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U.S. Department of Energy

Information Architecture Volume II

Part 1 Baseline Analysis Summary

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Foreword

The Department of Energy (DOE) Information Architecture, Volume II, Baseline Analysis, is a collaborative and logical next-step effort in the processes required to produce a Departmentwide information architecture. The baseline analysis serves a diverse audience of program management and technical personnel and provides an organized way to examine the Department's existing or de facto information architecture. A companion document to Volume I, The Foundations, it furnishes the rationale for establishing a Departmentwide information architecture.

This volume, consisting of the Baseline Analysis Summary (part 1), Baseline Analysis (part 2), and Reference Data (part 3), is of interest to readers who wish to understand how the Department's current information architecture technologies are employed. The analysis identifies how and where current technologies support business areas, programs, sites, and corporate systems.

Executives and Program staff will be interested in the summary of findings presented in part 1, section 3, Findings and Conclusions. Those requiring a greater understanding of the details will be interested in the current business case, business areas, and the description of technologies deployed throughout the Department for satisfying stakeholder information needs presented in part 2. Information management staff responsible for delivering information technology solutions are encouraged to focus on the technical baseline analysis in part 2. The analysis and description of deployed technologies form the conceptual and, ultimately, engineering design bases for a modernization effort.

The Information Management Planning and Architecture Coordinating Team (IMPACT) was chartered to establish a high-level information architecture to meet current and future DOE information needs. This Departmentwide activity was initiated to support DOE information management strategic goals. Recent changes in emphasis as reflected in Office of Management and Budget (OMB) Circular A-130 and recommendations made by the Information Resources Management Planning Process Improvement Team are recognized in this activity.

Volume II, Information Architecture Baseline Analysis, provides an analytical summary of the current DOE information architecture, based on the five-layer conceptual model developed by the IMPACT team in 1995. This analysis consists of three parts. Part 1, Baseline Analysis Summary, provides an overview of the methodology and the results of the analysis of the Department's baseline architecture.

Part 2 presents the analysis of the Department's current information architecture and depicts the existing baseline by using the Information Architecture Model and eight guiding principles

described in Volume I, The Foundations, as a means of assessing the current status in the context of future DOE information architecture. Part 2 describes the five-layer DOE Information Architecture Model and summarizes DOE missions and business areas, as well as the high-level models created and used to facilitate the analysis and detailed presentation of current information technology. Part 2 also provides an analysis of information technologies deployed throughout the Department and describes how these technologies are implemented across the nine business organization types. Findings and conclusions, which provide a basis for guiding evolutionary change throughout DOE, are also included in part 2. The primary themes of interoperability, connectivity, user accessibility, cost containment, efficiency, elimination of duplication, and information sharing to improve collaboration are used throughout the analysis to highlight strengths and weaknesses of the existing architecture. A glossary of technical terms is included in parts 1 and 2. A list of references is provided in part 2.

The part 3 loose-leaf format facilitates incremental revisions as the information architecture program evolves toward a vision architecture. Part 3 presents the data as assembled and organized to support this analysis. This information documents the data sets used during the analysis presented in part 2. The analysis is based primarily on information collected during the Information Management Activity Plan (IMAP) and Unified Budget Call (UNICALL) Supplemental data calls. In addition, material was assembled from recent long-range plans, working papers, brochures, market and industry data, and input from numerous staff offices. This collected information was input into analytical tools, such as the Business Relationship Maps and Palladian Windows in parts 1 and 2.

This document represents the completion of the second major architectural milestone for establishing the DOE information architecture. This analytical assessment of the baseline reveals how the existing architecture will not adequately serve DOE or the public as needed in the next decade. This analysis is a starting point for significant efforts at more detailed layers to realign infrastructure systems and technologies to the future architecture according to the Principles and Vision in Volume I, The Foundations. This analysis and other related architecture products are available on the World Wide Web at <http://www.hr.doe.gov/iat>. Future efforts of the Information Architecture Team will focus on specific components of the architecture providing guidance, best business practices, and standards that will enable the Department to build an infrastructure to provide support into the 21st century.

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Table of Contents

List of Figures	iii
List of Tables	v
Credits	vii
Background	1-1
Baseline Analysis Objectives	1-1
Scope of Analysis	1-2
Baseline Analysis Assumptions and Limitations	1-5
Assumptions	1-5
Limitations	1-8
DOE Information Architecture Business Case	1-8
Development of Eight DOE Architecture Principles	1-10
Department of Energy (DOE) Information Architecture	2-1
The DOE Enterprise	2-1
Core Competencies	2-3
Departmental Core Competencies	2-3
Information Management Core Competencies	2-4
Architecture Components	2-5
DOE Information Architecture Model	2-6
Five-Layer Model	2-6
Subarchitecture Description	2-7
Business Subarchitecture	2-9
Business Areas	2-10
Business Subarchitecture Organizations	2-11
Business Entity Relationship Maps	2-12
Information Subarchitecture	2-15
Source Domain	2-17
Throughput Domain	2-17
Destination Domain	2-20
DOE Information Products	2-20
Information Consumers and Users	2-22
Information Systems	2-22

Applications Subarchitecture	2-25
Data Subarchitecture	2-31
Technology Subarchitecture	2-31
Information Technologies	2-31
DOE Computing Hardware Technology Model	2-32
DOE Computing Software Technology Model	2-35
DOE Telecommunications	2-36
DOE Data Telecommunications Technology Model	2-37
Findings and Conclusions	3-1
Focal Area 1: Functional Duplication and Redundancy of Departmentwide Information Systems	3-2
Focal Area 2: Impact of Expanded E-Mail Use Departmentwide	3-4
Focal Area 3: Internet Connectivity	3-6
Focal Area 4: Unclassified Security	3-8
Focal Area 5: Standardization Strategies	3-10
Focal Area 6: Departmental Procurement Opportunities	3-12
Focal Area 7: Business Relationships and Technical Approaches	3-14
Focal Area 8: Benchmarks in Technology	3-16
Focal Area 9: Migrations Toward Advances in Technology	3-18
Focal Area 10: Age of Technology at Sites	3-20
Focal Area 11: Throughput, Speed, and Capabilities	3-22
Focal Area 12: Minimum Requirements for Desktop Platforms	3-24
Focal Area 13: Consolidation of DOE Data Centers	3-26
Focal Area 14: Data Warehousing	3-28
Conclusions	3-30

Glossary

List of Figures

2-1	DOE Organization Chart	2-3
2-2	Information Management Core Competencies	2-4
2-3	DOE Information Management and Planning Framework	2-6
2-4	Program and Business Architecture Relationships	2-8
2-5	Business Subarchitecture Model	2-9
2-6	Business Relationship Template	2-13
2-7	DOE Business Relationship Map	2-15
2-8	Information Subarchitecture Model	2-16
2-9	SRIS System Categories	2-23
2-10	DOE Computing Hardware Technology Model	2-32
2-11	DOE Computing Software Technology Model	2-35
2-12	DOE Telecommunications	2-36
2-13	Network Technologies	2-37
2-14	DOE Data Telecommunications Technology Model	2-38
2-15	Baseline Network Architecture Thread Model	2-39
3-1	Status of Baseline Information Architecture	3-33

List of Tables

1-1	Organization Types	1-3
1-2	Information Technology Related Categories	1-4
2-1	Annual Federal Agency Information Technology (IT) Expenditures	2-2
2-2	Subarchitectures	2-7
2-3	SRIS Keyword Search.	2-25
2-4	Headquarters Application Baseline Business Areas	2-26
2-5	Significant DOE Business Systems	2-27
2-6	MASL Keyword Search	2-30
2-7	Type W Systems	2-33
2-8	Type X Systems	2-34
2-9	Type Y Systems	2-34

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Special Recognition

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Background

The Department of Energy (DOE) was established to coordinate and administer a comprehensive national energy plan. DOE is the Federal Agency responsible for research and development of energy technology and conservation, nuclear weapons programs, Federal energy regulatory programs, and collection and analysis of energy data. In performance of these functions over several decades, the Department and management and operating (M&O) contractors have evolved a large, diverse base of information created and maintained on equally diverse computer hardware and software systems. Volume II, Baseline Analysis, was developed to document this diverse information architecture.

DOE information architecture provides a technology framework that supports business decision making and information sharing and defines components of the architecture model layers required by organizations to assist in achieving business objectives and missions. The framework provides a basic structure for organizing information, applications, organizational and technological components, and their interrelationships. It also establishes the principles and guidelines governing the planning and implementation of information systems.

Baseline Analysis Objectives

The following baseline analysis objectives were identified from the Information Architecture, Volume I, The Foundations, Baseline, published by DOE in March 1995.

- ☐ Analyze current Department information architecture baseline.
- ☐ Depict the current technology base.
- ☐ Identify the systems and data in place.
- ☐ Map networks and protocols.
- ☐ Determine existing software for all layers of the de facto information architecture.
- ☐ Identify standards already in place.

- ❑ Use the de facto DOE information architecture baseline as the starting point for identifying future changes. The data should provide insight into Departmental solutions to the following key issues.
 - Information technology, as implemented today, may be a barrier to Departmentwide interoperability.
 - Multiple networks exist; the current network architecture is a mesh of real and virtual assets and capabilities. Difficulties in aligning physical and logical capabilities may be hindering the realignment of technologies to support the business areas.
 - Duplicate data and redundant systems probably exist.
 - Interoperability, connectivity, and user accessibility to information can be improved, but the mechanisms causing difficulties are not clearly identified.
 - Ongoing processes and system technologies initiatives provide the basis for evolution and movement toward a vision architecture. An information architecture baseline should support proposed improvements.

The baseline data was established using Unified Budget Call (UNICALL) Supplemental, Information Management Activity Plans (IMAPs), DOE System Review Inventory System (SRIS), and other sources listed in the References section of part 2, Baseline Analysis. The data, which provided a starting point in the absence of Departmentwide inventories, drawings, and detailed specifications, were verified by Federal staff and selected contractors to ensure accuracy. The initial data collection was completed in August 1995, and a database was created. No comprehensive DOEwide inventory of assets and information technology capabilities from the listed organizations was prepared. The current information architecture was analyzed from the database and cautious inferences about interoperability, connectivity, and data sharing among sites and organizations were made.

Scope of Analysis

The types of organizations analyzed, presented in table 1-1, Organization Types, formed the clusters within business unit types about which technology characteristics were collected. Clusters of organizations of similar types and technologies allowed for inferences to be made when individual data was not available. Part 2, section 3, Baseline Analysis, includes a definition of each organization type and identifies the specific organizations included in the analysis.

Table 1-1, Organization Types
Field Office HQ DOE Office Operations Office Project Office Test Site Technology Center Plant Laboratory Complex

The following organizations were not included in the analysis.

- ☐ Strategic Petroleum Reserve Program and Offices. These are being considered for regulatory separation from DOE.
- ☐ Power Marketing Administration Program and Offices. These are being considered for regulatory separation from DOE.
- ☐ Metairie Site Office. This site was ordered to close as of the data cutoff date (August 1995).

Note: Site, area, and support offices are included within larger organization types because detailed data was not requested from them.

To facilitate the analysis, the Department's information technology capabilities were separated into 13 categories as shown in table 1-2, Information Technology Related Categories. The table includes examples of fundamental technologies, such as telephony, application services (e.g., facsimile transfer), and other samples of diverse Departmentwide capabilities and configurations.

Table 1-2, Information Technology Related Categories	
Facilities	Owned, rented, or contracted data centers, local area networks (LANs), telecommunications centers, and typical office sites
Wireless	High Frequency (HF), Infrared (IR), Ultra High Frequency (UHF) and Very High Frequency (VHF); microwave; satellite relays; radio frequency spectrum resources; paging systems (secure and unclassified); and other wireless communications
Telephone	Dedicated, dialup, cellular, facsimile, telex, teletypewriter exchange (TWX), telecopier, data, voice, and voice-mail systems (secure and unclassified)
Networks	Data, video, local and wide area networks (WANs), land line, external commercial services, twisted pair, coaxial, fiber distribution data interface (FDDI), dedicated use, and public use systems (secure and unclassified)
Computing Platforms	Central processing, client/server, distributed processing, and standalone desktop processing systems (secure and unclassified)
Information Processing	Desktop, graphical user interfaces, server/processors, data storage and retrieval devices, electronic mail (E-Mail) (secure and unclassified), electronic commerce/electronic data interchange, electronic document publication and distribution, and simulation and visualization for scientific computing
Applications	System and user commercial-off-the-shelf (COTS) software, custom-developed, integrated, standalone, office automation, E-Mail, antivirus, and add-in and add-on third-party software
Database Management	Structured Query Language (SQL), relational, flat, object-oriented, standalone, systems application-oriented, and included in COTS or used within applications
Graphics Generation	Drawing, drafting, computer-aided design (CAD) databases, data visualization, plotting, technical, scientific, and engineering graphics
Video	Broadcast, desktop, and multipoint and point-to-point teleconferencing
Operating System Infrastructure	Operating systems software, tools, and utilities for infrastructure
System Development	Tools and utilities
Physical Information Distribution	United States mail, Federal Express, United Parcel Service (UPS), courier (including physical document transfer to archives), and file storage

These categories define the technological envelope with which DOE provides information support to customers. This technical analysis contains terms and acronyms commonly used in information management. The document includes a limited glossary of technical terminology; acronyms are spelled out or defined at their first occurrence in each chapter.

This analysis represents a high-level view that must be updated periodically to measure the ultimate effectiveness of the architectural approach. The analytical models must be further evolved and refined and significant data gaps closed if they are to become primary information management tools. For example, detailed systems functional mappings and data modeling, as well as business process and information modeling, must be completed as the programs and sites build information architectures. Although the analysis is comprehensive, there are assumptions and limitations that must be understood to put the baseline into proper perspective and the findings and conclusions in context.

Baseline Analysis Assumptions and Limitations

Assumptions

- ☐ This baseline is a descriptive presentation that is neither prescriptive nor normative. It is intended to be a decision-making tool. Classifications and presentation schemes were developed to summarize and logically present data detailing the current DOE information architecture baseline. Findings and conclusions highlight potential opportunities, some that are being evaluated in greater detail and others that may warrant attention.
- ☐ While the analysis establishes a snapshot of the DOE information architecture, the baseline is undergoing continual change and evolution. Significant transitions and migrations to new and alternative technologies, hardware platforms, software and systems, and telecommunications networks are included.
- ☐ The resolution in each architecture layer varies with the essential elements of analysis and the detail of available information. Some discussions require summary at an organization, technology, or platform level. The resolution level is described in each technical presentation.

- ❑ The baseline analysis is not a complete inventory by organization. Available density information is provided as reported by field sites. A deliberate attempt was made to avoid placing an overly burdensome reporting requirement upon DOE elements, organizations, and activities. The primary sources of analysis data were IMAPs, UNICALL Supplemental questions, and SRIS. Other information products (such as Home Pages, reports, architecture, and previously filed information) were used to define the current baseline architecture and supplement the data.
- ❑ The absence of prior DOE Agency-level business process maps, models, or analyses required that surrogate business architecture and information subarchitecture layers be developed. This significant effort was dropped from the scope of effort by management direction. Based on the Secretary's realignment effort in 1995, the realignment implementation team recommended linking business needs and supporting information technology. This initiative impacted the scope and schedule of this analysis.
- ❑ The cutoff for submission of field data was August 1995. Materials used to supplement field data were prepared before, after, and separately from this analysis. These materials, listed in the References section, were used to expand the usefulness of the baseline analysis architecture overview presented in this document.
- ❑ The analysis team assumed that a capability or technology component (including assemblies of components) was not redundant according to the following criteria.
 - A capability or component was required for information security or privacy. Numerous instances of access and password applications were not, in themselves, unnecessary and were essential by design.
 - A capability was mandated or directed by the Government or DOE. For example, FTS2000 is a Federally mandated telecommunications system. The DOE Communications Network (DOECN) is the Departmental equivalent using FTS2000.
 - A capability required by a DOE partner or customer (a nonDOE entity) required an additional capability other than the choices adopted by others within the baseline. Examples include numerous WANs, office automation applications, scientific and engineering applications, and videoconferencing capabilities. Examples are isolated by different standards among DOE and external information users.
 - A capability was required for nonDOE use, especially when essential for public access, such as servers and storage devices used as firewalls between internal and external users.

- A capability or component is used when access to a DOE remote location user is otherwise limited. Examples include use of local Internet service providers, dialup access capabilities, and multiple copies of software used to transfer files from portable computers or remote locations (not necessarily a physical office). Other examples, such as database management systems (DBMSs), hardware platforms, and distributed corporate systems components, revealed that replication is not sufficient to determine the existence of unnecessary redundancy.
- The capability or component is required for backup or continuity of operations. Examples include backup storage devices, communications devices, alternative network capabilities, duplicate instances of DBMSs and other applications at the alternative data processing locations, and operational spare desktop platform replacements.
- An essential duplicate or alternative network is required to provide the needed bandwidth and the total costs of the combined bandwidth are, without further analysis, cost-effective. Examples include the need for circuits to process data, voice, and video information; the use of LANs and WANs to provide network capacity within and among telecommunications nodes; and networks intended to shift traffic-load capacity or response-time management.
- A capability or component has been approved as part of a pilot project or pending information management solution evaluation. Examples include Java language applications for World Wide Web (WWW), parallel processors and storage devices for data warehousing benefits, Lotus Notes and other COTS workgroup flow applications, and WWW authoring applications. Replaced capabilities or components are not considered to be unnecessarily redundant until the decisions, designs, and deployment plans are complete.

The analysis team could not determine if a capability or component was unnecessarily redundant, but the following indicators were used.

- Unnecessary redundancy might be indicated if, for example, a multi-network configuration had not been subjected to a deliberate benefit/cost trade-off analysis in which business needs were clearly identified. Other examples could include centralized or client/server design configurations. The responding organizations were not asked for this type of supporting information; however, the information provided by HQ DOE Offices may have referred to these types of analyses.
- A capability or component is not required for security, continuity of operations, or reliability considerations.

- An existing capability or component is used for the sole purpose of converting information capabilities among configurations based on different standards within the baseline when a single suitable standard is adopted.
- An operational capability meeting business and technology needs exists as an alternative without prior examination and justification of necessity. Related indicators included a relatively low user base, low usage patterns, duplicative data entry applications, and additional backup capabilities.

Limitations

- ☐ This analysis is not intended to be a design document, although the elements of implied designs can be discerned.
- ☐ This analysis is not developed to be the sole basis for information management resource allocations; however, it provides a view of the technologies in place and should improve resource use.
- ☐ This analysis does not include information technology projects of a research and development nature, which may be embedded within a DOE mission or program area.
- ☐ This analysis is not based on prior business process reengineering information, although the reasons to exclude organizations may be based on realignment decisions.
- ☐ Data items that are incomplete or unavailable are left blank or noted in this document as *Not Available*.

DOE Information Architecture Business Case

The DOE information architecture baseline analysis summarized below supports the Departmental business case, as presented in Volume I, The Foundations.

- ☐ DOE missions are being redefined and reengineered on a real-time basis.
- ☐ Enterprisewide problems require enterprisewide solutions.
- ☐ There are increasing requirements to provide on-demand information analysis with fewer resources.

- ❑ A flexible and fully integrated information architecture is required to effectively achieve business objectives. This architecture should include the following essential characteristics.
 - Accessibility
 - Data consistency and quality
 - Seamless enterprisewide integration
- ❑ Conceptual design should focus on programmatic and enterprisewide performance and cost-effectiveness to optimize overall Departmental investments.
 - Interoperability without a monolithic *grand design* approach
 - Common planning foundation
- ❑ The use of an information architecture is an industry best practice and worthy of adoption by DOE.

Several benefits of implementing an information architecture are listed in the following chart.

Customer Service Benefits	Improved Management Practices
<ul style="list-style-type: none"> • Increased ability for legal and regulatory compliance • Increased use and benefits from commercial partnerships • Improved public access to DOE information • Increased responsiveness to changing business and information technology conditions 	<ul style="list-style-type: none"> • Increased effectiveness of information management and strategic planning • Improved budget management effectiveness • Improved program and project management • Improved procurement and contract administration • Improved data integrity and quality • Improved communications • Continued process improvement • Increased data sharing • Improved management of intellectual property • Delivery of an enterprise solution to satisfy information requirements

Development of Eight DOE Architecture Principles

The DOE information architecture is founded on the following eight principles published in Volume 1, The Foundations. The principles are high-level statements of DOE philosophy and provide the foundation for standards and policy. They provide perspective for viewing the current baseline and identifying the characteristics of a realigned information architecture.

- ☐ **DOE information products and services are user-centric and customer-driven.** This analysis identifies current business relationships and information technologies.
- ☐ **The DOE information architecture is based on modular components.** This analysis identifies enterprise-level building blocks and models in which these modular components are expected to function.
- ☐ **Information architecture is based on an open systems approach.** This analysis provides a description of where and what modular components satisfy the open systems principle.
- ☐ **Security is designed into all architectural elements, balancing accessibility and ease of use with protection of data.** A variety of methods, devices, and designs for assessing this balance is demonstrated in this analysis.
- ☐ **Information is not only a Departmental asset but also a National asset for which DOE staff is the steward.** The scope of this stewardship and related information technologies is described in this analysis.
- ☐ **DOEwide access to information is the rule rather than the exception.** This analysis assists in identifying data accessibility barriers and opportunities.
- ☐ **The information architecture incorporates a robust interface that optimizes the nature, efficiency, and effectiveness of the human operator.** This analysis provides insight to the varied, unintegrated interfaces critical to daily business.
- ☐ **DOE will have an information technology infrastructure that seamlessly links offices, programs, facilities, and field locations.** This analysis provides a means of assessing what linking mechanisms apply to DOE organizations and information users.

Department of Energy (DOE) Information Architecture

The DOE Enterprise

An organization the size, scale of complexity, diverse missions and functions, and geographical dispersion of DOE is properly described as an *enterprise*. Enterprise information requires the constant access and use of operational and historical data. This information is obtained, processed, stored, transferred, and disseminated through the DOE information architecture. Volume I, The Foundations, describes information architecture as the conceptual framework that links Departmental and Programmatic missions, goals, and objectives and provides a mapping of the current and future DOE business information required to support them. The current information architecture encompasses the identification and integration of specific technologies in use to achieve or support business goals. Information architecture data is also enterprise information.

The relative scale of enterprise organizations similar to DOE, as expressed in annual information technology expenditures, is shown in table 2-1, which presents the DOE information technology peer group within the Federal Government.

Table 2-1, Annual Federal Agency Information Technology (IT) Expenditures		
Agency	Annual \$ (Billion) IT	
	(1994)	1995
Department of Defense (Other)	3.20	3.50
Department of Health and Human Services	2.83	2.91
Department of the Navy	2.23	2.31
Department of Transportation	1.96	2.18
Department of the Treasury	1.80	2.13
Department of Energy*	1.80	1.99
Department of Agriculture	1.09	1.17
Department of Justice	0.80	0.90
Sum of Selected Agencies	\$16.69	\$18.20
Governmentwide	\$25.80	\$27.30
Source: Information Resources Management Plan of the Federal Government, March 1995, page I-3. *Later reduced to \$1.6 billion for 1994. Other data may show minor adjustments downward. All remain well above the \$1 billion annual threshold.		

The Department provides leadership and partnership with other world-class corporations; non-Governmental groups; and Federal, State, local, and foreign governments. DOE internal business activities require that new technologies be employed effectively and provide responsive service to the public. Information technology and the information architecture through which it functions play an essential role in DOE success.

Information technology alignment is the capability of the information architecture to support Departmental business needs. As organizations achieve the scale of DOE, the difficulties of maintaining connectivity, interoperability, and data accessibility increase. When the difficulties impairing the ability of information systems to adapt or anticipate business changes, business and information architectures become misaligned. DOE, like others in the Federal peer group, uses remedial and planning mechanisms to reduce the misalignment between business needs and information technology capabilities.

The view of DOE as a business enterprise is described in this section. The organizational frame of reference for the enterprise is shown in figure 2-1, DOE Organization Chart.

Figure 2-1, DOE Organization Chart

* Deputy Secretary serves as Chief Operating Officer of the Department
 Chart is accurate as of November 1996

Core Competencies

Departmental Core Competencies

DOE organizations have valuable individual and collective expertise and resources to support diverse missions. The Department's unique energy-, defense-, and research-related responsibilities have led to distinctive and singular scientific and engineering core competencies, including the following.

- ☐ Energy and environmental technologies
- ☐ Advanced materials development
- ☐ Advanced manufacturing and process technologies
- ☐ High-performance computing and communications
- ☐ High-energy and nuclear physics
- ☐ Bioscience and biotechnology

Core competencies are the essential content of collaboration and coordination in the geographically dispersed scientific and production business environments of the Department. The DOE information architecture enables organizations to share and collaborate in their specialty areas. Interaction occurs through local architectures and Departmental capabilities, such as major information systems, applications, and data.

Information Management Core Competencies

DOE core competencies illustrate how essential knowledge is massed for accomplishing Departmental business. Information management (IM) is also a business area. Unlike the other business areas, IM crosses all business, organizational, and technological boundaries and contributes to the flow of information and decisions among internal and external business partners. The baseline information management core competencies (figure 2-2, Information Management Core Competencies) illustrate the need for information products and services, as well as the need to provide information management services for the Department.

Figure 2-2, Information Management Core Competencies

The figure illustrates the relationships of IM activities and IM business subareas. The foundation of the relationships is shown in the eight basic activities performed by an IM organization using the knowledge areas. The full range of IM activities and technologies is provided by the two business subareas. The two activities and three technologies supported by Infrastructure IM Products and Services are value-added capabilities that depend on timely delivery of Applied IM Services (Information Architecture, System Development and Enhancement, and Systems Integration). The two fundamental IM business subareas perform Technology Surveillance, Business Consulting, and Project Management for their respective areas of responsibilities. These core information management competencies are required in all information management support organizations.

Architecture Components

The following essential components or building blocks of the DOE information architecture are used in the analysis.

☐ Business components

- Missions
- Organizations - Refer to part 3, appendix B, DOE Business Architecture - Organization Types, for a list of all organizations included in the analysis.

☐ Information technologies employed

- Hardware (including peripheral devices and operating systems)
- Software (including commercial-off-the-shelf (COTS) applications and utilities; middleware; database management systems; and system development, operation, and maintenance tools)
- Communications (including hardware, network operating systems, routers, multiplexors, and related software)

The analysis describes how architecture components are arrayed to support DOE missions and functions (the as-is system design). Many sites support multiple programs, locations, and information consumers.

DOE Information Architecture Model

Five-Layer Model

The DOE Information Architecture Model, shown on the left of figure 2-3, DOE Information Management and Planning Framework, has five subarchitectures that are similar to the tiers of the National Institute of Standards and Technology (NIST) Enterprise Architecture Model. The tiers have been tailored to the DOE business environment and current IM strategic goals. Figure 2-3 also shows the relationship of the DOE information architecture to the IM strategic goals.

Figure 2-3, DOE Information Management and Planning Framework

Each subarchitecture has a specific role in achieving IM strategic objectives; thus, there are direct links among DOE missions and goals, the information architecture, and the IM strategic goals. Each subarchitecture layer is a domain of similar resources and capabilities. The contributions of the subarchitectures are shown in table 2-2, Subarchitectures.

This analysis uses the DOE information architecture model to investigate the current baseline. Subarchitectures within a single architecture layer or at a specific site are not described. Each layer is detailed using concepts, analytical models, tables of data, or flow diagrams to convey its functionality. Some models and data tables also represent essential functions or relationships among the subarchitecture layers.

Subarchitecture Description

The DOE information architecture consists of the four lower subarchitectures that support the business subarchitecture in achieving organizational missions and program objectives (table 2-2, Subarchitectures). An organizationally independent view of the baseline architecture is obtained by examining the subarchitectures. The subarchitectures aid in defining and describing the data, applications, and technologies needed to support the enterprise in any organizational configuration.

Table 2-2, Subarchitectures	
Subarchitecture	Description
Business Subarchitecture	Defines the core business procedures and processes of the enterprise at any level necessary to provide the requirements for infrastructure.
Information Subarchitecture	Identifies the subject matter, facts, figures, pictures, and all other relevant knowledge necessary to support the enterprise's business 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 usable information.
Technology Subarchitecture	Describes the physical layer of the infrastructure that is required to support the processing of data into usable information where and when needed.

A representation of the program areas within the five-layer model is shown in figure 2-4, Program and Business Architecture Relationships.

Figure 2-4, Program and Business Architecture Relationships

Input and Feedback to DOE Information Architecture (IA)

Business Subarchitecture

The Business Subarchitecture Model, described in figure 2-5, defines the core business procedures and processes of the enterprise at the level necessary to provide the requirements for infrastructure. Unlike the other four subarchitectures, which are both physical and logical, the business subarchitecture is logical only. It is based on the business areas defined in DOE strategic plans with the organizational and programmatic structures defined previously in The DOE Enterprise section. Within this subarchitecture, information is created and processed locally, at intermediate business levels, and at the Departmental level. The physical expression of the business subarchitecture takes the form of entity business relationships.

Figure 2-5, Business Subarchitecture Model

Business Areas

The direction and leadership of the Department are represented within the Department's business areas (listed below), which were defined in DOE strategic plans. Missions and functions within DOE business areas are expanding, contracting, and changing concurrently and, from a site perspective, independently.

- ❑ **Economic Productivity.**¹ Goal: *Promote sustained U.S. economic growth that stimulates creation of high-wage jobs, diversity in research and development collaborations, technology transfer, efficiency and pollution prevention, and global DOE technology usage and exports.*
- ❑ **Energy Resources.** Goal: *Develop and deploy energy efficient and renewable energy technologies; advance the efficient and environmentally responsible production, transportation, and use of domestic fossil fuels and other conventional energy sources; create sustainable energy technologies with high export potential; promote an equitable system of energy supply and end use; and reduce U.S. vulnerability to energy supply disruptions.*
- ❑ **Environmental Quality.** Goal: *Protect public health and the environment by understanding and reducing the environmental, safety, and health risks and threats from DOE facilities and develop the technologies and institutions required for solving domestic and global environmental problems.*
- ❑ **Science and Technology.** Goal: *Unleash the Department's deep reservoir of scientific and technological assets and capabilities to perform world-class basic and applied research in commercial and national security arenas, which will advance U.S. security and economic productivity. DOE will continue to support a wide national science and technology portfolio that spans from the supercomputing initiative with its oil and gas exploration applications to advanced materials research with its automotive applications.*
- ❑ **National Security.** Goal: *Support and maintain a safe, secure, reliable, and smaller nuclear weapons stockpile without underground nuclear testing; dismantle excess weapons; and provide technical leadership for national and global nonproliferation to reduce the continuing and new nuclear dangers in the world.*

¹ The term Economic Development for one of the Department's business areas was replaced by Economic Productivity in the Secretary's Performance Agreement for Fiscal Year (FY) 1996. This agreement was signed by the President, the Secretary of Energy, and the Secretarial Officer for each Program Office. The term Economic Productivity is used in this analysis because it is the most official form of designation.

Enterprise Internal Management, an enterprise support function, accounts for the value-added integrated capabilities provided by the information architecture. Information architecture infrastructure is also considered an essential business activity because it allows communications between the other business areas and is the major interest of the baseline analysis.

Note: Enterprise Internal Management provides support to all business areas, including activities such as management oversight; policy, legal and regulatory compliance; program and project management; customer interface; planning; acquisition; budgeting; real property management; records management; administration; information management; financial management; public safety; and security. These business elements are continuing, inherent functions that apply to each core business area.

DOE organizations design business goals, programs, and projects to fulfill assigned missions. Program areas use tailored information architectures to achieve these goals and missions. At lower levels of program information architecture, interoperability, connectivity, and user accessibility are woven into the DOEwide information architecture. Common resources and capabilities that link all organizations into the enterprise comprise the infrastructure.

Leveraging the DOE information architecture requires the integration of business needs and technological capabilities. When developing an information architecture, business and information considerations outweigh information management considerations. Technology is a tool rather than a determiner of capabilities to be used. In the application subarchitecture layer, business and information management considerations carry comparable importance during design and maintenance. At the data and technology subarchitecture layers, technological considerations, such as interoperability, connectivity, user accessibility, reliability, security, and similar considerations, have increased importance. At these two lower layers, technology is selected and guided to match business objectives.

Business Subarchitecture Organizations

The Business Subarchitecture represents the Department-level view of all enterprise processes and functions that support the Department's missions and goals. Headquarters (HQ) programmatic organizations direct and administer the work of the Department. The Departmental structure also includes executive business offices, such as the Chief Financial Officer (CFO); Assistant Secretary for Environment, Safety and Health; Associate Deputy Secretary for Field Management; Assistant Secretary of Human Resources and Administration; and the Office of Worker and Community Transition. Some of these executive offices have functions that are supported by other Headquarters offices and field organizations. Because of their oversight responsibilities, the Headquarters offices are analyzed as unique sites within the Headquarters complex.

The nine organizational building blocks are listed in table 1-1, Organization Types. DOE organizations are categorized based on factors such as organization title, operational or programmatic purpose, geographical size, number of staff, and relative hierarchical position. Each organization type is intended to represent clusters of information technologies used to achieve a common business purpose. The Unified Budget Call (UNICALL) Supplemental data accounts for approximately 137,000 of the estimated 148,000 Federal and contractor employees supported by the DOE baseline architecture. The excluded Petroleum Reserves and Power Administrations account for remaining staff. A complete listing of organizations and their classification in the analysis is contained in part 3, appendix B, DOE Business Architecture - Organization Types.

Analysis shows a correlation between the organization type (with assigned missions) and available information technology. Field offices and laboratories, for example, differ in supercomputing and large-scale telecommunications responsibilities. The general association among the organization type, computing scale, and telecommunications capabilities is also analyzed in this volume.

Business Entity Relationship Maps

The DOE organization chart (figure 2-1) was used to develop maps that describe business relationships between DOE and external organizations. The template used for mapping business relationships among DOE organizations and identified external organizations is presented in figure 2-6, Business Relationship Template.

Figure 2-6, Business Relationship Template

The Information Architecture Team performed an analysis to identify the business relationships (but not the hierarchical relationships) of Headquarters, field organizations, and external customers and partners. The team used these business relationship maps to examine baseline technology capabilities and constraints among business entities. Since information technologies are employed to meet business requirements, the team identified user relationships and attempted to focus on the technologies employed to satisfy the users' business information needs. This approach allows identification of significant capability voids and deficiencies.

A business relationship map represents an organizational viewpoint for identifying other mission-related entities. An organization is specified and placed in the highlighted box in the center. Headquarters staff offices are placed within the larger box surrounding the specified organization. The types of relationships extend outward to other DOE offices, laboratories, and contractors then to external organizations. A business relationship is established by the annotation that the two entities exist on the same page; thus, if there is no relationship, the customer organization is not identified. A relationship between entities does not imply frequency, cost, or duration. The existence of a business relationship does not depend on the presence or some specified level of information technology capacity but, rather, the defined

potential for business action, activity, coordination, or communication. Infrequent potential interactions are not listed unless they could be critical to an organizational mission.

The DOE Headquarters business relationship map (figure 2-7, DOE Business Relationship Map) was developed in a drill-upward manner. Using business relationship maps from a sample of Headquarters offices and organizations classified as complexes, a composite business relationship map for the DOE enterprise was developed. The DOE business relationship map provides a business view of the information users supported by the DOE information architecture. In this mapping, it is apparent that DOE offices interact with different organizational levels within external organizations. For example, it is reasonable for the Secretary of Energy to communicate directly with the Secretary of Commerce or Health and Human Services. Other DOE offices interact directly with subordinate organizations within these Departments, which may be located in other geographic regions. The map demonstrates the ways in which the DOE business subarchitecture interacts with the business subarchitectures of customers, partners, and stakeholders. The business relationship maps for DOE staff offices and organizations are grouped in part 3, appendix A, DOE Business Architecture - Business Relationship Maps.

Figure 2-7, DOE Business Relationship Map

Information Subarchitecture

Within the Department, information is created and processed to serve the following primary business needs.

- ☐ Collaboration within program and business areas for which DOE is responsible or is a partner to external organizations. This collaboration includes research, development, and business area expertise utilization or information sharing of scientific and technological knowledge among DOE and its business partners.
- ☐ Executive direction, command, control, coordination, and documentation of DOE business activities.
- ☐ Information received from or made available to the public.

The information subarchitecture identifies the subject matter, facts, figures, pictures, and other relevant knowledge necessary to support the business of the enterprise, procedures, and processes.² The model used in the analysis is illustrated in figure 2-8.

Figure 2-8, Information Subarchitecture Model

Departmental Business and Information View

The information subarchitecture can be divided into three domains, source, throughput, and destination, which are described in the following sections. Each domain can consist of one or more of these information types: data, voice, imaging, and video.

² To date, a singular, all-encompassing information model does not exist. Given the changes occurring with the business subarchitecture, it is anticipated that new models, perhaps with greater detail, will emerge from redesigned processes and operations.

Source Domain

There are several methods for gathering, retaining, and categorizing data in the automated portion of the baseline architecture — database, electronic library, document management systems, bulletin boards, Home Pages, Internet, World Wide Web (WWW), gopher, file transfer protocol, and other special applications, such as online directory systems. Most manual processes are being converted to or are using available electronic methods; manual capabilities were not studied in the analysis.

The database, or information system, is the most popular for inputting current, live data at the Department and can be placed into three categories.

- ☐ Programmatic/mission-related
- ☐ Administrative
- ☐ Enterprise-supporting

A list of 122 functions and processes, which support Departmental information needs, was identified within the Business and Information subarchitectures. This list is included in part 3, appendix C, DOE Information Architecture - Functions and Processes.

Databases are repositories for much Departmental data. They support specific applications and interface with other related databases and information repositories. The System Review Inventory System (SRIS) categories identify types of data being captured. Additional detail is included in the Applications subarchitecture.

Throughput Domain

In addition to information systems, Compact Disc-Read Only Memory (CD-ROM) electronic libraries have become popular as information repositories. Currently, there is no centralized list of Departmental electronic libraries; no in-use CD-ROM authoring hardware or software was identified during this analysis.

Some internal electronic libraries contain data and can be considered information repositories; applications with search and retrieval capabilities provide access to other libraries. Electronic libraries are available on Internet, through wide/local area networks (WAN/LAN), or within special standalone applications. As an example, the Headquarters Energy Library has standalone electronic library capability, which is planned for network implementation, accessible by all Headquarters staff. The following information can currently be accessed through library services.

- ❑ ProQuest Business and General Periodicals services, on CD-ROM with images, are provided via the University Microfilm International (UMI) ProQuest system: General Periodicals Ondisc (GPO) and Business Periodicals Ondisc (BPO). Each database has multiple index disks for specific years. The GPO database contains abstracts and indexes of more than 1,000 general-reference publications. The BPO database contains indexes and abstracts of articles from more than 800 worldwide business and management journals.
- ❑ Online Library China Lake Catalog (CL-CAT) service is used to find materials by author, title, or subject.
- ❑ The Energy Technology Data Exchange (ETDE) Energy Database service consists of Energy on SilverPlatter, an international bibliographic database of 2.5 million records that cover energy technology, delivery, research, and use.
- ❑ Foreign Broadcast Information Service, provided by the Central Intelligence Agency, covers broadcasts from around the world and includes reports, analyses, trends, perspectives, and reviews.

Another popular data repository is a Document Management System (DMS). DMS uses include an electronic library, an electronic file cabinet, and a repository of special textual information. A DMS can create, store, retrieve, and manage current or static information at high speeds and can also be used actively for integrated document creation, review, and concurrence. The two most popular commercial DMSs in the baseline are PC DOCS OPEN and SoftSolutions. At present, no centralized list of DMSs used within DOE is available. DOE DMSs exist concurrently with SRIS and Microcomputer Application Systems Library (MASL) implementations.

Bulletin boards have also become popular as an information repository. Bulletin boards are available on special application software, local area networks, and the Internet. The DOE Bulletin Board System at Headquarters can be accessed through a dialup or networking mechanism. Departmental bulletin boards also exist on networks. No central directory of DOE bulletin boards is maintained.

Another information repository is the Internet, which can be used for browsing or interactive entering of information. Information on the Internet can be current or static. Many Departmental organizations have established interactive work groups (or electronic discussion groups) on the Internet to obtain information quickly. These groups include LISTSERV, Mail Reflector, Network News, and specially developed interactive services, such as the Pacific Northwest National Laboratory (PNNL) multimedia system for coordinating project team efforts and issues prior to meetings (<http://terrassa.pnl.gov:2080/tmt/home.html>).

Home Pages have been developed quickly and populated with information on the Internet. Most Home Page information is static and meant for browsing only. The DOE Home Page is bidirectionally linked to program and field site Home Pages, as well as those of other Government Agencies and organizations.

Other special applications for information gathering and retention include the following.

- ☐ Electronic commerce for processing small procurements (under \$25,000), grants application support, and hazardous waste application support.
- ☐ CallUp Departmental online locator system, which contains personnel information, such as telephone numbers and Internet addresses.
- ☐ Distance learning via the WWW being developed by PNNL and shared internally and externally (<http://terrassa.pnl.gov:2090/DQO/home.html>).
- ☐ Videoconferencing for exchanging and receiving ideas. Two notable initiatives in desktop videoconferencing are the Headquarters videoconferencing service available to all organizations and the Office of Environmental Management (EM) desktop videoconferencing service that is available nationwide to 14 sites that comply with the H.320 standard.
- ☐ Workgroup computing, such as Lotus Notes and PC DOCS OPEN, Network Scheduler for calendaring, high-speed interactive multimedia with Asynchronous Transfer Mode (ATM), and CallUp for addressing messages.
- ☐ Electronic mail, such as DOECast, for obtaining or providing enterprise information rapidly.
- ☐ Electronic forms for obtaining and receiving timely data. There is no centralized Departmentwide listing or repository of established electronic forms for sharing and data definition standardization. There is an electronic forms application designated for use within Headquarters. These may not be compatible with field sites or external customers.

Destination Domain

Distribution or output methods and destinations are the same as those under Source domain: information systems, electronic libraries, document management systems, bulletin boards, Home Pages, Internet, and special applications. Nonelectronic sources are still available, but these are gradually being placed on one or more of the electronic resources. Internet is becoming a popular vehicle for distributing information through the following services.

- ☐ File Transfer Protocol (FTP) allows the transmittal of larger files that would be cumbersome and time-consuming using regular mail systems.
- ☐ Gopher server is a menu-driven browser.
- ☐ Wide Area Information Server is similar to a gopher server that performs index searches rather than menu selection.
- ☐ WWW servers are able to receive and display text and images at the local desktop.

Network services can provide information in a variety of ways. Some examples of Departmental information are Orders, plans, reports, letters or memoranda, manuals, standards, guidelines, procedures, files, databases, graphs, forms, data feeds, and corporate integrated models.

Within DOE, electronic mail (E-Mail) messages and attachments can be distributed to multiple recipients who individually store and retransmit the same information to others. These redundant messages consume storage space and transfer capacity throughout the baseline. E-Mail alternatives that provide pointers to single messages and attachments from anywhere within DOE could not be identified in the baseline.

DOE Information Products

The following examples of Information Subarchitecture products are identified in the baseline.

- ☐ Source data and documents
- ☐ Aggregated data and information
- ☐ Summarized data and information

- ☐ Information selected for use in decision documents
 - Internal planning, status, and tracking
 - Enterprise performance
 - Customer and public communications
- ☐ Reports about aspects and activities not yet contained within the information architecture (e.g., physical library materials, plans, undocumented conferences and phone calls, messages, ongoing events)
- ☐ Reprocessed reports and republished source data and information
- ☐ Copies of externally generated data and information
- ☐ Extracts and tabular references about available or planned information products

The following information product schema was used in the analysis.

- ☐ Paper-based data and information
- ☐ Primary data or drawings
- ☐ Processed data and text (entered, edit checked, math treatments, filed)
- ☐ Initial product-processed information
 - Aggregation of numeric data, summary of text
 - Initial interpretation of data and basic text and drawings
 - Initial summarization or impact evaluation
 - Distribution (to file or others) and archival
- ☐ Subsequent product-processed information purposes
 - Aggregation
 - Interpretation of aggregated information
 - Impact summarization
 - Document preparation
 - Distribution (primarily to others) and archival
 - Action assignments leading to decision making and tracking
- ☐ Summarization and widespread distribution

Information Consumers and Users

Information used within DOE can be divided into three broad groups.

- ☐ Scientific computing information for analysis and simulation within program areas
- ☐ Information related to management, coordination, and direction of DOE activities at and among all levels
- ☐ Information about the status and performance of the technology infrastructure that supports the other two groups

The organizations engaged in information exchange activities (figure 2-7, DOE Business Relationship Map) and other business relationship maps are presented in part 3, appendix A, DOE Business Architecture - Business Relationship Maps. The analysis does not document the 13 technology capabilities for each organization type with its information consumers in the business relationship maps; however, there is a flow of information up, down, and throughout DOE spheres of activity. The frequency, duration, and types of information processed are business-driven and require sufficient capacity and reliability to support a large number of daily interactions required by the 122 functions and processes identified in part 3, appendix C, DOE Information Architecture - Functions and Processes.

In the complex information environment, there are few permanent distinctions between real-time information needs of collaborative workgroups and management requirements for visibility of progress and status. The work-performed dynamic drives the progress-tracking dynamic. The current baseline analysis focuses on interoperability, connectivity, and user accessibility for these information consumers and users without regard for real-time or static information processing requirements.

Information Systems

Figure 2-9, SRIS System Categories, lists the categories and interpretations for approximately 850 UNICALL-reported DOE systems and applications. *Note: For ease of understanding, the analysis uses the existing term system. The list of systems includes desktop data repositories, data imbedded within application shells, and standalone applications, as well as corporate systems, which may or may not support enterprisewide activities.* For information on SRIS system and data constraints, refer to part 3, appendix F, Information and Application Subarchitectures.

Figure 2-9, SRIS System Categories

Finance and Accounting - Data for the systematic recording, classifying, summarizing, and reporting of financial information; and control and management functions, such as property, travel, funds control, accounts receivable, accounts payable, general ledger, cost accounting, payroll, finance, and audit. This category accounted for 14.8 percent or 94 information systems.

Administration - Data that support administrative activities in all DOE organizations, such as automated data processing equipment inventory, correspondence and action control, records and documents, communications, library/bibliographic, plants/land/buildings, Government organization/manpower/personnel, contractor organization/manpower/personnel, equipment/materials/supplies, transportation, health and safety, mail, and other lists. This category accounted for 37.1 percent or 328 information systems, the largest percentage evaluated.

Budgeting - Data that provide information to develop, maintain, and monitor long-term plans. Data are available normally for a 2-year or longer timeframe and include items such as Congressional year, budget formulation, and budget execution. About 4.4 percent or 39 information systems are in this category.

Executive - Data that provide information to DOE Secretarial Offices to achieve broad strategic goals and administer Departmental operations. This data generally contain multiple types of information (e.g., project, accounting, and procurement, including policy and execution management). Only 1 percent or 9 information systems are in this category.

Operations - Data that provide the broad range of information needed for the management of DOE operating organizations. These data require multiple information types (e.g., budget, accounting, and personnel data). About 7.2 percent or 64 information systems are accounted for in this category.

Planning - Data that provide information needed by DOE organizations for the development and maintenance of management plans, such as short-range and long-range plans. Only 2 percent or 19 information systems are in this category.

Procurement - Data that provide information needed to prepare, execute, and monitor contracts, purchase orders, grants and other awards (e.g., other financial assistance agreements), supplies/vendors, proposals/solicitations, and property management. About 8.2 percent or 73 information systems are used for this purpose.

Project Management - Data that support activities for planning and executing projects by outlay programs (e.g., proposal tracking), project assignment, and project monitoring. About 3.9 percent or 34 information systems are in this category.

Program and Management - Data that provide information for managers to accomplish program responsibilities. These systems generally require multiple data types (e.g., budget, accounting, and procurement data, including policy and execution management). About 7.6 percent or 67 information systems are used for this purpose.

Records Management - Data that provide records management information. About 3.6 percent or 32 information systems are in this category.

Safeguards and Security - Data that provide requirements information for protection of classified and unclassified facilities, material, and information. About 3.6 percent or 32 information systems are in this category.

Special Purpose - Data that provide information needed for managing specialized operating or staff functions (e.g., equal employment opportunity, public information, regulatory subarea, and other subareas). About 6.6 percent or 59 information systems fall in this category.

Applications Subarchitecture

The applications subarchitecture translates information requirements into an automated set of systems or applications that provide direct support to business processes. Another way to describe the information architecture is in terms of the purposes or functions of applications already developed to serve information users. A review of SRIS data, which excludes plant manufacturing, scientific and engineering applications, and test site management computer applications, is provided in part 3, appendix F, Information and Application Subarchitectures.

Custom applications, developed using application shells, as shown by SRIS and MASL, provide a capability to incorporate local requirements into standard systems, identify candidates for consolidation or elimination, and relate mission-essential and other applications to the business subarchitecture, processes, and functions.

SRIS contains approximately 600 DOE application systems of which approximately 258 systems operate at Headquarters. An analysis of database management shells, applications, and related platforms is provided in the part 2, Baseline Analysis section of this volume. The detailed list of SRIS, MASL, and other applications supported by each of the nine organization types is presented in part 3, appendix F, Information and Application Subarchitectures. A SRIS keyword search was performed, and the following results report systems by keyword.

Table 2-3, SRIS Keyword Search	
Keyword	Number of Hits
Document	143
Equipment	93
Action	120
Personnel	134
Budget	91
Schedule	57
Account	154
Plan	213

Table 2-4, Headquarters Application Baseline Business Areas, describes the Headquarters application baseline by the five business areas identified within DOE strategic objectives. The analysis was originally published in the document, Trends in Information Management at DOE Headquarters, May 1994, and was the result of the UNICALL Supplemental data collection. Less than two-thirds of DOE sites responded to this request, one-third did not respond or presented consolidated data for more than one site, and some sites did not update their information.

Table 2-4, Headquarters Application Baseline Business Areas		
Business Area	Number of Systems	Percentage
Environmental Quality	65	25%
Energy Resources	1	-
Economic Productivity	71	28%
National Security	54	21%
Science & Technology	67	26%
Total	258	100%
<i>Note: The number of systems shown in this table is limited due to a lack of ownership designation of current systems in tracking databases. The problem of ownership is further compounded by changes of organization names and missions.</i>		

The analysis of existing, widely used systems was limited to systems required for conducting DOE business. Twenty significant systems were identified from UNICALL Supplemental data. The following criteria were developed to assess which systems could be classified as corporate systems for the Department as an enterprise.

Note: Each business unit (e.g., field site, office, or program area) may have one or more of these systems in use. Other operational and administrative systems not on this list may satisfy unique local business unit needs.

- ☐ Corporate systems have DOEwide impact and are not limited to use within Headquarters.³
- ☐ Designated users at field sites and Headquarters offices can view data in systems and generate reports.

³ Since completion of this analysis, several important systems such as the CFO Travel Management System, Office of Policy Strategic Management System, SOLOMON Performance Measurement/Evaluation Information System, and DOE Career Counselor System have been adopted.

- ☐ Data in reports are provided to other Federal Agencies (e.g., Department of the Treasury, Internal Revenue Service, Office of Personnel Management, etc.).

Using these criteria, 13 of the 20 systems identified from UNICALL Supplemental data were classified as corporate systems. The remaining seven systems were classified as external systems (i.e., not accessible by the field and used primarily by Headquarters). Table 2-5, Significant DOE Business Systems, identifies the 20 systems by class (corporate or external), platform, and primary and secondary functions (major and submanagement areas supported by the software, such as accounting, budget, etc.). The majority of these systems perform accounting and administrative business functions and were developed by DOE or DOE contractor personnel.

Table 2-5, Significant DOE Business Systems					
Information System Name	Acronym	System Class	Platform	Primary Functions	Secondary Functions
1. DOE Payroll and Personnel System	*PAY/PERS	Corporate	IBM ES 9021-500	Finance and Accounting Administration	Payroll Government Organization, Manpower and Personnel
2. DOE Integrated Security System	*DISS	Corporate	**IBM ES 9021-500	Safeguards and Security	Personnel
3. Energy Manpower Personnel Resource Information System	*EMPRIS	Corporate	IBM ES 9021-500	Administration	Government Organization, Manpower and Personnel
4. Funds Distribution System	*FDS	Corporate	IBM ES 9021-500	Finance and Accounting Administration	Payroll Government Organization, Manpower and Personnel
5. Procurement and Assistance Data System	*PADS	Corporate	IBM ES 9021-500	Procurement	Contracts
6. Finance Information System	*FIS	Corporate	IBM ES 9021-500	Finance and Accounting	Finance

Table 2-5, Significant DOE Business Systems					
Information System Name	Acronym	System Class	Platform	Primary Functions	Secondary Functions
7. Government Owned Contractor Operated Employment System	*GOCO	Corporate	IBM ES 9021-500	Administration	Contractor Organization, Manpower and Personnel
8. Foreign Visits and Assignments System	*VAMS	Corporate	IBM ES 9021-580	Executive	Executive Management
9. EM Progress Tracking System	EMPTS	Corporate	Client/Server DEC ALPHA	Project Mgmt	Project Monitoring
10. Departmental Training Information Systems	DTIS	Corporate	IBM ES 9021-500	Administration	Government Organization, Manpower and Personnel
11. Online Locator System/Callup	OLS/ CALLUP	Corporate	IBM ES 9021-580	Administration	Communications Government Organization, Manpower and Personnel Contractor Organization, Manpower and Personnel Mail and Other Lists
12. Management Analysis Reporting System	MARS	Corporate	HP 3000-992/200	Finance and Accounting	Finance
13. Occurrence Reporting and Processing System	ORPS	Corporate	IBM ES 9021-500	Administration	Health and Safety
14. Labor Distribution System	*LDS	External	IBM ES 9021-500	Finance and Accounting	Cost Accounting

Table 2-5, Significant DOE Business Systems

Information System Name	Acronym	System Class	Platform	Primary Functions	Secondary Functions
15. Nuclear Waste Fund System	*NWFS	External	IBM ES 9021-500	Finance and Accounting	Finance
16. Consent Order Tracking System	*COTS	External	IBM ES 9021-500	Finance and Accounting	Finance
17. Departmental Integrated Standardized Core Accounting System	*DISCAS	External	HP 3000-992/200	Finance and Accounting	Finance
18. Weapons Data Access Control System	*WDACS	External	IBM ES 9021-500	Safeguards and Security	Personnel
19. Industrial Relations Reporting System	IRRS	External	IBM ES 9021-500	Finance and Accounting	Contractor Organization, Manpower and Personnel
20. Property Accounting Management System	*PAMS	External	IBM ES 9021-500	Finance and Accounting	Property
<p>* These systems are reported to be Major DOE Information Systems in response to Office of Management and Budget (OMB) A-130 guidelines. The DOE backbone communication net is a primary means for transferring information among these systems and field sites. It also allows for remote applications and similar distributed processing or distributed data functions.</p> <p>** As of August 1996, this system is being converted to a client/server platform configuration.</p>					

Many of these systems operate on mini or mainframe computers. The growth in desktop computing capabilities has resulted in numerous desktop applications and repositories. To obtain information on the uses and numbers of desktop business applications, a MASL survey was performed. Many of these desktop applications generate input to or extract data from larger systems for subsequent business use.

Within Headquarters, MASL is used to maintain active and inactive applications code and documentation developed for desktop users. MASL contains 131 active systems in 18 categories. A MASL keyword search was performed, and the following results report systems by keyword.

Table 2-6, MASL Keyword Search		
Application Category	Number of Systems	Percentage of Systems
Tracking	67	51%
Action	25	19.1%
Budget	9	6.9%
Contract/Proposal	9	6.9%
Data Communications	6	4.6%
Development Utilities	8	6.1%
Document Management	15	11.5%
Equipment	10	7.6%
Finance and Accounting	16	12.2%
Health/Safety/Environment	3	2.3%
Mailing and Labels	6	4.6%
Office Management	15	11.5%
Operations	1	0.7%
Personnel	21	16%
Procurement/Requisition	8	6.1%
Project Management	9	6.9%
Security	1	0.7%
Travel	5	3.8%

Nearly one-half of the 131 applications provide tracking assistance. The overlap between SRIS and MASL tracking could not be determined, but the need for reentry of data among applications appears to be excessive. The requirement for six mail/label applications appears redundant when there are alternatives within office automation programs or commercial applications. Twenty-one desktop applications for personnel seem excessive when a corporate system (PAY/PERS) exists. Eight applications for tracking Headquarters procurement actions and

requisitions are redundant. The applications and systems in use encourage redundant and inefficient data creation and maintenance.

Data Subarchitecture

The data subarchitecture identifies structure, definitions, and storage needs of the business entities, objects, and elements that allow the processing of data into usable information. As with the other subarchitectures, the data subarchitecture overlaps or influences other subarchitectures but remains unique. Although data can include documents and images, the focus is on information systems, where most Departmental data is encapsulated. Components of the data subarchitecture include data dictionary; file structure; programming language; storage capacity, access methods, medium, and techniques; backup and recovery; integrity; and data security.

The data subarchitecture as shown by the analysis of the applications subarchitecture suggests that information is either managed at the user's desktop (not accessible by others) or centrally managed and controlled (not easily downloaded into user-defined data sets). A summary of the database management systems (DBMSs) is provided in part 3, appendix G, Database Management Systems. No Departmentwide data subarchitecture could be identified during this analysis.

Technology Subarchitecture

The technology subarchitecture describes the physical layer of the infrastructure required to support the processing of data into usable information where and when it is needed by the enterprise.

Information Technologies

The baseline analysis identified 13 major categories of DOE information technologies (table 1-2, Information Technology Related Categories). Using these categories, three analytical technology models were developed to help describe the current baseline.

- ☐ DOE Computing Hardware Technology Model
- ☐ DOE Computing Software Technology Model
- ☐ DOE Data Telecommunications Technology Model

DOE Computing Hardware Technology Model

The hardware technology model is shown in figure 2-10, DOE Computing Hardware Technology Model.

Figure 2-10, DOE Computing Hardware Technology Model

Seven types of platforms were identified for the analysis.

Computing Platforms

- Type A Business desktop and portable laptop computers, such as Intel-based or Macintosh personal computers (PCs)
- Type B Scientific and technological workstations, such as UNIX-based desktop platforms and Sun workstations
- Type C Dumb terminals

Large Computing Platforms⁴

Type W Business Machines

Table 2-7, Type W Systems			
Manufacturer	Model	Manufacturer	Model
HP	9000/560	HP	955
HP	3000/48	IBM	9377/90
CDC	Cyber 830	DEC	VAX-8500
DEC	VAX-8300 VAX-11/785	IBM	4381-12
IBM	4361/5	DEC	VAX-8600
IBM	4341-12	IBM	4381-R13
WANG	VS 300/9	DEC	VAX-8650
HP	3000/68	DEC	VAX-8700
HP	3000/70	IBM	4381-R23
DGC	MV10000	DEC	VAX-6230
PRIME	9955	DEC	VAX-8550

⁴ Refer to the FY 1993 - FY 1997 Information Resources Management Long-Range Plan, February 1992, pages D-3 through D-7 for a detailed explanation of the basis for this classification.

Type X Large Business Machines

Table 2-8, Type X Systems			
Manufacturer	Model	Manufacturer	Model
IBM	9000-170	IBM	3090/180
IBM	3083E	HDS/NAS	AS/9080
CDC	Cyber 170/855	IBM	3084QX
DEC	VAX-11/780 + FPS-164	AMDAHL	5890-200E
IBM	3083J	UNISYS	1100
IBM	3090-150E	IBM	3090-180E
CDC	Cyber 170/875 (Dual)	IBM	3081K
CDC	Cyber 180-990	IHDS/NAS	AS/8053

Type Y Supercomputers

Table 2-9, Type Y Systems			
Manufacturer	Model	Manufacturer	Model
CVX	Convex C1XP	CRI	Cray X-MP/28
SCS	40/14	CRI	Cray 2
CRI	X-MP/14	CRI	Cray X-MP/416
CRI	Cray X-MP/24	CRI	Cray Y-MP/8-128

Type Z Massively Parallel Platforms

Servers

Type A Server Limited capacity server for use in small local offices.

Type B Server Large capacity server for applications, databases, and telecommunications for support of high-volume information-sharing requirements.

DOE Computing Software Technology Model

The baseline software model is shown in figure 2-11, DOE Computing Software Technology Model.

Figure 2-11, DOE Computing Software Technology Model

The software model consists of COTS and custom-developed applications for all platform types, platform operating systems, utilities and associated development applications, and network operating systems (e.g., LAN, WAN/metropolitan area network (MAN), and Global) and utilities. Some applications such as E-Mail, electronic forms, and security may be so basic in a corporate system that they can be considered integrated subsystems.

DBMSs include flat, integrated, hierarchical, and relational file structures and operate on various site hardware platforms and operating systems in mainframe and desktop versions.

Interface software includes middleware products executing on standalone platforms, such as application interface (API) and data interface (Object Linking and Embedding [OLE] or Dual Data Environment [DDE]). Interfaces also include products for network access, switching, and transmission, such as Transmission Control Protocol/Internet Protocol (TCP/IP), Sequenced Packet eXchange/Internet Packet eXchange (SPX/IPX), and Internet Protocol (IP).

There is an increasing use of groupware, which is software designated for use in collaborative environments, such as office automation, computer-aided software engineering (CASE), and decision-support systems. Examples include Lotus Notes and the Document Online Coordination System (DOCS), a document management system.

DOE Telecommunications

Figure 2-12, DOE Telecommunications, identifies three types of telecommunications networks (data, telephone, and wireless) used within DOE, four types of information (data, voice, imaging, and video) transferred over these networks, and two types of ownership (Service Providers and Government-Owned) for these network capabilities.

Figure 2-12, DOE Telecommunications

Network capabilities are portrayed in figure 2-13, Network Technologies. This figure shows the diverse telecommunications technologies used to transfer information Departmentwide.

Figure 2-13, Network Technologies

DOE Data Telecommunications Technology Model

This model presents examples of DOE-owned and vendor-furnished telecommunications hardware and services that support DOE worldwide activities. The data transfer portion of this model is presented in figure 2-14, DOE Data Telecommunications Technology Model.

Figure 2-14, DOE Data Telecommunications Technology Model

Two workstations or a host mainframe (1) at a location generate messages or data to be delivered to a remote location. The workstations connect to a LAN through circuit attachments with coaxial cable and internal or external transceivers. The host connects through larger networks to provide wide area service.

The workstation connections combine through a concentrator (2), which merges the different data inputs and manages access to the LAN (3) system. In DOE, LANs are usually local, Ethernet-based, using Carrier Sense Multiple Access with Collision Detection (CSMA/CD).

LAN data can be directed via the addresses assigned to each packet, either through a Dedicated Transmission Service (DTS) line (4) into the telecommunications company (TELCO) network (domain) for direct delivery by a predetermined circuit or transported by devices of varying sophistication and intelligence (bridges, routers, or bouters) (5) to a larger MAN (6).

Host mainframe machines may be connected to the MAN for client/server applications or routed into a WAN (7). Within the TELCO domain (8), passing of data is accomplished by multiple connections among different classes and service providers (Sprint to AT&T or C&P to FTS2000). Services are charged and classed based on DTS lines, MAN connections, or long-distance delivery via WAN cross-country connections.

Special arrangements can be made to route messages from the TELCO service provider to overseas destinations. Internet connections at Princeton University, Fermi National Accelerator Laboratory, and Lawrence Livermore National Laboratory, for example, manage the global traffic in TCP/IP protocols (9). Global messages to 102 countries using the open systems

interface (OSI) suite of protocols are converted, for example, to the X.25 format via a Packet Assembler/Disassembler (PAD) (10) and sent to foreign X.25 public networks (11). This process allows communication with any authorized DOE official on foreign travel.

Once the TELCO has delivered the message to the proper location, the above procedure can be repeated. TELCO system delivery via local routers is sent to small interconnected networks of LANs, MANs, or possibly back to a WAN (12).

Telecommunication occurs over circuits. Individual circuits serve as threads of connectivity. The basic thread types are shown in figure 2-15, Baseline Network Architecture Thread Model. No traffic analysis or routing studies were performed in this analysis.

Figure 2-15, Baseline Network Architecture Thread Model

Findings and Conclusions

This section presents the specific findings of material summarized from part 2, section 5, Findings and Conclusions, of the Baseline Analysis. They are analyzed in 14 focal areas, which represent topic groupings of management interest. The analysis was guided by a series of questions related to these focal areas for the technologies and organization types included in the baseline. These detailed questions, which are presented in part 2, section 5, Findings and Conclusions, of the Baseline Analysis reflect major areas of interest as demonstrated in project teams, information requests, and long-range planning activities. To enhance consistency and interpretation, the individual findings are displayed in a graphic (slider).

Each focal area is summarized two ways. Opportunities for improvement are highlighted in bold, italic text. A visual architecture status and a subjective estimate of movement direction within the baseline for important findings are presented in the form of a slider bar. Each slider bar has three status levels. Each slider button is color-coded. Directional movement is indicated with an arrow. A slider bar without an arrow indicates a stable condition where no movement is anticipated. Subjective designations of favorable, marginal, and unfavorable are assigned to each slider topic as a way to place the indicated aspect into the context of the entire architecture.

The detailed findings, presented in part 2, Baseline Analysis, provide a basis for the conclusions presented at the end of this analysis summary.

Focal Area 1: Functional Duplication and Redundancy of Departmentwide Information Systems

Unnecessary duplication of systems and processes exists at the local, intermediate processing, and corporate system levels. Direct support of these systems can be reduced or eliminated if Departmental business processes are analyzed, business systems guidelines developed, and site-oriented workflow process analyses performed. *Appropriate, commercially obtained applications are available and, if adopted, can enable information to be standardized for faster processing at a reduced overall lifecycle cost.* Specific positive examples of business processes being driven by systems guidelines include the following.

- ☐ Office of Policy Strategic Management System (SMS) and the SOLOMON Performance Measurement/Evaluation Information System
- ☐ Office of Environment, Safety and Health reporting systems
- ☐ Chief Financial Officer Department of Energy (DOE) Travel Manager System
- ☐ Office of the Executive Secretariat Document Online Coordination System (DOCS)
- ☐ Initiative to adopt a single electronic signature standard

No Departmentwide data architecture program or structure was identified during the analysis. The diversity of information types needed to support collaboration among science and technology subject areas to geographically dispersed users requires data structure design discipline. The collection, storage, retrieval, and transmission of information among sites, especially for corporate systems, require data architecture coordination and configuration management of data origination and consolidation activities. The use of desktop applications, such as xBase or spreadsheets, to collect and translate or convert data formats significantly increases the costs and delays of data reuse. Reengineering applications and interdependent data files are appropriate once data-sharing needs have been identified and a data architecture approach to support users has been established. *The effects of uncoordinated Year 2000 application modification on database conversions will be experienced throughout the baseline unless strategies for replacing obsolete applications or requiring existing information systems to comply with Federal Information Processing Standards Publication (FIPS Pub) 4-1, Representation for Calendar Date and Ordinal Date for Information Exchange, are applied. Clearly, data management and data architecture configuration management guidelines are required to improve user accessibility, data sharing, and reduced data entry and maintenance prior to deploying new systems and initiating broadly based applications-reengineering efforts.*

Focal Area 1

- Functional Duplication and Redundancy of Departmentwide Information Systems

- Hardware Redundancy

- Systems Redundancy

- Data Duplication

Focal Area 2: Impact of Expanded E-Mail Use Departmentwide

The lack of integrity of basic messages and attachments sent and received across the enterprise is the greatest electronic mail (E-Mail) problem. Efficient transfer is inhibited by desktop platform and software capacity, installed or legacy software, bandwidth, connectivity problems, and document exchange protocols. The recent Headquarters adoption of Simple Mail Transfer Protocol/Multipurpose Internet Mail Extension (SMTP/MIME) and X.400 file attachment standards is an important step in efficiently distributing typical business documents within DOE. ***A Departmentwide initiative, using a single procurement vehicle to provide increased commonality and a less costly Departmentwide license fee, can provide a suitable starting point. Objective measurements of E-Mail transfer, receipt, and storage for the entire Department are not available.*** E-Mail information is stored on desktop hard drives and office, site, and Internet servers. ***E-Mail file space could grow by 1Mb to 3Mb per month per user, even with periodic file elimination. As workgroup practices increase, the number of E-Mail file copies distributed (and associated storage requirements) can also be expected to increase.***

An opportunity to create and implement a methodology for the integration of Departmentwide directory services exists. Consolidating to a single format will provide DOE and contractor personnel seamless interconnectivity and the ability to locate anyone Departmentwide. Even if a single format is adopted, users will continue to require local control and access to the directory contents.

Departmentwide leadership, policy guidance, and assistance to steward these important process-enhancing technologies within the information architecture are clearly warranted.

Focal Area 2

- Impact of Expanded E-Mail Use Departmentwide

- E-Mail Capability Deployment Maturity

- Attachment Transfer Capability

- Typical Shared Electronic Format Frequency

- Message Storage Volume

- Interoperability within Sites

- Interoperability between Sites

Focal Area 3: Internet Connectivity

Home Page use is growing, but there has been little analysis to determine lifecycle cost and staff/training requirements for actively updated pages. ***Policy and guidance regarding the use of the Internet and World Wide Web (WWW) for information access and dissemination in a Distributed Computing Environment (DCE) should be promulgated. There is an immediate opportunity for this leadership to be provided by the Chief Information Officer (CIO).***

Firewall software is experimental until confidence is gained in ability to perform as advertised. Most firewalls are based on a separate and standalone design approach. Most sites having firewall software do not trust offsite access to systems because they cannot be assured that firewalls installed elsewhere are effective. ***Significant opportunity exists for guidance on firewalls and their implementation throughout the Department.*** It has been suggested that firewall technology could be leased so that all business units could be upgraded easily as technology and threats change.

Focal Area 3

- Internet Connectivity

- Inter-Business Unit Connectivity

- Connectivity Traffic Volume Frequency

- Inter-Business Unit Firewall Integration

Focal Area 4: Unclassified Security

Classified information systems protection is relatively mature. Unclassified information systems protection, including firewalls, cellular phone interception, and Internet and WWW capabilities, is immature. For example, Pretty Good Privacy (PGP) algorithms are not certified for use and Data Encryption Standard (DES)-based algorithms are still evolving. There are numerous initiatives to apply personal certification techniques from the secure systems environment to the unclassified information environment. Examples include electronic commerce applications, publications transmittals, and routine office applications (such as timecards, leave requests, travel documents, and procurement documents). Use of distributed authentication/digital signatures is expected to increase in financial and electronic commerce/electronic data interchange applications once standards and protocols are established. A related enabling technology, Smartcards, is now in an experimental stage at several larger sites. These applications include access control and transaction-level financial data capturing within an unclassified (and perhaps public) information environment.

These technologies (e.g., distributed authentication/digital signatures and Smartcards) provide significant opportunities to streamline current information processes and exploit the capabilities inherent in the baseline. The need for continuing DOEwide guidance in this area is apparent, especially for prototyping and testing various security measures and features.

Focal Area 4

- Unclassified Security

- Digital Authentication and Digital Signature Uses

- Smartcards (Secure Authentication) Uses

- Security of Routine Business Information

- Routine Business Data Accessibility

Focal Area 5: Standardization Strategies

Several platform technology strategies that offer opportunities for cost comparisons and analyses of the effectiveness as employed at sites were identified. These strategies involve converting proprietary mainframe systems to open-system client/server architectures, using open systems to develop parallel processing architectures, and replacing obsolete supercomputer architectures with client/server or other architectures based on use of open systems technology components. ***The thrust of these changes in the Department's technology subarchitecture is toward increasingly open systems and indirectly toward increasing standardization within client/server computing.***

There were seven graphical user interface (GUI) designs in the baseline: MS Windows, MS Windows NT, Macintosh, Presentation Manager, Motif, Open-Look, and NeXTStep. Of these, MS Windows, MS Windows NT, and Macintosh are becoming more prevalent within the baseline. These initiatives provide the opportunity to collect information on costs and performance, which can assist in evaluating reengineering alternatives. ***DOE is employing more data-intensive (central processing unit (CPU) cycle and storage-device-dependent) applications,*** such as computer-aided drafting and design; simulations; and experimental models for climatic, biological, and physics-based research. DOE is also using statistical and simulation models to evaluate the reliability and validity of results from partners and other researchers. ***Connectivity of the national laboratory framework needs to be flexible and universally accessible within the Department to ensure the highest degree of efficiency.***

Focal Area 5

- Standardized Strategies

- Standardization Approaches Employed

- Open Systems Implementation

- Business Unit Client/Server Adoption Frequency

- Formal Business Process Reengineering Frequency

- Middleware Interoperability Implementation Frequency

Focal Area 6: Departmental Procurement Opportunities

Relatively few Departmentwide products or techniques have been designated as DOE-standard.⁵ System Review Inventory System (SRIS) data suggest that inhouse development is directed at corporate systems and processes, infrastructure adaptation, and multi-user application utilities for large-scale applications. ***Commercial-off-the-shelf (COTS) solutions, such as Lotus Notes and DOCS, are available for replacing custom-developed administrative applications with long-term cost savings. The reduction in configuration management and data interchange difficulties would enable inhouse capabilities to focus on higher value services.***

Sites are using several versions of local area network (LAN) software because funding limits simultaneous procurement of packages for all users. Sites must also manage the complexity that multiple versions from a single supplier place on systems. Sites also use different LAN vendor products with DOS, MS Windows NT, OS/2, and UNIX operating system environments. ***A consolidated LAN software procurement opportunity exists.***

Similar problems exist with word processing, integrated office applications, virus detection programs, file and disk compression software, graphics applications, and database management systems (DBMSs). The movement to client/server configurations shows an increased use of COTS shells. New development is clearly aimed toward integrating capabilities rather than creating basic applications from scratch. ***Migration may be slowed by financial constraints, and consolidated procurements of tool suites may be an effective means to resolve these challenges.*** The recent proposal to acquire and support a full tool suite for Headquarters deserves serious consideration.

Many software applications and tools could be made more affordable and supportable if they were available from a reasonable range of producers/vendors under a Departmentwide procurement. The total estimated savings of a selective information architecture upgrade program is \$30-50 million (constant dollars) over 5 years after contract award.

⁵ The 1996 Information Management Planning and Architecture Coordinating Team (IMPACT) IV Vision Information Architecture meeting in Santa Fe, New Mexico, identified approximately 150 candidate standards for common use within the Department.

Focal Area 6

- Departmental Procurement Opportunities

- Urgency for Improved Data Storage Hardware

- Urgency for Improved Database Management Software for Data Sharing

- Need for Improved System and Information Engineering Tools for Increased System Effectiveness

Focal Area 7: Business Relationships and Technical Approaches

Technology capabilities and business needs are interwoven within the Department. Significant opportunities exist to leverage information technology using an architectural approach. The baseline has built-in design assumptions and limitations about information processing that may be out-of-date and inefficient with current technology. The recent partnership between the Office of Energy Research and the CIO to initiate enterprise architecture development is an important step toward integrated and redesigned architectures.

The frequencies, durations, and types of information being processed among the nine organization types are business-driven and require sufficient capacity and reliability to support a large number of daily interactions. *The volume of shared or exchanged information is large and growing*; for example, one laboratory has over 3,000 external sites on its Internet information server, and, in a recent 6-month period, the number of external accesses doubled to 65,000 per month. *The use of standalone systems with existing design limitations inhibits increased information sharing and evolution to data warehouses and executive information systems.*

There is an opportunity to map many aspects of the corporate information base and the various business information requirements so that the required data and information flow can be streamlined and more easily used. Over 77 different types or brands of DBMSs were identified in the baseline; this variety of format is a significant deterrent to making information universally available.

Technological capabilities are changing the information exchange patterns of workgroups. For example, *there are few distinctions between real-time information needs of collaborative workgroups and slower information exchanges through publications.* Business requirements drive technology choices, investment decisions, and technology usage. *The growing use of workgroup applications, such as Lotus Notes and data warehouse applications, suggests that more workstations are calling upon larger data sets and performing targeted analyses at widely separated sites.* The baseline lacks essential directories and information repositories to allow offsite users, for example, to access specific information. Groupware also provides opportunities to improve data accessibility and business processes without reliance on standalone systems and applications.

DOE business is driving the Department toward highly flexible network systems. The expanded range of applications (e.g., multimedia, videoconferencing, distance learning, simulations from remote terminal locations, and images) imposes increased telecommunications bandwidth requirements. No assessments of cumulative loads and projected bandwidth to continue infrastructure support were available.

Focal Area 7

- Business Relationships and Technical Approaches

- Document Management System Integration

- Information Exchange Mode

- Sites and Business Areas Alignment

- Departmentwide Alignment

Focal Area 8: Benchmarks in Technology

DOE best practices and benchmarking activities are in the initiation phases. Some field organizations have practices and benchmarking initiatives that are more mature than those found elsewhere in the Department. The absence of established guidelines for best practice and benchmark affinity groups, directory of subject area experts, and a repository for sharing peer group experiences and benchmarks inhibits the speed and cost effectiveness for maturing this strategic initiative.

Much of the progress toward interoperability is attributable to the existence of core capabilities, such as DOE networks, local site initiatives, and individual information management staff members cooperating among sites on an issue-by-issue basis. In contrast, the electronic commerce and videoconferencing initiatives demonstrate how cooperation can deliver useful Departmentwide technology capabilities. ***A business process analysis is needed to determine major electronic commerce/electronic data exchange requirements and establish performance measures or benchmarks.***

Focal Area 8

- Benchmarks in Technology

- Best Business Practices Adoption Frequency

- Information Architecture Baseline Benchmark Monitoring Frequency

- Program Area Hardware Benchmarking Frequency

- Program Area Software Benchmarking Frequency

Focal Area 9: Migrations Toward Advances in Technology

Workgroups, especially at laboratories, operations offices, and complexes, are becoming the focus for adopting new technologies in storage and retrieval, computing, and telecommunications. Platforms available to workgroups reflect the migration of users from mainframe to desktop platforms interconnected via servers and networks. The baseline reflects the fundamental shift from a host-centric mainframe and minicomputer structure to personal computing and networked client/server architectures.

The major information technology functions of applying information, especially presentation, processing, and data manipulation services, increasingly are being distributed across networks. *Users should be, but are not now, able to transfer information through one or more seamlessly distributed architectures without regard to platform type or system design.* The baseline reflects the past orientation of information prepared and distributed based on platform type and platform-based applications, such as E-Mail and custom applications. OfficeVision E-Mail on a mainframe and specialized database management systems for supercomputers are examples. One emerging technology area comprises integrating messages from E-Mail, fax, voice mail, groupware, and electronic data interchange to diverse desktop platforms. Other migration alternatives are devising larger storage solutions and clustering to bridge gaps between processor capabilities.

Specific guidance regarding workgroup computing applications and appropriate usage and implementation is not available. Because this collaborative means of doing work is so important to future process enhancements, it is prudent to establish guidance regarding these products.

The advancements in the integration of data, voice, video, and spectrum frequencies provide new design and performance capabilities to support business needs. The TELEcommunications Integrator Service (TELIS) initiative promises to provide a useful mechanism to obtain the operations, maintenance, and engineering products and services needed to support Departmental telecommunications requirements.

Focal Area 9

- Migrations Toward Advances in Technology

- Client/Server Architecture Implementation Style

- Object Oriented Programming Adoption Methods

- Videoconferencing Implementation Style

- Desktop Video Adoption Style

- Electronic Commerce Implementation Style

Focal Area 10: Age of Technology at Sites

Some sites continue to use magnetic tape as archive and information-exchange media. *The baseline still relies on data when available rather than data on demand.* Legacy systems are being adapted to use faster LAN speeds and capacities, larger and faster storage devices, and reuse or replacement of mainframe-based information technology designs. In addition, current DOE land-based mobile communications investments (\$300 million) may become obsolete because of advances in wireless technology and National economic policies.

Equipment and technologies within the existing architecture are starting to age. With budget restrictions, it is expected this trend will continue. Wireless technology advances and rapidly aging applications require innovative funding and architecture strategies. The correct selection of new equipment is critical to continued operational effectiveness.

Focal Area 10

- Age of Technology at Sites

- Desktop Platform Age

- Storage Devices/
Administrative Systems Age

- Processors/
Administrative Systems Age

- Wide Area
Telecommunications Age

- Data Transfer and Print
Immediacy Trend

Focal Area 11: Throughput, Speed, and Capabilities

The corporate network is a mesh of many networks and service providers. DOE messages can be exchanged in 102 countries; consequently, at the Department level, circuit analysis by itself does not offer high leveraging value. The information exchange bandwidth requirements are determined by the number of users supported; volume of data transferred; types of data (e.g., voice, data, image, and text) transferred; extent of voice, video, and data integration; and wire-to-wire connectivity and interoperability capacity of connecting sites. The analysis was unable to provide an overall estimate of the Department's total bandwidth requirements or throughput capabilities.

Network installations are primarily local and link most buildings within a complex. Telecommunications bandwidth constraints are being experienced between DOE complexes (rather than just within a site) for data and video applications. *Concurrently, some sites are installing the Integrated Services Digital Network (ISDN) protocol capabilities to improve voice, data, and video applications versatility, but many sites have not prepared to accommodate this technology trend.*

As described in the detailed findings for Focal Area 6, Departmental Procurement Opportunities, all organizations responsible for supporting LANs are experiencing challenges in providing initial software capabilities to existing users and managing the complexity imposed by numerous software versions. *A significant procurement consolidation opportunity exists to provide LAN and middleware coverage, reduce unnecessary LAN protocol diversity, and improve efficiency in LAN management at all sites.* The TELIS initiative is an excellent example of a Departmental approach.

The increased use of local Internet service providers suggests that a procurement consolidation of Internet access services on a regional basis should be considered. Benefits of this approach include the ability to bring servers at all sites to a uniformly high level, obtain economies of procurement price/volume, and obtain user support for small and remote offices.

Networks and associated servers and storage devices are becoming larger, more complex, and integrated to meet partner and stakeholder needs. Network areas being served are used more intensively, cover larger local areas (metropolitan area networks (MANs) and complexes), and longer distances (satellite-based, global landlines, and Internet). They are also increasing capacity with the transition from telephony and two-wire technologies to wireless technologies and fiber optics. No evidence exists indicating that methods of information transfer differ based on distance. Some site LANs are as large and have nearly as many users as other site wide area networks (WANs).

Focal Area 11

- Throughput, Speed, and Capabilities

- Current Desktop Throughput, Speed, and Capabilities

- Current Data Network Throughput, Speed, and Capabilities

- Information Architecture Design and Performance

- Flexibility to Serve Business Changes

Focal Area 12: Minimum Requirements for Desktop Platforms

During the period this analysis was performed, the combined Federal and contractor workforce was being reduced from approximately 150,000 to 130,000.⁶ The staffing impact on desktop computing inventory continues as obsolete equipment is replaced by more powerful desktop platforms. The analysis identified 135,000 Intel- and Macintosh-based platforms in active use.

The adverse effects of DOE dependence on older desktop platforms and operating systems are being felt at sites and offices. Software and data manipulation demands for heavy users in scientific and research communities are beginning to exceed 486 and Pentium capabilities. As described in parts 1 and 2, section 2, Department of Energy Information Architecture, and part 2, section 3, Baseline Analysis, the needs of remote offices dependent upon the increasingly networked environment are exceeding the available capabilities of many less-than-robust 386 machines. Intergraph and Sun-type workstations are required for heavy-duty applications. Evidence suggests that, within 3 to 5 years, current desktop personal computers will be useful for administrative and non-scientific/non-engineering purposes only because of application size and GUI demands.

⁶ Since this analysis, staffing levels have continued to decrease.

Focal Area 12

- Minimum Requirements for Desktop Platforms

- Current Desktop Interoperability within Sites

- Current Desktop Interoperability between Sites

- Desktop User Interfaces

- Desktop Performance Capabilities

Focal Area 13: Consolidation of DOE Data Centers

This analysis was unable to identify criteria that define a DOE data center or supported functions, essential telecommunications or computing scale, or configuration.⁷ Criteria used in a Federal data center benchmark study described in part 2, Baseline Analysis, section 4, Benchmarks, were not appropriate for DOE information architecture purposes, especially the specified criteria for five or more information technologists within a data center. The use of the organization type, complex, provides a useful scale of information technology that helps identify potential data centers. The six complexes identified in the baseline combine centralized, decentralized, and client/server designs and telecommunications capabilities that characterize a representative DOE-type data center.

⁷ Since the preparation of this analysis, significant activity has occurred within Headquarters to comply with Office of Management and Budget (OMB) Bulletin 96-02, Consolidation of Agency Data Centers, October 4, 1995.

Focal Area 13

- Consolidation of DOE Data Centers

- Data Management Redesign Opportunities

- Hardware Processor and Telecommunications System Redesign Opportunities

- Middleware System Redesign Opportunities

- Information Architecture Redesign Opportunities

Focal Area 14: Data Warehousing

Data warehouses consist of historical data, text, images, and graphs that enable executives to discern patterns and trends. They are updated periodically using operational and external information and can include access to storage devices located throughout the Department. Data warehouses may be logically and physically consolidated at responsible sites or distributed within a single data architecture design.

Generically, data centers are physical consolidations of information technology that support operational, business, historical, and forecasting data. They may also house data warehouse contents.

The total storage or server capacity, speed, storage technology, or primary uses for corporate or other systems and applications could not be determined from the baseline data, nor is there any ongoing analysis to estimate across the enterprise. ***Storage and server demands are significant and growing, but there is no measurement system in place for sizing them.***

Data warehousing is an emerging information management concept being explored by a few sites, but it has not yet been fully implemented using structured architecture principles or designs. DOE has not developed a specialized server architecture strategy to support data warehousing planning. Data have not been collected to describe how information users and data servers are mutually supported. No repositories or directories for process owners, data stewards, or data administrators are available to identify potential data warehouse storage assets, enhance information sharing and data reuse, or transfer data warehouse expertise among sites. A centralized list of data administrators is not maintained. ***There is no official data stewardship policy except as presented in Volume I, The Foundations.***

No guidelines for sharing information models are available within the baseline. The opportunity exists for DOE enterprise information or data models to be assembled for consensus building, planning, and decision making. Computer system documentation libraries do not capture the identity of specific business information products, even if they are placed online.

Overall, the state of maturity for data warehousing within DOE and the possibilities for satisfying business needs can be described as emerging from the technology discovery state.

Focal Area 14

- Data Warehousing

- Operational Data Warehousing Implementation Status

- Decision Support Data Warehousing Implementation Status

- Frequency of Information and Data Modeling

Conclusions

1. The current baseline information architecture reflects widely varying relationships between the forms of information and related information technology functions. The overall trend is a decentralized movement toward interoperability and realignment of the information management architecture to satisfy business needs. *Significant opportunities exist for information management to participate in ongoing business process reengineering and information architecture improvement efforts.*
2. Without input based on business architecture reengineering plans, it is impossible to determine how well the business and information architectures are aligned to meet business objectives or where gaps exist. The analysis of organizations indicates the following.
 - 2.1 There is no evidence of gross misalignment between DOE business lines and its information technology capabilities. Ad hoc teams, workgroups, and formal decision-making bodies at all levels are addressing pockets of minor misalignments requiring technological adjustments and enabling the baseline to evolve. Given the variety of information customers within and outside DOE, meeting or exceeding user and customer demands within the current architecture is a major ongoing achievement.
 - 2.2 Interoperability problems exist in areas such as E-Mail, document management and transfer, aging platforms, database (software and design), and diverse integrated desktop applications. These problems are being resolved by informal collaboration and adoption of solutions that cause the least technical disturbance. DOE organizations are pursuing strategies intended to employ common standards; however, the opportunities occur in the longer term and have had little impact so far. Architecture decisions are often made by shaping availability and delivering acceptable services rather than meeting the full range of user needs. This approach may not result in the right business decision; however, it does lead to a minimally acceptable technology level that delivers selected products and services across major parts of the enterprise. In many areas, technology is having a profound impact on how DOE does business.
 - 2.3 A mixture of solutions, driven by the installed base, de facto market standards, and cost effectiveness is being employed. DOE technology architecture leaders are moving in the same direction, but that does not ensure future interoperability or connectivity or that the effects of system designs are transparent to users.

- 2.4 Substantial cooperation exists among users and technology service providers. The expanded use of mature network technology and E-Mail within the enterprise and to major customers has improved collaboration and communication. The Information Management Activity Plans (IMAPs) and Unified Budget Call (UNICALL) Supplemental submissions highlight the increasing ability of individuals and organizations to collaborate. IMPACT, local information architecture organizations, electronic commerce, Year 2000, videoconferencing, Computer Incident Advisory Capability (CIAC), Scientific and Technical Information (STI), Payroll/Personnel System (PAY/PERS), Departmental Integrated Standardized Core Accounting System (DISCAS) modernization, Corporate Human Resources Information System (CHRIS) implementation initiative, and numerous other projects reflect the sharing of needs and views required to sustain continuous improvement in the baseline information architecture.
- 2.5 A tremendous range of available technologies is displayed throughout the baseline; however, they are not expected to be fully integrated. At some infrastructural level, increasing integration of physical and logical information technologies is required. The major point of physical technology integration within the baseline, except for DOE networks and the Secure Information Management and Exchange System (SIMEX), is at program and site levels, shaped by the existence of legacy systems and program and funding imperatives. The increased use of integrated desktop and LAN workshop applications, such as Microsoft Office and Lotus Notes, is improving workgroup and information integration at the desktop. Some of these products also provide a basis for adopting proven business processes.
3. Information architecture principles are guiding evolution toward a vision architecture, but there are no objective customer-satisfaction metrics in place to assist in guiding information architecture changes. The current baseline provides products and services determined by the installed architecture base rather than the requirements of reengineered processes. Often one impacts the other. Lack of sufficient infrastructure prevents rapid technology deployment to aid new business procedures while, in other instances, advanced technologies have not taken advantage of redesigned work flows. Adopting and upgrading technology are often based on subjective technology architecture impact forecasts, assessments, and anticipated funding constraints rather than on Departmental business opportunity and needs analysis.
4. The data subarchitecture needs systemic improvement to make inaccessible data reachable and viable. Organizational data resides on individual desktop platforms, in numerous (sometimes obsolete) databases, within COTS or custom applications, and between corporate systems and sites. Large amounts of needed information still remain trapped in inaccessible hard-copy documents. No mechanism is in place to encourage increased information sharing without redundant data entry and duplicative applications. There is no evidence, however, that documents are being unnecessarily converted to an electronic form.

5. The major operational information architecture shortcoming is document transfer. The maturing Departmental and site network structure is in place, but only simple messages without attachments can be widely and reliably transmitted. Documents cannot be located easily and probably cannot be reproduced in hard copy, even from the Internet. The effect is a limitation in deploying an effective Departmental document management system. *There is a significant opportunity in the short term for a Departmentwide effort to make document transfer easier. A standard viewer may solve this problem.*
6. Several information architecture leadership opportunities offer procurement economies as well as increased organizational effectiveness. Consolidated procurements would be based on aggregating quantitative and performance requirements over the range of site needs rather than specifying single products or vendors. Centralized funding of site products and services may not be required; however, some reimbursement combination may be appropriate. Procurement instruments can be either existing contract vehicles within the Government or new vehicles created by and for DOE. For example, a DOE procurement team is actively pursuing these approaches with the TELIS contract. Consolidated procurement candidates include desktop platforms with advanced operating systems and integrated software to replace aging platforms and applications, database structured query language, Departmental leasing of firewall technologies, and relational database software with Departmentwide licenses. Relational databases also include object-oriented software and associated training support. LAN file servers use proven technologies, such as Redundant Arrays of Inexpensive Disks (RAID), business reengineering tools, information modeling tools, information architecture tools, LAN software, Internet services, and software development tools. These acquisitions should include Departmentwide licenses for current-generation hardware and operating systems to increase programmer productivity and reduce time-to-application delivery and system maintenance costs.
7. The baseline has the seeds of change and modernization. Sites have special needs and expertise, which can be leveraged throughout the information management community, and are actively solving operational problems in the business and information subarchitectures. The baseline includes the necessary infrastructure but requires the application of structural information architecture principles to exploit the full potential. Use of this expertise will be even more essential in adapting the current telecommunications networks to incorporate wireless technologies.
8. The increase in information architecture awareness and the Department's willingness to address information architecture and interoperability issues provide hope and confidence. As shown in figure 3-1, Status of Baseline Information Architecture, DOE information architecture is being deliberately evolved from stovepipe and proprietary environments to a framework that encourages increased integration and increasingly more flexible and reconfigurable capabilities.

Figure 3-1, Status of Baseline Information Architecture

Glossary

<i>Application Software</i>	Computing element supporting particular business needs (e.g., payroll, accounting, spreadsheets, and other systems that provide information to the users in the course of conducting business).
<i>Application</i>	Mechanism for managing (entering, editing, sorting, changing, summarizing, archiving, analyzing, and referencing) the data of the enterprise.
<i>Architecture</i>	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.
<i>Asynchronous Transfer Mode (ATM)</i>	High-speed, high-bandwidth, cell-switching network technology for LANs and WANs handling data and realtime voice and video.
<i>Bridge</i>	Device connecting two LAN segments of either similar or dissimilar types, such as Ethernet and Token Ring.
<i>Carrier Sense Multiple Access with Collision Detection (CSMA/CD)</i>	Transmission technique used in local area networking technology that listens while transmitting to detect message collisions.
<i>Client/Server Technology</i>	Data processing where a program at one site sends a request (client) to a program at another site (server) and awaits a response.
<i>Corporate System</i>	Collection of distributed corporate data synchronized in a standardized format, adhering to established, defined communication and architectural standards, which can be accessed in a convenient and timely manner from any DOE location.
<i>Communications Security (COMSEC)</i>	Protection resulting from all measures designed to deny unauthorized persons information of value that might be derived from the possession and study of telecommunications, or to mislead unauthorized persons in their interpretation of the results of such possession and study.

Database Management System (DBMS)	Software that controls the organizing, cataloging, locating, storing, and retrieving data in a database to maintain its integrity.
DOE Enterprise System	Corporate systems or parts thereof that provide the essential capabilities and data for DOE to perform a full range of its missions even under the most adverse information technology considerations (e.g., natural disaster recovery, constrained telecommunications capacity by telecommunications carriers, catastrophic failure of computer platforms or storage devices, etc.).
Domain	Collection of at least one host or file server with additional terminals that is considered to be a network, with a bridge or router, which is acting as a gateway to other networks.
Electronic Mail (E-Mail)	Electronic means for communicating information (primarily text) by sending, storing, processing, and retrieving information.
Fiber Distributed Data Interface (FDDI)	Often known as a backbone LAN, the American National Standards Institute (ANSI) X3T12 standard for a dual-ring LAN operating at 100 Mbps and using token passing. FDDI rings can use up to 200 km of optical fiber or employ twisted copper pairs for short hops.
Firewall	Barrier set up to contain designated LAN traffic within a specified area.
Federal Telecommunications System 2000 (FTS2000)	Digital fiber-optic network for voice, video, E-Mail, and high-speed data communications for the U.S. Government.
Gopher	Distributed document delivery service used to search for and retrieve files from Gopher servers anywhere on the Internet. Gopher servers store files containing text or binary data, directory information, images, or sound. Links to other Gopher servers result in networkwide cooperation to form the global Gopher web, often called Gopherspace.
Government Open System Interconnection Profile (GOSIP)	Architecture that specifies open systems interface-based data communications standards for connecting computers, peripherals, and networks to support interoperability.

Infrastructure	Personal and collective experiences and enterprise technology assets required to enable individual enterprise organizations and partners to interoperate with common capabilities in achieving the goals and objectives of the enterprise.
Integrated Services Digital Network (ISDN)	International telecommunications standard for transmitting voice, video, and data over digital lines running at 64 Kbps.
Internet	Wide area network that connects thousands of disparate networks in industry, education, government, and research.
Internet Packet Exchange (IPX)	Standard describing software that keeps track of the Internet work address for different nodes, routes outgoing messages, and recognizes incoming messages.
Internet Protocol (IP)	NetWare communications protocol used to route messages from one node to another.
Interoperability	Ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and use the services exchanged to enable them to operate together.
Legacy System	System 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.
Local Area Network (LAN)	Communications network serving users within a confined geographical area. It is made up of servers, workstations, a network operating system, and a communications link.
Management Information System (MIS)	Organized assembly of resources and procedures required to collect, process, and distribute data for use in decision making.
Metropolitan Area Network (MAN)	Loosely defined term that describes a broadband network covering an area larger than a local area network.
Network	Interconnection of three or more communicating entities and (usually) one or more nodes.
Operating System	Master control software that runs the computer.
Output	Information transferred from computer storage to an output device, such as a video display (on a screen) or printer.

<i>Packet</i>	In data communications, a sequence of binary digits, including data and control signals, that is transmitted and switched as a composite whole.
<i>Platform</i>	Particular type of computer running a particular type of operating system software.
<i>Presentation</i>	Supports format translation capability needed in a multi-vendor environment to ensure that the representation of data is understood by communicating parties.
<i>Protocol</i>	Set of semantic and syntactic rules that determines the behavior of functional units in achieving communication; in layered communication system architecture, a formal set of procedures adopted to facilitate functional interoperation within the layered hierarchy.
<i>Redundancy</i>	Duplicative processes.
<i>Router</i>	Intelligent communications device in a network, usually a computer, that stores and forwards data packets between LANs and WANs.
<i>Schema</i>	Diagrammatic representation of the organization of data in a database. Schema can be partitioned as internal, external, or conceptual.
<i>Sequenced Packet eXchange (SPX)</i>	Enhanced set of commands implemented on top of IPX to create a true transport layer interface.
<i>Stovepipe (system)</i>	System procured and further developed to solve a specific problem, characterized by a limited focus and functionality, which contains data that cannot be easily shared with other systems.
<i>System Software</i>	Application-independent software that supports running application software.
<i>System</i>	Organized hierarchy of components having specified purpose and performance requirements.
<i>Telecommunications</i>	Transfer of information between two or more locations by wire, radio, telegraphy, telephony, facsimile, or other means.

Transmission Control Protocol/Internet Protocol (TCP/IP) Protocol for connecting many different types of packet networks.

User-centric 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.

World Wide Web (WWW) Hypertextual front-end navigator for the Internet. Hypertext links in documents link to other documents, lists, and resources, making it easy to access related pieces of information. Using a single interface, users are able to tap into data in different locations and different formats without having to use different tools or know locations.

Workgroup Computing Two or more individuals who share files and databases for a specific business task. LANs designed around workgroups provide electronic sharing of required data.

X.25 International standard for packet switching networking used in wide area networks primarily to support public packet switching.