Univ. of South Carolina, ExCom
Ahern, Timothy	IRIS, DMS
Aster, Rick	New Mexico Tech, E&O
Butler, Rhett	IRIS, GSN
Fowler, James	IRIS, PASSCAL
Ingate, Shane	IRIS, Director of Operations
James, David	Carnegie Institution, PASSCAL
Lay, Thorne	Univ of CA, Santa Cruz, GSN
Nolet, Guust	Princeton University, DMS
Stump, Brian	Southern Methodist Univ.
Shin, Candy	IRIS, Director of Finance
Simpson, David	IRIS, President
Taber, John	IRIS, E&O

Instrumentation Committee

Collins, John (Chair)	WHOI
Benz, Harley	USGS/ANSS liason
Hutt, Charles H.	USGS, Albuquerque
Owens, Thomas	Univ of South Carolina
Sacks, Selwyn	Carnegie Inst. of Washington
Vernon, Frank (Vchair)	Univ of CA, San Diego
Ahern, Tim	IRIS
Butler, Rhett	IRIS
Fowler, James	IRIS
Ingate, Shane	IRIS
Taber, John	IRIS

History of Executive and Standing Committee Membership 1984-2004

Executive Committee

NAME	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Shelton Alexander	VC	VC	VC																
Don Anderson	●	●																	
Adam Dziewonski	●											C	C						
Thomas McEvilly	C	●	●								●	●	●	●					
Robert Phinney	●	C	C	●															
Robert Smith	●																		
Ta-Liang Teng	●	●																	
Clifford Thurber	S	S	S	●	●										●	●	●		
Larry Braile		●	●	●	●														
Seth Stein		●	●																
John Orcutt			●	C	C	●													
Paul Richards			●	●	VC														
Thorne Lay				●	●														
Jeffrey Park				S	S	VC	VC	C	C										
Paul Silver				●	●	C	C												
Gary Pavlis					●	●									●	●	●	●	
Susan McGeary						S	S	●	●										
George Thompson						●	●												
Terry Wallace						●	●			C	C								
Douglas Wiens						●				●	●	●	●						
Arch Johnston							●	●											
Guy Masters							●	●											
Thomas Owens							●	●									VC	VC	VC
Thomas Boyd								S	S										
Alan Levander								VC	VC	VC	VC								
Guust Nolet								●	●	●	●								
Göran Ekström									●	●				VC	VC	VC	C	C	C
Hiroo Kanamori									●	●									
Anne Trehue									●	●									
Lind Gee										S	S	S	S						
Karen Fischer											●	●							
Randy Keller											●	VC	VC						
Eugene Humphreys												●	●	●					
Peter Shearer												●	●	●	●				
John Vidale													●	●					
Thomas Jordan														●	●	●			
Anne Meltzer														C	C	C			
Michael Wysessiion														S	S	S			
Stephen Malone															●	●	●		
Robert van der Hilst																●	●	●	
Susan Beck																	●	●	●
Andrew Nyblade																	S	S	S
Arthur Lerner-Lam																		●	●
Kate Miller																		●	●
Gregory Beroza																			●
Brian Stump																			●

Data Management System Committee

NAME	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Shelton Alexander	C	●	●	●	●	●	●												
Robert Engdahl	●	●	●	●	C	C	C	●											
Lane Johnson	●	C	C	C															
John Orcutt	●	●																	
Gary Pavlis	●	●	●	●															
Lawrence Ruff	●	●							●	●	●								
Fumiko Tajima	●	●	●																
John Woodhouse	●																		
Robert Crosson		●	●	●									C						
Alan Levander			●	●										C	C	C			
Keith Nakanishi			●	●	●														
William Menke				●	●														
Bernard Minster				●	●														
Clifford Frohlich					●	●	●												
Stephen Malone					●	●	●												
John Nabelek					●	●	●												
Toshiro Tanimoto					●		●												
Göran Ekström						●	●	●											
Peter Malin						●	●	●											
Francis Wu						●	●	C	C	C									
Geoffrey Abers								●	●	●									
Harley Benz								●	●	●	●	●	●						
Karen Fischer								●	●	●									
Martha Savage								●	●										
Susan Schwartz									●	●	C	C							
David Okaya										●	●	●					●	●	●
Thomas Owens										●	●	●							
Kenneth Creager											●	●							
Paul Richards											●	●	●						
Steven Taylor											●	●	●						
Terry Wallace												●	●	●					
Jonathan Lees													●	●	●				
Robert van der Hilst													●	●	●				
Peter Goldstein														●	●	●			
William Holt														●	●	●			
Monica Kohler														●	●	●	C		
Stuart Sipkin														●	●	●	●		
Guy Masters															●	●	●		
Robert Detrich																●	●	●	
Kenneth Smith																●	●	●	
Douglas Dodge																	●	●	●
Edward Garnero																	●	●	●
Daniel McNamara																		●	●
Guust Nolet																		C	C
Douglas Wiens																		●	●
Anne Trehue																			●
Suzan van der Lee																			●

Global Seismographic Network Committee

NAME	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Rhett Butler	●																		
Jonathan Berger	●	●	●		●														
Adam Dziewonski	C	C												●	●	●			
Hiroo Kanamori	●	●																	
Thorne Lay	●	●	●											●	●	●		C	C
Thomas McEvilly	●																		
Brian Mitchell	●	●																	
Ta-Liang Teng	●	●	●																
Sean Solomon		●	C	C															
Terry Wallace		●	●	●				●	●										
Kazuya Fujita			●	●	●				●	●	●								
Donald Helmberger			●	●	●														
Arthur Lerner-Lam			●	●	●														
Charles Langston				●	●		●	●	●										
Emile Okal				●	●														
Donald Forsyth					C		C	C											
Stephen Grand					●		●								●	●	●		
Gregory Beroza						●	●	●											
Heidi Houston						●	●	●											
Barbara Romanowicz						●	●	●						C	C	C	C		
Stuart Sipkin						●	●	●				●							
Douglas Wiens							●	●	●										
Lane Johnson									C	C									
Robert North									●	●	●								
Duncan Agnew										●	●	●							
Eric Bergmann										●	●	●							
Susan Beck											●	●	●						
Alan Chave											●	●	●						
Douglas Drager											●	●	●						
Göran Ekström											C	C	C						
Thomas Heaton											●	●	●	●					
Anne Sheehan												●	●	●					
Charles Ammon														●	●	●			
John Orcutt														●	●				
Harley Benz															●	●	●		
James Gaherty																●	●	●	
Cecily Wolfe																●	●	●	
Kenneth Creager																	●	●	●
Gabi Laske																	●	●	●
Jeroen Tromp																	●	●	●
Paul Earle																		●	●
Jeffrey Park																		●	●
Lianxing Wen																		●	●
Karen Fischer																			●

PASSCAL Committee

NAME	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Keitti Aki	●	●																	
Lawrence Braile	●	C	C	C	C	●													
William Ellsworth	●																		
Kenneth Larner	●																		
George McMechan	●	●	●																
William Menke	●	●	●	●								●							
Robert Phinney	C	●																	
Robert Smith	●	●	●	●	●	●	●	●											
Gilbert Bollinger		●	●																
Peter Malin		●	●																
Walter Mooney		●	●	●	●						●	●	●						
Paul Silver			●	●	●														
Anne Trehue			●	●	●	C	C	●											
David Okaya				●	●	●								●	●	●			
Thomas Owens				●	●									●	●	●			
David Simpson					●														
Thomas Brocher						●	●												
Diane Doser						●	●	●											
Brian Stump						●	●	●	●	●									
Frank Vernon						●	●	●	●	●									
Thomas Henyey							●	●	●										
Eugene Humphreys							●	●	●										
George Zandt							●	●	●										
Gary Pavlis								C	C	C									
Anne Meltzer									●	●	C	C	C						
John Nabelek									●	●	●								
Richard Williams									●	●	●								
Frederick Followill										●	●	●							
Thomas Pratt										●	●	●							
Clifford Thurber										●	●	●	●	●					
Egill Hauksson											●	●	●						
David James											●	●	●	●			●	C	C
Roy Johnson												●	●	C	C	C	C		
Kenneth Dueker													●	●	●				
Kate Miller													●	●	●				
Arthur Lerner-Lam														●	●	●			
Steven Roecker														●	●	●	●	●	●
Geoffrey Abers															●	●	●		
Kurt Marfurt															●	●	●		
Joan Gomberg																●	●	●	
John Louis																●	●	●	
John Collins																	●	●	●
Anne Sheehan																	●	●	●
John Hole																		●	●
William Walter																		●	●
Colin Zelt																		●	●
Matthew Fouch																			●
Camelia Knapp																			●
William Stevenson																			●

Education and Outreach Committee

NAME	97	98	99	00	01	02	03	04
Jeffrey Barker	●	●	●	●				
Larry Braile	C	C	C	C	C			
Karen Fischer	●	●						
Michelle Hall-Wallace	●	●	●	●				
Charles Hutt	●	●						
Glenn Kroeger	●	●	●	●	●			
Guust Nolet	●	●	●					
Lind Gee			●	●				
Robert Woodward			●					
John Lahr				●	●	●		
Robert Mellors				●	●	●		
Richard Aster					●	C	C	C
Michael Hamburger					●	●	●	
Susan Schwartz					●	●	●	
Thomas Boyd						●	●	
Alan Kafka						●	●	●
Steven Semken							●	●
Lisa Wald							●	●
Kathy Ellins								●
Seth Stein								●
Aaron Velasco								●

JSP Committee

NAME	90	91	92	93	94	95
Charles Archambeau	●	●	●			
Jonathan Berger	●	●	●			
Jeffrey Park	●	●	●	●	●	●
Paul Richards	C	●	●	●	●	●
David Simpson	●					
Terry Wallace	●	●	●	●		
Göran Ekström		●	●	●	C	C
John Filson		●	●			
Daniel Harvey		●				
Arch Johnston		●				
Charles Langston		●	●	●	●	
Arthur Lerner-Lam		●	●			
Gary Pavlis		●				
Michael Ritzwoller		●				
Paul Silver		●		C	●	
Stewart Smith		C	C			
Brian Stump		●	●	●	●	●
Frank Vernon		●				
Bernard Minster				●	●	●
Keith Nakanishi				●	●	●
Robert Phinney			●	●	●	●

Planning Committee

NAME	98	99	00	01	02	03	04
Adam Dziewonski	●		●	C	C	C	C
John Orcutt	●	●	●	●	●		
Barbara Romanowicz	●						
Robert Smith	●	●	●				
Terry Wallace	C	C	C	●	●		
Anne Meltzer			●	●	●	●	●
Arthur Lerner-Lam				●	●		●
Göran Ekström					●	●	●
Thomas Jordan					●	●	●
Alan Levander						●	●
Michael Wysession						●	●
David Simpson							●

Appendix II

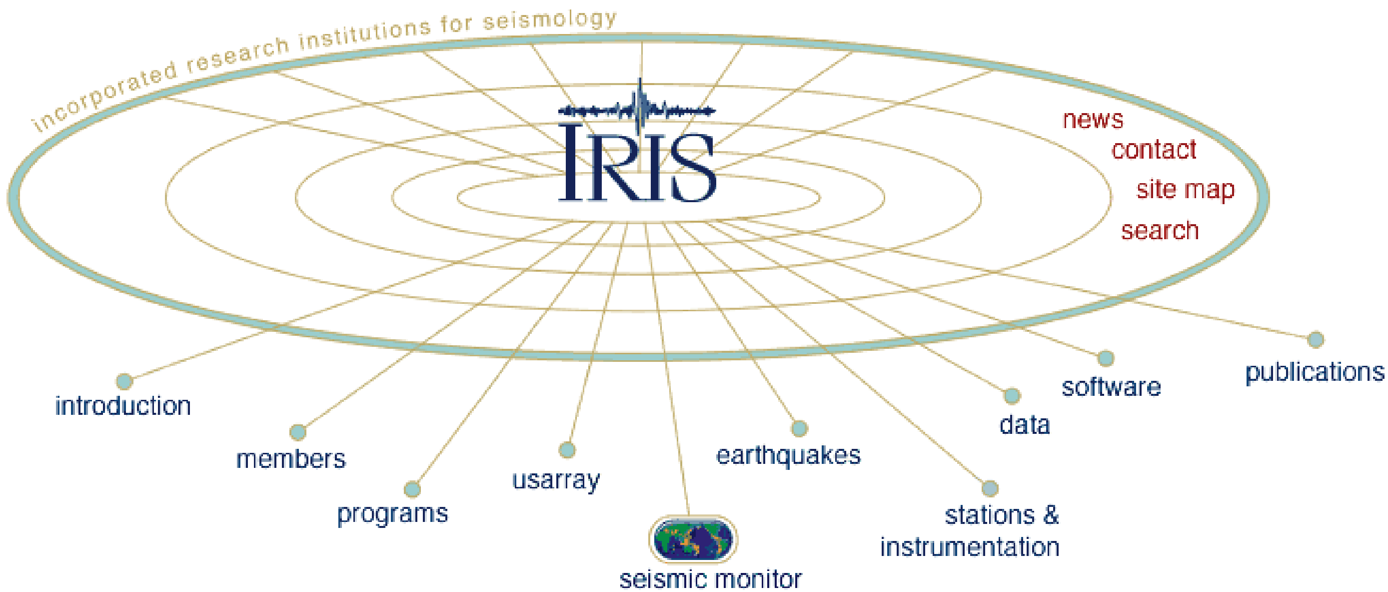
Timeline of Significant Events in IRIS History

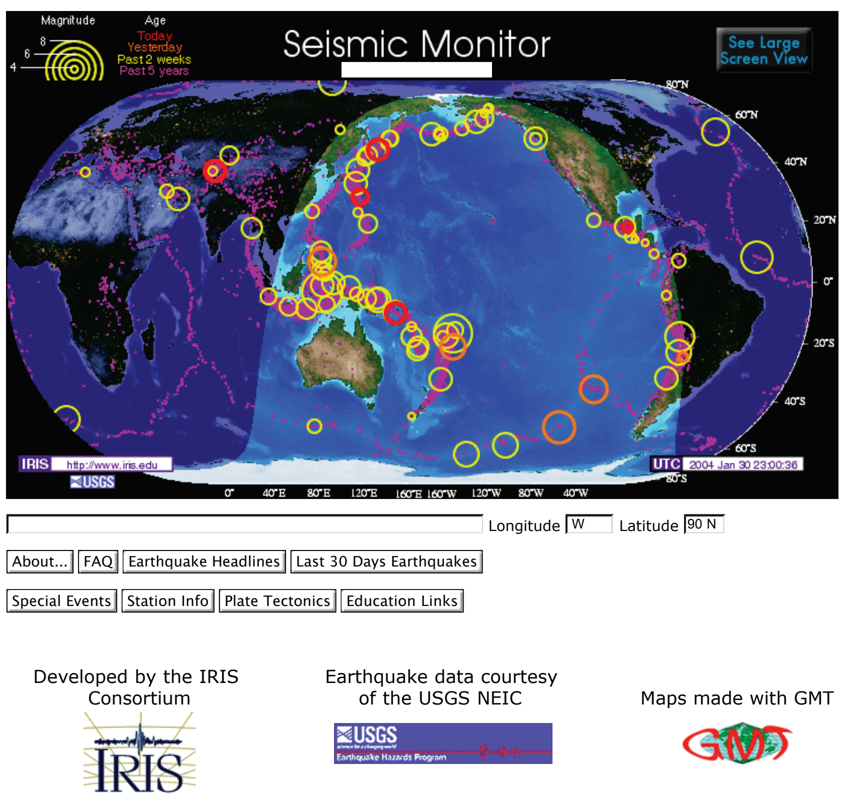
	Consortium	GSN	PASSCAL	DMS	E&O
1983	National Academy of Science/National Research Council releases a series of reports on facilities for seismological research.				
	Committee on Science, Engineering, and Public Policy (COSEPUP) recommends support for "a new Global Digital Seismic Array" and "seismic investigation of the continental crust."				
1984	IRIS is incorporated, May 8, 1884, with 26 founding members.				
		Science Plan for a New Global Seismographic Network.			
			Science Plan for PASSCAL.		
1985	IRIS and NSF sign first Cooperative Agreement. First year funding is for $200K for initial planning				
	IRIS Headquarters Office established in Rosslyn VA				
	Federation of Broadband Digital Seismic Network organized with IRIS as Founding Member.				
1986		First GSN very broadband seismometer upgrades at ALQ, Albuquerque, NM, COL, College, AK, and PFO, Piñon Flat, CA.			
		GSN RFP for new data acquisition system.			
		International Deployment of Accelerometers (IDA) at UC San Diego joins GSN.			
			Request for Proposals for PASSCAL Instrument published.		
			PASSCAL funds first two field experiments.		
				Strategies for the Design of a Data Management Center Published	
1987		First GSN dial-up station at HRV, Harvard, MA.			
		The University Network component of the GSN is initiated with HRV, Harvard, MA and PAS, Pasadena, CA.			
		Four IRIS/IDA GSN stations installed in former Soviet Union. GSN goals extended to include high-frequency seismometers.			
			Development contract for PASSCAL Instrument awarded to Refraction Technology.		
				Report developed by TASC for implementation of the IRIS DMS	
1988	Joint Seismic Program established with the USGS and the Academy of Sciences of the Soviet Union to install stations within the US and USSR. Congress provides $29M over next six years to support the JSP program.				
		GSN assumes responsibility for seismic station at the South Pole.			
			First 10 prototype PASSCAL instruments delivered.		
			First experiment supported with instruments from PASSCAL.		
				SEED format version 2.0 defined by the FDSN	
				Interim Data Management Center established at UT Austin	
				University of Washington develops first near real time data collection system.	
1989			First PASSCAL Instrument Center established at Lamont Observatory, Columbia University.		
			First 40 production PASSCAL instruments delivered.		
			First aftershock deployments supported after Loma Prieta Earthquake.		
			Development started on 3-channel active source instrument.		
			PASSCAL ceases funding of field experiments.		
				First SEED formatted data shipped from the IRIS DMC	
1990		Data Collection Centers in La Jolla, CA and Obninsk, USSR are linked by C-band satellite.			
		GSN has installed or upgraded 25 stations globally.			
		AT&T and Japan's KDD donate the Transpacific Cable-1 to IRIS and Earthquake Research Institute, initiating scientific re-use of undersea telephone cables.			
		Technical Plan for a New Global Seismographic Network issued by USGS and IRIS.			
			First portable PASSCAL experiment with broadband sensors.		
			Prototype 3-channel recorder delivered.		

	Consortium	GSN	PASSCAL	DMS	E&O
1991	IRIS and NSF sign second Cooperative Agreement. First year funding is $6.2M. IRIS membership now 69 institutions				
	KNET, a ten station telemetered network in Kyrghyzstan, becomes operational as part of the JSP program				
		First GSN borehole seismic systems at Albuquerque, NM, and Rarotonga, Cook Islands.			
		Low-gain accelerometers are included as standard GSN sensors.			
		Ocean Seismic Network borehole drilled by Ocean Drilling Program near Oahu.			
			First production units of the 3-channel system delivered.		
			PASSCAL Instrument Center at Stanford opened to support 3-channel systems.		
				Data Management Center established at University of Washington	
1992		Satellite link to South Pole for GSN data.			
			Purchase of first 24-bit PASSCAL systems.		
				DMC acquires first mass storage system (6 terabyte capacity)	
				Project IDA GSN stations begin near real time data delivery	
1993		KONO, Kongsberg, Norway is the first GSN site connected directly to the Internet.			
		MoU to cooperate on five joint GSN-GEOFON stations with Germany's GeoForschungsZentrum.			
		The first joint station is installed at PMG, Papua New Guinea, also in cooperation with Japan's POSEIDON Project.			
		Congressional funding begins for accelerating the installation of the GSN for use in seismic research relevant to nuclear treaty verification. In the subsequent three years, over 50 GSN stations are installed.			
				FARM event-windowed waveform data products established	
1994	National Science and Technology Council (NSTC) carries out interagency review of GSN role in as a multi-use facility.				
	Congress provides $42.5M over four years to accelerate installation of GSN.				
		Microbarographs are included as standard GSN sensors.			
		GSN upgrade of China Digital Seismic Network begins with BJT, Beijing.			
				Annual DMC/DCC coordination meetings initiated	
				DMC archive exceeds 1 terabyte	
1995		GSN has 83 stations installed globally.			
		Over 30 GSN sites participate in the Conference On Disarmament Group of Scientific Experts (GSE) Technical Test 3.			
				USGS Contributes GDSN Network data to the DMC in SEED format for archiving and distribution	
1996	IRIS and NSF sign third Cooperative Agreement. First year funding is $8.0M.				
		AT&T donates Hawaii-2 undersea telephone cable system to IRIS for scientific re- use.			
		Over 50 GSN stations are designated in the Comprehensive Test Ban Treaty for use in the International Monitoring System.			
		GSN coordinates funding from National Imaging and Mapping Agency for installation of GPS receivers at GSN stations in Siberia.			
		GSN Affiliate Status is created for other broadband stations to join GSN. BFO, Germany joins as an Affiliate.			
			First broadband PASSCAL data submitted to DMC in SEED format.		
				Networked Data Centers established	
					Development of the Seismic Monitor web display
1997	Following NSTC review, NSF funding to IRIS increased by $3M per year in support of role in nuclear monitoring				
	IRIS Headquarters Office move to Washington DC				
		Implementation Agreement with Japan to cooperate on 9 joint GSN-NIED station in the Pacific.			
		USGS assumes support for O&M of the IRIS/USGS component of the GSN through new funding by Department of Interior.			
			Broadband Array becomes part of PASSCAL instrument pool.		
				ASL establishes real time connectivity to IRIS GSN stations	
				WILBER I established as a Web-based access tool	
				DMC archive exceeds 5 terabytes	
					E&O committee formed
					IRIS/USGS Traveling museum exhibit completed
					First three educational one-pagers published
					First "Teaching the Seismologists to Teach the Teachers" workshop

	Consortium	GSN	PASSCAL	DMS	E&O
1998	USGS established new $3.8 M per year budget line for GSN				
		Internet service is established at Siberian GSN sites with funding from NIMA.			
		The Hawaii-2 Observatory (H20) is installed as the first undersea GSN station midway between Hawaii and California.			
			First Broadband Array deployment by PASSCAL		
			PASSCAL begins support of the Texan active source instruments.		
			The two PASSCAL Instrument Centers are consolidated into one facility at New Mexico Tech.		
				50 terabyte StorageTek Wolfcreek mass storage system becomes operational	
					First E&O program manager hired
					E&O program planning workshop
					First teacher workshop at annual NSTA meeting
					Exploring the Earth poster (Northridge earthquake) published
					First 3 undergraduate summer interns
1999		GSN cooperation with US National Seismic Network for GSN upgrade of RSSD, South Dakota station.			
		Meteorological sensors are co-located at GSN-GPS sites in Russia			
		Satellite telemetry using VSAT technology is established to Galapagos and Uganda GSN sites, in collaboration with NASA/JPL.			
				DMC archive exceeds 10 terabytes	
					First undergraduate faculty workshop at annual GSA meeting
					Museum displays installed at the American Museum of Natural History in New York and the Carnegie Museum of Natural History in Pittsburgh
2000		GSN has 125 stations globally installed.			
				BUD - Real Time Data System becomes operational	
					AS1 school seismograph program initiated
					New museum display installed at New Mexico Museum of Natural History
2001	IRIS and NSF sign fourth Cooperative Agreement. First year funding is 12.6 M				
		VSAT links to Chinese GSN sites are established in cooperation with Chinese National Network.			
			PASSCAL receives the first Congressional funding through DOE to allow for replacement of data systems.		
				DMC archive exceeds 20 terabytes	
				360 terabyte Storage Tek Powderhorn mass storage system becomes operational	
					Educational Affiliate membership category approved by Board of Directors
					Educational 1-pagers translated into Spanish
2002		GSN establishes a satellite earth station at Pacific Tsunami Warning Center (PTWC) on Oahu with funding from NEID, Japan, and US National Weather Service/NOAA.			
		The first GSN station on line to PTWC and Internet is PTCN, Pitcaim Island (the VSAT also serves as Internet access for Pitcaim Islanders).			
		GSN initiates use of Comprehensive Test Ban Treaty Organization Global Communications Infrastructure (VSAT system) on a sharing basis at SJG, Puerto Rico, and LSZ, Zambia.			
				DMC archive exceeds 30 terabytes	
				SPYDER® products derived directly from the BUD real time system	
					Education and Outreach Program Plan published
					First three Educational Affiliate members
2003	IRIS, UNAVCO, Inc and Stanford University funded by NSF MREFC account to initiate EarthScope project.				
				Up to 800 stations flow into BUD in real time	
				DMC archive exceeds 40 terabytes	
				DMS Strategic Plan finalized	
					First 2 IRIS/SSA Distinguished lecturers speak at venues throughout US
					50th AS1 seismograph distributed to a school
					IRIS/USGS exhibit installed at the Smithsonian Institution Museum of Natural History

Appendix III
The IRIS Web Site





The IRIS web site (www.iris.edu) provides a single portal into data, information and services provided by the IRIS Consortium and its facilities. In addition to being a primary mode of access to GSN and PASSCAL data through the Data Management System, the web site also provides information on the Consortium and its activities; instrumentation resources, schedules and support services provided by PASSCAL; education resources and publications available through E&O; and links to other seismological and Earth science resources. The following pages provide high-level overviews of key segments of the web site.

What is IRIS?

The Incorporated Research Institutions for Seismology is a university research consortium dedicated to exploring the Earth's interior through the collection and distribution of seismographic data.

IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and the verification of a Comprehensive Test Ban Treaty.

Support for IRIS comes from the National Science Foundation, other federal agencies, universities, and private foundations.

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How to cite IRIS in your publications

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IRIS Programs

Data Management System
Education & Outreach
Global Seismographic Network
PASSCAL

Staff

Staff pages
Job openings at IRIS (in bold)

Frequently asked questions

About IRIS...
About earthquakes...
About data...
Travel Tips
Web Statistics

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PASSCAL Instrument Center
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Telephone: 505.835.5070 | Fax: 505.835.5079

Data Management Center
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Seattle, WA 98105
Telephone: 206.547.0393 | Fax: 206.547.1093

Questions? send them to webmaster@iris.washington.edu

IRIS Site Map

The Incorporated Research Institutions for Seismology is a university research consortium dedicated to exploring the Earth's interior through the collection and distribution of seismographic data.

If you have questions or corrections, please contact webmster@iris.washington.edu

earthquakes

Recent earthquakes
Seismic Monitor
Maps of events
Special Event pages
Search event catalogs
Browsing and requesting event-related data
Moment tensor data
USGS-NEIC Earthquake Data Reports
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Educational resources
Educational links to other data sources
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Seismology Lessons and Exercises
Classroom Materials
Image Archive
Educational Links
Internships

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DMS Electronic Newsletter

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SEED Manual
SEED Readers
SEED Writers
SEED Response Evaluation Tools
Data Center Utilities
Instrumentation Manuals and Software
PASSCAL software
Data Extraction and Archiving Programs
Plotting and Display Programs
Processing Programs
Conversion Programs

data

Requesting and using data from IRIS
How to get and use data
Software and manuals
Types of data
Real-time data
How to Cite Data Usage
Search Data Problem Reports (DPRs)

IRIS data sources
Waveforms
Event Catalogs
List of permanent FDSN networks
List of temporary networks
FARM data
UV FARM data

How to check on data availability
SeismiQuery
BUD
WILBER II
Submitting data to the DMC
Checking on submitted holdings

FDSN data request statistics

forms

Temporary deployments:
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Demobilization form
Submit assembled data set
Instrument request form
OBSIP passive source deployment form
OBSIP active source deployment form

Request a network code
Request assembled data
Request use of IRIS bulkmail
Register for restricted data access

stations/instrumentation

Seismic station/channel information (via SeismiQuery)
Station response information (via SeismiQuery)
GSN station information
List of permanent FDSN networks
List of temporary networks

Temporary deployments:
Mobilization form
Demobilization form
Submit assembled data set

PASSCAL instrumentation:
Instrument request form
Sensor Comparison Chart
Sensor Spec Sheets
Data Acquisition
- Reftek 72A
- Reftek R125
- Quanterra Q330
- Reftek R130
- Geometrics RX60
Telemetered Array
Temporary Network Status

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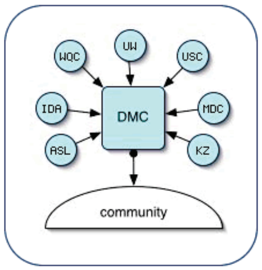
Introduction to the Data Management System

Download the PDF version of the Strategic Plan

The IRIS DMS presently consists of several components or "nodes". These nodes work together to insure the smooth flow of GSN and PASSCAL data from the stations to the seismological research community.

Data Management System Nodes

- Data Management Center (DMC)
- IRIS/USGS Data Collection Center (ASL)
- IRIS/IDA Data Collection Center (IDA)
- University of Washington
- Waveform Quality Center (WQC)
- Moscow Data Center (MDC)
- University of South Carolina
- Kazakhstan Seismic Data Center (KZNet)



Governance and Staffing

The IRIS DMS is given oversight by a standing committee representing the seismological community. (See action items from DMSSC meetings.) The IRIS Data Management System is managed by Dr. Tim Ahern. Here are the charges to the DMS.

DMS Internal Review Report (PDF file)
DMS Strategic Plan (PDF file)

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Data

What data does IRIS have?

Types of data available from IRIS

IRIS data sources for Waveforms and Event Catalogs

World and US Data Centers (coming soon)

Data Distribution Statistics

Requesting data from IRIS

How to get data from the large IRIS archive

Check on archived data availability using SeismiQuery

Check on real-time data holdings using BUD

How to check on status of a data request

View customized [request status]

View [recent shipments]

View status of assembled data requests

How to check on data problems

View data problems that resulted in a need for [re-archiving]

Search Data Problem Reports (DPRs)

How to submit data to IRIS

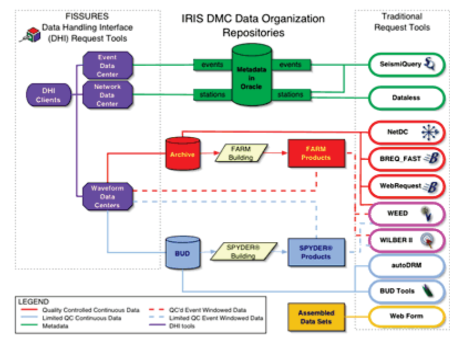
Submitting SEED data to the DMC

Submitting assembled data to the DMC

Checking on submitted holdings (DCC tools)

Frequently asked questions

request tools shortcuts - click on me



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PASSCAL Home Page

PASSCAL is one of two major instrumentation programs of IRIS (the other being the Global Seismic Network or GSN). PASSCAL operates a pool of over 1000 portable seismic instruments to record active source reflection data, active source refraction data or natural source recordings of earthquakes. The instrumentation is supported by an instrument center at New Mexico Tech, Socorro, New Mexico.

PASSCAL Instruments and support are available to the academic research community according to the rules and policies set by the IRIS Executive Committee. All data from PASSCAL supported experiments are made available through the IRIS DMC in Seattle, Washington.

Over the last several years the PASSCAL program has received significant support from the Department of Energy. Congress has appropriated the funds through DOE's National Nuclear Security Administration Nonproliferation and Verification research and development account. This money has allowed for the purchase of a new 25 element telemetered broadband array and the start of the replacement of the original PASSCAL dataloggers. During the last few years PASSCAL has significantly increased the support of DOE experiments.

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- Estimate Shipment
- Directions to the PIC
- Lodging near NMT
- Virtual Tour
- FAQ
- Training

Stations and Instrumentation

- Sensor Comparison Chart
- Sensor Spec Sheets
- Data Acquisition
  - Reftek 72A
  - Reftek R125
  - Quanterra Q330
  - Reftek R130
  - Geometrics RX60
- Telemetered Array
- Temporary Network
- Codes/Status

Software

- PASSCAL Distribution
- Antelope
- SPW
- Other Packages

Schedules

- Broad-Band 2003-04
- Broad-Band 2005-06
- Short Period 2003
- Multi Channel 2003
- TEXAN (R125) 2003

Forms

- Instrument Request
- Request FDSN Network Code
- Mobilization Form
- Demobilization Form

Data

- Assembled Data Sets Policy
- Existing Assembled Datasets
- Short Period Array Request Methods
  - SeismiQuery
  - Breq_fast Manual
  - Assembled Data Request
- Submitting Data to DMC

Information

- Standing Committee
- Instrumentation Committee
- Instrumentation Report
- USArray Design Workshop
- EarthScope Home Page
- Instrument Use Policy
- Data Delivery Policy
- RAMP, Rapid Array Mob

Links

Featured Deployments
- New Zealand 2001
- Hill AFB, Utah
- Superstition Hills, CA
- Tiwi
- Venezuela

Global Seismographic Network (GSN)

The IRIS Global Seismographic Network (GSN) is one of the four major components of the IRIS Consortium. The goal of the GSN is to deploy over 128 permanent seismic recording stations uniformly over the earth's surface. The GSN provides funding to two network operators:

- Global Seismographic Network
  - IRIS/ASL Network Operations Center
  - IRIS/IDA Network Operations Center

The GSN is governed by a standing committee made up of seismologists from IRIS member institutions. (The charges to the GSN are available for review.)

About the Stations

As of 2003 the IRIS GSN was made up of over 128 stations with affiliations to USGS, UCSD/IDA, GEOFON, Pacific21, NCDSN, GEOSCOPE, MedNet, BGR, BFO, USNSN, BDSN, TriNet, AFTAC and several other national and international networks. Eight new stations are planned for completion in 2003-2005.

The IRIS GSN stations continuously record seismic data from very broad band seismometers at 20 samples per second, and to provide for high-frequency (40 sps) and strong-motion (1 and 100 sps) sensors where scientifically warranted. It is also the goal of the GSN to provide for real-time access to its data via Internet or satellite. Over 75% of the IRIS GSN stations meet this goal.

- Data available from GSN stations (SeismiQuery)
- GSN Maps
- Instrumentation: Specifications and Committee Reports
  - GSN Datalogger Specifications, 11/2003 (11.51 Mb pdf)
- Harvard Seismology Project: Recent Noise Levels at GSN Stations
- Information about the Hawaii 2 Observatory

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IRIS Education & Outreach

The IRIS Education & Outreach (E&O) program, in collaboration with the seismological and educational communities, develops and implements programs designed to enhance seismology and Earth Science education in K-12 schools, colleges and universities, and in adult education.

- Earthquake maps, lists, general information
- Interactive Software
- Lessons and Resources For Educators
- School Seismographs
- Professional Development for Educators and Undergraduate Internship Opportunities
- IRIS/SSA Distinguished Lectureship
- E&O Program Plan

Image of the Week

Effects of the 1959 Hebgen Lake, Montana earthquake

Learn more...

Past Images

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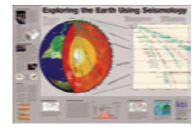
Publications

Posters

"Exploring the Earth Using Seismology"



[click to view]
(send requests to EandOproduct@iris.edu)

Earthquakes create seismic waves that travel through the Earth. By analyzing these seismic waves, seismologists can explore the Earth's deep interior.

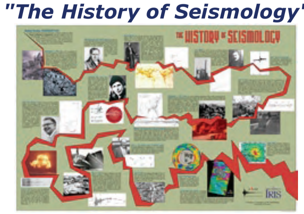
On January 17, 1994 a magnitude 6.9 earthquake near Northridge, California released energy equivalent to almost 2 billion kilograms of high explosive. The earthquake killed 51 people, caused over $20 billion in damage, and raised the Santa Susana Mountains north of Los Angeles by 70 centimeters. It also created seismic waves that ricocheted throughout the Earth's interior and were recorded at geophysical observatories around the world. The paths of some of those seismic waves and the ground motion that they caused are shown in this poster.

"Global Seismographic Network"

[click to view]
(send requests to EandOproduct@iris.edu)

The Global Seismographic Network (GSN) consists of more than 125 GSN stations located around the world with near-uniform spacing - from the South Pole to Siberia, and from the Amazon Basin to the seafloor of the Northeast Pacific Ocean. This multi-use facility provides data for scientific research, education, earthquake hazard mitigation, tsunami warning, and the international monitoring system for the Comprehensive Nuclear Test-Ban Treaty. In addition, real-time GSN data are broadcast to museum displays that are seen by over 10 million visitors each year.

"The History of Seismology"



[click to view]
(send requests to EandOproduct@iris.edu)

Depicting original sketches, photographs and colorful new imagery, this poster captures the major milestones of the development in the field of seismology. Seismology's rich history begins with Robert Hooke's 1676 paper titled "True Theory of Elasticity or Springness" and continues through the 1830 discovery of P and S waves, the 1930's discovery of the inner core by Inge Lehman, and includes recent innovations such as shake maps, real-time collections of maps depicting shaking intensity within seconds of an earthquake.

On-line Publications and Forms

- IRIS Newsletters
- DMS Electronic Newsletters
- Education and Outreach Series "One-pagers"
- Software Manuals
- SEED Reference Manual (pdf)
- Acronyms and Vocabulary Definitions

Off-line Publications

- IRIS Newsletters
- IRIS Annual Reports
- PASSCAL Users Guide
- PASSCAL Instrument Center Training Manual
- Nuclear Testing and Nonproliferation
- FDSN Station Book

Appendix IV
IRIS Publications

Planning Documents

Publications resulting from workshops and community activities that formed the basis for core IRIS Programs

April, 1984	Science Plan for a New Global Seismographic Network
Dec, 1984	PASSCAL - Program for Array Seismic Studies of the Continental Lithosphere
June, 1986	Strategies for the Design of a Data Management System
Sept, 1990	Technical Plan for a New Global Seismographic Network
January, 1993	A National Program for Research in Continental Dynamics
February, 1994	Nuclear Testing and Non Proliferation
2001	Making Waves – the IRIS Education and Outreach Program Plan

Proposals

IRIS Proposals to the National Science Foundation that from the basis for Five-Year Cooperative Agreements

1984 – 1990	The IRIS (Rainbow) Proposal
1990 – 1995	"Understanding the Earth's Dynamics and Structure"
1996 – 2000	"A Science Facility for Studying the Dynamics of the Solid Earth"
2001 – 2005	"Exploring the Earth at High Resolution"
2003 – 2008	"EarthScope: Acquisition, Construction, Integration and Facility Management," MREFC Proposal (joint with UNAVCO, Inc and Stanford University)

Regular Publications

IRIS Newsletters – Published 2-3 times per year, 1990-2000, the IRIS Newsletter provides a forum for information on the programs and facilities of IRIS and related organizations and highlights of scientific results of interest to Consortium members.

Annual Reports – Published each December, the Annual Report summarizes of the past year's activities for Consortium members, funding agencies and other interested parties.

IRIS Annual Workshops Abstracts/Programs

Manuals and User's Guides

July, 1991	PASSCAL Users Guide
August, 1985	PASSCAL - Field Data Management Plan
September, 1994	Federation of Digital Seismograph Network Stations Book
February, 1993	Standard for the Exchange of Earthquake Data (S.E.E.D)
February, 1993	S.E.E.D- Reference Manual
February, 1993	S.E.E.D- Programmers tool kit
February, 1993	Tutorial Guide - How to Use the IRIS-DMC SPROUT
February, 1993	POD- The IRIS S.E.E.D Writer
2001	IRIS - E&O Seismic Waves, Slinky Handouts (joint with SSA and L. Braile, Purdue)

Education and Outreach Materials

The IRIS posters and "one-pagers" are concise statements of significant topics in seismology, intended to supplement teaching materials for classroom use, Limited numbers of hard copies are provided free of charge to teachers, and full-resolution versions are also available on the web. The one-pagers are also available in Spanish.

One Pagers

1. Watch Earthquakes as they Occur- An Intro to the Seismic Monitor
2. Why do Earthquakes Happen?
3. How Often do Earthquakes Occur?
4. Seismic Events of Special Interest
5. Exploring the Earth Using Seismology
6. How are Earthquakes Located?

Posters

1994	"Exploring the Earth Through Seismology"
1995	"Topography And Seismicity of The Western United States"
1998	"Exploring the Earth Using Seismology"
2003	"The History of Seismology"
2003	"Global Seismographic Network"

USArray and EarthScope Planning Documents

March, 1999	USArray Workshop in Albuquerque, New Mexico
September, 1999	USArray 2nd Workshop in Houston, Texas
December, 1999	USArray, A Synoptic Investigation of the Structure Dynamics and Evolution of the North American Continent
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The IRIS bibliography now includes 1300 papers citing IRIS or its facilities. An HTML listing of these publications is available from the publications page of the IRIS web site.

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