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INEL WASTE AND ENVIRONMENTAL INFORMATION INTEGRATION PROJECT APPROACH AND CONCEPTS

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Published June 1994

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Prepared for the
U.S. Department of Energy
Office of Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-76ID01570

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EXECUTIVE SUMMARY

The Idaho National Engineering Laboratory (INEL) Waste and Environmental Information Integration Project (IWEIIP) was established in December 1993 to address issues related to INEL waste and environmental information including:

- Data quality
- Data redundancy
- Data accessibility
- Data integration.

This effort includes existing information, new development, and acquisition activities. Existing information may not be a database record; it may be an entire document (electronic, scanned, or hard-copy), a video clip, or a file cabinet of information. The IWEIIP will implement an effective integrated information framework to manage INEL waste and environmental information as an asset. This will improve data quality, resolve data redundancy, and increase data accessibility; therefore, providing more effective utilization of the dollars spent on waste and environmental information.

The IWEIIP promotes a philosophy and a culture change. One of the most important factors is the ability to change the INEL culture to accept new concepts regarding business processes and the supporting information.

Meeting the needs of data customers, improving data quality and accessibility, eliminating data redundancy, and capitalizing on previous efforts are the highest priorities. Because information systems are only a tool, establishing effective business processes is the critical first step toward developing an effective integrated information framework. Through this approach, INEL waste and environmental business processes are being analyzed to document and understand the processes as they currently exist. This is being done in conjunction with process owners and process performers, who are key to the success of business process analysis and re-engineering. This approach includes assessing:

- What INEL waste and environmental processes are performed
- What information these processes require
- Why these processes are performed (i.e., what are the "drivers")
- What information systems are needed to support these processes.

The IWEIIP embraces the INEL information resources management vision. The issues facing IWEIIP are not unique to INEL; similar situations are faced industry-wide. Other INEL studies and surveys have attempted to describe and understand the issues associated with the information environment. The situation is not just a "computer problem" because it involves both management and technical issues, and electronic and manual information.

To address and manage resolution of the management and technical issues, IWEIIP is establishing and implementing an integrated information framework. This framework provides a vehicle for changing the manner in which INEL waste and environmental information and information systems are developed, acquired, and maintained. The details of who and how the framework will be enforced will be developed and documented as part of the project.

Currently, there is no integrated information framework for INEL waste and environmental programs to follow. Each separate information system development or acquisition project determines its own project framework. With a defined integrated framework that applies to all INEL waste and

environmental information system projects, it will no longer be necessary to spend time and resources defining each project's framework.

The integrated information framework development is not a one-time effort. This framework must be established and maintained according to a set of appropriate standards and guidelines. Continuous review of these standards and the processes must be performed. Appropriate modifications in standards and processes must be managed to keep the framework current, practical, and useable. The framework consists of activities that must be managed in order to provide an environment in which many parallel information integration activities are performed and still allow for integration.

Enabling concepts facilitate implementation of the integrated information framework. The framework and enabling concepts provide a blueprint from which the INEL waste and environmental programs can build an environment to address long-term information needs. The INEL waste and environmental programs must move toward this target environment to provide flexibility in a rapidly changing business environment and to provide competitiveness in a global market.

The integrated information framework and its enabling concepts represent a new way of doing business. However, there has been considerable investment in the development and acquisition of information systems to support INEL waste and environmental programs that do not conform to these concepts. This significant investment of time and resources cannot be ignored; therefore, each "legacy" system will be evaluated and an appropriate strategy selected for integration and migration into this new environment.

FOREWORD

This document describes the approach and concepts to be used by the Idaho National Engineering Laboratory (INEL) Waste and Environmental Information Integration Project (IWEIIP) to integrate INEL waste and environmental information and provide better access to information. Successful integration requires management and coordination of organizational business processes, not making a series of independent hardware and software decisions. Although computer technology may be essential to the success of a process, it is not the complete solution and does not necessarily guarantee success.

The IWEIIP is based on the following premises:

- Information is a valuable asset
- An organization's opportunities for success are enhanced by effectively managing and using this asset.

The IWEIIP is working in conjunction with other INEL efforts to integrate information.

Sections 1 through 3 provide an overview of IWEIIP, while Sections 4 and 5 provide detail about IWEIIP approach and concepts. This is a working document expected to evolve and change through time. This project will follow all standards, methods, and guidance described in this document.

To obtain additional information, contact the INEL Waste and Environmental Information Integration Project Office at 526-6329 or OfficeVision SYSINT.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Tom Hill and Mr. Brent Stacey for their contributions to the paper.

The authors would like to acknowledge the contributions from Ms. Barbara Delimont and Ms. Arlene Ackermann.

The authors would like to express their appreciation to the reviewers of this document for their time and valuable input. This appreciation is extended to Dave Blumberg, Roger Scott, Jude Baker, Cathy Barnard, Kurt Derr, Brent Dixon, Judy Harris, Diane Hartley, Dave Hutchison, Bill Jahsman, Phil Lau, Christine Lee, Kent Linsemann, Jeanette Frasure, Ron Tallman, Todd Thiesen, Toni Austin, Kim Boyd, Dave Brown, Kayti Cook, Patti McGuire, and Mike Snyder.

ACRONYMS

ACCESS!	Automated Comprehensive Chemical, Effluent, and Solid Support System
ANSI	American National Standards Institute
API	application programming interface
B&W	Babcock and Wilcox Idaho, Inc.
BPA	business process analysis
CASE	computer-aided software engineering
CCT	Cross-Contractor Team
CSC	client/server computing
DOE-ID	U.S. Department of Energy, Idaho Operations Office
EG&G	EG&G Idaho, Inc.
ESB	Executive Stakeholders Board
IEEE	Institute of Electrical and Electronic Engineers
INEL	Idaho National Engineering Laboratory
IRM	information resources management
ISO	International Standards Organization
ISPG	INEL Strategic Planning Group
IWEIIP	INEL Waste and Environmental Information Integration Project
MK-FIC	M-K Ferguson of Idaho Company
OSF	Open Software Foundation
PC	personal computer
PTI	Protection Technology Idaho
SQL	structured query language
WINCO	Westinghouse Idaho Nuclear Company, Inc.

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INEL WASTE AND ENVIRONMENTAL INFORMATION INTEGRATION PROJECT APPROACH AND CONCEPTS

1. INTRODUCTION

Over the past twenty years there has been an explosion of new computer technology (e.g., hardware, software, and communications) and a need for more information. Additionally, many new concepts and methodologies (e.g., client/server, open systems, and information engineering) have been created to manage the increase in computing power, information, and information needs. The power of computing has moved from the mainframe to the desktop, where every employee has the capability to build and manage databases, deliver solutions for information needs or requirements, and use computer tools for personal productivity.

Optimal use of waste and environmental information has not been fully realized by the various Idaho National Engineering Laboratory (INEL) programs and functional areas for a variety of reasons. These functional areas include waste operations, environmental restoration, compliance and regulation, pollution prevention, and other waste-related activities performed by INEL contractors. The less than optimal coordination of this information has resulted in:

- Low cost efficiency/cost benefit from existing systems
- Inefficient and ineffective decision-making processes.

2. INEL WASTE AND ENVIRONMENTAL INFORMATION INTEGRATION PROJECT

The INEL Waste and Environmental Information Integration Project (IWEIIP) was established in December 1993 to address issues related to INEL waste and environmental information, including:

- Data quality
- Data redundancy
- Data accessibility
- Data integration.

The IWEIIP is addressing current and future information needs. The project will implement strategies to manage waste and environmental information as an asset. Over time, this will improve data quality, resolve data redundancy, and increase data accessibility, thereby providing more effective utilization of the dollars spent on waste and environmental information.

The IWEIIP is promoting a new philosophy and culture. One of the most important factors is the ability to change the INEL culture to accept new concepts regarding business processes and the supporting information. Users' expectations continue to escalate as the promise of access to required information become a reality. System developers are experiencing the pains of determining cost-effective software reuse and integration verses new development. Management frustrations reflect the risk of technical unknowns and a lack of instant clear solutions to complex information issues during a time that demands results. Monitoring and oversight functions are modifying their window into INEL activities as vast amounts of electronic information are becoming more accessible. These various perspectives are evolving into a general INEL information resources management (IRM) vision and philosophy that will determine fundamental information services well into the next century.

The IWEIIP has a vision of an information framework that will offer long-term benefits and expanded quality of information services. As IWEIIP pioneers a new mindset for management of INEL waste and environmental information, basic issues thought to be "sacred" will be challenged. Effective long-term solutions are not only established through implementation of the right answers but also by developing the right questions. Nothing can be exempt from scrutiny to paraphrase Albert Einstein, "problems can't be solved with the same mentality that was used to create them...."

Previous information integration efforts have identified valuable "lessons learned." These lessons have been incorporated into the IWEIIP approach. The critical components necessary for successful integration include:

- U.S. Department of Energy, Idaho Operations Office (DOE-ID) sponsorship
- Strong INEL contractor commitment and involvement
- Strong project team commitment
- Dedicated user teams
- Use of current advances in information technology
- Use of a results-oriented, phased implementation.

This document presents the approach and concepts to be used by IWEIIP in addressing INEL waste and environmental information. It is not meant to be a Project Management Plan nor an Implementation Plan.

The IWEIIP is focused on establishing an integrated information framework for existing INEL waste and environmental business processes. Meeting the needs of customers, improving information quality and accessibility, resolving data redundancy, and capitalizing on previous efforts are the highest priorities. Because information systems are only a tool, establishing effective business processes is the critical first step toward developing an effective integrated information framework. Through this approach, INEL waste and environmental business processes are being analyzed to document and understand the processes as they currently exist. This is being done in conjunction with process owners and process performers, who are an integral key to the success of business process analysis (BPA) and re-engineering. This approach includes assessing:

- What INEL waste and environmental processes are performed
- What information these processes require
- Why processes are performed (i.e., what are the "drivers")
- What information systems are needed to support these processes.

Ideally, major business processes will be re-engineered, as necessary, before an information system project is undertaken. A conceptual design of an integrated information system for the existing and improved processes will be developed. Flexibility will be a major element of the design in order to support continuing process improvement or re-engineering. All existing data will be identified, including purpose, use, and location. Lessons learned will establish the foundation for INEL waste and environmental information systems integration.

2.1 Project Scope

The IWEIIP scope is significant in that all INEL waste and environmental processes and their supporting information are included. The project addresses both electronic and manual information. This scope requires a systematic approach and methodical implementation over the next several years. It is recognized that waste and environmental business processes and information systems will continue to evolve. A re-evaluation of approach, scope, and objectives will be made periodically.

2.2 Project Objectives

The overall IWEIIP objective is to get the *right* information to the *right* people in the *right* place at the *right* time for the *right* cost. The requirements for *right* will be defined by the customer. For example, the right information may not be a database record; it may be an entire document (electronic, scanned, or hard-copy); a video clip; or a file cabinet of information.

The IWEIIP has two main objectives: (1) design and implement a technology-independent framework to provide long-term flexibility and to increase accessibility to data, and (2) promote an information management culture change in order to resolve data redundancy and improve data quality.

2.3 Project Structure

Figure 1 depicts the IWEIIP organizational structure. The project is sponsored by the DOE-ID Environmental Restoration and Waste Management Monitor. An Executive Stakeholders Board (ESB) was established to provide project guidance and resources to successfully integrate waste and environmental information. It is chaired by the Project Sponsor and is comprised of the waste and environmental executive management from the following INEL contractors:

- EG&G Idaho, Inc. (EG&G)
- Westinghouse Idaho Nuclear Company, Inc. (WINCO)
- Babcock and Wilcox Idaho Inc. (B&W)
- Protection Technology Idaho (PTI)
- MK-Ferguson of Idaho Company (MK-FIC).

A Cross-Contractor Team (CCT) was established with representatives from each of the contractors comprising the ESB. In addition, Argonne National Laboratory-West and the Naval Reactors Facility participate on the CCT to provide INEL-wide support. This CCT ensures that each contractor involved in IWEIIP has their issues, ideas, and input fairly addressed. The CCT members provide information for their contractor operations during business process analysis (BPA) and act as a single point of contact for their contractor throughout the project. They are instrumental in preparing and implementing the consolidated contractor transition plan, as it relates to IWEIIP.

A Core Project Team was established and is responsible for project execution. The Project Manager has overall authority and responsibility for the execution of IWEIIP in accordance with ESB objectives. The Core Project Team is staffed with full-time personnel who perform the day-to-day project activities and coordinate project deliverables.

2.4 Other Related Activities

Because of the complexity to integrate information and minimize data redundancy on as large a scale as INEL, IWEIIP is one of several projects actively addressing INEL "information integration." The IWEIIP is communicating with these efforts to ensure consistent approaches and the ability to leverage resources, ideas, and standards. Some of the integration activities are:

- EG&G company-level efforts (e.g., Chief Information Officer, Strategic Planning, Distributed Computing Team)
- INEL Application Systems Inventory
- Several efforts addressing different pieces of waste information integration [e.g., Automated Comprehensive Chemical, Effluent, and Solid Support System (ACCESS!)]

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Figure 1. Project organizational structure.

- Data Administration Council
- INEL Strategic Planning Group (ISPG)
- EG&G Environmental Restoration and Waste Management Department Business Process Re-engineering (in conjunction with Motorola University)
- WINCO efforts (e.g., Spent Nuclear Fuel System).

2.5 INEL IRM Vision

The IWEIIP embraces the INEL IRM vision, as described in the INEL Information Resources Management Site Plan FY-1996 (INEL 1994a):

"The INEL's integrated, interactive information resources must be managed around the programs and their information must have the following attributes:

- Is easily and quickly reconfigurable
- Takes advantage of reusable and multi-use software and solutions (e.g., networked concurrent licensing schemes)
- Is independent from underlying technology and the computers themselves so the information framework does not become obsolete
- Is scalable such that information resources are available where and when needed
- Is easily accessible; a single configuration-controlled source exists for each piece of information
- Is distributed and highly responsive to programs and users who benefit most from the tools
- Is fault-tolerant so that the reliability is equal to the user's dependence."

3. ISSUES

The issues facing IWEIIP are not unique to INEL; similar situations are faced industry-wide. Other studies and surveys have attempted to describe and understand the issues associated with the INEL information environment. The situation is not just a "computer problem"; it involves both management and technical issues. Aspects of management and technical issues are discussed below. Management issues include (Lee and Henscheid 1993):

- Direction for information management and software development is not focused

A consistent, integrated, rigorous, and proactive approach to information system design, documentation, implementation, acquisition, and configuration management has not been utilized. Almost every project that creates an information system: (1) creates the system differently, (2) defines its own deliverables and project methodology, (3) defines its own unique set of hardware and software standards to meet specific requirements, and (4) can define a set of proprietary, stand-alone requirements without following an overall integrated information framework. Rarely does a project schedule include tasks to coordinate with other projects for data and process integration. Because there have been no framework and common standards, INEL is now faced with the challenges and opportunities to implement a standard process in a very diverse environment.

- Information is not perceived as an asset

Information is not currently perceived as an important resource for achieving organization missions and objectives. Neither is information regarded as a significant product of INEL.

- Configuration management or data quality assurance processes are not consistent

No single, consistent configuration management or data quality process exists. Each organization can commit resources to build or acquire information systems to solve a problem or a piece of a problem.

- Data stewardship is not fully applied

In key business areas of waste and environmental programs, data stewardship has not been established.

- Business process and data solutions have been suboptimized

Organizations have created their own individual solutions to problems shared by others. Rather than developing integrated solutions, individual solutions have been created in order to modify a specific portion of a business process or access and manipulate desired data (e.g., many organizations have developed individual document control functions, training tracking functions, and action tracking functions).

- Integration efforts overlap

There is no clear "authority" for making decisions when integration efforts overlap. There may be multiple customers, schedules, and work packages. No place for "final" decisions on integrating systems exists.

Technical issues include:

- Data location should be transparent

Ideally, users accessing data should not have to know where the data are physically located or on what technical platform (e.g., database management system, operating system) the system is implemented.

- Implementation has been proprietary

Computerization at INEL has not followed a focused approach based on standards. Hardware and software acquisitions have been made to satisfy narrowly-defined requirements. A major technical challenge is to interconnect the various vendor platforms and software applications.

- Data accessibility has been limited

Users need to query data from multiple sources; however, they have been unable to effectively access information because computerized data are stored and built around vendor-specific implementations, which do not communicate with others [e.g., a FoxPro database on an individual's personal computer (PC) is difficult to access through a different PC]. In the current environment, access across different hardware and software platforms is difficult and inefficient, thus requiring the user to know many technical details.

- Existing systems must be integrated

Some data are on a mainframe, others are on minicomputers, while others are on individual PCs. Implementation of integrated standards will allow these differing pieces of hardware to

interconnect. Migration of the existing systems to an integrated environment requires a significant change in current computer networks, hardware platforms, software applications, and personnel skills.

- Hardware and software technology is rapidly changing

The average life expectancy for hardware and software is from 12 to 36 months. Because technology changes so rapidly, many companies treat such technology as an expense. Hardware and software are acquired so quickly that it complicates the integration of data and interconnectivity among the pieces.

- PCs functioning as "servers" will require more rigorous operational responsibilities

If a PC is a data "server", other computers can access the data on that PC, usually by having a network connection between the computers. Databases on individual PCs functioning as "servers" will require additional operational responsibilities (e.g., availability, backups, security).

- INEL network is inadequate

The current INEL network is inadequate to support an integrated environment. All waste and environmental personnel do not currently have the appropriate and consistent level of network connectivity. A significant investment in network capacity, reliability, and design must be made.

4. PROJECT APPROACH

The IWEIIP has adopted a framework that provides a vehicle for changing how INEL waste and environmental information and support systems are developed, acquired, and maintained. Currently, there is no integrated information framework for INEL waste and environmental programs. Each project must develop its own information system guidelines; in addition, many projects do not recognize the need for an infrastructure or framework. This results in different project implementations that cannot be integrated. With a defined framework, it will no longer be necessary for each project to expend resources on an independent project framework.

Development of the framework is not a one-time effort. As INEL and technology evolve, continuous review of established standards and processes must be performed. Appropriate modifications in standards and processes are required to ensure the framework remains current, practical, and useable.

This framework is presented as a layered concept with each layer based upon the underlying layer(s) (Figure 2). The details of who and how the framework will be enforced are yet to be developed. The premise behind this framework is that each layer depends on the others. A layer cannot be developed or implemented in isolation from the other layers. The layers are described in the following sections.

4.1 Information Infrastructure

The Information Infrastructure provides the foundation upon which the remaining layers of the framework are built. This layer consists of standards and rules that must be maintained for an integrated environment. Establishing and maintaining standards is a continuous activity that includes reviewing, identifying, and obtaining consensus for applicable standards that will become a foundation

Figure 2. Integrated information framework.

for all activities in the project framework. The business reasons for using a specific standard must be understood and the following questions need to be asked:

- Which strategic standard development organizations impact the project or organization?
- Which standards are appropriate for the organization?
- Which standards are robust enough to increase INEL waste and environmental programs' competitiveness?
- How committed are vendors to standards and open systems?

Standards include industry standards, government standards, guidelines, and/or best business practices. Some sources for these standards include:

- American National Standards Institute (ANSI)
- Institute of Electrical and Electronic Engineers (IEEE)
- International Standards Organization (ISO)
- Open Software Foundation (OSF)
- DOE orders
- INEL Strategic Planning Group (ISPG) guidelines
- Policies, procedures, and standard practices.

The standards should be nonproprietary whenever possible; however, if there is no recognized and accepted standard, it may be necessary to select one that is proprietary. Proprietary standards should be kept to a minimum. Each proprietary standard selected directly impacts future flexibility, interoperability, and integration. Proprietary standards will be re-evaluated and replaced as non-proprietary standards become available.

An infrastructure allows for many parallel information systems development and acquisition projects. As long as each project follows the same infrastructure, the use and reuse of information resources are maximized.

The Information Infrastructure identifies standards used across a wide spectrum of functions. The Information Infrastructure is intended to remain independent of applications, databases, and the technology with which it is implemented.

4.2 Information Architecture

The Information Architecture is a collection of integrated data and activity models, and their relationships to each other. It refines the definitions of INEL waste and environmental programs' activities and their required information. This architecture provides a basis for aligning business functions and information into business areas based on the way information is created, used, and changed. It also provides a structure for investigating the level of support provided by current systems (including software applications and manual processes) and existing information sources (both automated and paper-based databases). The Information Architecture highlights information used across a wide spectrum of functions and supports project planning activities to modernize the manner in which information is distributed to various functions in other business areas requiring it. The Information Architecture is relatively stable and is intended to remain independent of applications and databases and the technology in which it is implemented.

4.3 Business Systems Architecture

The Business Systems Architecture supports: (1) identification of which information systems should be in place to support INEL waste and environmental programs, and (2) development of models identifying the processes for software engineering.

The Business Systems Architecture documents how individual information systems interact to support INEL waste and environmental business. It conveys the approach used to implement the business activities and information needs expressed in the Information Architecture. The Business Systems Architecture documents the required information systems development environment. It is more dynamic than the Information Architecture, reflecting continuous business improvement processes implemented across INEL waste and environmental programs. The Business Systems Architecture is intended to be independent of the technology upon which applications and databases are implemented (MMES 1993).

4.4 Technology Architecture

The Technology Architecture provides detailed specifications for implementation of the hardware, software, and communications within the Business Systems Architecture. Acquired and INEL-developed software must be well-founded on the previous layers. The first option of each project providing INEL waste and environmental information systems is to determine if existing software is available that meets the necessary requirements, standards, and guidelines.

The Technology Architecture defines how applications and databases identified in the Business Systems Architecture will be deployed and operated. Strategies for information capture, analysis, delivery, and storage capabilities need to be evaluated periodically. Appropriate technology areas are identified and required strategies and capabilities are defined to meet business requirements. A list of recommended products (for building and operating information systems) to support technology areas are maintained. The Technology Architecture is more dynamic than either the Business Systems Architecture or the Information Architecture. The rate of change in advances in information technologies (e.g., computers, networks, and software development tools) is high and continues to increase. However, if efforts to preserve the independence of the Business Systems Architecture are successful, new technology approaches can be implemented in a timely fashion (MMES 1993). The Technology Architecture Reference Matrix presented in Appendix A illustrates how the appropriate infrastructure standards and guidelines could be related to a proposed Technology Architecture.

5. CONCEPTS

The framework layers provide a blueprint from which INEL waste and environmental programs can build an environment to address long-term information needs. The INEL waste and environmental programs must move toward this target environment for flexibility in a rapidly changing business environment and to provide competitiveness in a global market. Multiple enabling concepts allow IWEIIP to integrate information and include:

- Information Infrastructure concepts
 - Business Process Analysis (BPA)
 - Open systems
 - Client/server computing (CSC)

- Information Architecture concepts
 - Data management
 - Development coordination
 - Information sources
- Business Systems Architecture concepts
 - Data Directory
 - Information Broker
- Technology Architecture concepts
 - Hardware implementation
 - Application software implementation

These concepts were selected for special focus because they either represent new concepts or are not currently being performed consistently. They are discussed in more detail in the following sections.

5.1 Business Process Analysis

The IWEIIP is addressing information integration from a business perspective. Part of this approach is an understanding of what drives each business process. The IWEIIP is using a BPA technique, which is a process to identify and define what a business does in terms of work activities. It assists in developing a business model, which is comprised of an activity decomposition model (node tree), activity models, data models, and activity/data relationship matrices. Various computer-aided software engineering (CASE) tools can be utilized to create and maintain the models.

The IWEIIP will conduct BPA in conjunction with data/activity modelers, process owners, and process performers. Criteria will be developed to select a subset of INEL waste and environmental business processes for a more detailed BPA. Through the activity modeling process, each activity is defined with detail about what information is required (inputs), what products result from performing the activity (outputs), what drives the activity (controls), and who and/or what performs/supports each activity (mechanisms). This process assists in understanding how activities are interrelated. Data models show the structure of the information required by the activities.

Data models are used to document, define, and understand the information requirements for those activities described in the activity models. The relationship between data models and activity models describes how the activities use the information. Data models will be used to identify and manage data redundancy.

From the selected subset of processes, a priority will be established with the ESB to define a "proof of concept" pilot. This pilot project will be implemented using the framework developed by IWEIIP.

5.2 Open Systems

An open systems environment is a computing environment based upon an organization's requirements for standards. To position an organization to achieve its desired goals and objectives, this environment must encompass an enterprise-wide framework that incorporates portability, scalability, and interoperability (Vranas 1994):

- Portability

There is a clear need for applications, not the system software that supports them, to be portable. An organization's investment in application development or acquisition is an asset that must have flexibility and protection. Portability comes in two forms: (1) applications, and (2) users. Applications must be operational without regard to the hardware, database management system, and communications protocols. In addition, users' knowledge and skill base should be effective with any operating environment. This ability to port skills provides the leverage an organization needs to move to open systems.

- Scalability

Scalability is the ability of an application to operate with acceptable performance on computer platforms of varying sizes—from mainframes to minicomputers to PCs. This is important because it is desirable to run applications at different locations on the most cost-effective hardware solution for an organization, while maintaining the integrity of the application.

- Interoperability

Interoperability is the key factor in achieving open systems. More than simply connecting hardware platforms together, it enables applications running in a heterogeneous environment to communicate with one another. Interoperability allows an organization to protect investments already made as it moves to an open environment. To do this, an organization must employ a strategy that incorporates the interconnection of hardware platforms and provides application communication and the ability to distribute data, applications, and software on the network.

The purpose of open systems is not to achieve a technology where everything looks the same, but to establish a philosophy and methodology where all types of information technology can work in unison. The three basic requirements in open systems span three general areas of computing: application development, data management, and CSC. Open system requirements are based on:

- Using nonproprietary standards
- Hardware independence
- Software independence
- Vendor independence
- Maintaining the interoperability and interconnection of heterogeneous hardware and software.

5.3 Client/Server Computing

Client/Server Computing (CSC) is comprised of three elements: a client, a server, and a network. Each of these has a hardware component and several software components. Server software accepts requests from client software and returns the results to the client. The client manipulates the data and presents the answer to the user. Client and server applications can both be on the same computer, therefore not requiring a network. However, most CSC applications utilize a network.

There are numerous interpretations and development models of CSC. Any particular computer can be a client and/or a server. *CSC is more of a design concept than a specific technology option*, although the concept does require that a number of technologies be in place. It is important that the advantages associated with this general type of distributed, integrated, highly-networked strategy drive technical solutions.

CSC involves splitting an application into functions and putting each function on a platform where it can be handled most effectively. Depending on the application and the software, all data processing may occur on the client or may be split between the client and the server. The server is connected to its clients via a network. A model of CSC is shown in Figure 3. The components of CSC include:

- Servers

Computer hardware on which software performing a "service" executes.

- Services

Software applications that execute on a server platform and accept requests from client software, perform the requested function (i.e., provide a "service"), and return the results.

- Clients

Computer hardware that executes software applications that present the results received from a service software application.

- Middleware

Software applications that provide the capability to connect client software requests to service software. Middleware provides the glue that connects clients, servers, and networks into a seamless, common environment.

- Network

A combination of hardware devices and communication software that transmit requests from clients and returns results from servers.

5.3.1 CSC Operation

A CSC design strategy separates applications into their various functions. These functions can then be targeted individually to specialized high-capability platforms, all of which are interconnected through a system of networks. Through the use of modern information technology tools and techniques, network navigation can be embedded in CSC information systems. This allows a collection of databases, information systems, and other information technology based services to support users as a coherent and well-integrated system.

5.3.2 INEL CSC Tiers

An important addition to the CSC model is the concept of "tiers" (Figure 4). Tiers relate to the stratification of the information technology environment based on a combination of factors, most notably system or application functionality and degree of "openness." Generally, there are two tiers that are important; however, a third layer has been added to deal with the migration of current mainframe and department computers into a CSC environment. These tiers are:

- The Tier 1 (or "client") component of the CSC configuration focuses on the requestor of a service. User access typically, but not always, involves an intelligent workstation and a graphical user interface. This interface provides a "window" into the information resource environment and a mechanism for accessing the environment. The interface allows the user

Figure 3. CSC model.

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Figure 4. Representative three-tier model.

(or client) to access a variety of applications and service functions (e.g., data management, electronic mail, and information inquiry) via a window environment that can be adapted to the unique needs and preferences of the user.

- The **Tier 2** (or "server") component of the configuration includes all of the computing platforms that communicate with the client via a network and respond to client requests for services. When the client software needs information or a service it cannot satisfy itself, it uses the network to communicate with one or more servers that can meet the need. These service functions often reside on dedicated platforms that serve multiple clients. Typically, the user does not need to be aware of the navigation instructions issued throughout CSC in response to requests issued at the client level; the "system" handles the navigation automatically. This is a basic requirement for providing the logical or virtual connectivity in a heterogeneous environment.
- The **Tier 3** (or "host server") component includes existing mainframe and departmental computers. These are used as support platforms for legacy production applications that have not been integrated into a fully distributed, networked environment. The gateway concept allows these resources to coexist in a beneficial way by providing a linkage from the client tier to the host server tier.

5.4 Data Management

The purpose of data management is to ensure data quality and accessibility. Data management involves the planning, organization, operation, and control of information resources. It promotes an environment that recognizes the importance of applied data management practices. To successfully manage INEL waste and environmental information, a data management program must be established and implemented that includes (INEL 1994b):

- Data administration
- Data stewardship
- Data quality.

5.4.1 Data Administration

Data administration consists of administering data management activities, establishing data standards, reviewing data for compliance with standards. Data administration principles, as defined in the INEL Guidebook of Data Management Practices (1994b), will be applied. Data administration principles include, but are not limited to:

- Develop business models and integrate project data structures across INEL waste and environmental organizations
- Implement a Data Directory and define policies and procedures for its use
- Document and disseminate standard names, descriptions, and properties for entity types and attributes
- Define policy and/or procedures for data integrity, data sharing, stewardship, replication control, and conflict resolution
- Perform data analysis.

Each information system project will produce business models to provide a template by which each object (e.g., application software, information sources, entity types and attributes) can be compared in like terms. This will facilitate integration, maximize sharing of information resources, and communicate a common understanding of user requirements.

5.4.2 Data Stewardship

Data stewardship consists of assessing and maintaining data quality, developing procedures for managing information, monitoring data usage, and managing access to data. Data stewardship defines responsibilities to provide a consistent approach to effective data management. Both management and user commitment are required in data stewardship. Management provides the funding and resources necessary to develop or implement an integrated information system. User support makes information systems operational. Data stewardship is the linking pin between the high level data management strategies and the physical implementation or operation of data management practices in a data subject area or at the information system level. Figure 5 illustrates the concept of data stewardship and characterizes the relationship among the roles. The acknowledgement of responsibilities develops a culture that encourages an environment of teamwork and empowerment for the management of information (INEL 1994b). The IWEIIP will assist establishing data stewardship practices for INEL waste and environmental information during BPA.

Anyone who uses, manipulates, creates, maintains, and/or supports data is a data steward. Stewards are responsible for regarding data as a resource of INEL, and abiding by data protection and use procedures. Every person has data responsibilities and performs at least one of the following roles (INEL 1994b):

- Owner

Because data are an asset of INEL, the data owner is DOE-ID. INEL waste and environmental programs are responsible for structuring and chartering organizations to perform the functions that generate and exchange data as part of their processes. Data are the foundation for decisions; therefore, the ownership must remain at the highest level to provide strategic data planning and prepare for changes in the future.

- Trustee

Trustees are delegated by the owner to administer data in the best interests of INEL, independent of the information system boundaries. Trustees must be subject matter experts and reside in the subject matter organization. They are responsible for data-related decisions such as defining the data; defining internal controls to preserve the privacy, security, and integrity of data; establishing standards; and controlling who can use or change the data. Trustees are responsible for defining and implementing a process to verify the data. Overlaps in data usage exist and make the need for trustees and the interaction between trustees all the more important. Trustees can delegate certain data related activities to custodians for daily maintenance and operations.

- Custodian

Data custodians are assigned responsibility to enforce the policies and practices prescribed by the data trustee when creating or manipulating individual data occurrences.

- User

A data user is anyone who uses data, the services of a information system, or its products.

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Figure 5. Data stewardship.

5.4.3 Data Quality

The application of data stewardship leads to quality data and information. Controls are implemented to meet the data quality and protection requirements. This process covers all activities that handle the data within daily operations, including creation, collection, use, maintenance, deletion, and archiving.

Data stewardship provides a consistent approach to the day-to-day handling of data. The benefits include:

- Accountability for data is ensured with the assignment of responsibilities
- Data quality and integrity result as data are managed on a daily basis by employees who know and understand their responsibilities toward data
- Data and information can be used more effectively as quality and consistency are provided.

Data definitions are important in addressing data quality and integrity. It is important to have a common understanding of the data definitions by all people using the data. The data trustee and/or data custodian must be involved in developing the data definition.

Data input "edits" do not ensure data quality; the "fact" (data occurrence) must meet the definition defined in the business model. Regardless of how well the information system was developed, the data trustee and data custodian must validate the actual data by ensuring it is consistent with the definition. In addition, quality decreases as data are stored in multiple places; therefore, data redundancy must be resolved to ensure data quality.

5.5 Development Coordination

Information systems development personnel are facing new management challenges (e.g., how to effectively manage multiple interrelated development or acquisition projects in parallel). Information management is challenged to deal with issues arising from fast, accurate, more ambitious information system building, and implementation of procured software. Regardless of whether software is built or acquired, management practices are needed to ensure that the information system's life-cycle is coordinated and coherent while maintaining responsiveness.

Development coordination facilitates interactions between development projects, current systems, and software procurement activities. Development coordination ensures that common business objectives are incorporated into working practices, yielding information systems that are coordinated and consistent with each other to the level desired by INEL waste and environmental programs.

The Information Architecture assists in scoping new development or acquisition projects. This architecture can be viewed as the highest level at which INEL waste and environmental programs have agreed to be consistent. The existing information systems can be mapped to the Information Architecture to enable users and management to review coverage (i.e., how much of the Information Architecture has been implemented and where a proposed project fits). The Business Systems Architecture can assist in planning and sequencing projects to be either developed or acquired, and in identifying areas requiring coordination.

It is necessary to understand the conditions under which development coordination is implemented. This understanding is achieved by analyzing the current integration and data consistency situation, and determining how it should be. Information about business objectives, INEL structure, information systems organizations, organization culture, and management commitment to integration and consistency are examined. Development coordination activities include:

- **Project Management**

Project management requires checkpoints, interactions, and expected deliverables. Its goal is to facilitate inter-project coordination.

- **Change Control**

Change control defines guidelines for projects to follow when changing objects. Guidelines control the change management process from the point of request to implementation of the object.

- **Version Control**

Version control defines when and why versions of objects will be created, how to determine relevance of versions, and how versions will be tracked and changes communicated to other interested projects or support organizations.

- **Data Directory Management**

Data Directory management administers the repository for accumulated development and implemented production information. The Data Directory's performance and survival are critical to INEL waste and environmental programs.

- **Project Configuration Management**

Each information system project will follow a configuration management process (to be developed).

- **Configuration Control Board**

The Configuration Control Board represents the interests of end users who want integrated systems, consistent reporting, and improved data quality. In this capacity, the Configuration Control Board oversees development, acquisition, and maintenance of waste and environmental information, and ensures that: (1) all expenditures are cost effective, (2) changes make good business sense and are traceable to requirements, (3) the application deliverables meet user and INEL standards, and (4) the integrity of information systems and data are maintained.

5.6 Information Sources

Multiple existing information sources and systems currently support INEL waste and environmental programs, and will continue to coexist as they transition to defined standards and resolve data redundancy. They will be analyzed to determine their information category, which is based on what business processes the information supports. The categories (which will require BPA) include:

- **Operational Support Information**

This information represents the "current" facts about information used in day-to-day activities in direct support of "mission-specific" functions for INEL waste and environmental programs. Information in this category is very dynamic and must be current to the last update. This information may be very detailed and normally contains very little derived or summarized data.

- **Decision Support Information**

This information is used to perform:

- trend analysis (e.g., analysis of historical, operational, and/or change control information to determine significant trends)
- forecasting or projections
- strategic planning.

This information is used in direct support of management decisions related to "mission-specific" functions. It normally includes a different view of operational, historical, and change control information. Decision support information may be derived, summarized, or grouped different from operational support information. The information is considered static data, with no or minimal updates occurring. In addition, the information does not need to be "current" to the very latest update. The information may be de-normalized (i.e. same fact in more than one place) to improve performance and responsiveness. It may be necessary to determine the appropriate information for this category iteratively, one business function at a time.

- **Historical Information**

This information communicates specific facts about INEL waste and environmental information that have changed as part of the normal progression of performing activities. This information normally represents a view of what was "current" at some prior point in time (e.g., yesterday, last week, last month, last year, several years ago). For information to be in this category, it must represent the natural change in "current" facts about operational support information as part of performing the day-to-day activities.

- **Change Control Information**

This information communicates the changes in "current" facts about operational information that are not a "natural" result of the day-to-day activities. This category requires that the "current" operational fact only change when approved via a formal change control process. Normally, there is also a need to record the reason that the change occurred.

5.7 Data Directory

A Data Directory is a central source of information about data and activities supported by an information systems. It contains information about data and computer applications that process information. It is a tool to identify existing software and databases and is useful in avoiding development of redundant information. It also provides a means to identify other data custodians who may be affected by a proposed change to data or a data structure (INEL 1994b).

The INEL is implementing a Data Directory that includes the business models. It will be a central knowledge-base of all implemented processes and data rules. Additionally, it can store the relationships (e.g., where data attributes are physically located). Time and resources are required to populate the Data Directory with the existing information systems; however, for new information systems development or acquisition projects, this will occur as part of the effort. The CASE tools used to create and maintain the business models will be front-ends to the Data Directory. The development coordination process will be used to ensure the information entered to the Data Directory is consistent and nonredundant. Selected interfaces (Figure 6) are planned to be developed as part of IWEIIP, which will eliminate the need for manual re-entry of the business models to the Data Directory.

Figure 6. Data directory interfaces.

The Data Directory will be managed using configuration management and development coordination processes (to be developed). The data in the Data Directory are considered a valuable asset and will be accessible to all who need the data.

5.8 Information Broker

The Information Broker is an implementation of multiple integrated CSC applications. It provides users with a common navigational tool to access multiple information sources. Figure 7 highlights the basic Information Broker concept and depicts potential service areas.

5.9 Hardware Implementation

The end user's hardware may not be sufficient to operate in an open systems, CSC environment. Also, not all current PC configurations can be utilized as a server. In addition, network and server investments must be made and strategies developed to successfully integrate INEL waste and environmental information. To successfully implement CSC for INEL waste and environmental programs, a substantial investment must be made in the INEL network. Without a reliable, high-speed network at all locations, the success of IWEIIP will be severely limited.

5.10 Application Software Implementation

To be compatible with open systems and CSC concepts, design concepts for application software implementation must also be modified. The IWEIIP is using a three-schema architecture for application software (Figure 8). This architecture separates application functions based upon specific aspects of information processing. There is an external layer (presentation), a conceptual layer (information), and an internal layer (data storage).

The external layer focuses on managing the information and processes required for users to complete a business task. The external layer is completely independent from the internal layer. No structured query language (SQL) or data read/write statements reside in this layer. All requests for accessing or processing information are sent to the conceptual layer. In this way, the external layer does not have to know how the underlying information is structured or where it is located. It simply requests the information through a set of defined application programming interfaces (APIs) or through a messaging protocol from the services that comprise the conceptual layer.

The conceptual layer focuses on managing enterprise-wide information resources. All business rules and processing logic associated with these information resources are maintained in a reusable form available to all user interface front ends. This layer is based upon the business models developed as a result of BPA.

The internal layer focuses on the implementation of the physical data models and on the goals of the information management system performance, data integrity, and information storage management. Normal information tuning enhancements and redistribution of data can be implemented with minimal impact on the architecture's other components.

In addition, this three-schema architecture must be used as the basis for one of the criteria to evaluate purchased software (e.g., has the software been designed to allow separation of its functions across the CSC environment). All application software implemented in a CSC environment, whether developed or acquired, must be capable of placing each function on the appropriate CSC platform (i.e., client or server).

Figure 7. Information broker concept.

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Figure 8. Three-schema architecture for application software.

The separation of processing into these three layers is critical to building an adaptable information system architecture. Changes from management or users (including business rules and requirements) or changes based upon deploying server, database management system (DBMS) platforms, and cooperative processing can be applied to specific information functions independently. This architecture accommodates change rather than rejecting it.

6. LEGACY SYSTEMS

The integrated information framework and its enabling concepts represent a new way of doing business. However, there has been considerable investment in the development and acquisition of information systems to support INEL waste and environmental programs that do not conform to these concepts. This significant investment of time and resources cannot be ignored; therefore, each "legacy" system will need to be evaluated and an appropriate strategy selected for integration and migration into this new architecture of open systems and CSC.

For this document, legacy systems are defined as any INEL waste or environmental information system that exists or is under development at the point of the Information Broker implementation. There is no single method that will migrate all legacy systems into the new environment. One of the following strategies will be selected for each system:

- Do nothing

There is no requirement for information contained in the system to be accessed through the Information Broker and/or due to cost-effective use of time and resources, the system would not be moved into the target environment. It would continue to perform in its current environment without any modifications.

- Create/update the business model

The system adequately meets the business requirements and conforms to the defined standards. Valid business models would be necessary to allow the user to gain access to the system's data through the Information Broker.

- Re-engineer system for open systems, CSC environment

The system accomplishes all of the basic business requirements and should be modified only to follow open systems, CSC environment standards and guidelines. Re-engineering is a concept that originally focused on improving the maintenance and reusability of software applications. This has expanded to enable migrations to other platforms as required for downsizing or moving to CSC. Migrating legacy systems to a new platform with CSC is generally recognized as the ultimate goal of re-engineering. This typically means reverse engineering to capture requirements, then forward engineering to rebuild the application for the new environment. Reverse engineering is a process by which the existing system is analyzed to determine the underlying activity model and data model that represents what the existing system does (i.e., documents current system business requirements). Forward engineering is a process of defining the business requirements for the enhanced system by performing BPA and creating business models without being constrained by what the existing system does. There are tools effective in helping to move systems to a CSC environment. Used properly, these tools can save money, time, and customer goodwill.

- Redevelop system using re-engineering to enhance the software functionality

The system inadequately meets current business requirements; however, some portion of the existing system would be salvaged and enhanced to meet the missing business functionality. The existing system would be reverse engineered to document the business requirements the system supports. The business requirement functionality necessary to retain would be identified and the missing functionality would be forward engineered.

- Redevelop system as an entirely new application development

The system does not meet enough of the basic business process requirements to be worth salvaging. A completely new project would be defined to address the business requirements and business process(es) involved by applying forward engineering.

- Archive existing system and procure new software

The system has reached its life expectancy or does not meet the business requirements. Business requirements for the new system must be documented with supporting business models developed through BPA. The business models would then be utilized to evaluate the purchased software. New business models would need to be created or supplied by the software vendor that accurately reflect the process(es) supported and information managed by the selected software.

Regardless of which strategy is selected to migrate any specific legacy system, INEL waste and environmental programs must continue to review the business models to ensure they still integrate with the rest of the environment. The results of each strategy, except for "Do Nothing," will include the definition of the legacy system's business model in the Data Directory.

As shown in Figure 9, many factors must be assessed as implementation and migration plans are developed for each INEL waste and environmental information system. Each system should be evaluated against those factors that influence which strategy to select. To identify an appropriate migration strategy, the following factors must be assessed:

- Life expectancy

How long is the system expected to last before being replaced? For those systems with a short life expectancy, it may be more cost effective not to migrate the system.

- Mission critical

How critical is the system to the INEL waste and environmental programs' mission? Are the supported processes considered "mission critical" by senior management? Or is the system considered a "mission support" system?

- Requirements

How well does the current system meet the business requirements? What processes does the system support? What requirements drive the continued use of the system? Does the system contain process or data redundancy with other systems? If there is any process or data redundancy, is it possible for this redundancy to be managed and controlled?

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Figure 9. Factors influencing legacy system migration.

- Standards

How well does the current system conform to the defined standards? What would be required to bring the system into full compliance with these standards? Is it possible to accomplish full compliance as part of the selected migration strategy? Does this system need to be in compliance with the defined standards?

- Cost

What is the cost to migrate the system to the target environment in terms of both dollars and resources? What is the cost *not* to migrate the system to the target environment?

- Schedule

When could the migration begin and when would it be completed? Would the migration require full attention by the implementors, both information systems and end users, or be completed as part-time work?

- Funding

Is funding available to complete the migration? What is the funding source to migrate the system? When will funding be available?

- Technical issues

How difficult is the system to migrate in terms of converting the application code and moving the data to a different database? What skills are required by information systems personnel to perform the actual migration? What skills are needed by end user personnel to interact with the migrated system? Are any of these skills new and are there personnel that currently possess these skills? Will training be required for information systems personnel, as well as end user personnel? What dependencies and/or interfaces exist between this system and other systems? If there are dependencies or interfaces, how will these be maintained after the migration of the system?

- Information Broker

Will users need access to the information in the system utilizing the Information Broker?

7. SUMMARY

INEL waste and environmental information is a valuable asset that has become fragmented as to location, consistency, and accessibility. Getting the right information to the right people at the right time is paramount as INEL moves to a changing business environment.

The framework provides a blueprint from which IWEIIP will work to implement an environment to address long-term information needs. The INEL waste and environmental programs must move toward this target environment for flexibility in a rapidly changing business environment and to provide competitiveness in a global market. Multiple enabling concepts allow IWEIIP to integrate information and include:

- Information Infrastructure
 - BPA
 - Open Systems
 - CSC
- Information Architecture
 - Data management
 - Development coordination
 - Information sources
- Business Systems Architecture
 - Data Directory
 - Information Broker
- Technology Architecture
 - Hardware implementation
 - Application software implementation.

The integrated information framework and its enabling concepts represent a new way of doing business. Legacy systems must be brought into the new environment. This document outlines possible strategies to accomplish the migration.

Adopting the proposed framework will move INEL waste and environmental information into an environment that:

- Provides focused direction for information management and software development or acquisition.
- Treats and manages information as an asset.
- Through BPA, provides a mechanism to address suboptimized business process and data solutions.
- Implements data management processes to:
 - Provide data stewardship
 - Ensure data quality.
- Through development coordination, provides:
 - A forum to address overlapping integration efforts
 - Consistent configuration management processes.
- Implements:
 - A Data Directory to provide for data location transparency
 - An Information Broker to improve data accessibility.
- Emphasizes the use of standards to create an open systems environment that will allow:
 - The interconnection and integration of proprietary and heterogenous hardware and software
 - Replacement of rapidly changing hardware and software technology with minimal impact upon the business activities.
- Creates a CSC environment to effectively utilize the strengths and efficiencies of existing and future computer technology.

- Has less emphasis on technology and more on business.
- Responds to changing business needs and objectives.
- Has increased flexibility of information systems.

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APPENDIX A

TECHNOLOGY ARCHITECTURE REFERENCE MATRIX

APPENDIX A

TECHNOLOGY ARCHITECTURE REFERENCE MATRIX

The Technology Architecture (TA) reference matrix presented in this appendix is a structure proposed by the Idaho National Engineering Laboratory (INEL) Waste and Environmental Information Integration Project (IWEIIP) to identify standards in critical areas. The matrix cells are currently blank to facilitate discussion on individual components/elements. Follow-on efforts will determine significant portions of the TA reference matrix for subsequent phases of IWEIIP. The project will work closely with other INEL interfaces to achieve consensus for the standards.

The TA details are presented in the form of a reference matrix keyed to supporting narrative documentation. The objective of the reference matrix is to organize the components of a typical TA in a way that facilitates analysis, planning, communication, and use. In actual practice and in terms of physical implementations, the components of a sophisticated TA are interrelated and interconnected in highly complex ways. The TA attempts to abstract these components into a simplified model to allow strategies, options, and issues to be communicated more effectively.

The TA must be designed to meet INEL waste and environmental programs' needs, while at the same time remaining in the mainstream of industry trends and developments. A key technical driver for the TA is to rely on nonproprietary standards whenever possible.

A.1 TA Service Areas

The TA structure is based on several interdependent components called services. The IWEIIP has proposed service areas (which are described in more detail in following sections), selected from the "Open Systems Interconnection Model." These services will be evaluated for appropriateness as the project progresses. Some may be eliminated; others may be added. The proposed services include:

- Operating System
- Human/Computer Interaction
- Application Development and Maintenance
- Data Management
- Network
- Security
- Data Interchange
- Output.

A.2 TA Reference Matrix Description

A general format for the TA Reference Matrix is shown in Figure A-1. Points at which service area entries intersect with platform or INEL client/server computing (CSC) tier entries represent common information technology reference or decision points. These intersections are the cells of the matrix. Each cell provides summary technical guidance. In most instances, this summary guidance is backed up by more detailed narrative guidance keyed to the various matrix components. More detailed examples of components of the matrix are shown in Figures A-2 and A-3.

Figure A-1. General format of Technical Architecture (TA) reference matrix.

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Component	Element	Status	Tier 1			Tier 2	Tier 3
			Workstation	Personal Computer	Macintosh	Server	Host Server
Service Area	Service Area Breakout	target					
		preferred					
		legacy					

Figure A-2. TA reference matrix (summary format).

Component	Element	Status	Tier 1			Tier 2	Tier 3
			Workstation	Personal Computer	Macintosh	Server	Host Server
Information Management	Directory Services	target	X.500 Comp.			X.500 Comp.	X.500 Comp.
		preferred					
		legacy					

Figure A-3. TA reference matrix example.

A.2.1 Tiers

Vertical components of the matrix are organized into "tiers." Each tier represents a component of the preferred CSC configuration. Intersections of tiers and service rows of the matrix create matrix cells that contain various standards, products, and technology components.

For example (as shown in Figure A-3), X.500 compliance is the target for the Directory Services element of the Data Management Services component. In this instance, X.500 applies to all three tiers of the three-tier configuration.

A.2.2 Service Areas

As shown in Figure A-3, horizontal sections of the matrix represent various service areas (e.g., information management services). Some of these are further divided into subordinate levels called "elements." Element breakout is necessary to provide meaningful guidance in instances where products or standards relate to more than one aspect of a service area. For example, the Information Management Services area is further divided into Directory Services/Name Services, Data Directory, Data Dictionary, and Database Management elements. There are important standards, products, or other considerations that relate to each of these more detailed components of Information Management Services.

Each horizontal row also includes a status indicator for each service area. Where a service area is further divided into elements, there is a status indicator for each element. The status indicators are "Target," "Preferred," and "Legacy." These are defined as follows:

- **Target:** This is the generally accepted standard that applies to a service area. Designation of a standard (e.g., structured query language compliance) as a "target" suggests that the long-term objective for preferred products and technologies in this service area is to be compliant with the specified standard. In some instances, the target indicator might refer to a technology or product that can be viewed as a *de facto* standard when and if the standard: (1) receives a reasonable level of industry acceptance, and (2) INEL waste and environmental programs are prepared to support it.
- **Preferred:** This indicator designates products or technologies that are preferred, available, and currently supported within INEL waste and environmental programs. Use of preferred items will contribute to the orderly migration of the existing systems toward the INEL's overall information environment vision objectives. Moreover, selection of preferred items will ensure the user of the availability of sound technical support. In most instances, selection and use of preferred items will also save the user time and money.

Note: An information system designer will want to examine both the target and preferred categories carefully to make a fully informed decision. There may be instances when the prudent course of action would be to wait or perhaps to design a minimal system pending the acquisition of a target product or technology, the availability of which is imminent.

- **Legacy:** This status indicator relates to products or technologies that are presently supported within INEL waste and environmental programs because of existing investments and other important operational considerations, but have certain attributes that prevent them from being listed in the preferred category. For example, important production systems that operate on platforms or employ technologies that predate those shown in the preferred category are legacy systems. These items should be used selectively, based upon extenuating circumstances. Their use for new systems or major system upgrades should be curtailed. The general strategy

for legacy systems will be to develop formal migration strategies with definitive conversion and phase-out milestone dates. As these milestones are reached, the level of support for legacy products and technologies will be reduced accordingly.

A.2.3 TA Summary Reference Matrix

TA standards and preferred products will be summarized in the TA Summary Reference Matrix presented on the following pages (Table A-1). Many users and system developers will require more detailed information. To meet these needs, supporting information is provided in the following section (this section is keyed to the Service Area blocks of the Reference Matrix). These narrative sections should be consulted.

A.2.4 Supporting Narrative

Operating System Services - Operating systems provide the core services necessary to execute and administer application systems running on computing platforms. These systems also provide an interface between applications software and the computing platform. Operating system services include the sub-component functions of kernel operations, including program execution and file and directory management; system administration commands and utilities (such as resource accounting and command scripts); real-time extension to support application domains requiring deterministic execution, processing, and responsiveness; and system management, which includes authorization of resource usage, configuration and performance management of devices, and system backup.

Human/Computer Interaction Services - Human/computer interaction services define how people can interact with computer-based applications. Depending on the capabilities required by the user and the application, such an interface may include:

- CSC operations
- Window management.

Applications Development and Maintenance Services - The tools used to develop and maintain a computer-based application capture the procedural logic of the application. The choice of tools and methods of capture can have a significant impact on initial development and ongoing maintenance costs. The general strategy in this area is to develop open applications (i.e., those that have portability, scalability, and interoperability), and to use the highest level tools available to optimize the time of application system developers.

Applications development and maintenance tools for the CSC environment already provide a broad range of required capabilities. Integrated tools that presently address the centralized mainframe environment are being re-engineered for the CSC environment. Applications development and maintenance services include:

- Integrated software engineering environment
- Application generators
- Other tools
- CSC tools
- Compilers.

Information Management Services - Central to most systems is the management of information. Ideally, through the use of data management technologies and products, data can be defined independently of the processes that create or use it, can be maintained indefinitely, and can be shared among many processes. Information management services include:

- Data directory services
- Data dictionary
- Database management systems.

Network Services - Network services include application programming interface and protocol specifications to enable reliable, transparent, end-to-end data transmission across communications networks; transparent file access to local and remote files; microcomputer support for the interoperability of proprietary systems; and remote procedure call services to a CSC environment. Elements of Network Services include:

- Transmission media
- Data link services
- Data communication
- File services
- Network management
- Time services.

Security Services - Security services include those services that provide user and process authentication, authorization, and data protection throughout the entire architecture. The elements of this service are:

- Network security
- Platform security.

Data Interchange Services - To facilitate effective communications, data must be moved among organizations, across platforms and systems, and among applications and information products. These data may be in the form of text, graphics, still images, video, or audio. Some common examples of data interchange include the movement of text from one document to another, the transfer of data from a spreadsheet to a report, the transfer of structured data from a mainframe to a personal computer, or the transmission of product data from a design group to a manufacturing group. Data interchange implies that data will be manipulated after transmission. Elements of the output formats should be relatively inflexible to minimize decisions which must be made by output devices.

Data interchange services provide support for the interchange of data among applications on the same or different (heterogeneous) platforms. The National Institute of Standards and Technology's application portability profile describes several levels of complexity of data interchange. At the lowest level are representations of the actual data to be exchanged. The next higher level represents data content formats (e.g., text, raster images, audio). The next level contains object representations. These may be combinations of different content types, as in a complex document. Above the object level is the language level, which contains representations in a format that permits human understanding. The application level is the highest level of complexity and may use any of the lower levels of data representation to interchange data among applications.

Neutral formats (defined independently of any application) are the most cost effective method of data interchange. Initial Graphic Exchange Specification and Standard Generalized Markup Language are examples of neutral formats. Elements of Data Interchange Services include:

- Document/text
- Hypermedia/multimedia
- Raster graphics
- Vector graphics
- Product definition

- Electronic data interchange
- Electronic funds transfer.

Output Services - Output services provide the means of transmitting data files to output devices (e.g., printers, plotters, etc.) or to other computers in a format recognizable to and usable by the target device. Most standards relating to input/output relate to specifications of file formats that are acceptable to output devices. These formats can be divided into three major categories:

- Page description format
- Raster graphics format
- Vector graphics format.

Table A-1. TA Summary Reference Matrix.

TA Summary Reference Matrix			TIER 1			TIER 2	TIER 3
COMPONENT	ELEMENT	STATUS	WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST SERVER
Operating System Services		Target					
		Preferred					
		Legacy					
Human/Computer Interaction Services	CSC Operations	Target					
		Preferred					
		Legacy					
	Window Management	Target					
		Preferred					
		Legacy					
Application Development and Maintenance Services	Integrated Software Engineering Environment	Target					
		Preferred					
		Legacy					
	Application Generators - 4-GILs	Target					
		Preferred					
		Legacy					
	Other Tools	Target					
		Preferred					
		Legacy					
	CSC Tools	Target					
		Preferred					
		Legacy					
	Compilers	Target					
		Preferred					
		Legacy					
Information Management Services	Directory Services/Name Services	Target					
		Preferred					
		Legacy					

TA Summary Reference Matrix

			TIER 1			TIER 2	TIER 3
COMPONENT	ELEMENT	STATUS	WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST SERVER
Information Management Services (cont.)	Data Dictionary	Target					
		Preferred					
		Legacy					
	Data Directory	Target					
		Preferred					
		Legacy					
	Database Management	Target					
		Preferred					
		Legacy					
Network Services	Transmission Media (Between Tiers)	Target					
		Preferred					
		Legacy					
	Data Link Services	Target					
		Preferred					
		Legacy					
	Data Communication (Protocol)	Target					
		Preferred					
		Legacy					
	File Access	Target					
		Preferred					
		Legacy					
	Network Management	Target					
		Preferred					
		Legacy					
	Time Services	Target					
		Preferred					
		Legacy					

TA Summary Reference Matrix

			TIER 1			TIER 2	TIER 3
COMPONENT	ELEMENT	STATUS	WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST SERVER
Security Services	Network Security	Target					
		Preferred					
		Legacy					
	Platform Security	Target					
		Preferred					
		Legacy					
Data Interchange Services	Document/Text	Target					
		Preferred					
		Legacy					
	Hypermedia/ Multimedia	Target					
		Preferred					
		Legacy					
	Raster Graphics	Target					
		Preferred					
		Legacy					
	Vector Graphics	Target					
		Preferred					
		Legacy					
	Product Definition	Target					
		Preferred					
		Legacy					
	Electronic Data Interchange	Target					
		Preferred					
		Legacy					
	Electronic Funds Transfer	Target					
		Preferred					
		Legacy					

TA Summary Reference Matrix

			TIER 1			TIER 2	TIER 3
COMPONENT	ELEMENT	STATUS	WORKSTATION	PERSONAL COMPUTER	MACINTOSH	SERVER	HOST SERVER
Output Services	Page Description	Target					
		Preferred					
		Legacy					
	Raster Graphics	Target					
		Preferred					
		Legacy					
	Vector Graphics	Target					
		Preferred					
		Legacy					

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