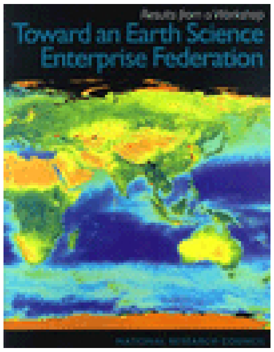

Toward an Earth Science Enterprise Federation: Results from a Workshop

Steering Committee for a Workshop on an Earth Science Enterprise Federation, National Research Council

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Toward an Earth Science Enterprise Federation:

Results from a Workshop

Steering Committee for a Workshop on an Earth Science Enterprise Federation
Committee on Geophysical and Environmental Data
Board on Earth Sciences and Resources
Commission on Geosciences, Environment, and Resources
National Research Council

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Front and back covers: Thousands of satellite images taken by the SeaWiFS instrument between September 1997 and April 1998 combine to produce this image of the Global Biosphere. In the oceans, green, yellow, and red indicate waters rich in phytoplankton. On land, tan colored areas depict regions where plant growth is minimal, limited by factors such as aridity, temperature, snow and ice cover; dark green areas show areas of high-potential plant productivity.
Back cover insets: (Top) April 12, 1998. True color image of the Mid-Atlantic Region from New York to the Outer Banks revealing vegetation patterns and urbanized population centers. The edge of the Gulf Stream is seen offshore as the sharp boundary between the deep blue and lighter blue waters off the Carolinas. Plumes of turbid water can be seen pouring from the mouths of many of the small bays and inlets and filling Pamlico Sound. (Bottom) March 2, 1998. SeaWiFS derived ocean color patterns in the Gulf of Mexico. Green, yellow, and red colors in the oceans indicate waters rich in phytoplankton.
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This report has been reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the authors and the NRC in making their published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The content of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their participation in the review of this report:

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Although the individuals listed above have provided many constructive comments and suggestions, responsibility for the final content of this report rests solely with the authoring committee and the NRC.

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Executive Summary

The goal of NASA's Earth Science Enterprise (ESE) is to enhance understanding of the earth system and its processes at a variety of temporal and spatial scales. At the heart of the ESE program is the Earth Observing System, a series of remote sensing instruments that will generate an unprecedented volume of data for a wide range of scientific disciplines. To manage these data, NASA is creating an experimental federation of partners. Federations provide a means for representing the interests of a broader community. As such, the federation concept is a reversal of NASA's traditional data management approach, because it places power and authority at the lowest level possible, consistent with getting the job done.

The prototype federation will consist of Earth Science Information Partners (ESIPs) drawn from academia, government, and the private sector. The ESIPs are charged with distributing and archiving scientific data and information (denoted ESIP Type 1), creating scientific products for the global change research community (denoted ESIP Type 2), and developing innovative, practical applications of earth science data for the broader community (denoted ESIP Type 3). The ESIPs Type 2 and 3 are also required, with NASA's assistance, to design and build the prototype federation over the next three years.

The latter task is difficult, because no existing federation can serve as an ideal model for an ESE federation. Federations have different objectives and structures, and consequently, different advantages and disadvantages as models for an ESE federation. To determine which lessons could be learned from existing federations, the Steering Committee for a Workshop on an Earth Science Enterprise Federation examined six federation models at a two-and-one-half-day workshop. The models were chosen to illustrate the diversity of federated structures--libraries (Association of Research Libraries and Harvard University Library), international organizations (NATO's Partnership for Peace), industry (Chevron), political (U.S. Constitution), and academic (University Corporation for Atmospheric Research). Other models, such as the Joint Oceanographic Institutions, World Data Center System, University of California System, and the Web Consortium at MIT, may also be appropriate. The models differ in their objectives, governance, potential costs and benefits, and measures of success. Based on comparison of these differences in the six federation models, and the needs of the four main ESE constituencies (data producers, global change scientists, knowledge brokers, and for-profit businesses), the Steering Committee selected the following lessons to be considered in an ESE federation:

Lesson 1. To be successful, a federation must be a community-driven, grass-roots effort, with empowerment at the individual member level. The ESE community is broader than ESIPs Type 2 and 3; it includes many other types of data and information users and providers. Therefore, the prototype ESE federation should be planned with this broader community in mind. A step toward ensuring that the interests of all the ESE constituents are represented is to include the Type 1 ESIPs in the prototype federation.

Lesson 2. A bottom-up approach should be carried into the governance of federations to ensure that the priorities of the broader community are honored. However, some centralized management is necessary for making major decisions on behalf of the partners, for representing the federation's interests, and for conducting day-to-day operations. The instrument of centralized management, however, should be used sparingly (i.e., the "light touch" management approach is preferred). It is essential for the ESE federation and NASA to agree on the reserve powers of the partners (that is, those prerogatives that cannot be moved to central control or to NASA).

Lesson 3. A cornerstone of federations is flexibility. In order for an ESE federation to respond to changing needs, the initial rules and procedures should not be overspecified.

Lesson 4. In an ideal federation, partners come together to achieve ends they could not achieve alone. However, since the ESIPs were chosen through a competition based on product deliverables, these common values, or the federation glue, will have to be developed by the partners. This is an essential step in forming a successful federation.

Lesson 5. It is important for any organization to decide how it will be evaluated *before* it is created. Quantitative metrics include measures of success and a baseline from which to measure performance on a regular basis. However, the intangible and qualitative learning that is likely to occur as the experiment proceeds is just as critical to the evaluation of the experiment. Some of the most important institutional elements are unlikely to fall within easily quantifiable categories. In the case of an ESE federation, it is incumbent on the ESIPs to determine (and NASA to agree to) the elements of this evaluation.

Lesson 6. Tensions can arise when partners in a federation have different privileges. While the ESE federation is small, equal status among prototype federation partners would help ensure that all constituents have an equal voice.

Lesson 7. There are major differences among the ESE constituents, which will lead to tensions and differing expectations. For example, there are major philosophical differences (e.g., commercialization policy) among the ESIPs. These differences must be accommodated in the mission of the ESE federation.

Ideally, a federation will increase the voice of ESE constituents, and thus their stake in the success of the program. Many of these constituents will use ESE data and information in new or non-traditional ways. A federated approach provides the flexibility and empowerment to allow them to respond rapidly to new opportunities. The payoff for greater use of the data is a greater return on the public investment in the Earth Science Enterprise.

1

Introduction

OVERVIEW

NASA is experimenting with new arrangements for managing data and information from its Earth Science Enterprise (ESE) program, formerly known as Mission to Planet Earth. A federation is an association of autonomous partners that agree to abide by certain interface standards, business practices, and expectations of conduct to achieve a common goal. Federation provides a mechanism for representing the interests of a broader community. Although federations have been used as an organizational model for centuries, the concept has rarely been applied to scientific data management. Consequently, William Townsend, then Acting Associate Administrator of NASA's Mission to Planet Earth, requested that the NRC conduct a workshop to educate users and producers of ESE data about federations. In this report, the Steering Committee on a Workshop for an Earth Science Enterprise Federation examines the federation concept, compares different governance models, and offers some lessons for managing scientific data in an ESE federation.

BACKGROUND

The roots of NASA's Earth Science Enterprise began in the 1980s. For the first time, earth scientists from government, industry, and academia used advances in computer technology to develop numerical models to understand the Earth as an integrated system of land, oceans, air, ice, and ecosystem processes. Simultaneously, advances in spacecraft and sensor technology led to a new generation of satellites that could provide vast quantities of remotely sensed data.

From these revolutionary developments in science and technology, the Earth Observing System (EOS) was born with the goal of providing new information on earth system processes and so foster an interdisciplinary research environment. In order for this research environment to thrive, NASA realized that it also needed a system for data acquisition, initial processing, back-up archiving, and distribution. The EOS Data and Information System (EOSDIS) was established to create this environment. (A brief history of EOSDIS is contained in NRC [1995b], NRC [in press]). NASA, with input from its earth science research community, defined a set of standard products, which will be stored and distributed by the Distributed Active Archive Centers (DAACs). At the time it was conceived, NASA used a traditional top-down, centralized management model for EOSDIS.

In the years since the inception of this model, several factors prompted NASA to consider changes in its approach:

- The growth and widespread diffusion of the Internet and World Wide Web brought vast amounts of information to a wide range of users. These new information technologies enhanced access to data services and transformed the ways scientists, businesses, agencies, and other organizations communicate.
- Advances in the capabilities of workstation computers enabled scientists to be both producers and users of data from their desktops.
- Demand for EOSDIS data products and information extended beyond the earth science community to embrace a broad range of users--policy makers, educators, business people, and the general public. The major constituents currently interested in this data and information are described in Box 1.
- The U.S. government encouraged commercial applications of earth science data.

BOX 1. PRINCIPAL ESE CONSTITUENCIES

- **Data Producers.** This constituency consists of NASA-funded instrument teams for EOS and the broader Earth Science Enterprise. Members produce standard products that describe accurate geo-located measurements of geophysical variables and are used to address scientific questions by global change researchers and by instrument team members themselves. The focus of producers is on timely and routine data production. They require a stable computing environment, interoperable formats, and quality control standards. Activities of this group are predicated on U.S. policy that directs that data for global change research are to be made available to users at no more than the cost of filling a user request.
- **Global Change Scientists.** This constituency consists of NASA and non-NASA scientists who use and synthesize scientific information. Some undertake exploratory studies, develop algorithms for new information products, or produce higher-order products based on the outputs of the instrument teams. Others prepare expert assessments for a wide range of sponsors in industry and government. Because this constituency consists primarily of data users, it concerns itself first with the availability of holdings, and then with the scientific quality and documentation of the contents. As occasional information providers, members of this constituency also concern themselves with the demands the data and information system places on them with regard to formats and metadata. Given traditional research budgets, prices exceeding the cost of filling a user request are likely to be a severe deterrent to use.
- **Knowledge Brokers.** This constituency consists of science teachers, college earth science students, policy analysts, interested public, and research scientists outside their discipline. Knowledge brokers use reliable, interpreted data products; typically, they browse until they find what interests them. They benefit from expository guides that explain key concepts and technical terms and that provide pointers to topics of interest to them. These guides accomplish online the functions of a reference librarian, but they require editorial skills rarely found in most scientific data centers. Low-cost information is critical for this constituency.
- **For-Profit Businesses.** Like the data producers, the for-profit business constituency is operations driven. They provide value-added data products for firms that use EOS data for client services. Commercial users are concerned that government will compete with them by distributing information products free of charge or at a subsidized price. They also are concerned about whether government will continue to make stable data streams—on which their large investments depend—available to them. For-profit businesses may become data producers, selling observational data and derived products to research scientists. In the future, these producers are likely to be distinguished not only by their pricing policies but also by proprietary restrictions they may place on their products. Producers of for-profit information who want intellectual property rights may prohibit further distribution of their information or disallow the use of their information in new information products. These business practices contrast strongly with the majority of federally funded data producers who assume data sharing is the norm and who furnish it at the cost of filling a user request.

The National Research Council (NRC) also recommended that NASA consider changes in direction. In 1994 an NRC report pointed out that the centralized architecture of EOSDIS would not allow users to combine data from different sensors, modify standard products to meet new scientific needs, or revise algorithms to process data for different purposes (NRC, 1994). The report concluded that the EOSDIS architecture was too rigid to support the scientific community for which it was built and recommended that the products be designed and controlled in part by the customers of the system. A 1995 NRC report went further, recommending that "responsibility for product generation, publication, and user services should be transferred to a *federation* of partners selected through a *competitive* process open to all" (NRC, 1995a). A follow-on report also recommended that NASA consider implementing the federation concept in stages (NRC, 1996). The report urged NASA to implement an "initial limited set of pilot or prototype federated projects, ... in the near term, while continuing to develop the framework of a fully federated system for the long term."

In response to changing conditions and NRC recommendations, NASA has decided to test the federation concept (see Box 2) as a means for restructuring EOSDIS. The federation experiment will involve more than EOSDIS functions; it will embrace all of the ESE program. Although NASA recognizes the potential benefits of a federated ESE, it is also mindful of the potential dangers associated with transferring major scientific functions of EOSDIS outside of the federal government. In order to make sure that EOSDIS continues to fulfill its broad public purpose, NASA intends to transfer functions in phases and to evaluate success along the way. If the experiment proves successful, EOSDIS functions will be awarded through a competitive bidding process. Meanwhile, NASA will continue to develop and launch satellites, ensure that standard data products are produced and distributed, and foster development of the federation.

The first phase of the experimental federation is a Working Prototype Federation of Earth Science Information Partners (ESIPs). NASA recognizes three types of ESIPs, which overlap with the four ESE constituencies described in Box 1.

- **Type 1 ESIPs**. These ESIPs are responsible for standard data and information products whose production, publishing/distribution, and associated user services require emphasis on reliability and adherence to schedules. Type 1 ESIPs include DAACs and data producers.
- **Type 2 ESIPs**. These ESIPs are responsible for producing innovative science information products and services, which primarily serve the global change and earth science communities. Type 2 ESIPs include data producers and global change scientists.
- **Type 3 ESIPs**. These ESIPs are responsible for providing innovative, practical applications of earth science data to a broad range of users beyond the global change research community. Type 3 ESIPs include knowledge brokers and for-profit businesses.

Members of the prototype federation consist of the Type 2 and Type 3 ESIP winners of two 1997 NASA Cooperative Agreement Notices (see Appendix D). According to these notices, the objective of the prototype federation is to experiment with and evolve processes to make earth science data easy to preserve, locate, access, and use for all beneficial applications, including those for research, education, and commerce. It was against this background that the workshop on an ESE federation was held.

ORGANIZATION OF REPORT

As the earth science community begins the transition from the original EOSDIS model to a federation model, it is important to consider options for governance and other federation issues. This report is based on a workshop held in February 1998, background materials prepared by the Committee on Geophysical and Environmental Data (CGED), and a seminal paper on federations by Charles Handy (1992). The workshop was organized by the Steering Committee on an Earth Science Enterprise Federation, which operated under the auspices of the CGED. Representatives of existing federations (libraries, international organizations, industry, government, and academia) described the characteristics of their organizations in plenary sessions, and working groups discussed broad federation concepts. More than eighty participants, including federation experts, representatives of existing federations, ESIP winners, DAAC managers, and the broader scientific community, attended the two-and-one-half-day workshop. The agenda for the workshop and the list of workshop participants are in Appendixes B and C, respectively.

Chapter 2, Working Group Summaries, raises the following questions:

- What are the objectives of an ESE federation?
- What are the major governance issues to be considered in the development of an effective ESE federation?
- What are the potential benefits and costs of joining an ESE federation? What are the criteria for judging the success of an ESE federation as a management model?

Chapter 3, Models for an ESE Federation, compares six federation models and provides lessons for managing ESE data and information. The models are described in Appendix A.

BOX 2: FEDERATION PRINCIPLES (HANDY, 1992)

The federation concept is a political philosophy applied to management to deal with the following paradoxes: "the need to make things big by keeping them small; to encourage autonomy but within bounds; to combine variety and shared purpose, individuality and partnership, local and global ...."

- **Principle 1.** "Subsidiarity places power at the corporation's lowest point." Subsidiarity, which is the reverse of empowerment, has to be formalized to be effective. The center of the organization should be small and can be small because of advances in information technology.
- **Principle 2.** "Interdependence spreads power around, avoiding the risks of a central bureaucracy." Federalism encourages collaboration and cooperation, not centralization.
- **Principle 3.** "A proper federation needs a common law, language, and currency—a uniform way of doing business."
- **Principle 4.** "Separation of powers keeps management, monitoring, and governance in segregated units." Separate functions are performed by separate entities (e.g., management is an executive function, monitoring is a legal function, and governance is a legislative function). Governance is the most important for the organization's future.
- **Principle 5.** "Twin citizenship ensures a strong federal presence in a strong independent region." Interdependence flourishes when members recognize they are also part of a larger whole (e.g., Texans are also Americans).

2

Working Group Summaries

Prior to the workshop, participants and speakers were provided with a paper that applied political principles (federalism) to business management (Handy, 1992). Many aspects of these principles have application to scientific data management. To educate participants about these principles, the workshop began with a set of presentations on different federation models. Then workshop participants were divided into working groups. These groups considered a broad range of issues pertaining to an ESE federation, which may be summarized under four headings: (1) objectives, (2) governance, (3) potential costs and benefits, and (4) measures of success.

OBJECTIVES

Before establishing an ESE federation, workshop participants agreed that a number of issues should be addressed. The following issues do not represent an exhaustive list, but they were deemed to be of high importance:

- **Goals**. A statement of purpose (e.g., foster effective stewardship of data and data products, provide easy access to useful data products, create innovative high-quality information products) states succinctly the central commitment of members to the guiding principles of the organization. Typically, the goals of an organization begin with a vision and mission statement. The wording should be agreed upon by all the prospective founding members and amended only after a deliberative process. An example of a vision and mission statement crafted at the workshop follows.

- *Vision statement. The* ESE Federation is a framework to enable optimum ways to develop, produce, and publish/distribute environmental information and to provide associated services to science and society.

  Mission statement. The ESE Federation will (1) facilitate collaboration among scientists of varied interests so that their research can address the complexity of the natural world and (2) facilitate collaboration between the scientific community and the general public, its agencies and organizations, businesses, and policy makers so that knowledge about the environment can inform their decisions.

- **Constituents**. The federation should identify its stakeholders. As described in Chapter 1, the constituents for an ESE federation include data producers, global change scientists, knowledge brokers, and for-profit businesses. These correspond roughly to NASA's ESIP Types 1, 2, and 3.

- **Common needs/values**. To function coherently, federation partners should identify common needs and values, including what sources of EOS and non-EOS data are available and whether data are needed in real time or at some point after collection.
- **Codes of conduct**. The members must establish codes of conduct, particularly expectations of behavior. For example, among the many issues to be decided is whether partners are free to cooperate or compete with the federation.
- **Legal standing**. To be effective, the federation needs to employ personnel and enter into legally binding commitments. This implies that the federation should be constituted as a corporation (e.g., non-profit corporation) under state laws. All the rules, behaviors (including disclosure of conflicts of interest), outcomes, and intervention mechanisms of the federated structure need to be crafted in "plain English" before lawyers craft formal articles of federation or bylaws.

GOVERNANCE

Governance means the mechanisms by which participants--funding agencies, system operators, data system managers, research and operational users, application specialists--share in the design, implementation, management, and operation of the information system on behalf of the broad constituency of users. There are many examples of federations that could serve as role models for an ESE federation (see Appendix A), but only the partners can recommend a structure and approach to suit their purposes. They can choose between tighter and looser forms of federation. They can also choose between more competitive and more cooperative styles, although science is generally a cooperative venture. The choice of what sort of federation to develop depends ultimately on how prepared members are to sacrifice a degree of autonomy in order to achieve ends (e.g., scientific advances, commercial advantage) they could not achieve alone.

The governance mechanisms implemented for the prototype federation should be viewed as an evolutionary process. The mechanisms adopted in a mature ESE federation may well be different from those of a federation in its infancy.

Key Management Issues

- **Management style**. There is a continuum of management styles, ranging from hierarchical to consensual. The former implies a high degree of centralized control, whereas the latter, which is more typical of federations, implies the ceding of power to the lowest possible level, consistent with getting the job done.
- **Role of NASA**. NASA has several potential roles in an ESE federation: to ensure that the goals of the Earth Science Enterprise are met; to provide funds, and therefore a voice in the federation; to nurture the development of the federation; and to evaluate the success of the federation. At the same time, it should encourage bottom-up management. As pointed out by Charles Handy, federalist centers are meant to be minimalist; they exist to coordinate, not to control (Handy, 1992).
- **Autonomy**. The choice of the type of federation to develop depends ultimately on the degree of autonomy members are prepared to sacrifice.
- **Sharing authority**. A key element of governance is the distribution of power and operating functions. In a federation, authority comes from the bottom, not the top. Adherence to the principal of subsidiarity is critical to an effective federation of partners (Handy, 1992). The central organization provides vision and leadership to the subordinate units, not micro-management. Ideally in a federation, subsidiary units should have the power to discharge the manager(s).
- **Priorities**. A federation exists to meet the needs of its constituents. This implies that the highest priorities of the earth science community at large will come to the fore.
- **Resources**. The partners must decide how financial resources are distributed throughout

the federation. Are resources allocated to centralized services to which federation members must then subscribe, or are they allocated directly to the members, who then decide whether or not to subscribe to the central services? In particular, can the members opt out of subscriptions to centralized services? To support these decisions about centralized vs. decentralized services, the federation must put accounting systems in place that track resource flows and relative performance.

- **Interoperability**. Currently interoperability among EOSDIS participants is provided through the EOSDIS Core System, which allows users to enter the system at any point and find data of interest. Although a common program interface may not be necessary in an ESE federation, some capabilities, such as search and retrieval, will remain important. It is therefore likely that the partners will need to choose protocols, technology, and algorithms to work together.
- **Leadership**. Visionary leadership is a prerequisite for organizations that have multiple missions. A champion--either from within the federation or from NASA--who works on behalf of the federation, would help ensure its success.
- **Accountability**. Because the ESIPs were chosen through a competitive process, a NASA project officer will be responsible for ensuring that they meet their contractual obligations. But NASA will be held accountable by Congress, not for the successful fulfillment of the contracts, but for furthering the science.
- **Communications**. Pathways must be multidirectional: between partners and management, and among partners. Pathways should also be defined for communicating with NASA, the broader community, and international organizations.

Key Membership Issues

- **Qualifications**. Openness and inclusiveness are desirable attributes of a scientific information system. Before joining, members should give evidence of substantial commitment to the purposes of the federation, including the need to represent and serve the broader community. Similarly, inadequate commitment, and therefore performance, would be grounds for ejection. In the prototype federation, membership is equivalent to receipt of funding following competitive selection by NASA. This criterion, however, precludes active representation of any entity, however committed, that is ineligible from such competition (e.g., a data center responsible to a foreign government).
- **Classes of membership**. The partners could consider different classes of membership, which would imply different roles and responsibilities among federation partners. Rules for who belongs in what class would also have to be devised. Alternatively, members could have equal status, although this policy could lead to problems as the federation matures.
- **Evolution**. Initially the prototype federation will be modest in size, and partners will need to define a process for adding new members. Technological opportunities and new scientific needs will also create a demand for new members. As the federation matures, its form and function will undoubtedly change.
- **Responsibilities**. Although the primary task of members in the prototype federation is to fulfill the terms of their contracts, they should avoid self-interest, while promoting the overall goals and needs of the organization and the broader constituency. It is also important to build in incentives that reinforce rather than discourage good communication and teamwork, and that link the self-interest of members to the needs of their constituents.

Governing Body Tasks

- **Models**. The partners should choose a suitable model for governing the federation, noting that different styles have different implications for the operations of the federation. For example, partners may elect a council or board of trustees, or they may choose a more distributed model, such as the Interact Engineering Task Force, a loosely self-organized group of individuals who make technical contributions to the evolution of the Internet. Working groups to address such issues as intellectual property, technology, and standards may also be established. Finally, the partners should consider the relative advantages of having rotating versus fixed headquarters.

- **Procedures and processes**. After a consensus on the vision and mission statements is reached, the partners should draft the articles of federation, including bylaws and guidelines. Day-to-day procedures for the federation, its sub-units, and the interactions among them need to be established. Processes for accomplishing the tasks of the federation, such as vetting products or defining metrics, will also have to be established.
- **Policies**. Federation members have diverse interests and will want different policies on such issues as quality control, intellectual property, and standards. With regard to the first, different constituents need different levels of quality control. Intellectual property issues, such as data privacy and commercialization, should be clarified and set in the context of federal law. For example, who has intellectual property rights to products produced by the federation: the federation or an individual partner? Finally, the partners should define a strategy for evaluating, selecting, rejecting, and evolving standards. They should also address whether federal standards (e.g., Federal Geographic Data Committee standards) or EOSDIS standards apply to federation partners.

POTENTIAL COSTS AND BENEFITS

The costs and benefits listed in Table 2.1 are expressed in general terms only, because they involve assertions about expected human behavior in the context of a "well-designed" federation, contrasted with an equally undefined centralized alternative. Such predictions can only be verified by actual experience, and the arguments supporting them are inevitably largely hypothetical. In addition, the costs and benefits are different for NASA, the federation, the partners, and users.

Table 2.1 Potential Costs and Benefits

Potential Benefits	**Potential Costs**
To Federation	
• engages a larger, non-traditional pool of experts	• disperses research and development personnel
• facilitates collaboration and formation of alliances	• increases management time, especially in the beginning, to develop new business practices and working relationships
• produces better science and applications	
• fosters creativity and innovation	
• provides resilience because failure of a partner will not result in failure of the federation	
• meets the needs of more types of users	
• improves access to and dissemination of scientific data	
• produces data products faster	
• spreads the resource burden	
• changes scientific culture	
• self-sustaining	
• attracts other funding sources	
	• has to identify and engage organizations with the necessary data and expertise
	• has to deal with a wide range of data quality and data policy needs
	• has to account for mixed motives
	• reduces likelihood of producing low-priority products

Potential Benefits	Potential Costs
To Partners	
• local control and bottom-up management	• diminishes power and authority
• increases clout and credibility	• federation receives credit for the work of a partner
• standards and policies are community-driven	• may need to adhere to NASA or other government standards
• produces better science and applications	
• new funding source	• commercial advantage
• shortens lines of communication	
• provides access to the innovations and advances of the other partners	
	• increases management time, especially in the beginning, to develop new business practices and working relationships
	• harder to create interoperability
To NASA	
• produces better science and applications	• reduces likelihood of producing low-priority products
• increases return on investment	• increases legal and initial management costs
• makes NASA data available beyond the earth science community	
• self-sustaining	• attracts other funding sources
	• gives up authority and control
To Users	
• more responsive to changing user needs and opportunities	• potentially less uniformity in the user interface
• improves access to ESE products, particularly to non-NASA data	
• increases participation (e.g., priorities, standards) in an ESE federation	
• easier to fill niches that meet the needs of specialized communities	
• greater diversity of funding sources makes it easier for non-NASA partners to buy in	
	• harder to create interoperability, making it more difficult to generate multidisciplinary data products

MEASURES OF SUCCESS

For the federation to be successful, it is important to decide at the outset how the federation should be judged. To do this, federation partners should develop a baseline from which to measure achievements of the federation, define metrics (e.g., number of new innovations), and obtain feedback from peers. Since success begets success, it is also important for the federation to get off to a good start with some early successful activities. These will instill confidence in the members and may defuse potential critics.

Success may mean different things to NASA, the federation, and individual partners. Some possible measures of success are given below.

Measures of success for NASA include:

- increased productivity of the science in the Earth Science Enterprise;
- wider dissemination of innovative information products;
- lower costs;
- ability to be self-sustaining; and
- reduced dependence on NASA funding. Measures of success for the federation include:
- increased productivity of the science in the Earth Science Enterprise;
- maintenance or advancement of position as the primary source of ESE information;
- satisfaction of the constituents;
- development of new information and capabilties;
- demonstrated commitment of the constituents and NASA;
- attraction of new members;
- ability to be self-sustaining;
- increased size and diversity of user community;
- effective stewardship of holdings (i.e., ensuring the scientific quality and integrity of the information products for the benefit of future generations of scientists); and
- reduced dependence on NASA funding.

Measures of success for the partners include:

- constituent satisfaction with the federation's data sets, capabilities, or technology;
- meeting the terms of the contract by advancing the science;
- easier generation of data products and other information; and
- increased market share.

3

Models For An Earth Science Enterprise Federation

This chapter compares federation models presented at the workshop and elsewhere, and presents lessons that may be applicable to an ESE federation. The Steering Committee examined six federation models, which are described in Appendix A and compared in Table 3.1. The rows in Table 3.1 are the key issues identified in Chapter 2.

OVERVIEW OF FEDERATION MODELS

All of the federation models examined have the following elements in common:

- the objectives of the federation are well defined and are described in a mission statement;
- the federation knows its constituents;
- priorities are established and reviewed regularly, which helps the federation respond to new needs;
- shared values and principles;
- dues or discretionary funds to operate the federation;
- well-established procedures for operating the federation, including admission criteria;
- a board of directors, committee, or secretariat to manage the routine operations of the federation; and
- partners have a voice in the community.

On the other hand, the federation models have the following major differences:

- the amount of power vested at the lowest levels varies widely;
- management styles range from relatively authoritarian to relatively democratic, with the latter tending to slow decision making;
- leadership is visible at several levels—by a prestigious person at the top (e.g., Harvard Libraries, NATO), a dynamic, capable person from within (e.g., Unidata), or both (e.g., Chevron);
- one or two levels (categories) of membership, with the likelihood for tension increasing when there is more than one level;
- membership ranges from open to closed, although most federations are open to their particular constituency; legal standing varies from highly regulated to informal; and the host sponsor, if one exists (e.g., NSF for UCAR, Harvard University for Harvard Libraries), exercises a level of control that varies widely.

Table 3.1 Comparison of Federation Models

Attribute	ARL	Harvard	ATO PfP	Chevron	Federal	UCAR
Objectives						
Goals	in mission statement	recognition by Harvard as an operating unit	in mission statement	in mission statement	in Constitution	in mission statement
Constituents	teaching and research community	university community	national governments	geophysical and petrochemical community	states and people	atmospheric science-community
Legal standing	not-for-profit corporation	informal, director is faculty member	non-binding political agreement		U.S. Constitution	not-for-profit corporation
Governance						
Management						
Role of host	not applicable	provides institutional support	not applicable	provides financing and infrastructure	not applicable	NSF-review of all programs and management
Autonomy	little loss of autonomy	little loss of autonomy	no loss of autonomy	no loss of autonomy	gives up autonomy on national issues, retains autonomy on local issues	multiple funding sources increase autonomy from NSF
Sharing authority	board can fire the manager	decisions with consent of the members	consensus decisions	Chevron maintains authority	states have local authority, federal government has general authority	board can fire the manager
Priorities	improve scholarly communication, stewardship	improve library system	defense, national security	long-term profitability	justice, domestic tranquility, common defense, common welfare, liberty	atmospheric research
Resources	member fees	university endowment, fees from faculties and federal grants	member taxes	Chevron operational funds	natural (territory), financial (taxes), and human (e.g., jury duty, selective service)	member fees
Interoperability		HOLLIS				Unidata
Leadership		director holds prestigious chair	ambassador	linker	elected officials and plebiscite	president and board

Membership						
Qualifications	by invitation	open to all Harvard affiliated libraries	elaborate conditions	Chevron sets conditions	potential new members apply to Congress	by invitation
Classes of membership	equal/one level	equal/one level	NATO members (voting) and partners (non-voting)	equal/one level	states (full rights) and territories (partial rights)	full members and at large members
Evolution	reviews of priorities lead to evolution	reviews of priorities lead to evolution	NATO slow to add new members, cumbersome decision making, thus slow evolution	federation sunsets when goal is accomplished	continual adjustment within constitutional framework	from NSF to multiagency support, some projects sunset, continual adjustment
Responsibilities	dual citizenship	dual citizenship	dual citizenship	dual citizenship	dual citizenship	dual citizenship
Gov. Body Tasks						
Models	elected board of directors	appointed director and staff	secretary general and staff	full-time managers	three branches	board of directors and committees
Procedures and processes	bylaws	harmonization of systems and standards	common language and way of doing business, standards	activities subject to approval by Chevron senior management	existing body of law	bylaws
Benefits						
For host	not applicable	economies of scale, integrates information, resources	not applicable	enhanced access to science and technology, flexibility	not applicable	dominant role in atmospheric sciences
For federation	collaboration with peer institutions, voice, leveraged funds	integrates information resources, economies of scale	promotes security and stability	advances research and development	distributed burdens, power base	voice in setting directions and access to major facilities
For partners	voice, receipt of funds	integrates information resources, economies of scale	voice, prepares some for NATO membership, political and military advice	funding, access to new challenges, committed partner	security, stature, transportation infrastructure, interstate commerce, funding	access to facilities, voice, convening function
Costs						
For host	not applicable	operating expenses	not applicable	project support	not applicable	development direction
For federation					tensions with and among states	

Attribute	ARL	Harvard	NATO PfP	Chevron	Federal	UCAR
For partners	dues and funding of individual projects, time spent on committees	less customization of library functions	dues, support own participation		tensions with federal government and other states, taxes	loss of autonomy, loss of competitive opportunity, UCAR costs the community money, time spent on committees, dues
Measures of success						
For host	not applicable	realizes economies of scale	not applicable	new science and technology	not applicable	
For federation	baseline for measuring success, community's interests are advanced	HOLLIS serves the community well, federation project (preservation center) is a national leader	membership has grown		extended reach, stability, citizen contentment, unified direction for general matters	30 years of successful accomplishments, attracted new funding, growth of activities
For partners	enhanced research library quality	patron satisfaction, enhanced quality of the research enterprise	alliances established under the NATO umbrella	scientific/technical progress	extended reach, local control over local matters, stability, citizen contentment	enhanced research progress; continued voice sets directions
Lessons learned	shared values, well-defined tasks, and active involvement of partners are essential; governance structure allows agile response; priority reviews enhance flexibility; collaboration strengthens the federation	it is possible to link libraries to better serve the community	size is limit On consensus decisions, tensions from two levels of members	linker is critical; management must dedicate time initially; team ownership of the goal; culture is important; give and take on intellectual property; agree to rules before partner ship begins; may lose valuable people	an interactive, participant-defined system can accommodate public and private interests over the long term with multiple and shifting centers of authority	Triad of individual investigators, major center and federal agencies can function successfully; tensions between member and federation programs over funding can be managed; potential competition with private sector

LESSONS FOR AN ESE FEDERATION

There is no ideal model for any federation; a strength for one organization may be a weakness for another. As Irwin Feller warned at the workshop, a federation model for industry may not be appropriate for science. Nonetheless, there are lessons to be learned from all of them. Based on comparison of the similarities and differences described above, and the needs of the four ESE constituencies, the Steering Committee for a Workshop on an Earth Science Enterprise Federation selected the following lessons from existing federations, which may be helpful in the design and development of an ESE federation:

Lesson 1. To be successful, a federation must be a community-driven, grass-roots effort with empowerment at the individual member level. The ESE community is broader than ESIPs Type 2 and 3; it includes many other types of data and information users and providers. Therefore, the prototype ESE federation should be planned with this broader community in mind. A step toward ensuring that the interests of all the ESE constituents are represented is to include the Type 1 ESIPs in the prototype federation.

Lesson 2. A bottom-up approach should be carried into the governance of federations to ensure that the priorities of the broader community are honored. However, some centralized management is necessary for making major decisions on behalf of the partners, for representing the federation's interests, and for conducting day-to-day operations. The instrument of centralized management, however, should be used sparingly (i.e., the "light touch" management approach is preferred). It is essential for an ESE federation and NASA to agree on the reserve powers of the partners; that is, those prerogatives that cannot be moved to central control or to NASA.

Lesson 3. A cornerstone of federations is flexibility. In order for an ESE federation to respond to changing needs, the initial rules and procedures should not be overspecified.

Lesson 4. In an ideal federation, partners come together to achieve ends they could not achieve alone. However, since the ESIPs were chosen through a competition based on product deliverables, these common values, or the federation glue, will have to be developed by the partners. This is an essential step in forming a successful federation.

Lesson 5. It is important for any organization to decide how it will be evaluated *before* it is created. Quantitative metrics include measures of success and a baseline from which to measure performance on a regular basis. However, the intangible and qualitative learning that is likely to occur as the experiment proceeds is just as critical to the evaluation of the experiment. Some of the most important institutional elements are unlikely to fall within easily quantifiable categories. In the case of an ESE federation, it is incumbent on the ESIPs to determine (and NASA to agree to) the elements of this evaluation.

Lesson 6. Tensions can arise when partners in a federation have different privileges. While an ESE federation is small, equal status among prototype federation partners would help ensure that all constituents have an equal voice.

Lesson 7. There are major differences among the ESE constituents, which will lead to tensions and differing expectations. For example, there are major philosophical differences (e.g., commercialization policy) among the ESIPs. These differences must be accommodated in the mission of an ESE federation.

CONCLUSIONS

The ESIPs are facilitators for ensuring that the Earth Science Enterprise meets its scientific goals. For the federation to succeed in increasing the productivity of the science, NASA has to ensure that the individual ESIPs are truly responsive to the needs and opportunities of the communities they claim to serve. NASA will need to develop innovative review mechanisms and contractual arrangements, metrics of performance, and rewards (contracts or otherwise). It will also need to retain a broad-minded view of the advantages and disadvantages of alternative approaches.

To date, there is no agreed federation model for managing data from NASA's ESE program, but the issues surrounding the development of the model are expected to be resolved through meetings of the prototype federation ESIPs. Designing a federation, which is an iterative process, will be time consuming and frustrating. Moreover, it may take years to realize the benefits of the federation.

But because the federation will be designed by the ESIPs and NASA, it will likely prove more flexible, adaptable, and responsive to the priorities of the ESE constituents.

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Afterword

At a meeting called by the ESIPs after the workshop, the Type 2 and 3 ESIPs decided to include the DAACs (Type 1 ESIPs) in the prototype federation.

Appendix A

Federation Models

Several individuals were invited to summarize examples of successful federation models. The examples selected are from a spectrum of organizations, including libraries, international organizations, industry, government, and academia. The examples of federation models appear as written by the authors, with minor editing for continuity of style.

ASSOCIATION OF RESEARCH LIBRARIES FEDERATION

Prudence Adler

Since there is no one model in the academic arena that will serve as the basis for designing an EOSDIS Federation, the following elements or factors culled from other federations, could be incorporated into a new model to best serve the needs of the evolving organization. Issues relating to identification of community values, investments in long-term preservation and access activities, and better definition of the relationship between the federation, NASA, and Congress will be important to delineate and will be central to the success of the federation.

- The federation model should allow the organization to evolve and change, in large part, to be responsive to changing user information needs. One key element of the model will be to ensure that the organization is responsive to membership—a membership comprised of multiple constituencies. It will be a formidable task to design a federation that is equally responsive to changing scientific requirements while meeting congressional demands.
- A common theme or glue in existing academic consortia is the set of values that the community brings to the effort. These shared values provide cohesiveness to potentially diverse communities. For example, one value for the federation relates to information policies such as the policy supporting the full and open exchange of data. Other motivations to consider include economic concerns and the need to improve a local situation through national initiatives.

- Understanding common values also assists the organization in managing and/or considering other relationships. The increasingly complex environment in which EOSDIS partners will operate suggests that a common set of principles would enhance the federation's ability to achieve its goals and collaborate with other initiatives.
- Articulating values permits the federation to draw in other partners, initiate other activities, and export its values set to other efforts that may complement or extend beyond its current operating structure.
- Partners in the federation should do an "environmental scan" to identify and understand potentially competing values or projects that could keep a partner from fully embracing an EOS-centric set of values or principles. For example, the very nature of this enterprise is international. How will the federation interact with international centers and users? Some of these relationships will be appropriately governed by U.S. data policies and practices; others are not so well defined.

- There is a need for careful definition of the relationship between the federation and NASA. EOS partners are legitimately seeking greater clarity in this relationship. As this relationship evolves, it will be important to be aware of how NASA will present this program to Capitol Hill, how the federation funding process will evolve, and how the appropriate committees (e.g., appropriations and authorization) will view NASA's relationship to the federation.
- Members of the research and education communities require access to both current and historical data. The federation should address issues relating to long-term preservation, access activities, and how the users will be able to integrate and use EOS data with other information resources located elsewhere.

Most academic federations and organizations include several common governance structures: full-time staff, a clearly articulated mission, a Board of Directors, an Executive Committee that can respond quickly to ongoing management issues, plus committees to advance the work of the membership. The EOSDIS Federation may need comparable organizational structures.

In addition, an appreciation of the benefits to members and, in particular, how collective action and collaboration advances the interest of the community are critically important to the success of an organization. Other key factors include: a well defined issue set, the ability of the governance structure (board and members) to respond quickly and with flexibility to issues, and the active engagement of members. A brief review of the Association of Research Libraries (ARL) organization is illustrative of these elements found in other academic federations and organizations.

Association Of Research Libraries Federation

GOVERNANCE	OBJECTIVES
Full time executive director; • Elected board (11 board members elected by full membership of ARL -121 North American research libraries); • Eight standing committees; • Many working groups and project advisory committees; • Executive Committee-president, past president, and president-elect; • All powers of a corporation (e.g., contracts, hiring, firing); and • Membership criteria: invitation to major research institutions with broad-based collections and services.	Mission statement: The mission of the ARL is to shape and influence forces affecting the future of research libraries in the process of scholarly communication. ARL programs and services promote equitable access to and effective use of recorded knowledge in support of teaching, research, scholarship, and community service. The association articulates the concerns of research libraries and their institutions, forges coalitions, influences information policy development, and supports innovation and improvement in research library operations. ARL is a not-for-profit membership organization comprising the libraries of North American research institutions and operates as a forum for the exchange of ideas and as an agent for collective action. Membership in ARL is institutional. There are currently 121 members that meet twice a year. • **Scholarly communication & information policies**. To understand, contribute to, and improve the system of scholarly communication and the information policies that affect the availability and usefulness of research resources. • **Access to research resources**. To make access to research resources more efficient and effective. • **Collection development**. To support member libraries' efforts to develop research collections, both individually and in the aggregate. • **Preservation**. To support member libraries' efforts to preserve research collections, both individually and in the aggregate. • **Technology**. To assist member libraries in exploiting technology in fulfillment of their mission and assess the impact of education technologies on scholarly communication and on the role of research libraries. • **Staffing**. To identify on an ongoing basis the capabilities and characteristics required for research library personnel to best serve their constituencies and to assist member libraries and educational programs in the recruitment, development, and effective use of staff. • **Management**. To assist member libraries in augmenting their management capabilities. • **Performance measures**. To describe and measure the performance of research libraries and their contributions to teaching, research, scholarship, and community service.

COST/BENEFITS	LESSONS LEARNED AND OUTSTANDING CHARACTERISTICS
Cost to individual members • Financial contributions in the form of dues in addition to selected contributions in support of particular projects as determined by each institution; • Members serve on committees, working groups, task forces, ARL Board of Directors.	• Collective action and collaboration advance interests of the community. • Shared value set and principles are central to the success of the organization. • Targeted issues permit focus of organization and high success. • Active involvement of the members is critical to the success of the organization. • The governance structure allows for quick/agile responses to issues. • Regular review (yearly) of priorities permits needed flexibility and ability to tackle new and/or changing issues/circumstances. • Collaboration (ARL has created or participates in a very large number of coalitions) with other public and private sector organizations and entities enhances and strengthens the organization's ability to address issues.
Benefits to to individual members • Collaboration and collective action on a host of key issues of importance to the research library community • a community-wide voice; • significant leveraging of funds and resources; and • targeted issues to advance core set of concerns/ opportunities.	

HARVARD LIBRARIES

Thomas M. Parris

Surprising as it may seem there is no single "Harvard Library System." Rather Harvard operates more than 90 autonomous libraries. Each has it own endowment, reports to its own dean or department chair, and so forth. However, these libraries have federated so that in many respects they look like a single system to the outside world. There were three compelling reasons for this federation. The first was driven by patron demand. Our research community became vociferous in its disdain for having to search the many card catalogs maintained across a large campus. This was particularly true for the growing number of student and faculty performing interdisciplinary research. Second, the individual libraries were facing a common set of expensive decisions relating to the construction of computerized card catalog systems, preservation laboratories, and off-site depositories. Each of these efforts have significant economies of scale. Third, rapidly rising monograph and serial prices forced libraries to collaborate more closely on purchases. We could no longer afford to have multiple libraries buying the same expensive materials.

The structure of the Harvard library federation allows the individual libraries to maintain complete control over collection policies, finances, and all aspects of internal operations. Money flows from these autonomous libraries to support unifying services, such as online catalog, depository, and preservation. There is no mandate that forces libraries to subscribe to these services. Indeed, some libraries do not participate in the campus-wide card catalog system (HOLLIS), and some maintain their own preservation and off-site storage facilities. The executive committees of the federation are dominated by representatives from member libraries and are structured with some bias toward the smaller libraries.

The result is impressive. As a group, the Harvard libraries are the largest academic library in the world. The online card catalog has over 8 million bibliographic entries. The Harvard Depository, our centralized service for off-site storage, has attracted significant business from other local libraries and businesses.

Harvard University Library Federation

GOVERNANCE

- Full-time director, joint appointment of an active senior faculty member to one of the university's most senior prestigious chairs. The Pforzheimer professor and the University Library report to the Office of the President.
- Full-time staff, including associate directors for administration and programs, as well as information systems and planning.

- Two advisory committees:

1. The University Library Council is comprised of the librarian of each faculty library and the University Library's associate directors. This body meets once a month.
2. The Harvard Overseers' Committee to Visit the University Library is drawn from a distinguished community of international leaders, many of whom are alumni with interests in the Harvard University Library.

- Working groups are drawn from throughout the Harvard library community to address specific operational issues.
- Participation is open to all Harvard affiliated libraries.
- The Harvard University Library is funded primarily through an endowment established by the corporation at its inception and the university's central administration, of which it is a department. In addition, some program support is realized through federal grants and by fees to the faculties for a portion of the system's operation and off-site storage costs.

OBJECTIVES

- The Harvard University Library serves as the coordinating body for a distributed system of library units, which vary in size.
- The central coordinating body is charged by the corporation of the university to perform those functions that make sense to do centrally. Such functions include:

- Development, implementation, and operation of the online catalog and related library information systems;
- University archives;
- Preservation and special collections conservation;
- Publishing ventures and institutional communication;
- Human resources administration;
- Institutional research;
- Sponsored projects management;
- Coordinated acquisition of networked resources (prospective);
- Development of the Library Digital Initiative;
- Membership in national associations; and
- External relations.

COST/BENEFITS

- Realizes economies of scale across libraries.
- Integrates intellectual access and related services to over 90 independent libraries.
- In return, individual libraries give up a measure of control and potential for local customization of University Library functions.

LESSONS LEARNED

- The model works.
- The Harvard Online Library Information System (HOLLIS) maintains records on over 8 million bibliographic titles. HOLLIS is an effective first point of consultation for research at Harvard. The University Library is now in the process of procuring a second-generation integrated library system.
- The Harvard Depository has been successful in serving the Harvard library community
- The Harvard University Library Preservation Center is recognized as a national leader in its field.

NATO'S PARTNERSHIP FOR PEACE

Charles J. Dale

In 1994 the North Atlantic Treaty Organization (NATO) established the Partnership for Peace (PfP) as a vehicle for developing bilateral security relationships between the alliance (and its sixteen member states) and the non-member nations of Europe and Central Asia. Twenty-seven non-NATO nations, with such diverse strategic interests as Switzerland and Russia, have now established unique, bilateral partner-ships with the alliance. The Partnership Work Programme from which each individual partnership is derived includes over 1,000 activities annually, activities such as workshops, technical exchanges, exercises, consultations, and training courses. The partnership covered a broad range of security issues from military exercises in peacekeeping to the democratic control of armed forces.

PfP is established within the federal structure of the Alliance itself. Within NATO, the sixteen member states hold power and the "center," the secretary general and his staff, govern by their consent. NATO's members have shared interests and values and are treaty bound to come to each other's defense. NATO decides by consensus—one nation, one vote—at all levels. The voice of the United States is no more, or greater, than that of the Netherlands or Iceland. NATO has a common language and way of doing business (several thousand standardization agreements, for example) that define technical standards for interoperability of forces. The "work" of the alliance is guided by alliance foreign and defense ministers, who meet twice a year to provide strategic direction. The North Atlantic Council, the highest standing political body of the alliance in which ambassadors represent their nations, meets at least weekly to oversee and direct the everyday work of the alliance. "Corporate NATO" is comprised of several hundred committees, agencies, and working groups—the profit centers of the alliance—each with an independent mandate and authority from the center.

The partnership draws on the strength of NATO's federalism. Partner nations are fully enfranchised within the context of their bilateral relationship with the alliance. The work of the partnership is decentralized through the NATO structure. Partners have dual citizenship, as sovereign nations and as members of the partnership. They share interests and common values and are committed, in both a collective and individual sense, to common objectives. The partnership has its own political framework, instruments and procedures, in most cases modeled after NATO's.

But the NATO PfP marriage is not perfect; in fact, it has a fundamental tension built in. Partnership is not membership. The sixteen alliance members retain significant reserve powers to decide the strategic direction of PfP. Partners have a voice, but no vote. This built-in tension is causing fault lines within the partnership as partners call for more say on "important" issues affecting the partnership writ large.

Nato's Partnership for Peace Federation

GOVERNANCE

- PfP has mixed models:

- NATO member states decide on reserve issues involving strategic direction of partnership itself;
- Partners are involved in joint decision making on bilateral issues.

- Secretary general and "center" govern by consent of nations;
- Biannual meetings of defense and foreign ministers provide strategic direction;
- North Atlantic Council (NATO ambassadors) meetings weekly—with partners monthly, highest level working bodies;
- "Corporate" NATO—several hundred committees, agencies, working groups have independent mandate and are self-governing at the working level;
- Decisions taken by consensus.

OBJECTIVES

- Mission statement and objectives established through non-binding political agreement (framework document).
- Framework document:

- Established shared values;
- Objectives;
- Governing principals.

- Strategic objectives:

- Prepare some partners for NATO membership;
- Support new NATO missions;
- Element of new Europe security architecture.

- Operational objectives:

- Support defense reform: restructuring armed forces and revamping national security decision-making processes and structures;
- Promote democratic control of armed forces;
- Develop interoperable forces.

COST/BENEFITS

Cost to individual members:

- As a general rule, nations support their own participation and activities. Some partners with limited resources are subsidized.
- NATO collective funds (cost shared among NATO nations). Supports NATO-sponsored activities and organizational costs.

Benefits to individual partner nations:

- Offers bilateral relationship with the alliance short of full membership.
- At strategic level, participation supports national security objectives:

- Offers voice in European security affairs;
- Prepares some for membership in NATO.

- At operational level, partnership provides direct advice and assistance (political and military).

Benefits to NATO and partner nations at large:

- Promotes security and stability—confidence building and transparency

LESSONS LEARNED/TENSIONS AND OUTSTANDING CHARACTERISTICS

- As issues grow in importance, partners demand a vote.
- Strategy to "do business" in PfP the "NATO way" works.
- Bilateral characteristics—an essential characteristic of PfP—also fosters independence among partners.
- Limits of consensus decision making—" How big is too big?"
- NATO member states, not partners, bound by treaty.
- Nations enfranchised at all levels of decision making.
- PfP is a series of independent bilateral partnerships—27 unique relationships designed around NATO.
- Partners "self-differentiate" (i.e., each country designs its program of activities via NATO based on its interests and capabilities).
- Over time PfP developed its own common language and institutional identity.
- Nations have dual (or multi-) citizenship, as sovereign states, allies, partners.
- PfP created with only one new structure—minimum new bureaucracy.

STRATEGIC RESEARCH AT CHEVRON PETROLEUM TECHNOLOGY COMPANY

Robert Heming

Chevron Petroleum Technology Company is charged with bringing the best available technology to Chevron's upstream (exploration and production) business. The company covers a wide range of technical expertise and deals with a very geographically dispersed customer base.

In 1992 we radically redesigned our approach to providing technology and, in particular, we changed the way we gain access to new science and technology. It was felt that our previous efforts to find new and radical technologies of potential value to our business were badly flawed. We needed a rethink.

The results of that rethink is something we call strategic research. Its objective is to scan the technology horizon for new science, much of it not traditionally used in the oil and gas business, which has the potential to change the way we do our business or reveal new business opportunities. By calling it strategic research and by giving the responsibility to one individual we believe we have made it a strong and focused part of our overall technology strategy.

That strategy can be depicted by a broad arrow running from high-risk but low-cost and highly leveraged technology investments to relatively low-risk, high-cost investments that are designed to take products and services to the customer. The stages along the way are called tiers and the continuum can be viewed as a pipeline with a wide opening at the strategic research end where we invest relatively small amounts in several new science and technology ventures. Successful technologies are then developed and matured to the point where they can replace existing technology.

As well as stretching our "technology horizon," we also decided that to be successful our approach to collaboration must be different. We wished to be regarded as good partners by a wide range of groups within the invention community, from national laboratories and research institutes through universities and small entrepreneurs to other industrial R&D companies.

To accomplish this we designated the role of linker. Someone who could be "at home" within our research group as well as a research group in a university for instance. To us "at home" means being accepted as a co-worker and colleague and not being viewed as an interloper.

To achieve this we practice certain key principles. The first is to be explicit and clear about what success looks like in each organization. Next we develop a collaboration that will allow both parties to succeed. The real objective is to allow both partners to achieve success, or win, as defined by their respective cultural and business models. For example, when collaborating with a university, it is important to recognize that ownership of the invention and publication rights are vital to the mission of a university. In setting up a research collaboration we try very hard to match the cultural and business objectives.

The final key is to be very clear about the role of the linker and the personal attributes necessary for that role to be successful. Then management must reinforce the principles and behaviors needed. It must support, coach, provide vision, and encourage both creativity and collaborative behavior.

Our experience since 1993, when we made our first strategic research investment, has been positive, but we have learned several hard lessons, too. Do not underestimate the importance of the linker—a good one makes all the difference. Do not underestimate the importance of cultural and business differences. A natural tendency of technical people is to focus first on the technical issues and last on the cultural or so-called soft issues. In our experience it is the soft issues that cause hard falls. Be prepared to relocate people to an appropriate common work site. Stretching the physical boundaries of one's organization does wonders to people's views of issues, problems, solutions, etc. We see great strength in creating a much more virtual organization to accomplish our strategic research goals.

We are pleased with what we have achieved, but we realize that we need to learn much more. Above all, we have learned the importance of clarity. Clarity of vision, objectives, intents, success factors, and so on. Get everything on the table right at the beginning. Anything left under the table is a potential show stopper at some future date, so take time in the early stages to understand your potential partner and understand what is motivating that person to collaborate with you.

Communicate and communicate as much as you can, but always be clear and explicit about where you want to go and how you want to get there.

CHEVRON PETROLEUM TECHNOLOGY COMPANY STRATEGIC RESEARCH

GOVERNANCE

- Full-time general manager, strategic research;
- Guidance team composed of member of technology companies and Chevron's upstream operating companies;
- Project selection process driven by the GM-strategic research, one manager and team of technology managers;
- Final budget approval by the corporate VP-technology.

OBJECTIVES

To participate in and fund research and development into new science and technology that can substantially improve the performance of our upstream oil and gas business or provide new business opportunities.

PRINCIPLES/BENEFITS

- Clarity of objectives;
- Explicit measures of success for both parties;
- Single team/single objective;
- Mutual access to intellectual property (IP) decided at beginning;
- Appoint linker to work in project.

Benefits to Chevron:

- Enhanced access to novel science and technology;
- Ability to collaborate with best scientific and technical ideas anywhere in the world;
- flexibility.

Benefits to Collaborator:

- Access to new problems, data and application trials;
- Multi-year funding commitment;
- Committed partner dedicated to working as a full team member;
- Ability to meet own objectives/measures of success.

LESSONS LEARNED

Linker—a very important role—"a day job."

- Management must dedicate time, especially in the beginning.
- Allow the team or workgroup to make the "goal" their own.
- Do not short-circuit the cultural development.
- Be creative in selecting work site.
- Be clear on IP, but give and take.
- Describe framework, "rules," behaviors, outcomes, intervention mechanisms in "plain English" before lawyers "boilerplate."
- You may lose valuable people.
- Virtual R&D organization that allows access to wider range of creative ideas than possible in traditional internal industrial R&D organization.

THE SCIENCE OF FEDERALISM: PAST AND PRESENT

Joanne I. Gabrynowicz

In 1987 the United States began a third century of government under its present Constitution: a constitution that has successfully brought an energetic nation through the passage of time, the expansion of physical space, and national crises. This presentation suggests that the framers of the United States Constitution engaged in what they called "a science of constitutions," which employed the scientific method; a geometric model; measurements and proportions; Newtonian physics; and, what is today recognized as systems science. It addresses the goal of the Constitution framers, the science they used, their design process, and the resulting system.

It is suggested further that the use of a similar approach in modem times can provide a model for a federated data and information acquisition, processing, and distribution system that transcends local limitations and centralized control, if it is founded on general principles that have a more universal applicability.

United States Federation

GOVERNANCE	OBJECTIVES
• Democratic authority originates from consent of participants. • Elected officials; staggered terms of office. • Authority/power separated according to function: rule making; rule interpretation; execution of rules. • Executive entity directs, advises, carries out day-to-day activities, responsible for fulfilling policies determined by regulatory (legislative) entity. Includes chief executive and an advisory body. • Regulatory (legislative) entity drafts group rules, governs joint finances, determines governing policies. Proportional representation. • Conflict resolution entity (judicial). Authority to resolve questions, conflicts, and issues raised by constituent members of the federation. Determinations are binding on members. • Specific mechanisms to change governing system as necessary. • Location of function control, local or central, is determined by the *nature* of the function. • New members meet preestablished criteria designed to enhance whole system.	• A participant-defined organization that ensures stability and common values over time; • A more perfect union; • Decentralized authority, sometimes co-located; • Interaction among local parts and whole system; • A structural foundation that balances predictability and change as events and new participants emerge over time; • Equality of stature for all participants.

RESULTS OF COLLABORATION	LESSONS LEARNED
• Distributed benefits; • Distributed burdens; • Flexibility over time; • Coexisting experiments in different local parts with same or similar subject matter allows best alternatives to emerge; • Self-financed with distribution of fiscal resources according to self-determined governing policies.	• A systemic, holistic model based on an interconnected mixture of distributed local authority and a central, overarching authority works; • The American experiment: based on Newtonian concepts; • Science can be the foundation *of governance* (not necessarily government) systems; • Complementarity of science and commerce; • Complementarity of private and public interests; • Can be long-term; • Geographic coherence required; • Political will is necessary; • Location of authority can migrate over time.

UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH FEDERATION

Frank Eden

The University Corporation for Atmospheric Research (UCAR) mission is "to support, enhance, and extend the capabilities of the university community nationally and internationally; to understand the behavior of the atmosphere and related systems and the global environment; and to foster the transfer of knowledge and technology for the betterment of life on Earth." UCAR was incorporated in the late 1960s and is now a consortium of 63 universities.

This mission has evolved into the management of a variety of major facilities and projects broadly related to the atmospheric sciences. The first and most visible of these is the National Center for Atmospheric Research (NCAR). UCAR also manages large distributed data systems, including Unidata, which provides meteorological data and networking to well over 100 researcher and user institutions, and the Distributed Active Archive Center, which similarly provides ocean data services. UCAR initiated the Global Positioning System Meteorology Instrument program. UCAR sponsors extensive educational activities and provides for commercial and technological transfer activities.

UCAR has a strong central management system with a full-time president and staff and an elected Board of Trustees. Its relationship to its principal sponsor, NSF, has changed from contractual to a cooperative agreement system, which stipulates direct NSF-led review of programs and management.

UCAR has clearly operated successfully for over 30 years. It has managed and provided major facilities and an institutional voice and focus for the atmospheric sciences community. It appears to have successfully managed a triad of a major center, university members, and federal agencies. On the downside there have been failures (e.g., losing the management of the National Scientific Balloon Facility and withdrawing from the Institute for Naval Oceanography). The growth of UCAR activities has strained the board's oversight. There has always existed a tension between individual investigators and UCAR over the division of NSF funds between them as a zero sum game and the potential opportunity loss for individual universities to own and operate major facilities. There have also been issues of UCAR programs competing with the private sector.

University Corporation For Atmospheric Research Federation

GOVERNANCE

- Full-time president;
- Elected board (17 members elected by representatives of the 63 member universities), which includes at-large members outside of scientific disciplines;
- Five standing committees of the board, including UCAR management committee;
- Member committees and meetings;
- Cooperative agreement (formerly a contractual arrangement) stipulates NSF involvement and NSF-led review of all programs and management;
- All powers of a corporation (e.g., contract), operations governed by bylaws.

OBJECTIVES

Mission statement defines broad strategy. Specifics include:

- Manage NCAR for NSF:

- Provide major facilities and planning capability for programs of atmospheric research;
- Conduct atmospheric research in cooperation with universities.

- Manage other projects (e.g., Unidata, DOTS, GPS Met through UCAR office of programs for NSF and other agencies, including significant educational activities);
- Provide for commercial and technology transfer activities through separately incorporated activities.

COST/BENEFITS

Cost to individual members:

- Financial contribution supports UCAR corporate fund;
- Member service on committees;
- Some loss of autonomy and opportunity loss in competing individually for large facilities/programs;
- Division of research funds between university programs and UCAR programs.

Benefits to individual members:

- Access to large centrally managed facilities and planning capabilities at NCAR probably beyond the ability of individual members to acquire;
- Institutional focus for joint planning and coordination plus;

- A community-wide voice facilitates communication and interaction among members.
- A physical and intellectual center of international status provides a resource for the community through visits, colloquia etc.

Benefits to atmospheric science community at large (non-members):

- Representation in and resolution of issues affecting the entire meteorological research, education, and user community (e.g., development of the Unidata system to ensure distribution of meteorological data to the university community, maintenance of a distributed ocean data system).

LESSONS LEARNED/ISSUES AND OUTSTANDING CHARACTERISTICS

- Over 30 years of successful mission accomplishments.
- Original NSF sole support has evolved to multiple federal sponsors (a transition advocated by NSF).
- Strong board has effected management changes, including presidents.
- Growth of activities (to > $150M) expands the necessary scope of the board's oversight to include fiduciary, policy, and political issues.
- Some UCAR programs terminated: Institute for Naval Oceanography at Stennis Walter Orr Roberts Institute, National Scientific Balloon Facility.
- Potential for UCAR programs to compete with private sector.
- Ongoing tension between university researchers and UCAR/NCAR over division of NSF funds—a zero sum game.

Outstanding Characteristics

- Centralized governance;

- Primary mission to manage large programs/facilities;

- Successful triad of universities, a major center; and federal agencies led by NSF.

Appendix B

Workshop Agenda

WORKSHOP ON AN ESE FEDERATION
February 23-25, 1998
Wyndham Bristol Hotel
2430 Pennsylvania Avenue, N.W., Washington, D.C.

February 23, 1998

9:00 a.m.	Introduction	Orcutt
9:15	Toward a Federated EOSDIS	Asrar
10:00	Federation Concept	Parris
11:00	Findings of EOSDIS Panel's Federation Meeting	Glover
11:30	Future of the Research Enterprise	Feller
12:15 p.m.	Lunch Break	
1:15	The Short History of EOSDIS	Dutton
1:45	NATO Partnership	Dale
2:30	Break-Out Sessions	
6:00	Adjourn/Dinner	

February 24, 1998		
9:00 a.m.	Break-Out Sessions Summary	
10:00	Industry Federations	Heming
10:45	Academia Federations	Adler
11:15	The Science of Federation: Past and Present	Gabrynowicz
12:00 p.m.	Lunch Break	
1:00	Break-Out Sessions	
6:00	Adjourn	
February 25, 1998		
9:00 a.m.	Plenary Meeting Conclusions, Final Thoughts	
12:00 p.m.	Lunch	
1:00	Steering Committee Meeting	

Appendix C

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Appendix D

Winners Of Nasa's 1997 Cooperative Agreement Notices

TYPE 2 ESIPS

The Distributed Oceanographic Data System: A Framework for Access to Scientific Data in the EOS Federation, led by Peter C. Cornilion, University of Rhode Island, Narragansett.

The Earth System Science Workbench: A Scaleable Infrastructure for ESIPs, led by James Frew, University of California, Santa Barbara.

Seasonal to Interannual Earth Science Information Partner (SIESIP), led by Menas Kafatos, George Mason University, Fairfax, VA.

Progressive Mining of Remotely Sensed Data for Environmental and Public Health Applications, led by Chung-Sheng Li, International Business Machines, Yorktown Heights, NY.

A Web-Based System for Terrestrial Environmental Research, led by Berrien Moore, University of New Hampshire, Durham.

ESP2Net: Earth Science Partners' Private Network, led by Richard Muntz, University of California, Los Angeles.

Evolution of Snow Pack in the Southwestern United States: Spatial and Temporal Variability from a Remotely Sensed and In Situ Data Set, led by James J. Simpson, Scripps Institution of Oceanography, University of California, San Diego.

Tropical Rain forest Information Center, led by David L. Skole, Michigan State University, East Lansing.

An On-Demand Data Processing and Delivery System for Climate Studies Using Passive Microwave Data Sets, led by Roy W. Spencer, Marshall Space Flight Center, Huntsville, AL.

A Landcover Earth Science Information Partnership, led by John R. G. Townshend, University of Maryland, College Park.

GPS Environmental and Earth Science Information System: GENESIS, led by Thomas P. Yunck, Jet Propulsion Laboratory, Pasadena, CA.

Improved Ocean Radar Altimeter and Scatterometer Data and Atmosphere-Ocean Model Simulation for Coastal and Global Change Studies, led by Victor Zlotnicki, Jet Propulsion Laboratory, Pasadena, CA.

TYPE 3 ESIPS

Institutionalizing MTPE Data for Land and Environmental Management , led by Thomas E. Burk, University of Minnesota, St. Paul.

California Land Science Information Partnership, led by Gary Darling, California Resources Agency, Sacramento.

Performing a Regional Assessment and Prototyping Internet Accessible MTPE Products for the Upper Rio Grande Basin, led by Stanley A. Morain, University of New Mexico, Albuquerque.

Integrating Environmental and Legal Information Systems, led by Konstantinos Kalpakis, University Space Research Association (USRA), Greenbelt, MD.

A Public Access Resource Center (PARC) Empowering the General Public to Use EOSDIS Phase III Operations, led by George A. Seielstad, Upper Midwest Aerospace Consortium, University of North Dakota, Grand Forks.

WeatheRoute, led by Kevin Meagher, Reading Information Technology, Inc., Reading, MA.

MTPE Education Series, led by Catherine Gautier, Planet Earth Science, Inc., Santa Barbara, CA.

Integration and Application of MTPE Data and Information to the San Francisco Bay Area and Monterey Bay Region, led by David C. Etter, Bay Area Shared Information Consortium, Mountain View, CA.

Museums Teaching Planet Earth, led by Patricia Reiff, Rice University, Houston, TX.

Terrain Intelligence Products from EOS Sensor Data, led by Douglas H. Kliman, MRJ Associates, Tucson, AZ.

NBC News and Information: Extending MTPE Data to the World, led by David F. Jones, WRC-TV4, Washington, DC.

MTPE-Derived Data Products for the Fisheries, led by Patrick K. Simpson, Scientific Fishery Systems, Inc., Anchorage, AK.

Acronyms

ARL	Association of Research Libraries
CGED	Committee on Geophysical and Environmental Data
DAAC	Distributed Active Archive Center
DODS	Distributed Ocean Data System
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
ESE	Earth Science Enterprise (formerly Mission to Planet Earth)
ESIP	Earth Science Information Partner
GPS	Global Positioning System
GPS Met	Global Positioning System Meteorology Instrument
HOLLIS	Harvard On-Line Library Information System
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCAR	National Center for Atmospheric Research
NRC	National Research Council
NSF	National Science Foundation
PfP	Partnership for Peace (NATO)
UCAR	University Corporation for Atmospheric Research