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Information Architecture Volume I The Foundations

March 1995

US Department of Energy
Assistant Secretary for Human Resources and Administration
Deputy Assistant Secretary for Information Management

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U.S. Department of Energy

**Information Architecture
Volume I**

The Foundations

March 1995

Assistant Secretary for Human Resources and Administration
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for

MASTER

Message from the Designated Senior Official for Information Management

Secretary O'Leary recently commented in the strategic alignment plan that "The Department of Energy provides some of the Nation's most critical products and services in national security, environmental management, science and technology, and energy resources." As we continue to focus our efforts on providing efficient support in these areas, we must look at new approaches for getting the job done. The creation, maintenance, and utilization of a comprehensive Departmental Information Architecture provides the necessary foundation for ensuring quality information while helping us plan for making the best choices for scarce budgetary resources.

The Information Management Planning and Architecture Team (IMPACT), which is comprised of a diverse representation of personnel across the Department, has developed the **Department of Energy Information Architecture. Volume I.- The Foundations** as a framework for aligning information initiatives with Departmental business initiatives to better serve our customers.

Implementation of this Architecture directly supports the Secretary's report "Saving Dollars and Making Sense - Strategic Alignment and Downsizing", as it ensures linkages from the business processes to the technology infrastructures that serve the information needs of the Department, our primary customers, and the public. It is a necessary tool because it provides a common foundation for technology resource planning in the Department of Energy's distributed decision-making environment, resulting in improved coordination and communication between Headquarters, the field offices, laboratories, and our contractors.

As the Designated Senior Official for Information Management, I believe this to be a significant quality improvement for the Department and I encourage you to join in support of it. The success of the Departmental Information Architecture in improving information management, and through it ensuring "best business practices", depends on each of us.

S.W. Hall, Jr.
Deputy Assistant Secretary
for Information Management

Foreword

DOE Information Architecture, Volume I - The Foundations

This document is entitled Department of Energy Information Architecture, Volume I: The Foundations. This first architecture document lays the foundation for the processes required to produce an information architecture for the entire agency. The document is a collaborative effort that reflects the concerns and interests of participants throughout the Department of Energy. Accordingly, it is intended to serve a diverse audience composed of both program management and technical personnel.

The modern information architecture paradigm promises to provide solutions to management's business information needs.

All sections of this document will be of interest to readers who wish to understand DOE's direction, and the ways in which an information architecture will assist the consumers in satisfying their information needs. Management will begin to see how the use of the modernized information architecture paradigm promises to provide responsive technological solutions to their business areas' information needs. Program staff will be particularly interested in the presentation of the current business case, its description of business areas, and its vision for satisfying the needs of their stakeholders using a modern information management architecture.

The scenarios, entitled "A Knowledge Worker's View", at the end of each section are prepared from a program office perspective, and provide insight into the business area benefits that the future information architecture could deliver to them. Technical personnel responsible for delivering information technology solutions are particularly encouraged to focus on the baseline characterization and standards processes because these will, with future refinements, form the philosophical and engineering basis for the modernization effort.

Executive Summary

The Information Management Planning and Architecture Coordinating Team was formed to establish an information architecture framework to meet DOE's current and future information needs. This Departmentwide activity was initiated in accordance with the DOE Information Management Strategic Plan. This activity also supports the Departmental Strategic Plan. Finally, it recognizes recent changes in emphasis as reflected in Office of Management and Budget Circular A-130 and the Information Resources Management Planning Process Improvement Team recommendations.

This document provides the foundation for establishing DOE's Information Architecture. As described in the **Background** section, the current technology baseline evolved without fully addressing DOE information requirements. This section describes the application of the National Institute of Standards and Technology Enterprise Architecture Model and the concepts upon which the DOE Information Architecture is based.

The **Business Case** section presents the premise that enterprisewide problems require enterprisewide solutions. The major benefit of this information architecture strategic planning approach is the reduced duplication of effort and increased integration of activities through improved information sharing. Improvements in operational capabilities will enable DOE to achieve an increased return on its information and operational investment decisions.

The **Baseline** section characterizes the technology baseline that is currently in place within DOE. Headquarters, special project sites and energy technology centers, a program office, an operations office, and ten labs participated in a voluntary survey to form the basis of the characterization.

The **Vision** section sets forth eight guiding principles for the future DOE Information Architecture. The driving concept for this vision is the notion of a user-centric system in which the architecture is developed to support users and that all authorized users will be able to share information. The increased synergy between DOE business needs and emerging information technologies to deliver optimum business processes will result in improved coupling of mission areas, business processes, and information consumers.

The **Standards Process** section describes the importance of open system standards within DOE and their role in increasing information sharing. The use of DOE selected standards and variations throughout the standards lifecycle allows for flexibility in adapting to and integrating technology to meet emerging and changing business needs. The scope of these standards, their applicability, and a recommended process for their institutionalization are described in the document.

The **Policy and Process Integration** section describes the relationships between information architecture and business processes. The major business area benefits are expected to be improved openness, communication, information access, and enterprisewide management practices. These benefits will enable DOE to leverage this new architecture to improve current business processes and to exploit new process-enabled opportunities by the use of emerging and proven technologies.

The **Next Steps** section describes the approach to be used to develop an architecture that will provide effective solutions as new technologies mature, new laws are passed, new corporate level relationships are established, and as new opportunities present themselves. In the near term, standards adoption, the current baseline, and architecture guidance will be developed in greater detail. The goal is to prepare the foundations for communicating the urgency to change information management practices and to begin putting a suitable and supportable architecture in place for the long term.

Following each section of the document is a scenario. A **Glossary of Technical Terms** is also provided at the back of the document.

This document is the first architectural and management block for building the DOE Information Architecture. It was developed by representatives from throughout DOE to assure that it would result in systemic and high value improvements for their stakeholders. The characterization of the current baseline reveals that the current architecture will not serve DOE or the public well in the next decade. The vision, based on information sharing and standards, describes an architecture that will be responsive to business area needs, will be flexible to incorporate technology advances, and will be affordable from an enterprisewide investment standpoint. The vision provides a basis for refocussing DOE on its stake holding customers' needs and its key mission delivery processes. The suggested paths into the future assure that the DOE Information Architecture, in spite of changes and uncertainties, will be fully capable of supporting the agency's missions and functions well into the 21st Century.

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Credits

Information Architecture Team

Core Team

Michael Tiemann (HR) - Leader

Nancy Ahr (CDSI)
Carol Blackston (HR)
Gayle Brace (ASKCD)
Laurie Davis-Covin (CDSI)
Bridget M. Henry (CDSI)

Michael Farber (Weston)
John Kapke (CDSI)
Jay Keating (Batelle)
Matt Newman (Weston)

Sandy Santivanez (Meridian)
Brent Stacey (Sciencetech)
Rebecca Trenta (Ogden)
Jack Watterson (CDSI)
Rusty Wilbur (CDSI)

Extended Team

Mary Albert (CDSI)
Roberta Albert (Battelle)
Barbara Allen (EM)
David Anderson (CDSI)
Clarence Beck (ANL)
Gary Bellin (SRO)
Scott Bennion (Hanford)
David Berkau (HR)
Tom Brengle (LLNL)
Jim Brown (PNL)
R. Michael Cahoon
(LLNL/SNL)
Greg Chartrand (PNL)
Helen Clark (HR)
Alton Cox (HR)
Sue Farrand (CDSI)
Jerry Forman (OAK)
Chuck Guyker (HR)
Dennis Hall (LBL)

Pat Heinig (EH)
Dennis Jensen (AMES)
Andy Johnson
(Westinghouse/SRS)
Joe Jones (NV)
John Kelley (HR)
Kent Linsenmann (INEL)
Jean Livingston (CDSI)
John Low (Weston)
Jennie L. Negin (SNL)
Greg Parson (ID)
Vikas B. Patel (Raytheon/NV)
Jack Pfister (FNAL)
Louise Planet (EE)
William Price (Raytheon/NV)
Howard Rohm (NE)
Dan Rupinski (CDSI)
Fred Schuyler (HR)

Dave Seibel (LLNL)
Tina Shake
(Westinghouse/SRS)
Steve Simon (EH)
Roger Spurzem (KOH
Systems)
Bob Tannert (Galaxy)
Brenda Thomas (CDSI)
John Unik (ANL)
Becky Verastegui (ORNL)
Mark Walecka (CDSI)
Diane Weir (LANL)
John Wheeler (MM/ORNL)
Ed Wilczynski (Battelle)
William R. Wing (ORNL)
Karl-Heinz Winkler (LANL)
Ahmad Zadah (ID)
Terry Zeilman (TRW)

Special Recognition

Office of Energy Research - Dick Yockman

Idaho Operations Office - Toni Love, Greg Parson &
Scott Applonie

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Background

DOE realized the importance of focusing on management of information.

This section describes the background, concepts, and approach that are being used to lay the groundwork for development of the U.S. Department of Energy (DOE) Information Architecture.

The Department of Energy and its predecessor agencies planned, acquired, and implemented information technologies throughout the Department's approximately 50-site locations without comprehensively addressing important information requirements of Departmental management, the integration of equipment and business processes, duplication of efforts, and corporate information resources. Over the past several years, the Department realized that information management and strategic planning efforts must focus on the utility of information and the management of information, rather than management of technology.

Departmental and programmatic architectures are key components in the success of a proposed integrated planning process.

In April 1992, an Information Resources Management Process Improvement Team was chartered to facilitate improvement of the Department's information management planning process. The team was tasked with developing a process that would be driven by program and mission needs, be integrated with other Departmental strategic planning processes, and provide the necessary infrastructure and support for Departmental information functions.

The DOE strategic plan emphasizes using information technology to improve communications, internally and externally.

The Process Improvement Team identified the development and implementation of Departmental and programmatic information architectures as key components in the success of a proposed integrated planning process. Moreover, it was found that these architectures should include standards for interoperability and information exchange and establish points of responsibility for the creation, management, and delivery of information.

In April 1994, the Departmental Strategic Plan was published. This plan describes the Department's five business areas and four critical success factors. Development of the Department of Energy Information Architecture supports this strategic plan

Development of the architecture is a specific action item of the Information Management Strategic Plan.

and most directly supports "Communications and Trust" and "Management Practices," two of the Departments critical success factor strategies. The communications and trust strategies emphasize making public access to information easier and utilizing current and new information technology to improve communications, internally and externally. The management practices strategy emphasizes using the best-business practices and the development of integrated and open management systems that are results oriented and cost effective.

The Information Management Strategic Plan, issued in July 1994, calls for development of an information architecture. The goals, strategies and actions laid out in the plan support the defining of common Departmental requirements, development of a Departmental architecture and improved integrated information management planning and budgeting activities.

The architecture is critical to ensuring quality support and application of best management practices.

The information architecture is viewed as a framework for aligning future information technologies to support the Department's missions. It will provide a focus for planned and ongoing Departmental information management activities and projects. The architecture is critical to ensuring quality support and application of best management practices to find better ways to meet information needs more quickly and at less cost.

Information Architecture Definition and Concepts

An architecture must be developed according to the unique business and information environment of the Department.

The word "architecture" refers to a "structure." Indeed, several analogies can be drawn between the construction of buildings and the construction of information processing systems. Blueprints are analogous to system designs, building codes to standards for information systems, building permits to approvals to implement information systems, and building inspections to operational system reviews.

The literature, written by practitioners, states that there is no single commonly accepted definition for information architecture. It appears the concept must be approached and developed according to the unique business and information

environment of the enterprise. For the Department of Energy, the following definition describes information architecture:

"A conceptual framework that links the Departmental and Programmatic missions, goals, and objectives, and provides a mapping of the current and future DOE business information required to support them."

The DOE Information Architecture is based on principles that focus on open standards and interoperability. Implementing the architecture will take time; the goal is to find a heterogeneous approach. The architecture will be implemented cooperatively on a decentralized basis throughout DOE. Adopted standards based on a broad common vision will guide the transition from current baseline architecture to the vision of the "target" architecture and its seamless operations.

The Department of Energy Information Architecture Model, which will be referred to as the "Architecture Model," is being patterned after the National Institute of Standards and Technology Enterprise Architecture Model displayed on the following page.

National Institute of Standards and Technology Enterprise Architecture Model

Reference: NIST Special Publication 500-167, "Information Management
Directions: The Integration Challenge"

A five-tiered framework is provided for organizing, planning, and building architectures.

The Model has been promoted within the Federal sector of the government as a management tool to illustrate the interconnectivity of the business, information, and technology environments of an enterprise and their relationships at any point in time. It provides a five-tiered framework for organizing, planning, and building an integrated set of information and information technology architectures. The five tiers are defined separately, but are interrelated and interwoven as indicated on the following graphic.

The DOE Architecture Model also has five tiers which are labeled as subarchitectures. Each of these five subarchitectures are similar to the tiers of the National Institute of Standards and Technology Model but they have been tailored for DOE use. This tailoring was performed to be consistent with the unique DOE business environment and the Information Management Strategic Plan.

DOE Information Management and Planning Framework

The alignment of the layers of the Architecture Model and the Goals of the Information Management Strategic Plan are also displayed on the previous page.

Brief descriptions and examples of these five subarchitectures follow.

Subarchitectures	
Type	Description
Business Subarchitecture	Defines the core business procedures and processes of the enterprise at whatever level necessary to provide the requirements for infrastructure.
Information Subarchitecture	Identifies the subject matter, the facts, figures, pictures, and all other relevant knowledge necessary to support the business of the enterprise and the procedures and processes.
Applications Subarchitecture	Translates the requirements for information into an automated set of systems and/or applications that provide direct support to business processes.
Data Subarchitecture	Identifies the structure, definitions, and storage needs of the entities and elements and allows the processing of data into useable information.
Technology Subarchitecture	Describes the physical layer of the infrastructure that is required to support the processing of data into useable information where and when needed.

The DOE model has five tiers labeled as subarchitectures and tailored for our use.

The Architectural Model provides a framework to interconnect the current "stovepipe" business unit or programmatic defacto information architectures to better support the Department's strategic plan and mission. As Department of Energy program offices begin to establish documented and formal information architectures, the Architecture Model will serve as a unifying force for the implementation of application systems, data management, and information technology infrastructures throughout the DOE enterprise. The following figure, Understanding the Information Architecture, helps to illustrate the Architecture Model. This initial architectural effort focuses

on the bottom three tiers of the Architecture Model. Future efforts will be concentrated on expanding the Architecture to the full five tiers. This focus is due to significant pressures to better manage the Department's existing technology investments. This does not mean that the business process and information subarchitecture layers are not important, but rather a recognition that program initiative and involvement not available at this time of Departmental restructuring, is required to define them. This will be accomplished through future guidance and assistance provided to the program clients.

Understanding the Information Architecture

**Generic
Sub-architecture
Model**

**DOE Information
Architecture Concept**

Also, these three layers are the primary domain of the "business" of information management. In other words, before attempting to help clients strategically improve their businesses, information management must provide immediate and tangible results in its own enterprise area.

The new Departmental Information Management Planning Process will provide a complementary component that will feed new requirements into the architecture and will receive

Understanding the Information Architecture

***Generic
Sub-architecture
Model***

***DOE Information
Architecture Concept***

Standards will be implemented through a consensus approach.

guidance for future planning activities from the architecture thus forming a continual wheel of designing, planning, and building information systems. Based on the plans, we can retrofit the design, and based on the design, change the plans. Although this approach is not a new one for designing, planning, and building, it often has been superseded in the information management area by pressures to provide any system or support service quickly.

Another component of the architecture concept is the standards process outlined in this document. This process is expected to be implemented and operate concurrently with the architecture implementation and guidance process. A consensus process that implements standards to aid planning and acquisition of information technology that is open and interoperable is the key to guide the way to the future architectural vision and can be viewed in the DOE Information Architecture Conceptual Design Approach illustration, below.

Approach

Several Department of Energy field sites and Headquarters Program Offices as well as other government agencies had already begun to define internal or organizational information architectures. The Office of the Deputy Assistant Secretary for Information Management tasked an action officer to leverage

This first document, produced from the efforts of a DOEwide team, provides a foundation on which to build the architecture.

and coordinate these efforts while creating and implementing a Departmentwide information architecture Strategic Action 3.1.2 of the Information Management Strategic Plan).

A nationwide crosscutting team of information management professionals from the Department and its contractors, the Information Management Planning and Architecture Coordination Team, was established to begin the architecture development process. The team met in five working groups at two 3-day meetings to discuss, strategize, identify and create this significant beginning for the Department of Energy Information Architecture. This first formal document, produced from the products of the five working groups, provides a foundation on which to build the architecture.

Publication of this document is a means to communicate the Information Architecture Model and concept throughout DOE. Subsequent publications will present a detailed baseline architecture analysis and information architecture guidance in the form of standard practices and technical guidance based on the eight guiding principles of the architecture. Over time, a detailed architectural design will emerge, based on validated business requirements. The future steps are elaborated in the **Next Steps** section.

A Knowledge Worker's View

Shirley Greyhorse, site manager, stares at the screen of her new office workstation, a powerful personal computer connected to a network. *"It's a great gadget, Ray, but how will this piece of equipment revolutionize the way I do business?"* she questions Ray Saunders, the manager of the site's Information Management Branch. *"Information management is key to accomplishing this site's missions. The data accessible through this computer, within the site complex, throughout the Department, and around the world, is a tool in reaching these goals,"* Ray explains. *"But, Ray, how can separate desktop computers work together to meet the goals and mission of this site?"* *"Well,"* Ray responds, *"Sitewide information management is essential to planning, building, and maintaining information infrastructures. A formal information architecture provides a technology structure that guarantees that accurate information is available to the right people at the right time."*

Several weeks later, Shirley adapted much of her daily routine to the paperless environment supported by her workstation. She accesses the site's procurement and personnel applications through the network, scans the news through Internet, and schedules meetings and appointments using calendaring software. Using electronic mail, she broadcasts messages and exchanges regular status reports with her Branch managers. On this particular sunny Tuesday

Business Case

DOE is undergoing a major redefinition of its role within the Federal Government.

Driven by National Performance Review Initiatives, DOE is undergoing a major redefinition of its role within the Federal Government. This reinvention challenges past Departmental performance metrics and establishes new criteria for evaluation of the Department's contribution to the welfare of the American public. Symptoms of this change are typified by:

- Increased departmental emphasis on the environment and U.S. industrial competitiveness, accompanied by a diminished emphasis on defense activities.
- Increased emphasis on effective cost control and project management in the face of pressure to do more with fewer resources.
- Greater complexity in facility operations and management, as illustrated by the number of DOE facilities now managing and controlling multiple programs.
- Legislative and regulatory mandates requiring quick implementation and adaptation to new requirements.
- Increasing requirements to provide new operational information or new analyses of information upon demand.

There are increasing requirements to provide analyses of information upon demand.

In addition to requirements driven by the National Performance Review and government-wide reinvention initiatives, the Department has also undertaken many internal actions to reevaluate and renovate business processes to reflect the best practices used in the industry. The nature and direction of internal initiatives are shown on the following page.

DOE Internal Initiatives

Initiatives	Past Focus	Current Direction
Business Culture	Closed & Private	Open & Accessible
Success Factors	Program Performance	Enterprise Efficiency
Investment Planning	Project-Driven	Investment Leveraging
Information Management	Ownership	Stewardship
Resource Planning	Program Compartment	Resource Sharing
Contractor Management	Award Fee/Management Fee	Performance-Based Incentive

The architecture will offer guidance for migrating capabilities when change is necessary.

Achieving this Departmental metamorphosis will not be easy, but with proper organizational restructuring, operational and policy changes and redefinition of programmatic objectives, a redefined DOE can emerge. However, if the Department is to become a smaller, faster and more responsive organization, it must be able to make decisions of fact rather than intuition. Therefore, existence of and access to timely, accurate information is essential to the implementation of the Department's strategic plan. Information management must become a significant element of each program or business area and must support decisions at both programmatic and Departmental levels of the organization. The business objective of supporting program operations and decision-makers at all levels with appropriate information and guidance can be achieved by applying the following best-practices principles throughout the Department.

Enterprisewide problems must be solved with enterprisewide solutions.

- Optimize Departmental budgeting and expenditures by planning and coordinating information management resources across programs and sites.
- Promote sound decision making by providing relevant information on demand.
- Respond quickly to requests for information by organizing the Department's databases and systems for optimum accessibility, manipulation, and reporting.
- Solve enterprisewide problems with enterprisewide solutions by minimizing replication across programs and providing consistent and compatible data services across the DOE enterprise.
- Optimize Departmental investments in information technology through the development of programmatic information technology plans and architectures that focus on both programmatic and enterprise-wide performance and cost effectiveness.
- Promote the integration of Headquarters, field site, and contractor information and processes through incentives that encourage the retirement of isolated and outdated systems and technologies that perpetuate non-interoperability.

Defining a Departmentwide Information Architecture will meet DOE's business objectives.

Defining a suitable Departmental Information Architecture is a positive and necessary step towards meeting DOE's business objectives. A DOEwide Information Architecture will:

- Include technical standards and guidelines.
- Map where and how information system components interconnect to support business functions.
- Describe a target environment for managing distributed resources.

Process reengineering of enterprise-wide functions is a key requirement for building a Departmental architecture.

- Provide a common foundation for resource planning in DOE's distributed decision-making environment to coordinate the activities of Headquarters, field sites, and contractors.
- Achieve major process improvements for distributed business functions.
- Delineate system design elements that organize Departmental business functions using information technology resources.
- Provide the framework in which managers can be sure that their technology investments will integrate with the DOE community at large.

The information architecture approach presented in this document has been proven effective by large private organizations. Firms such as Walmart, Federal Express, and Motorola are using an integrated approach of business process re-engineering and information architecture to reduce operational costs and improve responsiveness to customers. These firms use information resources to achieve a competitive advantage and as a tool to manage their businesses, directly resulting in corporate growth and profits. Their customers perceive these resources as a distinguishable service that differentiates these firms from competitors.

Both government and private organizations report success using an information architecture approach.

The United States Air Force is also using a similar methodology to optimize its support functions and reduce requirements for indirect costs. These examples illustrate that a framework for creation and exchange of information is critical to achieving optimal organizational performance. The activities proposed in this document provide the Department of Energy a path to significant improvement in many operational areas.

Projected Benefits

Several aspects of the Department's business can reap long-range benefits from the successful implementation of a DOEwide Information Architecture. This is suggested in the business case conditions that follow.

Currently, no method exists for preparing cross-cutting reports and ad hoc user queries.

The architecture will support commercial partnership efforts.

The architecture will facilitate public access to DOE information.

- ***Legal and Regulatory Compliance.*** Department activities are driven by oversight of operations and programs. Monitoring operations for compliance with laws and regulations imposes extensive routine reporting requirements and spawns many ad hoc requests for more specific information. Currently, no DOEwide tracking system exists that allows cross-cutting reports and ad hoc user queries. An effective information architecture allows establishing enterprisewide information systems with functions such as regulatory requirements compliance tracking.
- ***Commercial Partnerships.*** The body of knowledge represented in national laboratories and contractor organizations can form the basis for powerful commercial partnerships. Some progress is being made in this area at individual sites. An information architecture based infrastructure provides the design for enterprisewide access to information for more, wide-ranging partnership agreements.
- ***Public Access to DOE Information.*** The Secretary's openness initiative requires that DOE and contractor personnel change ways of doing business. Historically, DOE has been mandated to compartmentalize and protect information, especially that related to nuclear weapons testing and radioactive experimentation. Compartmentalization has made information hard to access. An information architecture will support the necessary infrastructure improvements necessary to provide management with the ability to meet routine reporting requirements and ad hoc information requests from many previously inaccessible data stores.

Within reasonable limits, vast amounts of non-sensitive, non-proprietary DOE information can be made available through the use of public computer networks and electronic bulletin boards. Increasing the accessibility of this public information by stakeholders requires less burdensome one-time data collection and response generation activities.

The architecture will facilitate cohesive strategic planning.

■ ***Information Management Strategic Planning.***

An effective DOEwide information management strategic planning process has only just begun. DOE, therefore, must still develop and present a good business case for and provide a performance based accounting of expenditures for the approximately \$1.6 billion annual investment in information systems, technology, and services. The implementation of an effective information architecture throughout DOE will facilitate cohesive strategic planning and tracking of how annual funding and procurement requests fit into long-range business and information technology plans.

A major benefit of an information architecture is the integration of all organizations participating in DOE missions and business activities through the use of common information repositories connected by a reliable information distribution network. The information architecture, itself or by itself, will not actually accomplish what occurs in management channels such as planning or prioritizing. What the information architecture can do is to provide a mapping between the information management and other programmatic and core business area goals, ensuring that planned information technology projects and acquisitions support business objectives. If measurement of very selective business or information architecture activities are required to provide a better basis for decision making, then the information architecture suggests that such measurements should be made for the affected business areas.

***The architecture will
promote effective
program management.***

- ***Budget Management.*** As Departmental budgets come under increasing scrutiny, the pressure on management to gain better control of project and program performance also increases. Managers require information systems that provide current, relevant, and accurate budget and project performance data. They also need systems that can exchange data seamlessly with external systems maintained by contractors and other entities in DOE. The implementation of an information architecture will ensure that budget and project management systems are designed to provide data that is critical to effective project and program management of activities which are geographically dispersed.

- ***Program and Project Management.*** Inherent in the other benefit descriptions is the implied ability to better support program and project management. Ready access to information across the enterprise is now, and will continue to be, more important to making sound business decisions and ensuring accurate and complete milestone tracking.

Programs and projects are typically assigned to a variety of geographically dispersed activities with specialized scientific and information technology capabilities. The ability to share data, reformatting it for different information consumers, provides a significant opportunity for increased productivity and improved timeliness for critical decisions. The improved ability to aggregate data and summarize it easily across numerous organization boundaries will increase lead time for better evaluation and for improved report preparation.

- ***Responsiveness to Changing Conditions.*** In the present economic and political climate, DOE must be more agile than ever before. Reduction in the Federal budget and workforce are major drivers currently facing DOE. To meet the challenges of changing conditions, DOE must possess information systems that cut across program and organizational boundaries and promote an enterprisewide approach.

The systems themselves must also have intrinsic flexibility, allowing changes or additions in program and organizational focus without extensive systems redesign. Establishing this information architecture facilitates the design and implementation of information systems that support efforts for improved organizational processes.

Implementation of an architecture is a critical first step toward supporting procurement reform.

Procurement and Contract Administration.

Extensive contract reform efforts across the Government along with recent major legislative changes are focused on improving this internal and interagency process. For example, DOE would benefit significantly from architecturally structured systems efforts supporting procurement review processes, agency procurement requests, and delegation of procurement authority. Many goals of procurement improvement will not be achievable without a structured, integrated approach. Implementation of an architecture is a critical first step toward supporting this procurement reform.

The architecture will promote the integrity of data.

Data Integrity and Quality. In the current environment, each Headquarters element, programmatic office, and field site develops its own information systems solutions. Often, multiple solutions for one functional requirement are developed at a single site. For example, one site can have separate tracking systems for human resources, Equal Employment Opportunity, and regulatory compliance. Although the scope of system and data redundancy has not been determined, it is perceived to be substantial. Data integrity problems have been experienced by some managers. A single, information architecture solution will identify and address these issues, providing long-term cost savings and, more importantly, allowing senior management to obtain current, consistent, and reliable information without the current penalties of delay and cost of re-work.

Enterprise Solution to Information

Requirements. Effective communication among and within DOE organizations is another major area of opportunity. Implementation of a comprehensive

The architecture will facilitate effective and efficient communications.

information architecture across DOE will facilitate effective and efficient communications. For example, the effort to establish a DOEwide electronic mail directory has been hindered by the lack of cohesive strategic direction and further complicated by incompatibilities between existing platforms. An effective information architecture will ensure that a strategic direction is established and followed so that as individual sites upgrade current electronic mail platforms, they will become compatible and interoperable.

A Knowledge Worker's View

Shirley smiles as she opens her electronic mailbox on Friday morning; responses have been received from everyone. Ah, but what's this -- the attached files have disappeared from several of the submittals; some of the text documents have lost their formatting; other files are unreadable in the spreadsheet package Shirley uses from the network. Frustrated, Shirley goes to the phone and requests that hard copies of the seven missing or unusable submittals be sent by facsimile. To be ready for her departure on Tuesday morning, Shirley and her secretary, Paula, must work through the weekend to re-create and validate missing information. A weary Shirley attends the meeting in San Francisco. She wishes she had access to additional information from her workstation and files in her office; several of her colleagues have brought their materials on notebook computers that can access their networks through local data lines. A major topic of discussion at the meeting is the need for fast and easy information sharing and transfer. Shirley recalls Ray Saunders telling her about how developing and using an information architecture would provide a structure for establishing a common environment for information exchange and promote cost savings in procurements and system developments required to provide accurate, timely, and consistent management information. Again she thinks, *"Maybe Ray has a point about improving the current information architecture **Baseline**".*

Baseline

Overview

The task is to define what is currently in place in order to design what is needed for the future.

Sophisticated information systems are in place throughout DOE to provide the support structure required by the diverse DOE user community. This collection of systems, processes, and technologies is the defacto DOE Information Architecture. An architecture as it exists at some point in time is called a ***baseline***. Characterizing the Department's current Information architecture baseline will indicate where architectural improvements can be made.

The approach is taken from the Pareto Principle which advises locating the 20% of the enterprise that takes up 80% of the resources.

This baseline characterization is high-level and not intended to be the definitive detailed statement on the current DOE information environment. In compiling this report, DOE analysts relied on survey information, personal expertise and knowledge, and other relevant information sources at DOE. This report follows the Pareto Principle approach seeking to identify the 20 percent of the infrastructure that engulfs 80 percent of the resources and activities.

Concentrations of Information Technology In the Baseline Architecture

There is an increasing interest in Federal data centers and their place in an enterprise information architecture. The National Performance Review's Government Information Technology Services Working Group defined a Federal data center as any automated information processing operation with a staff of five or more non-programmer full time-equivalents that met one or more other qualifiers. These other qualifiers included providing time sharing, centralized office automation and records management services, network management support for agencywide area networks, and processing agency-approved automated applications systems among others. Local area networks supporting office automation activities were excluded from this Federal data center definition.

Using this Working Group definition, DOE reported on November 30, 1994 that it had 21 such data centers. These consisted of the data centers at the Ohio Field Office, Nevada Operations Office, Chicago Operations Office, Savannah River, Naval Petroleum Reserve California, Los Alamos National Lab, Western Area Power Administration, Headquarters/Germantown, Strategic Petroleum Reserve Office, Brookhaven National Lab, and Oak Ridge Operations Office with 58 full time equivalent staff members at the Headquarters and 301 field Federal and contractor full time equivalents. These centers represented an annual capital budget of \$10.695 million and their operating budget totaled \$66.41 million (1994 dollars). Clearly, this represents a significant investment in the current information architecture and requires continuing financial support to provide services to their system users.

Aged legacy systems adversely influence DOE's ability to provide modern processing and connectivity.

Within the overall baseline architecture, DOE reported in 1993 that twenty of DOE's organizations had 338 systems in place which were supported by 120 mainframes (e.g., Amdahl 600E and 5890 series, Control Data Corporation 7600 and Cyber 170, 800, and 900 series, IBM 4300, 3000, 9000, and ES 9000 series, and Unisys 1100 and 2200 series) and 43 minicomputers (e.g., VAX 11/700, 11/800, 6000, 8000, and 900 series, Prime 2700, 4100, 6100, and 9900 series, and HP 3000 and 9000 series). The average age of the hardware platform baseline was about 6.25 years for each equipment line item. Their median age was six years or almost one full generation of technological life. The overall range was one year of use in 1993 for four items and fifteen years of use for three items. Thus, the oldest equipment in the baseline architecture can be said to be between one and two generations old. Clearly, aged legacy systems, by their continued presence, adversely influence DOE's ability to provide modern processing and connectivity capabilities in a rapidly changing business environment. In addition, the DOE computing capacity to which these platforms are connected include Cray 2, C90, X-MP, and Y-MP and similar scientific and engineering computer platforms for high speed computations and simulations. These platforms provide computing services to DOE staff and to other authorized users to whom time sharing services are provided.

During the recent Strategic Alignment Initiative effort (March 1995) the Strategic Alignment Team observed that there are inconsistent, non-integrated DOE information management and communications systems which do not meet specific functional/programmatic needs, resulting in many functions/programs having independent, duplicative, and insufficient systems. As evidence, they cited applications, systems, and network examples which indicated to them that there is no standardization of computer or telecommunications hardware, software, and data administration such that information can be readily shared across functions or the Department. They concluded that DOE has not disciplined its information management systems development process to assure that Departmentwide systems meet the needs of all the users. In many cases, they conclude, there is a lack of uniformity and commonality which has resulted in many functional and/or program managers developing their own systems.

The defacto DOE Information Architecture baseline is the starting point for any future changes.

Clearly, the complexity and scale of DOE's world class computing needs and its users' demands for additional capabilities to address leading edge scientific and engineering solutions requires a vast array of system components which must be acquired and deployed within budget realities. The defacto DOE Information Architecture baseline is the starting point for any future changes in current capabilities, standards, and policy and process integration. The following section describes the methodology being used to further characterize the current baseline.

Methodology

Survey results form the basis of characterizing the technology baseline.

To reduce the burden of information collections on the field, a voluntary survey was circulated by the Architecture Team throughout DOE. Eighteen DOE entities responded to the survey. These groups represented Headquarters, one program organization, two special project sites, one power administration, two energy technology centers, one operations office, and ten labs. The results of this survey were analyzed and summarized to begin characterization of the baseline. In

An ongoing effort by a contractor organization will validate and update the baseline characterization.

In addition to the survey, a Secretarial initiative to distribute DOE directives electronically has fostered a baseline characterization of approximately 75 more sites. Results of this characterization were also included to support this baseline discussion.

The systems and applications portion of the baseline was further characterized by analysis of the contents of documents Systems Review Inventory System database. This characterization also incorporates viewpoints from information technology professionals representing many DOE sites. While this information was not as quantifiable, it is based on current documented knowledge of the operations and environments of these DOE locations.

This initial baseline is not intended to be exhaustive nor complete in an analytical or scientific sense, thus it is only a characterization limited by the time and information available for this report. An independent ongoing parallel effort will validate and build upon this characterization to provide a more detailed and well-documented technology baseline assessment across DOE. The detailed baseline, once established, will be updated regularly to assist in determining future directions and to measure progress.

This baseline characterization centers on two layers of the DOE Information Architecture Model (at left): the technology and applications subarchitectures. Sufficient time and information was not available to adequately characterize the data subarchitecture.

Technology Baseline

The following paragraphs characterize the technology subarchitecture baseline, moving from the desktop through the local networks to the world at large through global networks such as Internet. The emphasis of this part of the characterization is on intersite connectivity.

Desktop Configurations - Approximately three-fourths of DOE desktops feature IBM-compatible processors. Of the remaining one-fourth the majority feature Macintosh machines.

All of these processors are currently connected (about three-fourths), or slated to be connected, to a site network. UNIX-based platforms support much of the DOE research and development community.

The emphasis of the technology baseline is on intersite connectivity.

Electronic Mail - All site networks feature electronic mail applications with about one-third using electronic mail, one-third using All-In-One, and the remaining one-third using any one of eight other systems. Approximately two-thirds of the sites use Internet to connect to the outside world. The remaining one-third use X.400 Gateways. The growth is away from X.400 toward Internet. Wide area networks other than Internet consist of private lines.

DOE Wide Area Networks - Stovepipe wide area networks have proliferated at DOE. The two types of networks, programmatic networks and special function (proprietary), are discussed below.

- Programmatic Networks - Energy Research, Environmental Management, Civilian Radioactive Waste Management, Emergency Operations Center, Departmental Integrated Standardized Core Accounting System (DISCAS)
- Special Function Networks - DOE Communications Network (DOECN/televideo), IBM/Systems Network Architecture (IBM/SNA), Professional Office System (PROFS)

Each of the networks and configurations described represent a defacto architecture.

The following chart shows where programmatic and proprietary networks exist. Each of these network hubs have other unique, and semi-unique locations to be supported. Each of the individual networks and configurations described here represents one instance of the current DOE defacto architecture. More examples of what a DOEwide architecture should provide are described on the following pages.

Programmatic and Proprietary Networks

Site	DOECN	PROFS	ESNet	IBM/ SNA	EOC	EMNet	DISCAS	RW
Albuquerque	•		•	•	•	•	•	
Chicago		•	•	•	•		•	
Denver		•	•	•				
Headquarters	•	•	•	•	•	•	•	•
Idaho		•		•	•	•	•	
Nevada	•			•	•	•	•	•
Oak Ridge	•		•	•	•	•	•	
Richland			•	•	•	•	•	
Rocky Flats	•				•	•		
San Francisco			•		•	•	•	
Savannah	•			•	•	•	•	

Internet Gateways - The DOE laboratories have taken the lead in embracing Internet as an integral part of their working environment. They provide full Internet capability to about three-fourths of their staff. This capability provides access to bulletin boards, other wide area information systems, remote applications using data, audio and video, and most importantly, connectivity to otherwise incompatible systems. Other DOE sites have only begun implementation of Internet capability. The laboratories, along with Headquarters, connect to Internet through the Energy Sciences Network. The other sites use regional networks which are usually sponsored by universities to connect to Internet. Internet accessibility is essential for

leading scientific and engineering organizations to stay abreast of current developments.

Security on Internet - Security concerns are being addressed as sites implement Internet capabilities. There are currently two primary Internet security concerns being addressed. They are network accessibility safeguards and individual identification safeguards. About one-half of the sites are working on a security architecture for distributed authentication. Kerberos is the current solution of choice along with secure identification cards.

Information on Internet - Approximately two-thirds of the sites have at least one WorldWide Web home page and access to all Internet services. About one-half of the sites are evaluating the Andrew File System, a wide-area distributed file system. For example, the Information Architecture Team is using the Internet world wide web (<http://www.inel.gov>) for disseminating architecture information.

The Energy Sciences Network is an example of a strong technology base providing both network infrastructure and support services.

Energy Sciences Network - The Energy Sciences Network is an example of a strong technology base providing both network and support services for a program and business area. It represents an enabling environment for intersite operations for those sites attached and could be extended to other sites connected to and integrated with Internet.

Services such as electronic mail are provided in a coordinated manner. Each site provides the required level of local service. The Energy Sciences Network further augments this basic functionality by providing a gateway to the Internet. Reliability through selective redundant links and replication of services are provided as a matter of design by a coordinated team of technical professionals. Coordination among sites is achieved through committees, working groups, and task forces that address many of the technical and business issues, furthering the identification and deployment of fundamental information technology. Consensus among sites is typically achieved in this manner and results in high levels of utilization resource and user satisfaction.

Providing such an enhanced service as the Energy Sciences Network to sites as a centrally funded, site-justified resource provides a clearly identifiable business area cost picture. As a fundamental information architecture component, it can be managed through performance monitoring and capacity

planning in an objective way. Changes in technology can be deployed according to budget capability and strategic mission orientation.

The Telecommunications Integrated Services Project may address stovepipe architectures.

Telecommunications Integrated Services Project -

There are difficulties in having so many stovepipe architectures, however well they are individually implemented. Non-value added redundancies of services between sites are costly. The accommodation of the different technological network approaches at any one site may unnecessarily complicate the technology configuration of the other connected sites. The Telecommunications Integrated Services Project is an example of a future DOEwide procurement for network services which could help address stovepiped architectures as well as possible cost savings through large-scale acquisitions.

The Executive Office of the President and the General Services Administration are collaborating in a joint project to improve communications between Government and industry in information technology acquisitions. The Deputy Assistant Secretary for Information Management pledged the Telecommunications Integrated Services Project as the DOE contribution to this effort. The project will provide a mechanism to assist DOE Headquarters and field sites in easily and cost effectively obtaining support services for systems integration of voice, data, video, and network systems. This project is slated to address the fact that telecommunication costs and additional requirements are increasing DOEwide. Fragmented networks and contracts are calling for better integration and less overlap. Significant cost savings from the project are forecast over the next 5 years for this portion of the technology baseline.

Application Baseline

The DOE application baseline for Headquarters is represented by the System Review Inventory System.

An application subarchitecture baseline was also developed. The Systems Review Inventory System, a representation of the current administrative/business applications baseline, is a subset of all applications in the "as-is" DOEwide applications baseline. The system currently contains information about more than 600 DOE application systems, over half of which operate at Headquarters. While this inventory is perhaps a fair representation of the Headquarters base, it currently contains little information about systems at field sites or systems of a scientific or technical nature.

SYSTEMS BY BUSINESS AREA

The pie chart depicts 5 business areas and internal management systems.

The business categories were assigned by considering the general mission of the organization coupled with a description of the information system. Several systems were identified that addressed generic internal operating functions. These systems were classified as internal management systems. The pie chart, located to the left, graphically depicts the percentage breakdown of the Headquarters application baseline by the five business areas presented in the Departmental Strategic Plan along with internal management systems. This analysis was originally published in the Trends in Information Management at DOE Headquarters, May 1994.

Both custom developed and desktop level applications are used to depict this baseline. One of the inherent characteristics of these applications is that their associated databases and user interfaces are embedded within the application. This merging of the applications subarchitecture and the data subarchitecture results in reduced opportunities to access and share data freely as a corporate information resource. To put it another way, much of the data is inaccessible without direct access through the application software.

Traditional Collaborative Development - An example of how information requirements of DOEwide interest are currently approached is presented in the following true scenario. Tiger Team findings at several DOE sites required that these sites develop systems for tracking chemicals. Most sites chose to develop their systems independently using a variety of approaches. Under Headquarters encouragement, some sites chose to use the chemical inventory system developed at a DOE laboratory as a "starter kit". In the finished systems, direct sharing of data was not possible, including those based on the laboratory's system. The systems were, however, sufficiently similar that sharing via a "data warehouse" capability could be accomplished in a straightforward manner should it be needed.

During the development process, two system components were identified that could be shared across all sites. These included an electronic Material Safety Data Sheet application and a chemical properties database. It was recognized by all sites that having one site to develop these "infrastructure" components would be universally welcomed.

It was further recognized that the infrastructure component could be made to work in the computing environment of every

There is nothing that prohibits collaboration of system development, but it rarely happens.

site. Although all sites agreed on the desirability and cost effectiveness of having a shared infrastructure, none was developed. In the current DOE baseline environment, implementation costs are independently absorbed by each site. There is nothing that prohibits collaboration, but in practice it rarely happens. The potential savings are usually seen to be offset by “collaboration” costs. Savings include increased design costs to accommodate the broader requirements of multiple sites, communication and travel costs for maintaining the collaboration, extra management costs, hardware/software costs for establishing a common computing environment, and delays brought about by increased development time.

Innovative Development Examples - In contrast, there are a few examples of programs breaking away from these traditional approaches. The Enterprise Management Information System Program, the Environment Safety and Health Technical Information Services and the Tank Waste Information Network Systems project are examples that exhibit facets of a more standardized open systems approach. While no existing systems exhibit all aspects of the future architectural vision, these systems do represent three independent efforts that support many of the architectural features described in the next chapter.

The challenge of an information architecture is to capitalize on current good practices.

These innovative examples have focused on narrow business areas. They are currently being reviewed and adopted by DOE offices. These examples validate the robustness of using application subarchitecture principles and demonstrates their utility in other problem domains.

Characterization Summary

From the above information, a characterization of the current DOE defacto information architecture emerges, and is depicted graphically on the next page.

The new DOE focus demands more synergy and integration of information assets.

The current environment does not correlate well with the new Departmental customer orientation. The new focus demands more synergy and integration of Departmental information assets, and better coordination of funding of intersite and crosscut programmatic efforts. It is increasingly important that stakeholders be able to readily locate and access needed information. Data from different systems must be easily collated and generated. The financial and budget data must be accurate and consistent whether it is utilized at a program level

Current Model for the DOE Information Environment

2. Business processes are defined in a hierarchical manner. Multiple independent missions = duplication of effort.

1. Information is hard to access; there is minimum flexibility. The focus is internal. The user is missing from the picture.

3. Paper only and other unconnected processes create records and information that remain permanently outside the architecture.

4. Organizational stovepipes proliferate encouraging incompatibility and lack of technology sharing.

6. Data and applications are intertwined. Information flow is confined.

5. Technology drives application and processes.

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or in testimony before Congress. Today these capabilities and traits are not inherent in our information architecture. Tomorrow they must be.

A Knowledge Worker's View

A few days later, "I am beginning to see how important an information structure is to our site," Shirley tells Ray. "My recent experiences with the budget exercise and the incompatibility of our current systems and technologies made me think about what you said. But I'm still not sure about what an information architecture is or how we go about creating one."

"An information architecture defines the components required by an organization to achieve its mission; it provides a structure for information, applications, technology, and operations. As a first step, we need to establish a baseline of what we already have in place. Equipment and applications must be inventoried and successes documented," Ray responds.

"If you're ready to start this project, I'll have my staff members put together a user survey and an inventory form. They can collect and analyze this information while we talk about what kinds of capabilities you think you and the business staff would **Envision** for the future."

Vision

Shared information is the foundation of the future architecture vision.

The purpose of the DOE Information Architecture is to ultimately provide a framework to support decision making and information sharing. It defines the components at various layers of the architecture model required by an organization to attain its objectives and achieve its business mission. This framework provides a blueprint for structuring information, applications, organizational and technological components, their relationships, the principles and guidelines governing their design, and their evolution. It also forms the basis for planning and implementation of information systems.

Information architecture is focused on the user.

At this stage in the development of the Departmental Information Architecture, a vision for the future architecture is not defined herein in great technical detail. Indeed, the vision can best be depicted graphically, particularly in contrast to the graphical representation of the current defacto architecture previously represented in the **Baseline** section. On the following pages, two views of the vision are represented: a structural, overall view and a view from the part of the knowledge user.

What has been defined in detail, however, are the guiding principles upon which the vision will be based. These guiding principles appear later in this section along with the rationale behind them and the implications and effects they will have on the DOE information environment.

The characteristics of the future vision of the information environment are presented on the following pull-out page.

Another way of looking at the future vision of the architecture is through the eyes of the individual knowledge workers or users at their desks. Users include DOE employees and contractors that provide products and services for their customers. This user-centric perspective is illustrated below.

Business processes drive the need for information. ➡

Users get information to support business processes by accessing various applications. ➡

Applications and data function with the technology architecture through modularly designed standard interfaces. Individual applications take advantage of the infrastructure to inter-operate and access data. ➡

Data repositories are a key component of the architecture. Data can be made available independently from applications. Access to data is not tied to working within a specific business process. ➡

The technology infrastructure is open and provides an interoperability environment for data, applications, and business processes. ➡

User-Centric Perspective

Future Vision Of the DOE

1. The Synergy between business needs and empowering emerging technologies yields leveraged business process improvements not otherwise possible

2. There is an integration and coupling of missions and business processes. Data sharing occurs across missions meeting multiple business needs.

3. Data and applications are independent yet mesh when utilized. The model is based on a virtual distributed query system. There are no predetermined paths to gather information or prevent it. Flexibility is the watchword.

4. Since the model cannot be instantaneously implemented, there is a provision for legacy systems, a remnant shown from the baseline view.

Information Environment

5. The technology infrastructure is hidden from the user. Multiple processes transpire underneath the users view much as real world utilities do. Information sharing is the rule, with security as an automatic imbedded feature.

6. The environment is user centric. The user can drive applications and move and utilize data and information with almost intuitive ease and at will.

7. The DOE Complex is connected to the Global Information Infrastructure (GII). External stakeholders also have access to DOE information that is useable consistent, and timely. Opportunities to do business in new unanticipated ways, through a flexible infrastructure become apparent

Information Architecture Principles

The basic building blocks of an information architecture are its principles, or basic truths and assumptions about what and how information technology will be implemented.

The information architecture, as a blueprint, is founded on principles. The principles are high-level statements of the DOE philosophy, expressed in terms of objectives and goals, intended to endure, and provide the foundation for standards and policy. The DOE Information Architecture is founded on the following eight principles.

- DOE information products and services are user-centric and customer-driven.
- The DOE Information Architecture is based on modular components.
- Information architecture is based on an open systems approach.
- Security is designed into all architectural elements, balancing accessibility and ease of use with protection of data.
- Information is not only a Departmental asset but also a national asset for which DOE staff is the steward.
- DOEwide access to information is the rule rather than the exception.
- The information architecture incorporates a robust interface that optimizes the nature, efficiency, and effectiveness of the human operator.
- DOE will have an information technology infrastructure that links offices, programs, facilities, and field locations together seamlessly.

In the following discussion, the principles are numbered for easy reference; the numbers do not represent a hierarchy. Each principle has relatively equal ranking. Each principle is followed by the rationale, or reason for it and is concluded with its implications, such as the expected issues, required changes, and/or effects of designing and deploying our information technology in concert with these principles.

Principle #1

DOE information products and services are user-centric and customer-driven.

The architecture is a tool whose value lies in satisfying customer needs.

Rationale:

To be successful, the information products and services must meet users' requirements and enable effective decision making.

- With declining budgets and staffing levels, the need to increase productivity and efficiency is critical. Users will require access to information in an easy-to-use manner with the ability to retrieve information from many sources.
- Information products and services are critical to business process reengineering.

Implications:

- Information products and services may exist on a variety of servers and locations but must be available to the user in an integrated, seamless fashion.
- DOEwide connectivity for both internal and external users will be required through high-speed communications networks.
- Users will require support on multiple desktops (e.g., personal computer, Macintosh computer, etc.), including standards for these desktops and the ability to customize their work environment.

Principle #2

The DOE Information Architecture is based on modular components.

Rationale:

A modular architecture supports organizational changes.

- A modular architecture is resistant to obsolescence, since obsolete modules can be replaced with minimal impact on the overall architecture.
- Using modular components will improve the ability of systems to adapt to changing requirements, as changes can be isolated to only affected modules.
- A modular architecture provides the ability to support organizational changes or growth more easily, thus enabling resources to be scaled to the mission need.

Implications:

- A means of identifying, defining, and communicating the standards must be developed.
- DOE must establish a process for continual review of the architecture.
- A library of terms, definitions, access rules, characteristics, and interrelationships of each standard component needs to be implemented to support corporatewide requirements.
- The current situation of stovepipe systems must be replaced by integrated subsystems. Standalone systems adopted for use by DOE from external organizations and partnerships will be integrated as subsystems by virtue of their data, their processes, or their need for telecommunications or security.
- The success of this architecture requires establishing a DOEwide standards body. This body must actively participate in standards making activities in coordination

with external Government agencies, academia, and industry.

Principle #3

Information architecture is based on an open systems approach.

Rationale:

Easy-to-use standard data formats and search-and-retrieval tools are needed, with the ability to both accommodate older formats and media and adjust to emerging multimedia technologies.

- Software applications and information need to be more easily moved to computers of various sizes or brands.
- Computers of different sizes and brands need to communicate with each other in an interoperable environment.
- A vendor-neutral architecture provides long-term potential cost savings through enhanced competition in the marketplace.
- A DOEwide architecture utilizes commonly available, vendor-neutral standards but does not prescribe an implementation strategy or specific products for any specific organization.
- Specific DOE organizations can select their own products and standards as long as the overall ability to transfer information is not diminished.

Implications:

- The skills of people become portable, that is, to be applicable to different computing environments.
- Resources, information, and software applications can be shared.
- Short-term functionality, based on proprietary solutions, may be sacrificed for long-term interoperability.
- Lifecycle costs should be minimized, although cost savings from implementing a standards-based information architecture might not be achieved in the short term.

- The architecture must accommodate the large inventory of legacy systems built on proprietary components.
- DOE must continue to encourage vendors to provide products based on open systems standards.

Principle #4

Security is designed into all architectural elements, balancing accessibility and ease of use with protection of data.

Rationale:

Security is designed into all data, products, and services.

- DOE data, products, and services reside in an environment characterized by multiple levels of sensitivity.
- Existing laws, acts, and regulations require the safeguarding of national security and privacy data.
- Security must be designed into architectural elements from the beginning; it cannot be added later.

Implications:

Open sharing of information must be balanced against security restrictions, privacy laws, and the confidentiality of scientific data.

- In order to adequately provide access to open information while maintaining secure information, security will need to be developed at the data level versus the application level.
- Both internal and external users will continue to require increased access to DOE information. The right-to-know will be priority over the need-to-know unless strong reasons for protecting the information exist or are established.
- Increasing numbers of industrial partnerships within DOE require a variety of methods to protect users' information.
- A DOEwide solution for secure access to multiple networks is necessary.
- The information architecture can promote uniform implementation of computer security at DOE sites.

Principle #5

Information is not only a Departmental asset but also a national asset for which DOE's staff is the steward.

Rationale:

- One of the goals of the Administration's Reinventing Government Initiative is to make quality information available to every citizen in a timely fashion. Treating information as a Departmental asset is necessary to accomplish this goal.
- The availability of timely and accurate information is a key ingredient of sound decision-making. As such, information warrants a similar degree of management as other Departmental resources (e.g., people, money, facilities, etc.). Information management involves ensuring the integrity, timeliness, protection, and sharing of information.
- Stewardship rather than ownership encourages information use without sacrificing security.

Implications:

- DOE needs to establish a process to share information complexwide, and must address:
 - Consistent data definitions.
 - Standard data interchange formats.
 - A management approach commensurate with the value of the information.
 - The establishment of an information locator capability as part of a meta data repository.
 - Information stewards responsible for the definition, integrity, and timeliness of the information within their domain.

Information and data are vital assets that warrant a level of management comparable to personnel and capital.

Identified stewards are responsible for data, applications, and the infrastructure.

- Operational issues related to the physical implementation of a shared information environment.
- Partnership with information stewards and information technologists is critical.

Principle #6

DOEwide access to information is the rule rather than the exception.

Rationale:

Productivity, decision making, and customer service all benefit from easy, direct, and timely availability of information.

- For optimal decision-making, people need access to the broadest range of information possible within the constraints of Departmental policy and applicable law.
- Time spent overcoming unnecessary hurdles in the quest for quality information can be wasted. Time is often the most precious of resources. Timeliness is also an important information quality indicator.

Implications:

- For unclassified information, the right-to-know should be presumed unless policy or law specify otherwise.
- The business necessity of sharing information must be established.
- Technology must be deployed to distribute and allow access to information.
- Classification of information must be clearly stated -- rules need to be better defined. Secure information must not be accidentally released.

Principle #7

Usability engineering pays off in cost effectiveness, quality, and ease of use.

The information architecture incorporates a robust interface that optimizes the nature, efficiency, and effectiveness of the human operator.

Rationale:

- The effectiveness of information delivery systems is jeopardized if the human interface is too difficult for noncomputer-literate users to master.
- The attainment of successful work group collaboration using networked computers requires knowledge of the Human/Computer Interaction issues.
- Usability engineering pays off in cost effectiveness, quality, and ease of use.

Implications:

- The expertise required for a productivity enhancing system must be engineered into all levels of DOE systems.
- The Human/Computer Interaction field is an interdisciplinary field with roots in ergonomics, cognitive science, and human factors. A foundation for this understanding must be developed within DOE.
- An advocacy position for the importance and use of the Human/Computer Interaction knowledge in all aspects of system development needs to be developed in DOE and propagated to information technology development stakeholders.
- Human computer interactions are complex domains requiring more than the use of a graphical user interface. DOE must develop methods of incorporating informed Human/Computer Interaction knowledge into its systems development efforts and its end products.

Principle #8

The information technology infrastructure is based upon interoperability and standards, supporting the sharing of resources.

DOE will have an information technology infrastructure that links offices, programs, facilities, and field locations together seamlessly.

Rationale:

- Artificial barriers to accomplishing the Department's missions often are the result of the lack of a consistent and robust information technology infrastructure.
- The infrastructure can be centrally coordinated and implemented in a decentralized manner so that non-value added redundant efforts as well as implementation gaps are identified and eliminated.
- A seamless information technology infrastructure facilitates sharing of information and other resources across DOE.

Implications:

- Central direction and a degree of central funding will be required to provide an infrastructure which is consistent across DOE.
- Organizations must give up some degree of autonomy to achieve the necessary consistency.
- A major component of this infrastructure must be DOEwide network capability that allows the exchange of sensitive (unclassified) data. This requires management of security policy issues at the Departmental level.
- The information technology infrastructure includes some common databases and applications with commonly available access mechanisms.
- Information technology infrastructure planning and implementation requires wide and active participation from various organizational elements.

Shared resources include data, information, applications, infrastructure, and computing, enabling users to leverage the work of others.

A Knowledge Worker's View

While Ray's staff inventories and analyzes the current technology environment, Shirley and Ray develop a multi-stepped approach to identify and document elements of the site's information architecture. *"The architecture development team must include users as well as information management professionals,"* Ray tells Shirley, *"to ensure that business requirements are met satisfactorily. The first task for this team is to develop a high-level information strategy for the site that will guide subsequent development and acceptance of policy and standards and provide direction for business process reviews."* A series of principles underlying the architecture are developed and related issues and required changes are identified.

Shirley tells Ray, as the documentation begins to come together, *"I'm beginning to see the connection between what we do, the information we need and what systems and technology will be required to support it."* Ray says, *"I thought you would, but there's still one area we've got to get in place to start the change in the right direction."* *"What's that?"* Shirley asks. Ray replies, *"We must put in place some **Standards.**"*

Standards Process

Interoperability throughout the DOE enterprise is a key goal of the architecture.

The standards setting process must serve the needs of the DOE enterprise and be able to change with the technology base.

The adoption of already developed and widely accepted standards outside of DOE would facilitate interoperability.

Achieving the information architecture vision for DOE information resources requires a degree of interoperability throughout the enterprise that does not currently exist. The necessary level of interoperability requires the adoption of DOEwide standards, protocols, and best practices that will facilitate information exchange. It is important to remain aware of the diversity within DOE as well as the rapidly changing technology base within the information management field. The standards setting process must meet the needs of the entire DOE community and be dynamic enough to change as the information technology base changes. These adopted standards are analogous to building codes. There must be a fundamental set of requirements established to ensure that the DOE Information Architecture is a solid structure. It should interface safely and effectively with the utilities, such as applications and networks, while allowing the owners to optimize their businesses according to internal needs and the nature of those businesses.

Open Systems Standards

Standards are available to DOE through several sources. The most likely source of potential standards are those already developed and widely accepted outside of DOE (e.g., industry standards and other agency standards, etc.), which have proven their benefit through the test of time. Adoption of such standards would facilitate interoperability not only within DOE but also with the external community. In lieu of the availability of appropriate external standards, DOE could choose to develop its own internal standards. DOE could also choose to adopt already widely used protocols and tools within DOE as de facto, consensus-based standards, (e.g., the transmission control protocol/Internet protocol and the underlying formatting tools of Mosaic and similar products). The concept of "open systems standards," is illustrated on the following page.

Open System Standards

① The intersecting circles represent groups that contribute to DOE's information environment. These groups have adopted their own set of standards. These standards are born, evolve, and die.

② The center shaded region represents a core set of standards, agreed to by these groups, and is relatively stable.

③ Some areas are covered by multiple, potentially conflicting standards. An entity can claim open systems compliance and still not be able to interoperate with a second open systems-compliant entity.

④ The core set of standards might not be able to support all aspects of DOE's information environment. This has resulted in the need to select additional standards accepted by only some of the groups (see extended area).

⑤ The total set of accepted standards may not be sufficient to support the desired environment. The next most desirable source of support is the set of industry de facto standards. These standards are mainly proprietary solutions controlled by a single vendor but published openly and accepted by the industry as a common reference point.

These de facto standards, while not as desirable as open standards, are an acceptable solution for the information architecture.

⑥ The combination of both formal and de facto standards is still insufficient in many cases to fully support DOE's information environment and must be supplemented with either nonstandard proprietary commercial products or custom-developed products. These nonstandard solutions will not be specified in the information architecture for DOEwide adoption. Individual programs or sites may choose to standardize on such products. These are represented by the standalone circles, and are the least desirable for a DOEwide Information Architecture.

Standards Criteria

Several criteria have been developed to focus the DOE standards adoption process.

- Policy and standards must support each other. They must incorporate the spirit of the principles of the vision and they should interface with other tasks in the Departmental Information Management Strategic Plan.
- Standards activities are directed to the development of guidelines and processes designed to facilitate the exchange of information, i.e., elements of data management, data interchange, and network services.
- Migration toward an open systems environment is a major system design objective to promote exchange of data and information, and to reduce overall costs to DOE.
- The adoption and implementation of standards throughout DOE cannot occur in isolation. To ensure success, the adoption and implementation of standards must be strongly consensus-based with active participation of the DOEwide stakeholders.
- The criteria embellishing the scope of the information architecture are defined as scalability, extensibility, portability, interoperability, and affordability.
- A multi-tier approach is recommended for promoting interoperability throughout DOE, stemming from issuance of mandatory standards, principles, standard practices, and guidance for discretionary as well as nondiscretionary activities. Compliance assessment activities must recognize discretionary guidance as truly discretionary.

The adoption and implementation of standards must be strongly consensus-based with active participation of the DOE stakeholders.

Standards Scope

The diagram to the left categorizes the full spectrum of service areas where standards for the vision will be implemented.

The service areas are explained in the following paragraphs.

User Service Area: Define the methods by which people can interact with an application.

Application Service Area: Provide the functions required for creating and manipulating displayed images, multimedia, client-server operations, etc. This service can be characterized as workstation functions.

Programming Service Area: Provide the structure to develop and maintain software that exhibits desired characteristics. This includes languages, tools, and methodologies.

Data Management Service Area: Provide the functions to establish data dictionary and directory services, database management systems, and access to distributed data.

Data Interchange Service Area: Provide specialized support for the exchange of information, formats, and semantics of data entities between applications on the same or different platforms.

Network Service Area: Provide the capabilities and mechanisms to support distributed applications requiring data access and applications interoperability in heterogenous networked environments.

Operating Systems Service Area: Provide the software environment and base interfaces within all computing devices to function while maximizing machine resources and capabilities.

Hardware Platform Service Area: Provide the physical layer and address the infrastructure necessary to support the other services.

Security Service Area (Crosscutting): Provide support distribution and integrity of data and information, and protect the computing infrastructure from unauthorized access at all levels.

Management Services Area (Crosscutting): Provide the mechanisms to monitor and control the operation of individual applications, databases, systems, platforms, networks, and user interactions with these components at all levels.

The standards scope is focused on five of the service areas to allow the greatest opportunity to achieve integration and interoperability: data management, data interchange, network, security, and management.

The standards criteria were restricted to five of these service areas: data management, data interchange, network, security, and management. These areas provide the greatest opportunity to achieve integration and interoperability quickly and efficiently. A key point is that the maximum need for standards focuses on the bottom two layers of the Architectural Model. Within these layers lie the features of the infrastructure that are presenting the immediate barrier to improve processes and better support business functions.

The following paragraphs describe these five service areas in more detail. The focus of these categories and their respective components addresses the importance of assisting organizations in achieving integration and interoperability. The guidance is intended to assist organizations in making informed judgements regarding selection and use of standards in each component area. The components mentioned in each category are not considered to be all inclusive but represent a good start.

Network Services

Network services provide connectivity and basic services to foster communication across workgroups and sites. These services comprise the network infrastructure to provide the capabilities and mechanisms to support distributed data access and interoperability in a heterogeneous environment.

Components of this category include data communications,

electronic mail services, directory services, transparent file access/transfer, remote network access, and remote procedure call.

Data Interchange

Data interchange provides specialized support for the exchange of information, including format and semantics of data entities, between applications on the same or different platforms.

Components of this category include text data, spreadsheet data interchange, desktop publishing interchange, graphics interchange, image compression/decompression, and calendar data. Other types could include geospatial or geographical data and specialized or scientific data

Data Management

Central to most systems is the management of data that can be defined independently of the processes that create or use that data, maintained indefinitely, and shared among many processes. This encompasses the procedures, practices, methods, and software used to manage data. Components of this category include data dictionary/directory, database management system, and distributed data.

Security Services

Security services support the secure distribution and integrity of information and protect the computing infrastructure from unauthorized access. These services control access to system data, functions, software, and hardware. The security services also provide confidentiality through encryption techniques, integrity, auditing, and electronic signatures. Components of this category include operating system security, network security, data interchange security, and data management security.

Management Services

Management services are integral to the operation of an open system environment. They provide the mechanisms to monitor and control the operation of individual applications, databases,

systems, platforms, networks, and user interactions with these components. Management services enable users and systems to become more efficient in performing required work. Management is better able to streamline the operation and maintenance of open system components. Components of this category include fault management and control, configuration, accounting, and performance.

Standards Baseline

The standards baseline consists of the existing Federal Government sector standards. The DOE policy is to comply with all mandatory Federal standards and specifications. Federal standards (e.g., Federal Information Processing Standards Publications) and DOE policy statements that specify standards were identified for the five service areas. Other defacto parts of the standards baseline will be identified when the full baseline analysis is completed.

Lifecycle Process

The Lifecycle process promotes the idea that adopted standards will be useful to a majority of the DOE community.

The process from identifying the need for a specific DOEwide standard, through developing the standard, to implementing the standard, to retiring the standard must be considered. The benefit to be gained should outweigh the potential of increased costs and barriers to operations. This section presents a process that provides a high degree of confidence that standards adopted will be beneficial to a majority of the DOE community, thus supporting mission information needs.

The success of this process depends on the critical performance of "the owner", or steward, of the process and the degree to which the stakeholders (DOE Information Management, Program Offices, and contractors) are active in the process. Clearly, the most successful standards are those adopted as a result of a consensus-based participatory process that actively involves the stakeholders. The following graphic illustrates the Lifecycle Model.

Purpose of Lifecycle

Standards related to information technology have a relatively short period of use. The Lifecycle process, from proposal, to adoption, and finally retirement, changes very rapidly and requires continuous attention. The previously discussed standards framework provides a means for relating categories to specific standards. However, the framework does not provide a mechanism for standards adoption or maintenance. A standards Lifecycle process is necessary and includes the following characteristics.

- Categorizing standards within the lifecycle.
- Well-defined criteria for evaluating standards.
- Flexible, timely, and consistent.
- Fixed life span ("sunset" reviews)
- Enterprisewide expert technical review and recommendation.
- Enterprisewide official review and approval.
- Standards adoption of non-Government standards.

Recommendation and approval does not require 100 percent concurrence.

Process Overview

The high-level standards adoption approach, depicted in the previous graphic consists of four processes: identify, develop technical proposal, obtain official approval, and the Federal Information Processing Standards waiver. Descriptions of these processes are discussed in the following paragraphs.

Identify Process: Standards can be proposed by any DOE contractor, field site, or organization to the information architecture standards working group. These organizations can also request that existing standards be reviewed for continued applicability. Standard proposals will be collected and integrated with the quarterly call routine for review. The Identify process will have an Applicability step and a Categorize step. In the Applicability step standards are reviewed for applicability within the information architecture standards

scope, and in the Categorize step standards are fitted into one of the five categories (i.e., network services, data interchange, data management, security, and management services).

Technical Proposal Process: This process can receive input from the Identify process or from the official approval process that need modification. The Technical Proposal process will have a Distribute step, a Comment step, and a Consolidation step. The Distribute step identifies the correct technical organizations to review the proposed standard. The Comment step allows for dialog on the proposed standard, and comments are available electronically or in hard copy. The Consolidation step integrates all comments resulting in either a recommended standard, a rejected standard, or a resubmitted request to the original authors. Controlling inputs consist of acceptance criteria including the scalability, extensibility, portability, interoperability, and affordability guidance. The mechanisms are peer review sites (technical reviewers).

Official Approval Process: This process is similar to the DOE draft Order acceptance process. Outputs will be requesting a technical reevaluation, notice, approved standard, retired standard, or rejected standard. Technical reevaluation request or rejected standard determinations will be communicated to the author and standards working group.

Federal Information Processing Standards Waiver Process: To adopt a conflicting standard, the official waiver process will be followed to request a formal exception or temporary waiver to the Government standard. This process can be initiated at any point when appropriate in the Lifecycle process. This lengthy and time-consuming process will require prior notification for timely completion.

Recommendations for Institutionalization

Process Owner

The selection of a process owner is critical to the successful implementation of the Lifecycle process.

A process owner should be identified to facilitate implementation of the standards Lifecycle process. The implementation effort, which is very similar to existing organizational processes, is significant and critical to the success of the information architecture. The owner's acceptance of this process will require additional work to decompose the existing standards Lifecycle process several more levels

The process owner must form a DOE-sanctioned technical standards working group. This group will be composed of knowledgeable individuals from various DOE and contractor locations to provide a balanced perspective of the issues facing local implementation and industry trends.

Future Call

Information from the field is required to keep the five service areas of network services, data management, data interchange, security, and management services current. To foster a cooperative process, a call should be issued to identify the standards important in the five areas. The call should include the standards in place in the organization and the standards that are needed to facilitate ease of data and information exchange across DOE.

Candidates for Success

To cultivate credibility when establishing standards throughout DOE, early successes are critical. Early success in establishing a limited area of standards can best be met by addressing the potential scope. This could achieve almost 100 percent acceptance by the information architecture community rather than attempting to address the full scope, which could meet resistance and guarantee a lack of full concurrence.

There are five opportunities identified for DOE to achieve early success: video teleconferencing, status of Government Open Systems Interconnection Profile network coordination, authentication and digital signatures, and de facto, consensus-based standards. These candidates for success were identified by the Core Information Architecture Team, and are fundamental to all five service areas.

Candidates for early success will help to advance viability and legitimacy of the architecture.

Video Teleconferencing Policy: Considerable benefits can be achieved by the approval of the proposed change to the current Departmental policy regarding video teleconferencing systems. This proposed policy allows for incorporating technology improvements. Adoption of the policy would decrease the need for petitioning for waivers.

Government Open Systems Interconnection Profile: The Department should revise the current policy, which has failed to become the intended Governmentwide standard and which has already been modified to make Government Open Systems Interconnection Profile compliance optional rather than

mandatory. A future standard will include other widely used protocols.

Network Coordination: There is duplicate network installation that is clearly a waste of resources. Networks coordination is essential if DOE expects to establish a seamless information infrastructure.

Authentication and Digital Signatures: The application of these new technologies will allow for opportunities to change business practices to reduce cost and overheads. A common authentication and digital system standard throughout DOE would be beneficial. To realize the benefits of these applications, policies regarding the movement of sensitive data through both local and wide area networks must be reviewed.

De Facto, Consensus-Based Standards: Early success can be achieved by adopting standards across the entire DOE enterprise that are currently accepted. Also, these standards and practices are used throughout most of DOE and are driven by the marketplace or a broad consensus of their utility and benefit. The Office of the Deputy Assistant Secretary for Information Management can promote even wider usage and acceptance of such standards through the dissemination of lessons learned, best practices, and technical review information, as well as organization of conferences where standards issues could be focused on.

A Knowledge Worker's View

A month later Shirley gets an electronic mail message from Ray on the progress being made. It reads,

Shirley, we've been analyzing findings from process reviews against the site's information management goals. The information architecture team has documented a variety of technology and business recommendations that include business process re-engineering and elimination of non-value added procedures. Minimal workstation configurations, recommended communication protocols, and standard software specifications are drafted. These should allow us to make the best use of baseline equipment and available funding. Emerging technology and software advances are also addressed to retain interconnectivity in light of new user requirements. Long-range plans are being reworked to base new procurements and anticipated requirements on recommended architectural elements. I think we are really making some progress -- Ray

Shirley closes her message and wonders what impact the new architectural approach will have on **Policy** and other business processes.

Policy and Process Integration

Policy

The policy encompasses all Departmental information resources and initiatives, yet provides the flexibility needed to promote technology research and development.

The scope of the following information architecture policy is enterprisewide and sanctioned by the highest level of DOE management. It captures and communicates the essence of the Departmentwide information management philosophy. Development of the information architecture clearly supports the "Management Practices" critical success factor strategy of the Departmental Strategic Plan. The vision of this strategy, as well as the information architecture, emphasizes integrated and open management systems that are results-oriented and cost-effective.

DOE will implement a Departmentwide information architecture to support its programmatic and business goals and missions. Guiding principles will be used to define a standards-based architecture that will ensure integrity, reduce duplication, and promote interoperability, efficiency, openness, integration, and accessibility of the Department's information resources. The policy encompasses all Departmental information resources and initiatives, yet provides the flexibility needed to promote technology research and development. Successful implementation of the information architecture can only be accomplished through full collaboration between all Departmental elements, field sites, national laboratories, and contractors.

Use of the Department's information architecture will be a primary consideration as a means of employing "best business practices" for all future systems, applications, business processes, and/or major information systems enhancements.

Process Integration

The information architecture provides a framework for planning and evolving to information management tools that automate and permit integration of business processes. The following Information Architecture Integration Model illustrates ways in which the information architecture touches various business functions conducted by Departmental elements. In the following discussion, details of how the relationships between the architecture and business processes are defined, and how they can help achieve business goals, are presented.

Information Architecture Integration Model

Customer

Customers control the allocation of critical resources.

The information architecture will position the Department with the ability to provide accurate and timely information to internal and external customers. As DOE continues to develop its business strategies, the information architecture will be tuned to facilitate the complexities in obtaining the necessary information management support to accomplish those strategies. Through the implementation of an information architecture, DOEwide information accessibility with common user interfaces, independent of source or user location, will be accomplished to meet the evolving DOE business needs and enhance communication and trust. Openness of an information data repository will make it much easier to get the needed information.

Information Technology Planning

The Department's high-level strategic plans guide and define the information architecture.

Planning is a function that permeates all levels of DOE, from high-level Departmental planning to field tactical and operational planning. All Departmental elements are involved. The relationship between the information technology planning function and the information architecture is bidirectional. The Department's high-level strategic plans guide and define the information architecture. The architecture will in turn guide and direct the development of tactical and operational plans. The baseline provides a uniform structure for organizing and analyzing planning information and provides an approved foundation against which the quality and effectiveness of information technology planning documents, and the plans within them, can be measured.

Information Technology Budgeting

The Department must focus on cost-effective technologies.

The enterprisewide Information Architecture will serve as a primary guidance mechanism in the information management budget decision-making process. The architecture will also assist in the analysis of programmatic and Departmental initiatives in identifying duplicative and overlapping information technology activities and areas where partnering can occur. Ultimately, the architecture will play a key role in the new performance-based information management budget process by assessing how closely the technologies developed or acquired will map to the business function needs. The architecture determines priority assignments and required time frames for planned programmatic and infrastructure information technology and services initiatives.

Information Technology Acquisition

The architecture facilitates the process of vendor selection, bids evaluation, and performance validation.

A Departmentwide architecture improves the acquisition process in the areas of quality; reduced costs; shorter cycle times; and evolving partnerships between customers, service providers, vendors, and implementors. It can facilitate the process of vendor selection, bids evaluation, and performance validation to confirm that specifications and requirements are met. Vendors use baseline, standards, and vision to adjust product development, tailor inventories to better meet Departmental needs, and utilize electronic commerce to reduce delivery times and control costs. For those who propose, design, and implement, the architecture provides a convenient source of technical reference material to ensure successful completion of their projects and allow better estimates of costs, impacts, and milestones for improving project management.

The architectural baseline provides a high-level inventory of existing resources that can be utilized, extended, or replicated, eliminating redundancy and reinvention of solutions. For those who must review and approve acquisitions, the architecture provides a template to judge timeliness, practicality, and benefits to shorten approval times required for completion of information technology procurement. The architecture defines opportunities for consolidation of buys or negotiation of favorable terms based on volume.

Management Oversight

Information management must foster the sharing, protection, timeliness, and integrity of information and data.

A well-defined information architecture assists management and business process reengineering by providing the necessary framework for organizing future expansion or enhancements to existing applications. It encourages efficiency and productivity by providing direction for future planning -- a common blueprint to which evolving information systems can be designed to incorporate lessons learned and proven solutions. A properly managed information architecture will achieve consistency in the management of information providing open, integrated, interoperable, accessible, information systems and resources.

Technology Application

Interoperable tools make it possible for users to share information, solve problems quickly, and produce compatible and consistent results.

The evolution of information technology has been advancing very rapidly in the last decade. The information architecture will define requirements for cost-effective use of best-in-class technology to improve openness, communication, information access, and management practices across the Department's organizations and locations. Communication tools such as video services, electronic mail, and electronic commerce will be managed in a corporate environment defined by a common architectural approach. Client/server technology and centralized computing resources will be balanced by an accepted architectural framework. At the same time, software application tools, such as database and desktop support software, will be shaped and molded by best-in-class architecture guidelines in corporate and common-interest approaches.

As new technology emerges, projects demonstrating efficient use of creative application of new technology will be driven by architecture guidelines and opportunities to fill gaps in areas where manual or inefficient methods of information management persist. The information architecture will also define opportunities to leverage this new technology to improve business processes and identify new processes enabled (driven) by technology.

Policy

The Department's existence depends on compliance with applicable laws, orders, and regulations.

Policies are the foundation of good business practices. The development of a Departmental Information Architecture that is in accordance with external Federal Government laws and regulations is driven by best business practices for managing information as a valuable resource. Consequently, the establishment of the Departmental Information Architecture can impact and help define existing DOE policies such as Orders, Directives, and standard guidelines. Policy letters can be issued for changes to policies and/or to put new standards into effect. This applies not only to the business of information management but across the Department and in all business areas. In addition, roles and responsibilities assigned to Departmental information management elements may specifically include the requirement for establishment and maintenance of information architecture at various layers (programs) and geographic locations (sites) of the enterprise.

Records Management

By automating many of the functions, problems related to program versus site responsibilities can be minimized.

Information architecture can be used to support the records management program by providing the framework for organizing and automating the creation, maintenance, and use of records information. Automated capabilities will allow images to be scanned, catalogued, and conveniently retrieved. By automating many of the functions, the age-old problems related to program versus site responsibilities can be minimized. Information architecture can support a structured means for archival and retrieval of records information and further the Department's commitment to open communications as stewards of information for generations to come.

Benefits of Process Integration

The following are benefits of integrating the information architecture with the Department's business functions and processes.

- Support the identification and definition of Departmental and programmatic information needs that can be translated into crosscutting requirements and specifications for Departmental corporate and executive information systems, as well as Departmental and programmatic information infrastructural enhancements.
- Provide the ability to influence and exploit emerging technologies and new capabilities that can emerge business processes or functions, new or old.
- Provide the opportunity to integrate Departmental and programmatic information architectures and information technology to improve the efficiency and effectiveness of the Department's information resources, as well as to facilitate cost-effective information resource sharing across Departmental and programmatic elements.
- Provide management with a framework for systematically defining the information resource needs of the Department and evaluating or assessing, through management oversight, the extent to which those needs are being met by existing information management plans, policies, procedures, processes, and practices.

- Facilitate easy, seamless availability of all types of information and the legitimate access to Departmental information by anyone, anyplace, anytime, internal and external to DOE. Classified data will still be safeguarded and privacy data will be properly protected.

Managing Information Architecture

The management of the Departmental Information Architecture must be responsive to changing DOE mission requirements, advances in technology, and fiscal limitations.

Creating an information architecture for DOE enhances the enterprise's ability to guide decision-making, manage change, and communicate the organization's business goals, objectives, and policies up and down its hierarchy and across its functional components. The architecture provides the framework for ensuring that enterprisewide goals, objectives, and policies are accurately reflected in decision-making related to building, acquiring, or changing information systems. Without appropriate architectures, there is no assurance that standards for interprocess communication, data naming, data structures, and information systems will be consistent or appropriately applied across the enterprise.

Managing change has become a pervasive issue, particularly as the penetration of information technology quickens the pace of change within the enterprise. The management of the Departmental Information Architecture must be responsive to changing DOE mission requirements, advances in technology, and fiscal limitations. The following Information Architecture Management Process graphic describes how the Departmental Information Architecture will be managed to meet the requirements of its stakeholders and a changing environment.

The Designated Senior Official for Information Resources Management, who is also the Deputy Assistant Secretary for Information Management, is the Departmental owner of the information architecture. The Designated Senior Official is responsible for ensuring compliance with externally mandated information management related laws, regulations and standards. The Designated Senior Official will lead the design, development, and implementation of the enterprise architecture and communicate policies and standards across Departmental elements. The Designated Senior Official will ensure that the architecture serves as a unifying plan for the information infrastructure throughout the Department to support its strategic plan and mission and accrual of benefits to its stakeholders.

The Information Management Council, which is comprised of stakeholders from Headquarters program and staff offices and field elements, will be the caretakers of the information architecture model. The Council will be responsible for adopting information management initiatives, approving standards, and incorporating changes to the architecture model. The Council will have oversight responsibility for the Architecture Steering Group, a proposed special interest group of the Council.

The Architecture Steering Group will be comprised of "Designated Architects" from DOE Headquarters program and staff offices, field elements, and other sites. This group of architects will be responsible for translating Departmental strategies into information management initiatives, facilitating the adoption of new standards, proposing formal architecture model changes to the Council, and assisting in the development of DOE architecture guidance. In addition, this group would be instrumental in helping prototype architectural approaches within their program at their sites.

Concept of Operations for the Management Model

The Information Architecture Management Model begins with senior-level management leadership, support, and guidance from the Designated Senior Official and the Information Management Council. The Information Management Planning and Architecture Coordination Team was chartered under the Information Management Strategic Plan to prepare the top-level architecture view for the Department. This view will become the focus for the Architecture Steering Group, which will steer and oversee the development and promulgation of DOE architectural guidance. The guidance will be developed using a three-tiered approach consisting of guiding principles, standard practices, and technical guidance. The DOE Architectural

Guidance will direct the transition from the baseline or de facto Departmental architecture through approved information management program plans and budgets to the future architecture.

Through the Department's Information Resources Management Assistance Visit program, the Designated Senior Official will work to assist Departmental elements in the implementation of architecturally compliant systems and technology solutions to achieve openness, interoperability, and a reduction in duplicative systems. This process will lead the Department to the goal of DOE-integrated systems and highly accessible DOE information.

Summary

The Department of Energy Information Architecture, the framework that establishes policy, guiding principles, and standards and defines how they integrate is critically important. It will serve as a tool to provide and maintain the information infrastructure so that it meets the needs of the entire DOE complex. The architecture will be understandable and guide the planning and acquisition of information systems and services for future years. The Designated Senior Official, Information Management Council, and Architecture Steering Group must be strong advocates for the architecture and work closely with stakeholders and users to translate architectural policy and guidance throughout the Department to ensure the successful implementation of the architecture.

A Knowledge Worker's View

At the end of a briefing from the Information Architecture Team, Shirley commends them on their good work, and rushes back to her office to handle some last minute action items before her meeting with Ray. Ray walks into Shirley's office carrying a flip chart. "It's as you said Ray. This piece of equipment (pointing to her desktop computer) *did* change the way I do business," Shirley says. "And the information architecture will help make it possible for me to communicate and work efficiently and effectively through my computer within the site complex, throughout the Department, and around the world. I feel confident that the information infrastructure we're developing will also support Departmental, site, and program missions. But what else do we have to do?"

Ray looks at Shirley with a smile and flips the first page on his charts revealing an outline of other actions to continue the work they had begun. The page was titled "Next Steps".

Next Steps

The high-level vision presented should remain constant in the near-term.

The current focus of the Departmentwide Information Architecture initiative is one of planning for transition. The Department, recognizing that information must be managed as an asset, has started to move from a technology-centric to a user-centric environment. There is a revitalized drive to improve the interoperability and platform independence of user applications, and to increase productivity and the efficient use of resources. The high-level vision presented should remain constant well into the near-term. However, updates to the document will be made to highlight transition progress, accomplishments, and additional ideas being implemented to address new challenges. The future will be vastly different with new technologies, new laws, new barriers, and new opportunities. Even the possibility of a “new” realigned, right-sized Department exists. The architecture must be prepared to accommodate these changes.

Transition Strategies

Investment decisions will be supported by information on interoperability and connectivity.

Because this transition has assumed diverse and often competing forms, a comprehensive information architecture is needed to ensure that implementation priorities and financial resources are secured under a well-orchestrated framework. Investment decisions about costly items such as equipment, methodologies, data storage and retrieval, and training of expert personnel will be supported by information on factors such as interoperability and connectivity. The ability of the Department to accelerate its competitiveness in the engineering and scientific arenas through the use of high-performance computers will be directly tied to the tenets of the information architecture. The Department's objective to become a foremost influence in the development of the National Information Infrastructure will be defined and sustained by the concepts contained in the architecture.

Future Initiatives

The effort to create a top-level DOE Information Architecture is well underway.

In publishing the document, Volume 1 - The Foundations, the effort to create a top-level DOE Information Architecture has been established and is well underway. There are several specific objectives that are logical corollaries to this effort that may be defined as future initiatives. They are direct means to access, adapt, and maintain the currency of the architectures in support of DOE's information business. The emphasis of the Departmentwide Information Architecture in the near-term, is to define in greater detail the Baseline, Standards Adoption Process, and Architectural Guidance. The approach for publishing the results of these near term efforts is shown in the Next Steps illustration. The reference numbers in the illustration identify corresponding Departmental Strategic Plan action steps.

Baseline

The next task, on-going at the time of this publication, is to further analyze and document the Department's current information architecture baseline so that architecture improvements can be made.

This effort will provide a methodical and well-documented technology assessment of the entire DOE enterprise. The "detailed" baseline, maintained in electronic formats, will be updated periodically to assist in determining what future directions will be taken and to measure the progress of the architecture.

Management sponsorship will be requested.

In order to achieve an accurate representation of the current baseline, management sponsorship of collecting the necessary data and information through site reporting and consultation with representatives from all parts of the enterprise will be requested. Even though this is unpopular and viewed burdensome, it is necessary to do the job right. This was the position of the Information Architecture Team which included field site participants.

Publishing Volume 2 - Detailed Technical Baseline, as depicted in the Next Steps illustration located at the end of this section, establishes an architecture model of the current or defacto architectural structure for the bottom three layers of the architecture model.

Standards Process

Standards provide a description of the performance requirements or features of a device, software, or the algorithms used in hardware or software which are established to ensure that connectivity between technology components exists as intended by the standards setting body. The overall movement toward an open system environment continues to establish and refine standards relating to connectivity. The implementation of connectivity oriented standards in the DOE information architecture infrastructure will focus on common information interface formats for user convenience in sharing information and to device and application interface requirements for the information technologist.

Working together with other stakeholders, the adoption of standard interface formats will result in the elimination of non-value added redundant information and inconsistent data. The improved services to information consumers in an open and shared information environment provide a major contribution in the achievement of the enterprise values and goals expressed in the 1994 Departmental Strategic Plan.

Another important "next step" is the establishment of a Standards Lifecycle Process, as presented in the **Standards** section. The early steps in implementing this process can operate independently of the other architecture follow-on activities, which are depicted in the Next Steps illustration located at the end of this section. However, detailed process mappings will include steps to validate against architectural elements, principles, and later, guidance.

A standards process steward must be appointed.

The success of the Lifecycle process depends on the assignment of an effective "owner" or steward of the process. This person will have to facilitate the involvement of the stakeholders (DOE Information Management, Program Offices, and contractors). The steward would also be responsible for implementing the Lifecycle process.

The Lifecycle process should be further developed to include other characteristics that are listed below.

- Categorizing standards within the lifecycle.
- Developing well-defined criteria for evaluating standards.
- Open involvement to the entire enterprise to participants in the official review and approval process.
- Adoption of non-Government standards.

The Lifecycle process should also be "decomposed" several more levels, so that its practical application enterprisewide will become more clear.

Information Architecture Guidance

To start managing information and information technology differently, the enterprise has to make a complete transformation.

All levels of the enterprise will need guidance to adopt the architecture.

All levels of the enterprise will need guidance to adopt the architecture and begin making it a "best management practice". After the Architecture Team has established the baseline and a standards process, the next step is to provide guidance. Published guidance would focus the specific direction and design for Departmental infrastructural components, as depicted in the Next Steps illustration at the end of this section, under Volume 3 - Information Architecture Guidance.

Quality Performance

The results will be the efficient and effective quality management of DOE information.

The results of the planning for the transition to an information architecture will be the efficient and effective quality management of DOE information. A comprehensive architecture designed to support the requirements of DOEwide business needs will result in technology that is powerful enough for all programmatic areas, in data that is structured for sharing among all users, and automated systems that are developed to provide accurate and timely information to the public.

Once the information architecture is in place, the Department must continually adapt to continuous changes to the political environment and technology. Hardware, software, and techniques are constantly evolving. The information architecture must similarly evolve and benefit from the lessons learned. This ongoing process will guard against obsolescence, make appropriate use of emerging technologies, and will be of ongoing value to DOE and its employees. From this perspective, the information architecture must be viewed as a continuing process with ongoing performance evaluation.

The success of the architecture will be documented in Volume 4 - Information Architecture, "An Update", as depicted on the following page.

Next Steps

A Knowledge Worker's View

*"Shirley, would you have thought, a year or so ago, that we would be asked to present our architecture at this symposium? We'll have to tell them about applying the **Vision** principles, the techniques we've developed for documenting, maintaining, and analyzing the **Baseline**, how we've established our **Standards** process, and what we've done to **integrate** the architecture **with our business processes**. Let's post our **Guidance** on-line for use during the symposium...."*

*"Ray, I'm proud of all that, too, and particularly of the role the staff played in ensuring that this architecture would meet our **Business Needs**. I know what I want to tell the symposium. I'll tell that story about being embarrassed at a meeting because I couldn't collect the information I needed. I went to a similar meeting last month and had to do little preparation because of what was already online throughout DOE. All the information I had to gather last time was electronically at my fingertips, and I could concentrate on analyzing the information and making recommendations for crosscutting management decisions. In addition, I can show how better, more accessible information is being used to make day-to-day decisions in our program." - A new day has begun....*

Glossary of Technical Terms

This glossary is intended for the non-technical reader of this document.

authentication and digital signatures

The network equivalent of signing a message so that you cannot deny that you sent it. Authentication verifies to the recipient that the sender is authentic. Digital signatures ensure that senders are who they say they are.

business process re-engineering

A methodology used to redesign a way an enterprise does business to achieve dramatic improvements in performance.

client/server technology

Data processing in which a program at one site sends a request to a program at another site and awaits a response. The requesting program is called a client; the answering program is called a server.

electronic mail

The transmission of memos and messages over a network. Users can send mail to a single recipient or broadcast it to multiple users. A message sent from one computer user to another is stored in the recipient's "mailbox" until that person next logs onto the system. The system can then deliver the message.

extensibility

The capability of being expanded or customized. For example, with extensible programming languages, programmers can add new statements, data types, or hardware capabilities.

Government Open System Interconnection Profile

An architecture that specifies open systems interface-based data communications standards for connecting all types of computer, peripherals and networks to support interoperability.

Internet

A wide area network, connecting thousands of disparate networks in industry, education, government, and research.

interoperability

The ability of two or more applications to exchange information and to use the information that has been exchanged, regardless of hardware platform or software.

<i>legacy system</i>	A system that was originally designed to meet the historical needs of an organization, cannot be readily eliminated, and may not be widely supported by the marketplace. Most legacy systems are stovepipe systems.
<i>mosaic</i>	A graphical user interface to the Internet.
<i>open standard (open system standard)</i>	Widely held standards specifying that different vendors' hardware and software operate compatibly with one another.
<i>portability</i>	Ability of software designed for one computer system to be used on other systems. Little software outside the Microsoft Disk Operating System (MS-DOS) software for IBM and IBM clone computers is portable to other platforms. UNIX software is portable to an extent. Mainframe operating systems tend not to be portable.
<i>scalability</i>	Allows for pilot projects to coexist with current structures; implies minimal change in current procedures in order to accommodate growth.
<i>stovepipe (system)</i>	A system procured and developed to solve a specific problem, characterized by a limited focus and functionality, and containing data that cannot be easily shared with other systems.
<i>transmission control protocol/Internet protocol (TCP/IP)</i>	A specification for software that bundles outgoing and incoming data into packets, manages the transmission of packets on a network, and checks for errors. TCP is the portion of the TCP/IP protocol suite that governs the exchange of sequential data. Internet protocol (IP) software tracks the Internet address of nodes, routes outgoing messages, and recognizes incoming messages.
<i>user-centric</i>	Information architectures developed primarily to support users, and enable users to access and share information easily from anywhere in the DOE system, regardless of where the information resides and how the data is stored.
<i>X.400 gateway</i>	Enables disparate electronic mail systems to exchange messages. Acts as a translating software making communication between the electronic mail systems possible. One problem with electronic mail sent between X.400 gateways is that the senders' name is not included.

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