enterprise DATA MANAGEMENT PRACTICE

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Segment Data Architecture Best Practices Analysis

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HUD EA Practice Support

HUD BLUEPRINTS BUILDING IT TOGETHER

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SECTION 1. EXECUTIVE SUMMARY

The Segment Data Architecture Best Practices Analysis Report summarizes the Enterprise Data Management Group's (EDMG) analysis of the practices and governance used by selected Federal agencies to develop segment data architectures, as well as our analysis of methodologies that have contributed to successful data architecture programs in general. The objective of these analyses is to provide HUD with recommendations for a formal Segment Data Architecture Methodology and governance to develop their own segment data architectures.

This Report is the first of two documents. In the second document, the EDMG will align the Segment Data Architecture Methodology recommended in the current Report to HUD's existing Software Development Methodology (SDM), as well as to HUD's Information Technology (IT) Lifecycle, and provide recommended changes to the SDM.

1.1 Segment Data Architecture Best Practices Analysis Approach

Our approach to best practices analysis was to interview Federal agencies and research prevalent Enterprise Architecture (EA) methods and frameworks. We chose three agencies for detailed analysis based on the following criteria.

- Architecture maturity
- Awards for EA activities
- Involvement in the Federal EA community.

The three agencies that were chosen are the Department of the Interior (DOI), U. S. Customs and Border Protection (CBP), and the Department of the Navy (DON). The Department of Defense Architecture Framework (DODAF) and the Information Engineering Methodology (IEM) were chosen as best practices methodologies.

The EDMG selected DOI because of its FEA DRM pilot program that demonstrated actual use of the DRM and because of the numerous awards the DOI has received for its EA environment. CBP was selected because of the agency's use of a data architecture to resolve many of the challenges they were facing in an extensive modernization program. The DON was selected due to the maturity of their architecture as well as its comprehensive EA management tools.

1.2 **Segment Data Architecture Best Practices Review**

1.2.1 Department of the Interior

The DOI has over 900 application systems registered in its repository and eight semi-autonomous bureaus, with each bureau having its own CIO office. This decentralized structure is necessary to manage such a large IT environment, but it has also led to undesirable effects, which include disparate and redundant data. The DOI took a Department-wide approach to EA in order to achieve its primary data management objectives of data reuse and sharing.

The DOI modernization blueprint process drives its EA development by connecting DOI's existing information assets with the target data architecture. Once this connection is made, the Department can use its target data architecture to identify opportunities for data sharing and integration. Critical to the success of this process is the Data Stewardship Program and robust EA management tool.

1.2.2 U. S. Customs and Border Protection

The foundation of the Customs and Border Protection (CBP) modernization program is the Automated Commercial Environment (ACE). The ACE program has many technical challenges to manage the assembly of the technical solution. It is acquiring COTS solutions, leveraging legacy systems, and developing new components. In addition, ACE has extensive external interfaces with the ports, other Federal agencies, and the trade community in order to manage trade and control terrorism.

The ACE and CBP data architectures are core to the success of the ACE program. The data architects continually align and synchronize the program and enterprise data architectures. The CBP is committed to this on-going effort because of the tremendous benefits the architectures and their alignment have provided to the ACE program. Some of the key uses of the data architectures are:

- Provide an integration point for all the components of the technical solution
- Provide the vocabulary for the enterprise, and act as the translator for external interfaces
- Ensure all the external interface information requirements are captured
- Support transition planning and release management.

1.2.3 Department of the Navy

DON EA development has been driven by a technology change, the implementation of the Navy Marine Corps Intranet (NMCI), and a mandate to reduce its application portfolio by

95%. All applications at the DON were reviewed for migration to the new Intranet. The Application Rationalization Review reduced the Navy and Marine Corps application portfolio from 100,000 applications to 60,000 applications. The final phase of these reviews will reduce the application portfolio to approximately 5,000 supported applications. The analysis of the legacy databases to support this review process provided the information to build data architectures by functional area. The DON assigns Functional Area Managers (FAM) and Functional Data Managers (FDM) to be responsible for the development, maintenance and control of these data architectures.

1.3 **Segment Data Architecture Best Practices**

The EDMG identified eight best practices that were common among these agencies and methods that contributed to their program's EA success.

- **Top-down and bottom-up analysis.** All the agencies established initiatives to build their enterprise data architectures using both a top-down and bottom-up approach. The top-down perspective produced the taxonomy to organize their enterprise-wide data architecture based on the business functions in their BRM. The bottom-up efforts served to decompose, detail and validate the data architecture with the as-is artifacts.

- **Incremental development.** In order to make the decomposition and definition of its enterprise data architectures more manageable, each agency developed strategic plans based on business priorities to incrementally develop data architectures for targeted business areas.

- **Alignment of data and business architectures.** Processes were implemented to ensure the decomposition of the data and process models retained alignment so that the artifacts of the models could be mapped. This mapping served to 1) validate the synchronization of the data and business process models; 2) validate the information exchanges; 3) identify missing data elements and business processes and 4) identify opportunities for data reuse and/or integration.

- **Communicate, coordinate and collaborate.** The "3 Cs" concept is common; all the agencies had established at least one working groups as a means to foster the concept across the enterprise. These working groups contribute the structure and definition of the enterprise data architecture, coordinate the alignment and harmonization of the functional data architectures with the enterprise data architecture, and foster governance within their respective organizations.

- **Business Data Stewardship.** All the agencies interviewed had a Business Data Stewardship program in place.

- **Established and enforced data architecture governance.** Each agency stated that developing their enterprise-level data architecture would not have been successful

without established policy, procedures and standards for architecture development and data management. Furthermore, the governance had to be flexible enough to allow for program or functional-area extensions. Established governance was not enough; it also had to be supported by senior -level management to ensure that data artifacts produced by the various areas adhered to the agency's policies and standards.

- **Architecture driven modernization efforts.** The agencies use their enterprise data architecture models to provide common semantics and structure for the physical data definition and specifications for information exchange.

- **Centralized and effective access to EA artifacts.** DOI and DON have an extensive centralized repository or application that enables enterprise-wide access to the artifacts of the data architecture and other EA models.

SECTION 2. INTRODUCTION

2.1 **Objectives**

Within the Federal Government there are emerging practices, structures and methodologies that are used to develop and oversee enterprise architectures. The EDMG analyzed the practices and governance used by Federal agencies that have mature and successful data architecture in order to provide HUD with a recommended approach to its segment data architectures development. The EDMG also analyzed two methodologies used prevalently in Federal agencies and private industry to develop and manage enterprise-level data architectures. The specific objectives of the EDMG's analysis are to leverage best practices identified during this analysis and provide recommendations for

- A governance structure to oversee the development of HUD's data architecture
- A methodology to develop a segment or line of business (LOB) data architecture
- Changes to HUD's current Software Development Methodology (SDM) in order to incorporate or align with the recommended Segment Data Architecture Methodology.

2.2 Scope

The scope of this document is to provide a summary of the EDMG best practice analysis of Federal agencies' data architecture programs. The results of this analysis will provide the foundation for a recommended segment data architecture development methodology. The document is organized in the following manner. The first part of this document describes the approach the EDMG used to select the Federal agencies for best practices interviews. The next part of the document summarizes the data architecture development methodology and governance used by each agency, as well as best practices leveraged from established methodologies. The final part of this paper summarizes eight best practices common among these agencies and methodologies.

This document is the first of two, the second of which will provide recommendations for a segment data architecture methodology, governance structure and changes to the HUD's existing SDM.

2.3 Background

In order to optimize IT expenditures across the Federal Government and within each Federal agency, Congress enacted legislation such as the Clinger-Cohen Act of 1996 that made it a requirement for every Federal agency to develop an enterprise architecture (EA). An EA is a business-based framework that describes and documents the relationships between an agency's business functions and the IT assets that support those functions. By using this framework, the Federal Government will be able to identify IT assets that can be

reused and redeployed, thus yielding substantial cost savings and improved services for its citizens.

2.4 Federal Enterprise Architecture Framework

The Federal Enterprise Architecture Program Management Office (FEAPMO) developed a Federal Enterprise Architecture Framework (FEAF) in 2002. The intent of the FEAF is to enable the Federal Government to define and align its business functions and supporting IT systems through a common set of reference models. These models are defined as:

- **Performance Reference Model (PRM).** The PRM is a standardized framework to measure the performance of major IT investments and their contribution to program performance.
- **Business Reference Model (BRM).** The BRM is a function-driven framework for describing business operations of the Federal Government independent of the agencies that perform them.
- **Service Component Reference Model (SRM).** The SRM is a business and performance-driven functional framework that classifies service components with respect to how they support business and/or performance objectives.
- **Data Reference Model (DRM).** The DRM is a model describing, at an aggregate level, the data and information that supports program and business line operations.
- **Technical Reference Model (TRM).** The TRM is a component-driven, technical framework used to identify the standards, specifications and technologies that support and enable the delivery of service components and capabilities. [1]

The objectives of the FEAF are to enable the Federal Government and agencies to:

- Leverage technology and reduce redundant IT expenditures across the Federal Government
- Facilitate cross-agency IT integration and sharing of data
- Apply common architecture practices
- Assist agencies to meet their EA legislative mandates.

The focus of the EDMG analysis is the best practices used by Federal agencies to develop an enterprise-wide data architecture. The content of an agency's data architecture should align to the business functions in its BRM and the structure provided by the FEA DRM. The alignment of the business and data architectures will drive the specification for the desired target application components. The following sections provide a more detailed description of the FEA BRM functional hierarchy and the FEA DRM structure.

[1] Overview of the Federal Enterprise Architecture, http://www.feapmo.gov/resources/FEA%20Overview.pdf

2.4.1 Federal Enterprise Architecture Business Reference Model

The FEA BRM represents a high level view of Federal Government business areas. The BRM is being developed through an iterative and continuous process, incorporating input from Federal agencies as their EAs evolve. The BRM has a three-tiered hierarchy with Business Areas at the highest level, followed by Internal/External Lines of Business and finally Business Sub-Functions (see Figure 2-1).

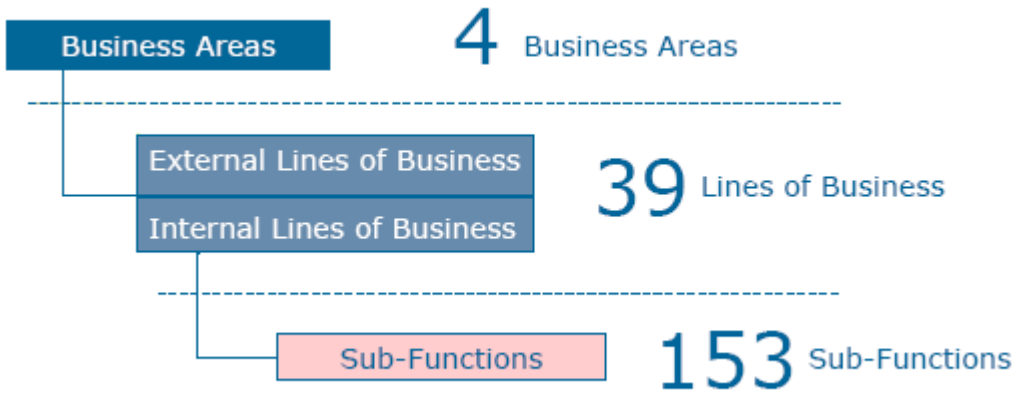


Figure 2-1. FEA BRM Structure

Descriptions of these levels and their content are described in the document, *FEAPMO Business Reference Model*, *Version 2.0,* as follows:

> **Four Business Areas** separate IT operations into high-level categories relating to the purpose of government: 1) Services for Citizens; 2) Mode of Delivery - the mechanisms the Government uses to achieve its purposes; 3) Delivery of Services - the support functions necessary to conduct Government operations; and 4) Management of Government Resources - the resource management functions that support all areas of Government business.
>
> These four Business Areas are comprised of **39 Lines of Business**. Nineteen of these Lines of Business are found in the Services for Citizens layer and describe the purpose of government in functional terms. These Lines of Business are referred to as External Lines of Business. The remaining twenty Internal Lines of Business describe the support functions the Government must conduct in order to effectively deliver services for citizens. For the sake of simplicity, the generic term "Line of Business" will be used to refer to both internal and external business lines.
>
> Each Line of Business is comprised of a collection of sub-functions that represent the lowest level of granularity in the BRM Version 2.0, which contains **153 Sub-Functions**.

2.4.2 Federal Enterprise Architecture Business Data Reference Model

Volume One of the FEA DRM was released in October 2004. Volume One establishes a high-level overview of the DRM approach, which presents a common method for the categorization, exchange and structure of data (see Figure 2-2).

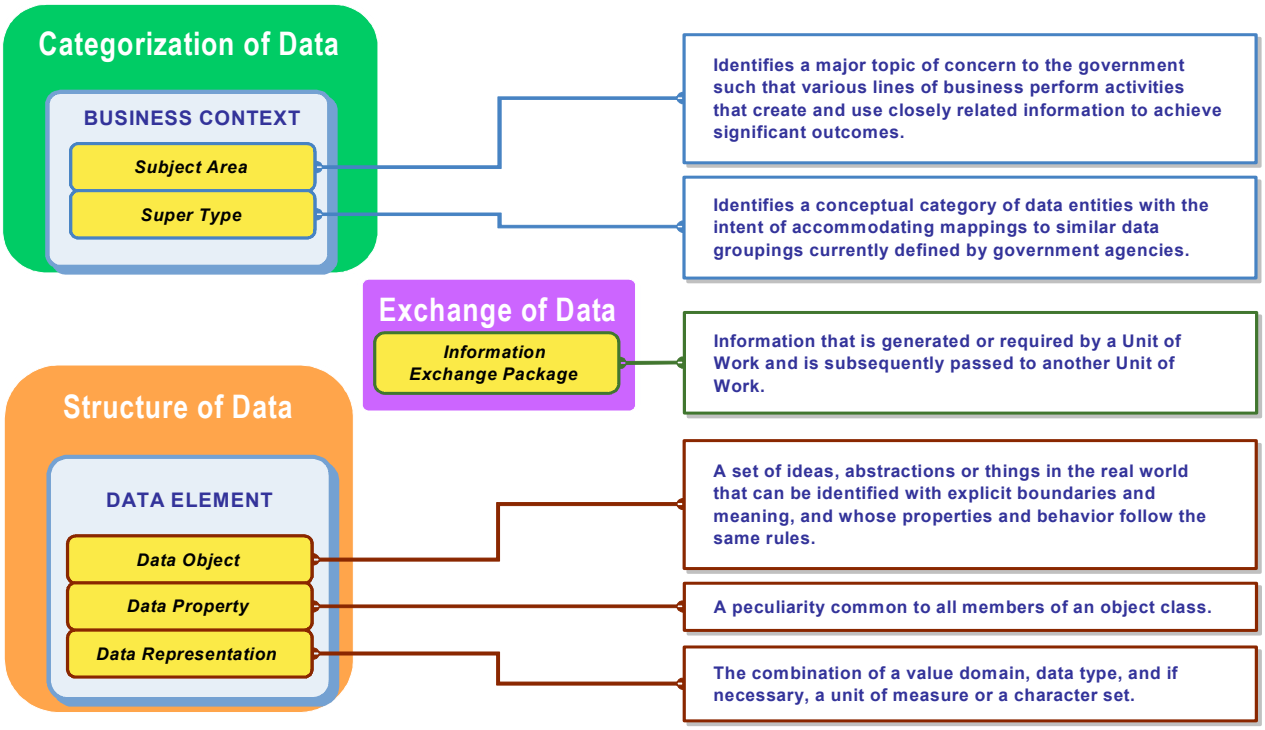


Figure 2-2. The DRM Approach

The FEA DRM approach to the categorization of data requires a business context to be defined for a set of data that represents the business use of the data. The Business Context layer contains Subject Areas and Super Types (also referred to as Subject Classes) to further define the data. The Exchange of Data layer describes the information that is exchanged between two units of work. The Structure of Data layer describes the data element as the underlying structure of the DRM and describes the actual data.

The DRM framework provides a common structure that agencies will use to build models of their existing data assets. This approach of identifying and standardizing information exchanges will be the mechanism for standardizing data across the Federal Government. At the top-level of the DRM, data is categorized by business context to allow agencies with common business areas to identify opportunities to share and reuse data.

2.5 HUD EA Initiatives

2.5.1 HUD's Enterprise Architecture Maturity

The Government Accounting Office (GAO) surveys Federal agencies on the maturity of their EA activities. They evaluate over 100 Federal agencies and rate its EA status based on the following stages of development. Stage 1 is considered to be ineffective and Stage 5 is considered to be highly effective.

In 2001, the HUD EA effort was evaluated at Stage 1[2] and by 2003, HUD increased its maturity rating to 1.8. With a current focus to improve the maturity of its EA practice, HUD predicts they will achieve Stage 3 by June 2005. The EDMG best practices analysis of segment data architecture methodology and governance is a result of HUD's commitment to increasing the maturity of its EA program.

2.5.2 HUD Enterprise Architecture Framework

HUD established an EA Framework to develop and maintain its EA. The framework defines the relationships between various architecture components and how the architecture will be used to support the Department's strategic planning and IT investments (Figure 2-3).

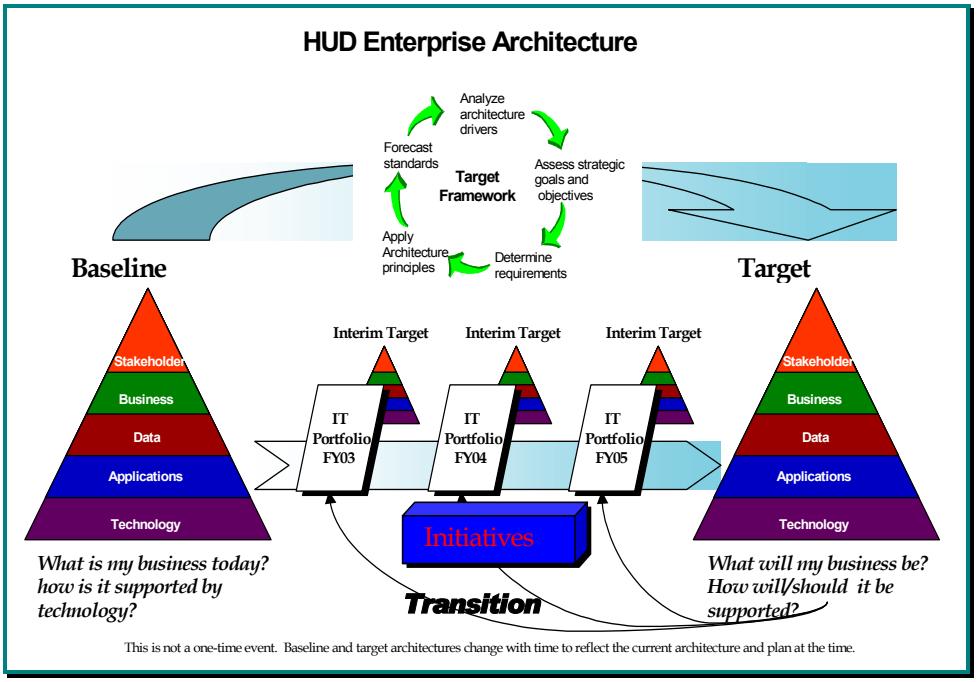


Figure 2-3 - HUD EA Framework

[2] U.S. General Accounting Office, *Information Technology - Enterprise Architecture use across the Federal Government can be improved*, GAO-02-06 (Washington, D.C.: February 2002)

The HUD EA framework provides the structure necessary to develop, use and maintain its EA. The framework describes the means by which HUD transforms the EA concept into a practical methodology. The development of the HUD EA begins with establishing an 'as-is' or baseline architecture that is used to detail the 'to-be' or target architecture.

2.5.3 HUD's Target Business Architecture

The Target EA describes the desired end state that will enable HUD to achieve its strategic vision and goals. The first release of the Target EA defines the HUD Business, Technology and Application and Service Layers (Figure 2-4).

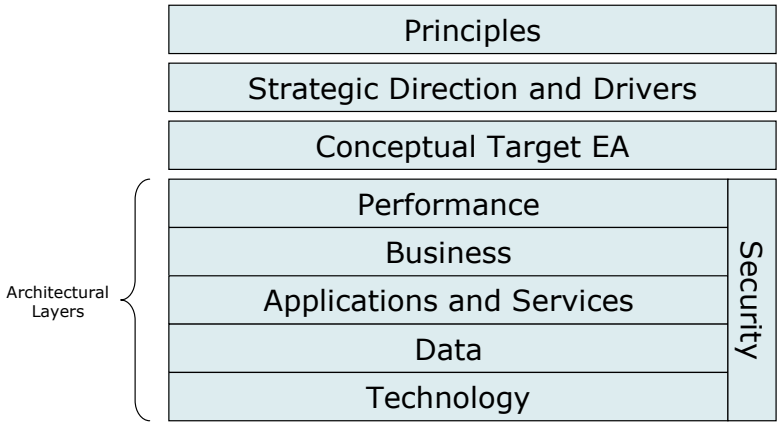


Figure 2-4 - HUD Enterprise Architecture Layers

The Principles, Strategic Direction and Drivers**,** and Conceptual Target EA set the foundation to establish a high-level conceptual understanding of the Target EA. The next six elements, or architectural layers, provide the details of the Target EA. The Target Business Architecture Layer establishes the scope and foundation for the Segment Architectures.

The Business Architecture Layer reflects the work performed by HUD to accomplish the Department's mission independent of HUD's organizational structure. It identifies both internal and external functions and aligns them to the FEA BRM (Figure 2-5). The business functions can then be aligned with the other layers of the architecture, such as the Data Architecture Layer. This alignment will provide a view across HUD's business functions to identify data sharing opportunities. Furthermore, the Business Architecture Layer provides the standard terminology that is used to describe business functions within HUD.

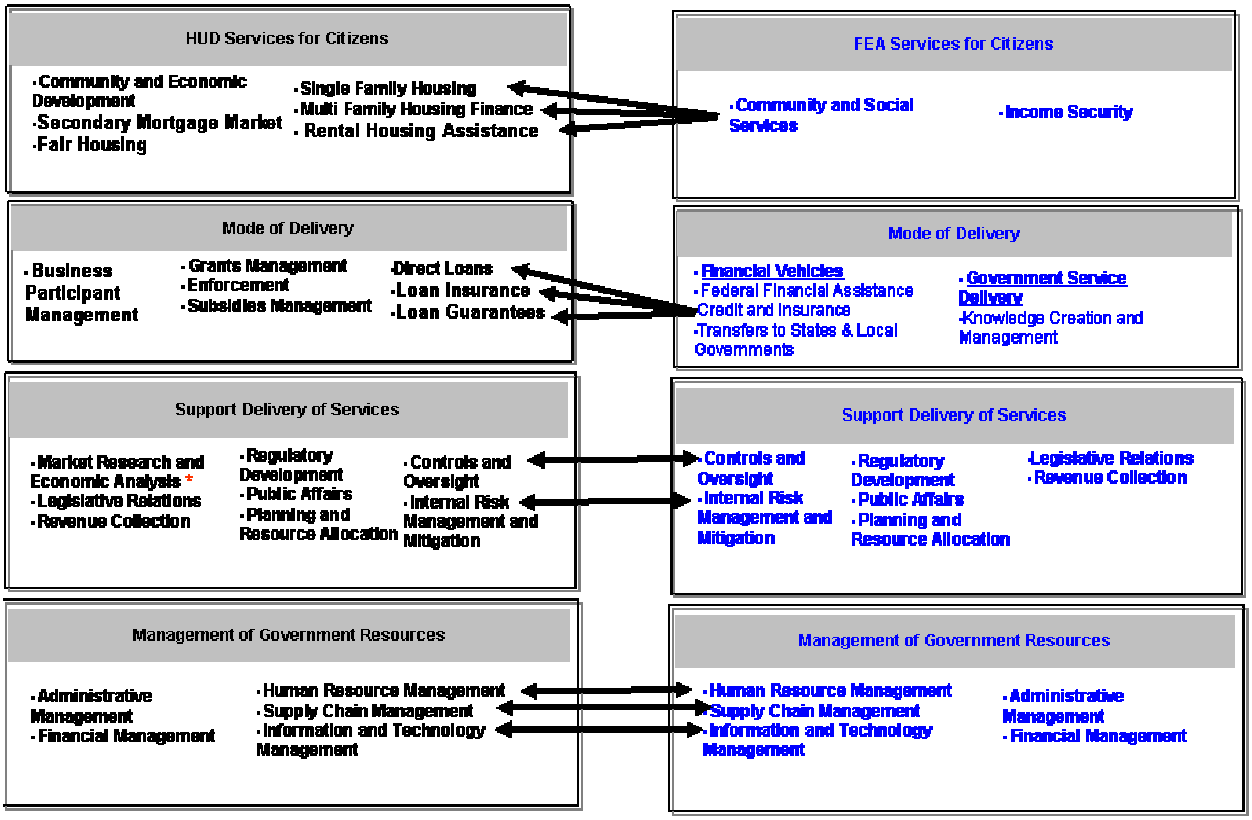


Figure 2-5 - HUD BRM Alignment with the FEA BRM

2.6 Segment Architecture

The Segment Architectures detail the Business Architecture Layer of HUD's Target EA using both a top-down and bottom-up approach that incrementally builds the Target Enterprise Architecture. The business architecture layer identifies the scope of the segment architecture development and the high-level business context of the data architecture. The segment data architecture is detailed by assessing HUD current system portfolio and data stores and aligning them to the business context of the segment data architecture. The data elements are mapped to business areas, categorized into conceptual data structures, and standardized to establish a standard definition for the HUD target architecture.

SECTION 3. SEGMENT DATA ARCHITECTURE BEST PRACTICES ANALYSIS APPROACH

3.1 Best Practices Approach

In order to research data architecture best practices among Federal Government agencies, the EDMG first reviewed the GAO report that contained ratings of agency EA maturity. From this review, a list of the top ten agencies was generated. The EDMG then searched for detailed EA information on the Internet for each agency on the list. The following criteria were used to determine which agencies were chosen for more detailed analysis.

- Degree of data architecture development
- Presentations on data architecture practices
- Awards presented to the agency for EA activities
- Agency recommendations from the HUD data architect.

Using these criteria, the EDMG chose three agencies and scheduled interviews with personnel familiar with the agency EA efforts, who provided the EDMG greater insight into their data architecture practices.

In addition to reviewing Federal Government agencies, the EDGM reviewed government and industry EA methodology and frameworks for best practices and artifacts. The Department of Defense Architecture Framework (DODAF) and Information Engineering Methodology (IEM) were chosen as best practices.

3.2 Best Practices Agencies and Departments

The following sections describe why the following three Federal agencies were selected for in depth review and interviews.

3.2.1 Department of Interior (DOI)

The EDMG chose the Department of Interior for one of the three best practices interviews because of its work on implementing data management using the FEA DRM. The U.S. Department of the Interior (DOI) has received numerous awards for its EA environment. Federal Computer Week gave its "Leadership in Government Transformation" award to the Department for its EA methodology and repository, while the E-Government Institute cited it for an "Excellence in Enterprise Architecture" award. Early involvement with the FEA DRM was indicated by a pilot program (conducted with the FEAPMO) demonstrating actual use of the DRM, as documented in Section Four of the Volume One FEA DRM. The DOI pilot program used the DRM approach to structure data in the Department's recreation business area.

The DOI EA Web site is extensive and offers excellent details on the direction and status of the Agency's data architecture development process. The EDMG found that DOI has

many components of a mature data process and data architecture in place. The Web site provided access to guidance documents, data management and standardization program plans, an enterprise data model and a data repository tool.

3.2.2 Department of Homeland Security (DHS), Customs and Border Protection (CBP)

The EDMG chose Customs and Border Protection for one of the three best practices interviews because of its practical approach in developing a data architecture. In July 2001, both the U.S. Treasury Department and the Federal CIO Council recognized the Customs and Border Protection (CBP) enterprise architecture as a 'best practice'. In the latest GAO evaluation of EA maturity, the Department of Homeland Security (DHS), under which CBP is evaluated, was rated at Stage 3.[3] Currently, CBP is undergoing a major modernization of its IT program; the first project resulting from this effort, the Automated Commercial Environment (ACE), was at one time deemed by the GAO to be an at-risk program.[4] Today, however, it is considered a major success story due in large part to implementation of a data architecture practice aligned with the CBP EA. CBP is also an example of an agency that developed a bottom up data architecture under Departmental EA guidance.

3.2.3 Department of the Navy

The EDMG chose the Department of the Navy (DON) for one of the three best practices interviews due to its development of Functional Data Architectures and for the architecture tools used to build and control its data architectures. The DON CIO Web site provides extensive research materials for determining the extent to which the DON data architectures were developed. The DON has numerous mature tools to support its architecture development. The DON Application and Database Management System (DADMS) was of interest for reviewing best practices tools.

[3] U.S. General Accounting Office, *Information Technology - Leadership Remains Key to Agencies Making Progress on Enterprise Architecture Efforts*, GAO-04-40 (Washington, D.C.: November 2003), pg. 85.

[4] U.S. General Accounting Office, *Customs Service Modernization ACE Poses Risks and Challenges,* GAO/T-AIMD-97-06*,* (Washington, D.C.: May 15, 1997).

SECTION 4. SEGMENT DATA ARCHITECTURE BEST PRACTICES REVIEW

4.1 Acknowledgments

The EDMG would like to thank the following individuals who gave their time and provided presentation materials that were used throughout this section of the analysis.

- Suzanne Acar (DOI)
- Bob Green, Frank Brady and Gregory Michaels (DON)
- Deborah Brooks, Cindy Walker and Bob Brekke (CBP).

Most of charts and graphs in the following sections were copied from presentation materials provided by these generous individuals.

4.2 Department of Interior

4.2.1 Background

The Department of the Interior (DOI) has a wide-ranging mandate in that it manages one of every five acres of land in the United States, provides for wilderness protection, oversees land reclamation and water management efforts, operates the National Park Service and manages natural resource protection. DOI manages an annual IT budget of approximately $1 billion and has over 900 major IT systems across eight DOI bureaus. These eight bureaus function semi-autonomously, with each bureau having its own CIO office reporting directly to the DOI CIO.

With over 900 IT systems, this decentralized structure is necessary to manage such a large IT environment, but it has also led to undesirable effects with regard to data management, including the creation of disparate data, redundant data and many data stovepipes.

To address these problems, DOI has taken aggressive action to develop a data architecture to meet the following goals.

- Reduce the life cycle cost of data through integration, standards and the use of authoritative data sources
- Provide a DRM that addresses information important to the business of DOI
- Provide a metadata registry to support data standardization and re-use
- Provide a data resource management infrastructure to ensure data integrity, quality and security.

DOI has a well-defined data architecture methodology and has made measurable progress in meeting its data management goals.

4.2.2 Methodology Overview

The DOI Modernization Blueprint process drives its EA development by defining a roadmap connecting the Department's existing and target applications architecture with transition plans for migrating between the two. The results of this blueprint process improve the alignment of proposed IT investments with the DOI strategic plan, minimize data redundancies and direct new systems to use state-of-the-art technologies consistent with the DOI TRM.

4.2.2.1 Modernization Blueprint Process

The DOI blueprint process is an iterative process (see Figure 4-1). When regulatory requirements change and new leading practices show the need to improve the IT environment, blueprint activities are started again to revise the target architecture.

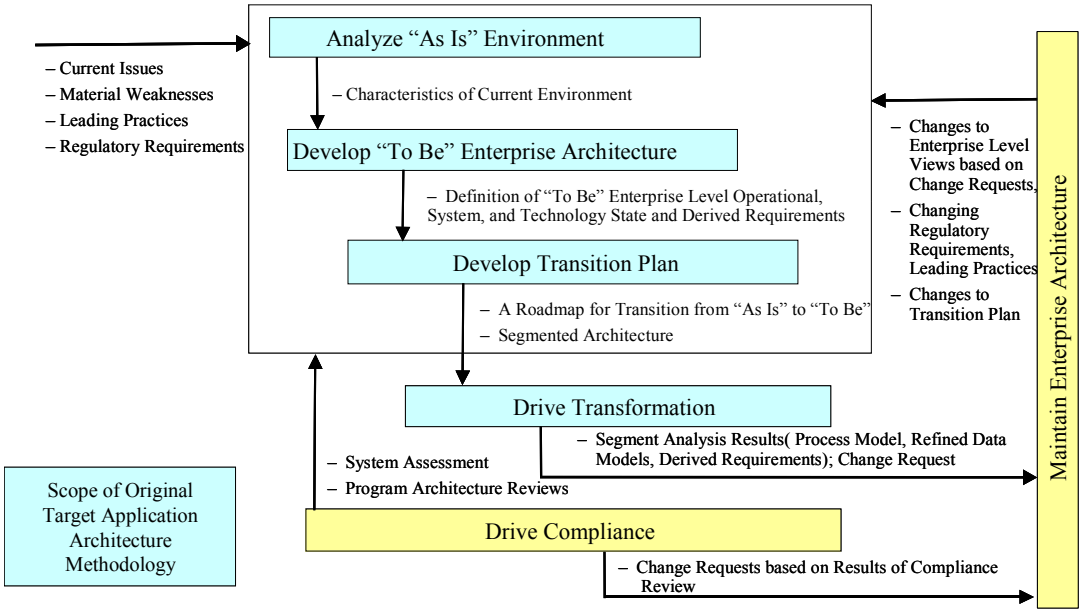


Figure 4-1. Iterative DOI Blueprint Process

The blueprint process starts by analyzing the as-is environment that is comprised of business operations and system portfolio. The as-is environment reflects current business operations, which provides the reference point for the development of the to-be architecture and the transition plans between the as-is environment and the to-be environment.

Analyzing DOI business operations involves building an inventory of business processes and documenting them in the DOI BRM down to five levels. These business processes are modeled using an IDEF0 function/activity model for the lines of business.

In analyzing the as-is system portfolio, DOI analyzed only the systems critical to DOI business in order to reduce cost of this phase of the blueprint process. Systems are mapped to capabilities (SRM), functionality (BRM), purpose (PRM) and informational requirements (DRM) to determine its business fit.

Systems are scored based upon pre-established measurement criteria to generate an architecture maturity score. Part of a system's architecture maturity score is determined by the extent to which systems map to the DOI DRM. The measure criteria used is:

- Existence and documentation of data standards and protocols compliant with DOI and Federal data standards (as applicable)
- Relative maturity and accessibility of system data and access methods
- Relative overlap with data stored in other Interior systems.

In addition to the DOI DRM maturity score, the system is evaluated based on its alignment with business and technology target architectures. The overall score determines if a system will be retired, integrated or migrated (see Figure 4-2). As DOI identifies systems to keep or migrate in the blueprint process, the data associated with these systems are analyzed for data sharing opportunities and data redundancies.

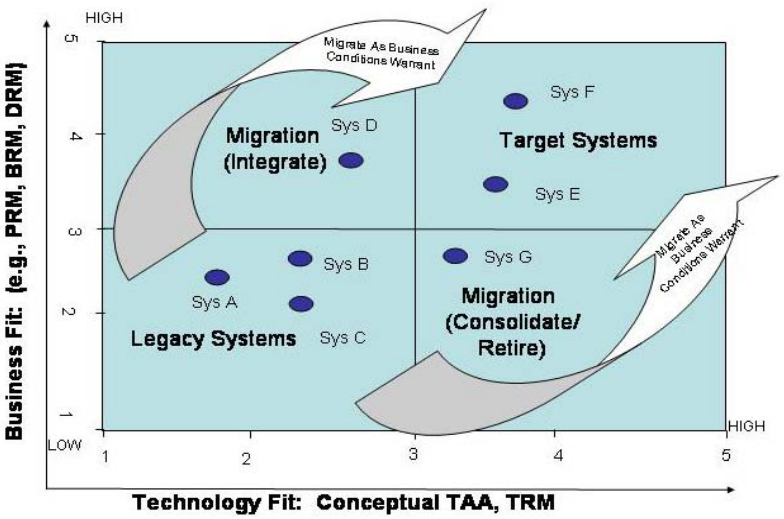


Figure 4-2. DOI System Grouping Analysis Template

4.2.2.2 DOI Data Architecture

The DOI data architecture is a framework for building shared and reusable data across DOI. The building of the DOI DRM has been an incremental process focused on six priority business lines. The development of a standardized conceptual data definition among these business lines is key to the DOI data management priority of data sharing and reuse.

The DOI data architecture framework is built upon four foundation components (see Figure 4-3). Data Standardization and Information Exchange/Information Sharing Requirements are focused on business requirements providing a common understanding of data semantics. Synchronization and Implementation Support and Delivery Mechanism foundation components focus on the physical implementation of data requirements. Governance policies and governance teams, such as the Data Resource Management Steering Group (DRMSG) and the DOI data stewards group, keep these four components in harmony with each other.

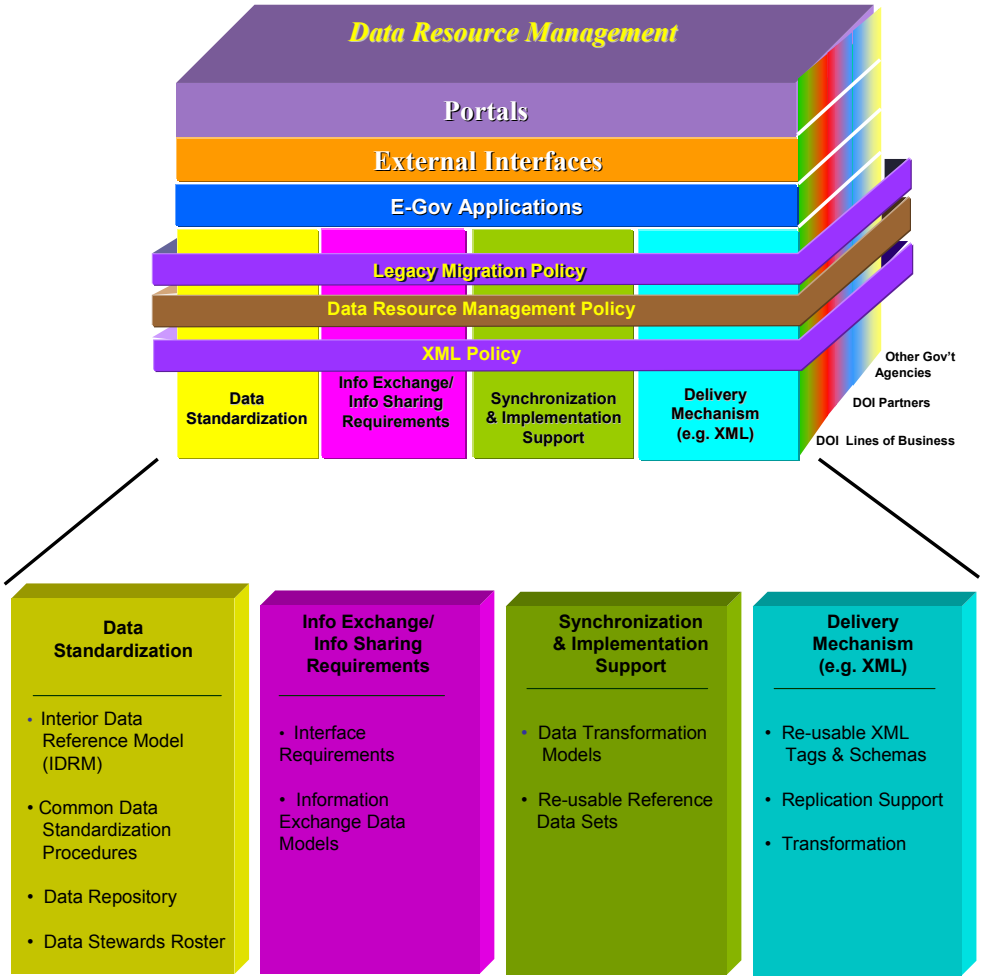


Figure 4-3. DOI Data Architecture Framework and Foundation Components

For the six business lines, the DOI has developed a high-level data architecture comprised of data subject areas and super types aligned with the BRM, a key-based entity relationship diagram, and a fully attributed logical data model capturing some of the data requirements.

Mapping system data elements to the DOI DRM Subject Areas and Super Types classifies the system data into common data elements that will identify duplicative data sources and expose data sharing and reuse opportunities (see Figure 4-4).

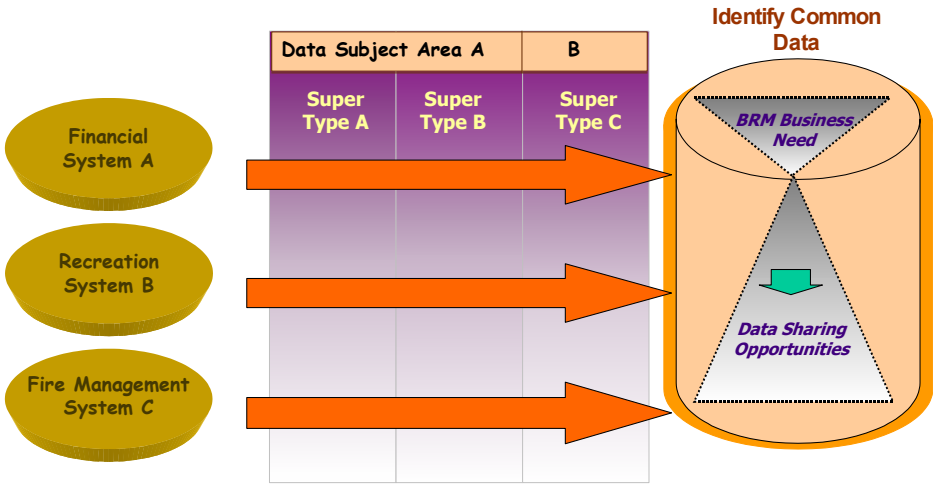


Figure 4-4. DOI Data Architecture Role in Modernization Blueprints

The data subject area mapping process is a three-step process (see Figure 4-5). Step one involves identifying and defining the Data Subject Areas and Super Types. DOI internal and external Data Subject Areas are reviewed and, if necessary, new Subject Areas and Super Types are created. Step two involves using the DOI EA repository (DEAR) to identify the database schemas that relate to the data subject area. With the system artifacts and the collaboration of the Subject Matter Expert (SME), DOI data architect and the DRMSG, the mapping between systems and data subject areas is completed.

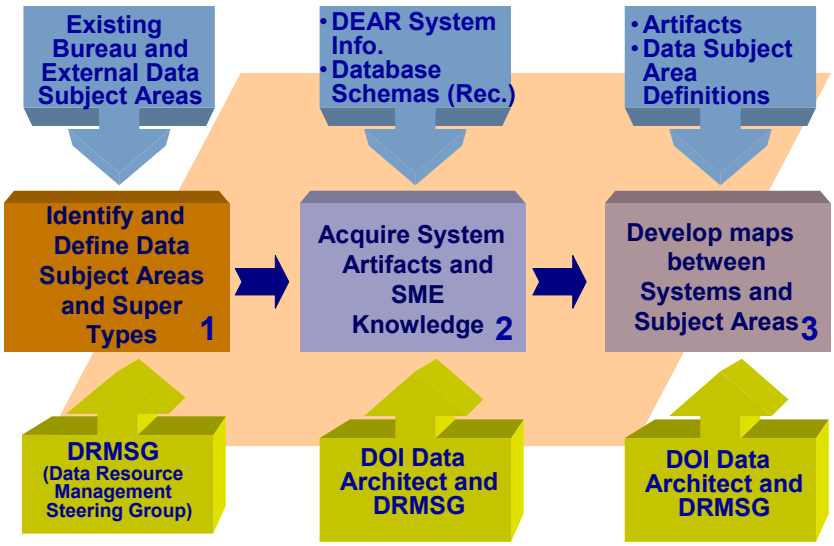


Figure 4-5. DOI Data Subject Area Mapping Process

DOI uses a data standardization process to further define the data within the Subject Areas and Super Types (see Figure 4-6). First, the system data structures are harmonized to

create the proposed attributed normalized reference model. The normalized reference model is reviewed by the Business Data Stewards via a submission package. The submission package describes the data entities and attributes related to the business line under review. Once the submission package is approved by the Business Data Stewards, the resulting changes are integrated into the DOI DRM.

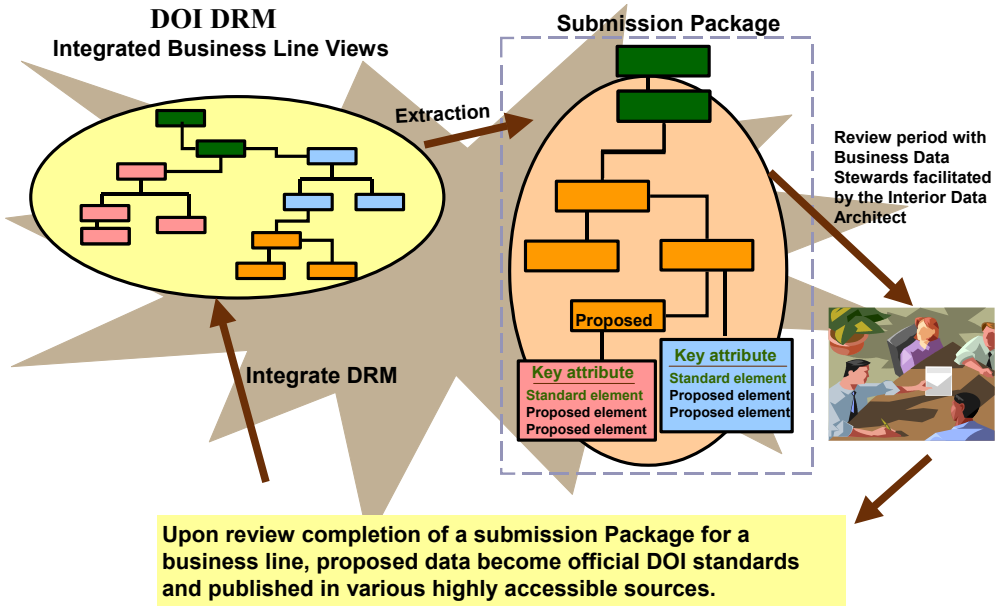


Figure 4-6. DOI Data Standardization Process

4.2.3 Tools

The DOI EA has a number of tools to support its EA activities. The DOI Office of the Chief Information Office (OCIO) has an EA Web page (http://www.doi.gov/ocio/architecture/index.html) that promotes EA activities, provides EA training and allows access to many of the DOI EA artifacts such as, reference models, DEAR and blueprints (see Figure 4-7).

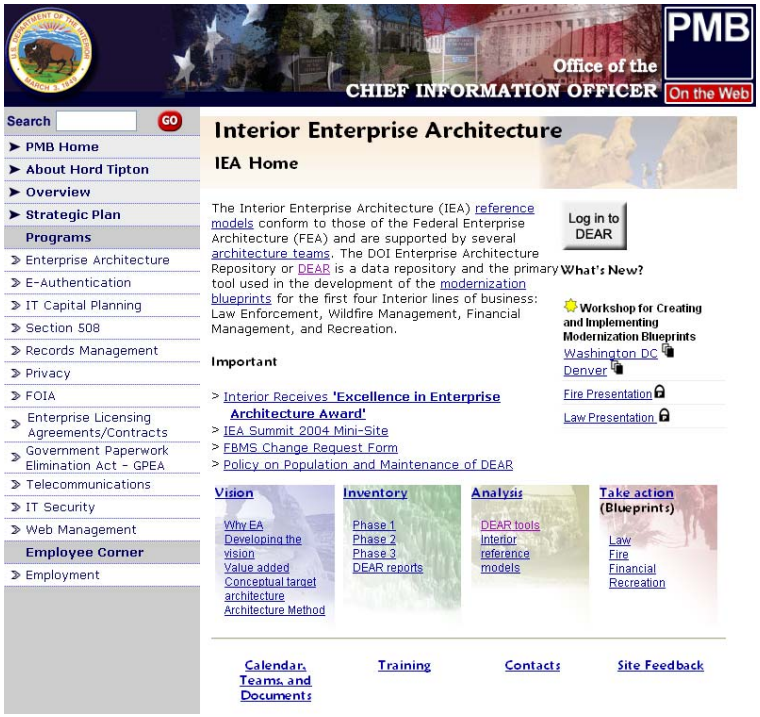


Figure 4-7. DOI EA Web Site

The DOI Enterprise Architecture Repository (DEAR) tool, a tailored version of Popkin System Architect, is one of the most robust EA tools found within the Federal Government (see Figure 4-8). This tool has proven to be so useful as an EA repository that both the Department of Energy and the Department of State are in the process of creating its EA repositories using this tool.

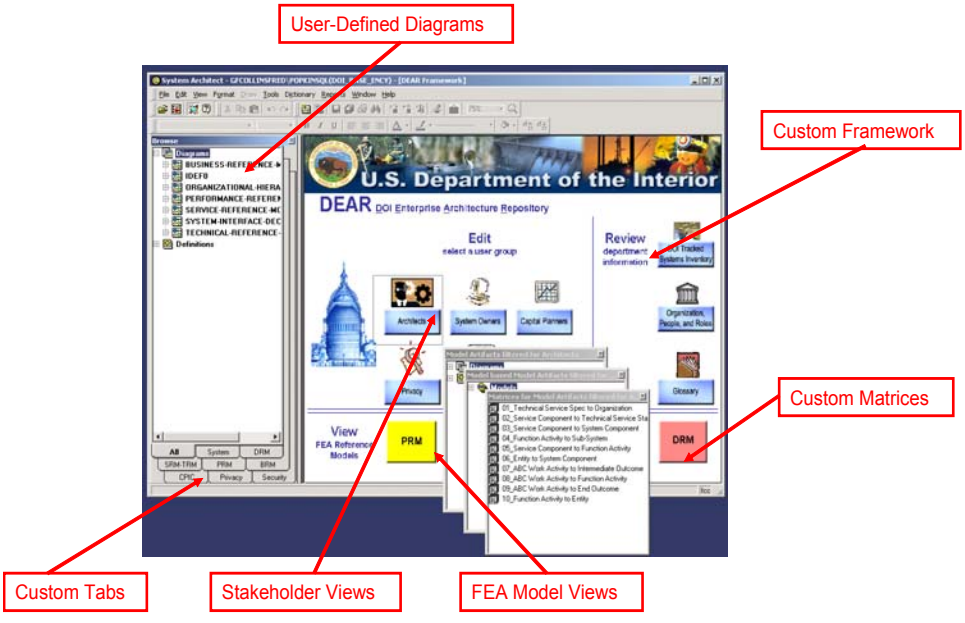
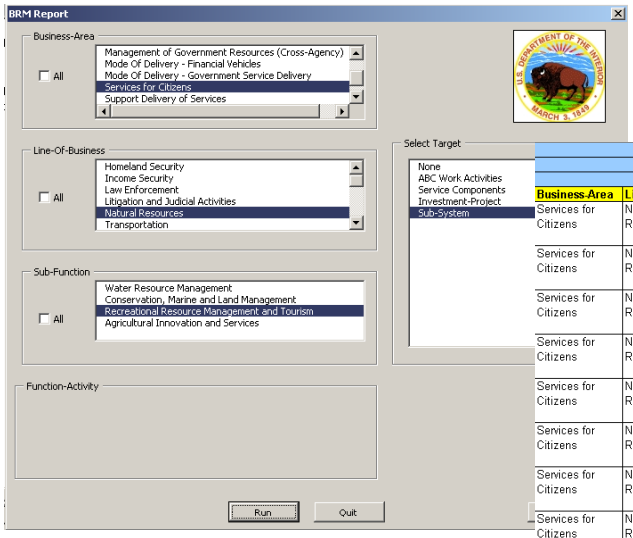


Figure 4-8. DOI DEAR System Interface

Each DOI bureau creates and controls its own Bureau EA Repository (BEAR). Bureau data is used to update the Departmental-level data in DEAR and to relate bureau-level data to DOI EA objectives and goals.

DEAR allows querying and reporting on the contents of the repository. Figure 4-9 shows a BRM report generated from DEAR. It is flexible enough to allow the storage of data models from various data-modeling tools, in addition to providing its own data-modeling tool. DEAR provides all the necessary information for DOI managers to build blueprints to modernize its IT environment.



DOI Enterprise Architecture Repository
Business Reference Model
Delivered as final: 12-08-2003

Business-Area	Line-Of-	Sub-Function	Sub Systems	Version	Acronym	System
Services for Citizens	Natural Resources	Recreational Resource Management	Denver Office General Support System	V-x	DOGSS	Denver Office General Support System (DOGSS)
Services for Citizens	Natural Resources	Recreational Resource Management	E-Gov for Planning and NEPA	V-x	ePlanning	E-Gov for Planning and NEPA
Services for Citizens	Natural Resources	Recreational Resource Management	Fire Effects Assessment Tools	V-x	FEAT	Fire Effects Assessment Tools
Services for Citizens	Natural Resources	Recreational Resource Management	Geospatial One-Stop	V-x	GEOSPAT	Geospatial One-Stop
Services for Citizens	Natural Resources	Recreational Resource Management	Great Plains General Support System	V-x	GPGSS	Great Plains General Support System (GPGSS)
Services for Citizens	Natural Resources	Recreational Resource Management	Historic Preservation Learning Portal	V-x	HPLP	Historic Preservation Learning Portal (HPLP)
Services for Citizens	Natural Resources	Recreational Resource Management	Indian Integrated Resource Information	V-x	IIRIP	Indian Integrated Resource Information Program (II
Services for Citizens	Natural Resources	Recreational Resource Management	Interior Enterprise Geographic	V-x	EGIM	Interior Enterprise Geographic Information Managem
Services for Citizens	Natural Resources	Recreational Resource Management	Landsat Project	V-x	LANDSAT	Landsat Project

Figure 4-9. DEAR BRM Report

The DOI Data Architect uses a MS Access database as an interim DOI Data Repository (see Figure 4-10). This repository provides the architect with the capability to track data lifecycles and to search, sort, parse, or map data elements for analysis work.

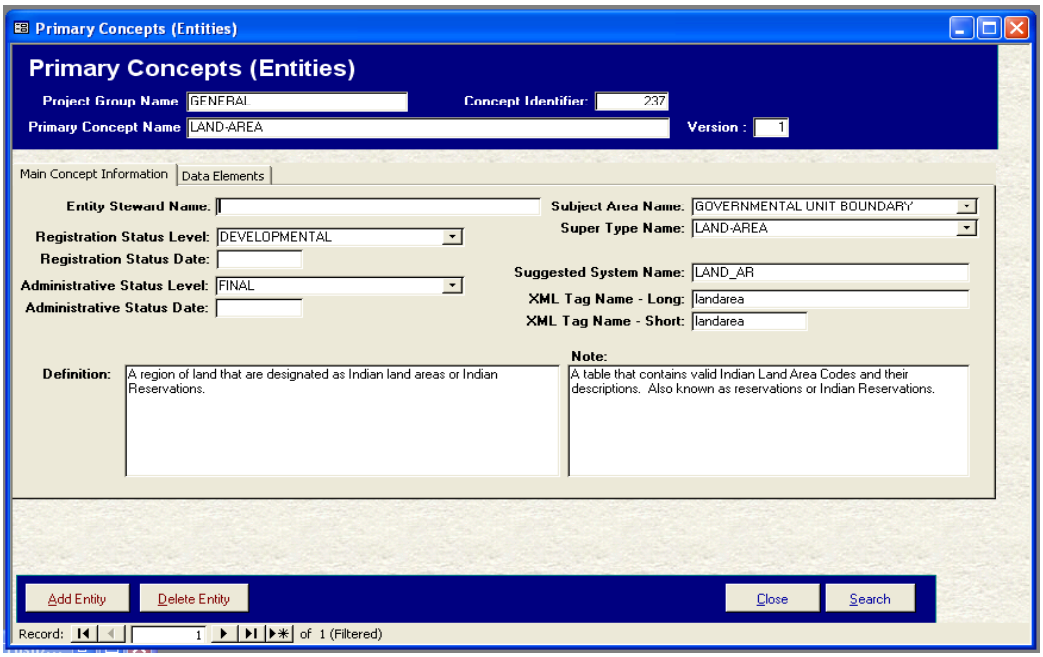


Figure 4-10. DOI Interim Data Repository

4.2.4 Governance

The DOI Interior Architecture Work Group (IAWG) is tasked with maintaining and assuring the accuracy of EA data. This group is comprised of enterprise architects and subject matter experts from each organization or bureau of DOI. They are the point of contact for their organization for changes to the EA.

The DOI Data Resource Management Steering Group (DRMSG) is tasked with the governance of the DRM and is comprised of data architects from each DOI bureau and major offices. The group ensures technical compliance with the DRM and represents the interest of their organizations on crucial enterprise data design matters. The eight DOI bureaus and three major DOI program offices are represented with voting members on the DRMSG.

Since the DRM and the BRM are closely related, the decisions of the Interior Business Architecture Team (IBAT) can impact the DOI DRM (see Figure 4-11). The IBAT is comprised of the business professionals who own or have stewardship of a business area and its processes and data. The IBAT defines and describes the data that is important for inclusion in the DOI DRM.

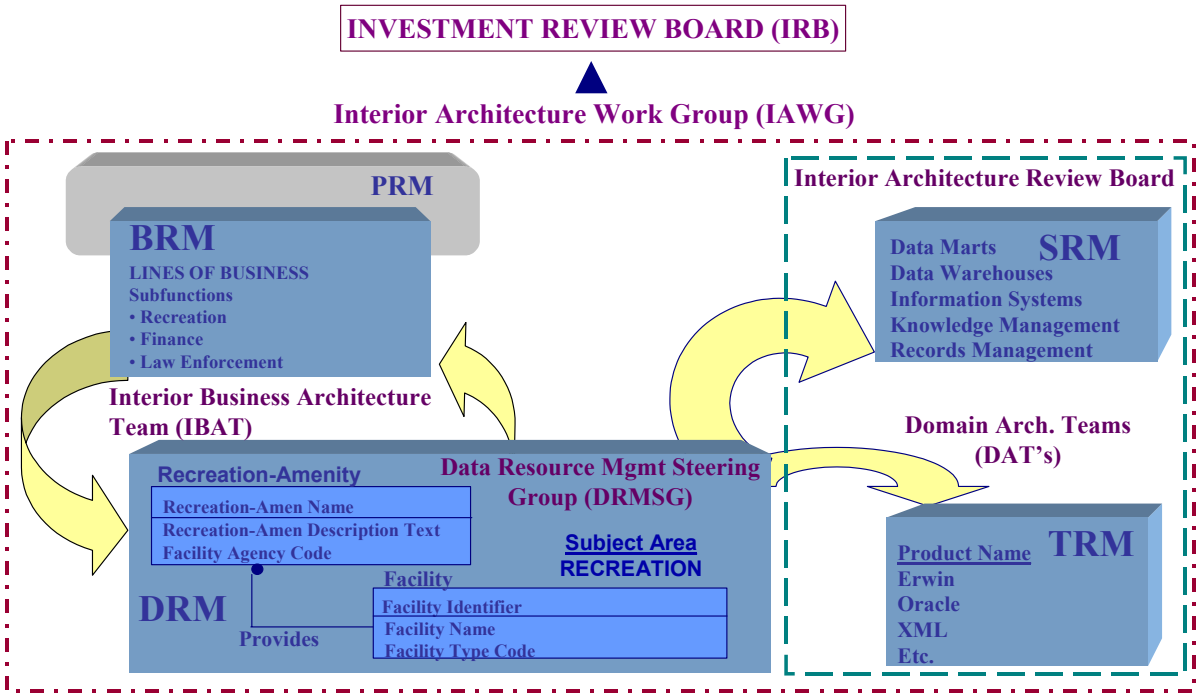


Figure 4-11. DOI Governance Teams Relationships

To facilitate the creation and control of data standards within each business area, the DOI OCIO has created a role of a Principal Data Steward. The Principal Data Stewards take their direction from the DOI Data Architect and are responsible for coordinating and integrating all data requirement for their business line (see Figure 4-12). Refer to Appendix A for a detailed description of DOI's data governance roles and responsibilities.

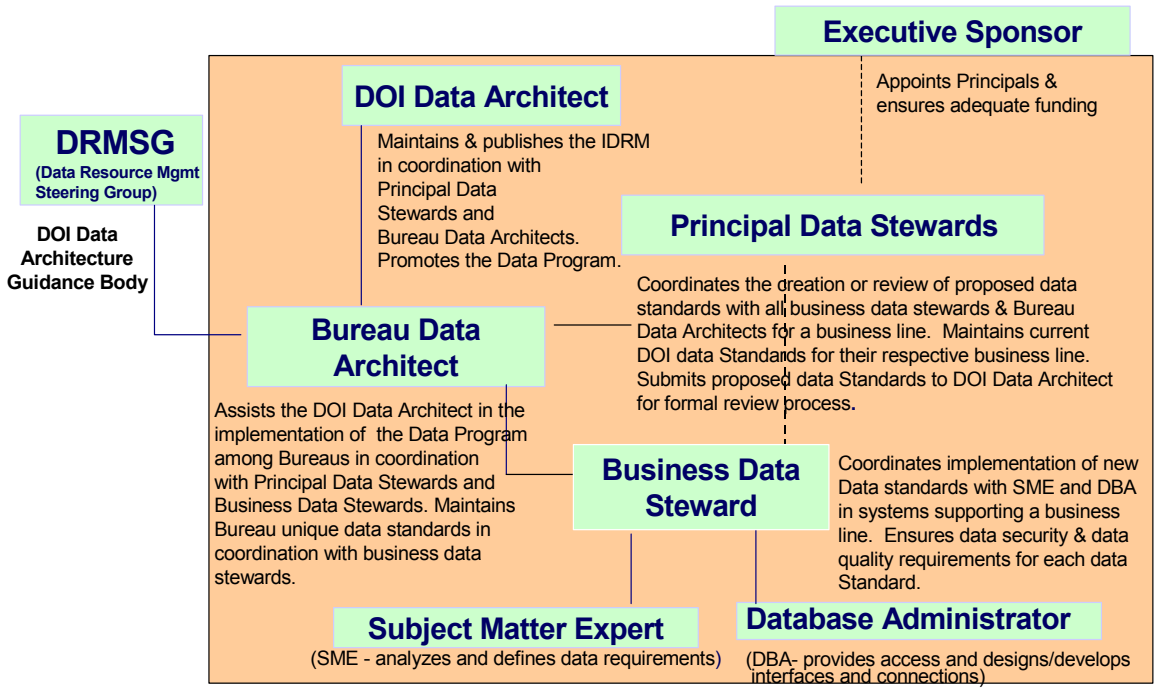


Figure 4-12. DOI Governance Roles

4.3 U. S. Customs and Border Protection

4.3.1 Background

Department of Homeland Security (DHS) of the U.S. Customs and Border Protection (CBP) became the unified border agency for the United States in 2002 when DHS was formed. CBP combined the workforces and border authorities of U.S. Customs, U.S. Immigration, Animal and Plant Health Inspection Services and the U.S. Border Patrol. With more than 41,000 employees, CBP manages, controls and protects the nation's borders.

One of CBP's largest IT initiatives is the Modernization program. The primary objective of this program is "to improve the effectiveness of CBP, all concerned agencies, and the trade and travel business communities by designing and implementing enhanced operational processes supported by automated systems that get the right information, to the right people, at the right time and place."[5]

The initial and most significant component of the Modernization program is the Automated Commercial Environment (ACE). The ACE program was initiated in 1994 as part of a plan to replace the current import system, Automated Commercial System (ACS) and other related legacy systems. Concerns about the ACE program were the subject of many General Accounting Office (GAO) reports and testimony to Congress in the late 1990s. In

[5] : *Overview of Key Features for the Trade, U.S Custom and Border Protection.*

1996 the GAO reported that Customs was ill-prepared to replace ACS due to the fact that Customs selected an information systems architecture without first analyzing its business requirements. In addition, systems under development did not adhere to Customs' own development policies. In 1999 the GAO reported that ACE was being built without a complete and enforceable enterprise system architecture as mandated by the Clinger-Cohen Act of 1996.

In 2001 the CBP Modernization program was refocused and gained momentum. It implemented sustained and substantive actions to develop improved IT management practices to correct the weaknesses of the ACE program. A component of this commitment was to establish and enforce an enterprise-wide architecture based on the business needs and requirements needed to guide the ACE and the Modernization programs.

The results of this refocused program have been significant. In July 2001 both the Treasury and the Federal CIO Council recognized the Customs EA as a "best practice." In May 2004 GAO reported that the ACE program successfully complied with the CBP EA. This compliance is attributed to the EA certification program, which requires the EA to be extended for each ACE release. Future plans include developing a detailed process to ensure the alignment of ACE with the DHS Department-wide EA.

ACE is comprised of two functional components, Screening and Targeting and Secure Cargo Management. These functional components are being developed using an incremental approach that features a series of releases. Each release leverages the foundation components and functionality from previous releases and brings new capabilities. ACE is being designed to be flexible and adaptable so that it can change as business needs change or as new technologies become available. The flexibility of ACE is attributed to the CBP EA. The EA is component driven, which enables it to interface with multiple systems, both internal and external.

The CBP Enterprise Data Architecture (EDA) is defined and governed from three different layers of the CBP Modernization program. These layers include the 1) ACE program layer, 2) CBP EDA layer and 3) CBP EA Governance layer. These layers, or organizations within the CBP Modernization program, work collaboratively to ensure that the data architectures developed at each layer of the Modernization program are cohesive, complete and align with the overall EA framework. The establishment of a comprehensive EDA program with participation from organizations at each layer of the Modernization program has been a significant part of the program's success.

The HUD EDMG was fortunate to have representatives from each layer of the Modernization program present at the briefing. Methods, governance and lessons learned were provided based on their experience developing the ACE program-level Data Architecture and CBP Enterprise Data Architecture.

4.3.2 Methodology

4.3.2.1 ACE Program Layer Methodology

The ACE program has a myriad of challenges to meet the Department's goal of providing a single, integrated, end-to-end solution. ACE uses SAP as the backbone of its application infrastructure, guided by the data requirements of CBP business functions. CBP is acquiring other COTS solutions, leveraging legacy systems and developing new components to assemble the ACE technical solution. With all these different methods being employed, ACE has developed multiple methodologies specific to the type of project being conducted (e.g., COTS acquisition, COTS extensions, legacy modernization, component development, etc.).

The ACE Data Architect focuses on the content of the artifacts produced that influence ACE program-level data architecture, as opposed to the methodology used to develop them. The ACE program-level artifacts used to extend and validate the ACE program-level data architecture and described in the sections below include:

- ACE Logical Data Model
- ACE Interface Specification Document
- ACE Information Exchange Matrix
- ACE Legacy System Analysis and Assessment.

ACE Logical Data Model

The ACE program-level Logical Data Model (LDM) captures the design of the data across the entire ACE program. The model contains approximate 800 entities, corresponding relationships and attributes using a subject-area taxonomy. The ACE data architecture domain also includes project-level LDMs for capturing the data design for releases, acquisitions, transition, maintenance or new development. ACE project-level LDMs are reconciled with the ACE program-level LDM.

The ACE program-level LDM is vertically aligned with the:

- CBP Enterprise Conceptual Data Model (ECDM)
- ACE project-level LDMs and Physical Data Models (PDM)
- ACE Release Physical Interface Definitions required by SAP and other COTS applications.

The ACE program-level LDM is horizontally aligned with the:

- ACE Concept of Operations
- ACE Technical Architecture
- ACE Performance Architecture
- ACE System Transitioning and Sequencing Plan
- ACE-Release Business Process Models (BPMs).

ACE Interface Specification Document

The ACE Interface Specification Document captures and serves as the baseline for the details of the interfaces between legacy system data and ACE. It describes the detailed design, supports the integration and provides requirements for testing CBP internal interfaces with ACE. For each interface, the specification document includes the type, frequency of execution, stakeholder(s), and source and target data systems.

ACE Information Exchange Matrix

The Information Exchange Matrix documents all external data providers and consumers of ACE application components, as well as the information exchange specification at the data element and attribute levels. The matrix is used to:

- Ensure all external user data requirements are captured in the program and project-level data models
- Map external data elements from external interfaces to ACE program and project-level models
- Support the detailed specification for detailed system design
- Support transition planning
- Develop workforce-training materials.

ACE Legacy Systems Analysis and Assessment

The ACE program plans to perform Legacy System Analysis and Assessments using a secure hardware platform and a 'profiling tool' to assess the health of the legacy source data. This assessment process will also identify the metadata content, metadata storage requirements and reporting capabilities of the source data elements. These results will assist the ACE Data Architect in:

- Mapping the source data elements to the ACE LDM to validate the data design and definition
- Identifying data health issues
- Establishing remediation and transition plans.

The ACE Data Architect shared his experience and lessons learned. These lessons learned are as follows.

- **Use the ACE program-level LDM as a common integration point.** The LDM should be used as the single integrating source for data management across the program. This includes acting as a common point for integrating other products.
- **Prevent Releases from generating its own LDM.** If the Releases create its own LDM, they will not use the ACE program-level LDM as the common integration point, and much time will be spent retrofitting the Release LDMs into the ACE LDM.
- **Map everything to the ACE program-level LDM**. The ACE program-level LDM should be used to establish a common vocabulary for the entire ACE program,

including all of its releases and interfaces. If everything is mapped to the LDM, the LDM can serve as a translator.

- **Require a sufficient level of detail in the artifacts that support the validation of the LDM.** The Business Process Models (BPM) are used to 1) define the requirements of the business processes; 2) validate data used by the process; and 3) define information exchanged between the processes. The BPM should be detailed enough that specific entities, attributes and metadata are exposed and LDM naming conventions are used.
- **Use common data modeling tools across the program.** Using a common data modeling tool across the program will reduce the cost and effort to capture, maintain, synchronize and integrate data from all the sources where data are captured. Currently, the ACE program-level and CBP EDA architects use Popkin System Architect while the ACE project-level architects use ERWin, Rational Rose and Ascendant tools. With the constant change in data architecture baselines, not having a standard data-modeling tool makes it very time consuming and expensive to capture and synchronize data designs across the program.

4.3.2.2 Enterprise Data Architecture Layer Methodology

The ACE Program had an established program-level LDM before the Enterprise Data Architecture (EDA) initiative was started. The ACE LDM was based on the data requirements for U.S. Customs business functions. The first priority for the EDA team was to develop a top-down, Enterprise Conceptual Data Model (ECDM) that included the data requirements from ACE and from the other agencies that were realigned to form CBP (e.g., Border Patrol). This model included 99 super types, which provided the taxonomy for the EDA and aligned the ACE LDM to the enterprise level. The subject areas in the ACE program and project-level LDMs mapped to the super types in the ECDM.

The second priority was to assemble the CBP Enterprise Logical Data Model (ELDM) as a federation of program and project-level LDMs. The ELDM is not really a model in its own right. It is a virtual model represented by the mapping of project and program-level LDM to the ECDM. The combination of the mappings to the ECDM, Interface Exchange Matrices and Interface Specifications, enable the EDA team identify gaps and data redundancy at an enterprise level.

Changes in the ACE program and project-level LDMs are synchronized with the ECDM and ELDM. The EDA team oversees the changes to the ACE program-level LDM and continuously integrates the changes into the ECDM. Furthermore, the EDA team oversees the development of ACE Information Exchange Matrices and Interface Specifications, and uses these artifacts to validate the ECDM.

For new programs and projects within the Modernization program, the EDA team will use the ECDM to seed program and project-level LDMs. This approach will provide the programs with a standardized data baseline, retain the alignment with the ECDM, and

reduce the cost associated with retrofitting established program-level LDMs into the ECDM.

The lessons learned by the EDA team are as follows.

- **Invest in the vision.** Federal agencies should proactively invest in establishing an enterprise-level conceptual data model prior to undertaking large Modernization programs, such as ACE, to establish the context for all lower-level data architecture initiatives.
- **Focus on best-value activities.** Federal agencies undertaking enterprise-level data architecture initiatives should focus on the activity that provides the greatest value to mission. In the case of the CBP EDA initiative, it was decided that the initial focus should be to develop the CBP ECDM, rather than the ELDM. The development of the ECDM was selected because the EDA team had limited resources, and the ACE LDM was relatively mature. The ELDM was then assembled as a virtual model by mapping the program and project-level LDMs to the ECDM.

4.3.3 Tools

The CBP ECDM and ACE program-level LDMs are developed and managed using Popkin System Architect. The project-level LDMs and PDMs are developed using ERWin, Rational Rose and Ascendant. As stated in the previous section, significant benefits could be realized if CBP adopted a standard data modeling tool.

Other artifacts (e.g., Information Exchange Matrices), are documented using MS Word and Excel. The configuration and versioning of the ACE program and project-level artifacts are stored and managed within Serena Version Manager (from the makers of PVCS).

CBP EDA does not currently use an enterprise-level metadata repository to facilitate data standardization, sequencing, transitioning and migration from legacy systems.

4.3.4 Governance

As stated previously, the CBP briefing included representatives from three organizations of the Modernization program that support the definition, maintenance and governance of the EDA. Members of each of these organizations actively participate in working groups and certification programs to ensure that the ACE program and project-level LDMs are compliant, complete and are in alignment with the EDA.

4.3.4.1 ACE Program and Program-layer Governance

The ACE Program has an established Data Architecture program. The responsibilities of the program are to:

- Develop an ACE program-level data architecture

- Vertically align and horizontally integrate the ACE program-level data architecture with other data architectures (e.g., ACE project-level architectures, ECDM)
- Provide guidance and oversight to the design of the ACE project-level data models and participate in release-design activities to capture the metadata for the program-level LDM
- Support the legacy system data transition efforts by assessing the health of the source system data and identifying data transition issues.

The ACE program-level LDM is subject to EA certification at key points within its development and release life cycle. The ACE program's success with the EA certification process is attributed to its close ties and strong alignment with the EDA team.

The ACE program-level LDM enables all applications, application components and external interfaces to communicate using a common language. If all the program artifacts map to the LDM and adopt its language, then all resulting applications and application components should be able to communicate.

As stated previously, all layers of CBP and the ACE program actively collaborate in data architecture governance initiatives to ensure that the overall mission and goals of the Modernization program are achieved. As illustrated in Figure 4-13, the ACE program-level data architects support enterprise, program, and project-level groups and activities.

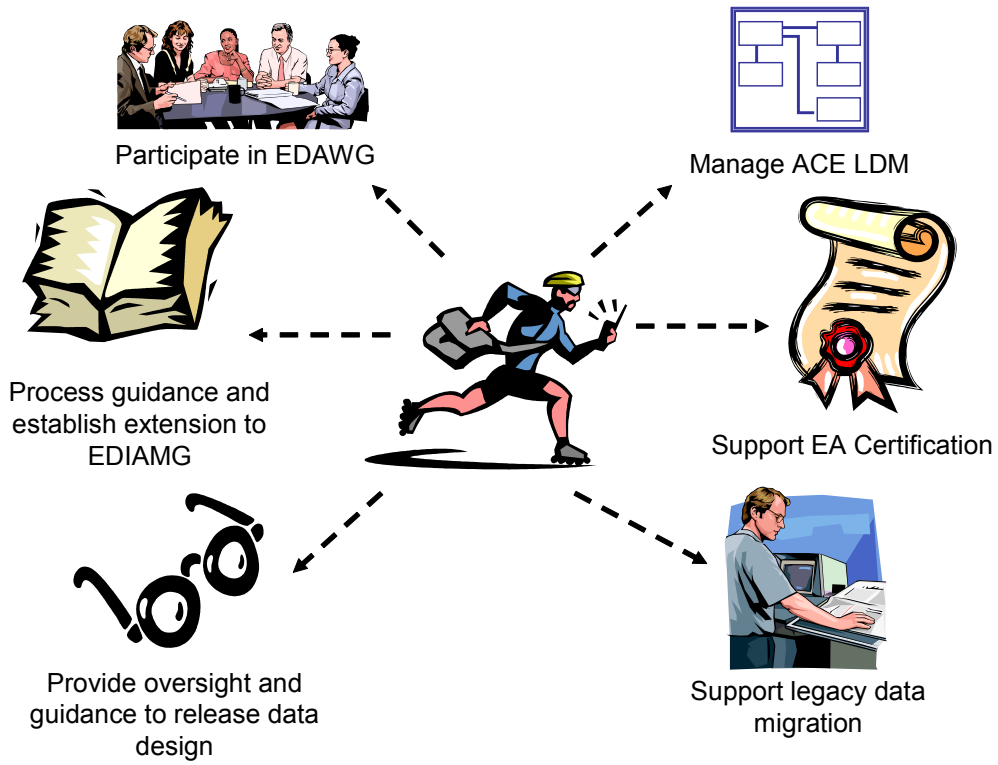


Figure 4-13. ACE Data Management Participation in Data Governance Activities

As noted above, the ACE program data architect participates in several governance-related activities, such as:

- Participating in the Enterprise Data Architecture Working Group
- Performing peer reviews and configuration management of the ACE LDM
- Processing guidance from the Enterprise Data and Information Architecture Management Guide (EDIAMG) and establishing ACE-unique extensions to the EDIAMG policies and standards
- Supporting the ACE program-level LDM perspective for the EA Certification process
- Providing oversight and guidance to the ACE project-level data design efforts
- Coordinating data migration from legacy systems.

4.3.4.2 CBP Enterprise Data Architecture Governance Layer

The primary role of the CBP Enterprise Data Architect is to develop and support a strategy for data architecture design and information sharing for the CBP EA. Specifically, the CBP Data Architect is responsible for:

- Developing the CBP EDA and integrating it with other components of the CBP EA, eventually aligning it with the DHS EDA
- Providing guidance to, and oversight of, the ACE program-level LDM
- Providing guidance to the ACE project-level LDMs and PDMs
- Providing guidance to other CBP programs and project-level data architectures.

The CBP data architect chairs the Enterprise Data Architecture Working Group (EDAWG), which is comprised of 12 to 15 participants from various CBP oversight and development organizations. The group meets weekly to facilitate communication, collaboration and resolution of data structure-related issues. For example, they peer review ACE data architecture artifacts in order to 1) ensure the completeness, quality and compliance of the artifacts with established standards; and 2) establish traceability within the Information View of the Composable Enterprise Architecture Framework (CEAF).

Data architecture governance and standards will be documented in the Enterprise Data and Information Architecture Management Guide (EDIAMG). The EDIAMG includes the data modeling standards, guidance and direction for integration of the data architectures with other components of the CBP EA. The EDIAMG is currently being developed and key guidance areas will include:

- Data Architecture Integration
- Information and Data Sharing
- Data Health
- Mapping and Transition
- Ownership and Stewardship

- Security and Privacy
- Modeling Standards.

The lessons learned by the Enterprise Data Architect were:

- **Establish a centralized data architecture strategy.** In order for an EDA program to be successful and cost effective, a centralized strategy should be developed to guide lower-level data architecture development.
- **Communicate, coordinate and collaborate.** Communication, coordination and collaboration are critical to the successful development and maintenance of an EDA. The more decentralized the data architecture development, the greater the need to practice the three Cs. Regularly scheduled working groups with vertical and horizontal representation are an effective means to support this objective.

4.3.4.3 CBP Enterprise Architecture Governance Layer

The CBP EA Governance group combines policy, process, and people to govern information and data assets. Specifically, the core components of CBP EDA governance are:

- An enterprise-wide policy that establishes information and data as strategic business assets
- Standard data management processes
- Data stewardship
- A data decision board
- Data working groups
- Well-defined relationships between the components.

CBP established data governance to ensure that the following outcomes of the EDA initiative are realized.

- Data-related risks are managed and mitigated by establishing policies, processes and responsibilities
- Data is aligned with enterprise goals and objectives to support the performance of the CBP mission
- Data is used responsibly and all opportunities to maximize benefits for the enterprise are exploited.

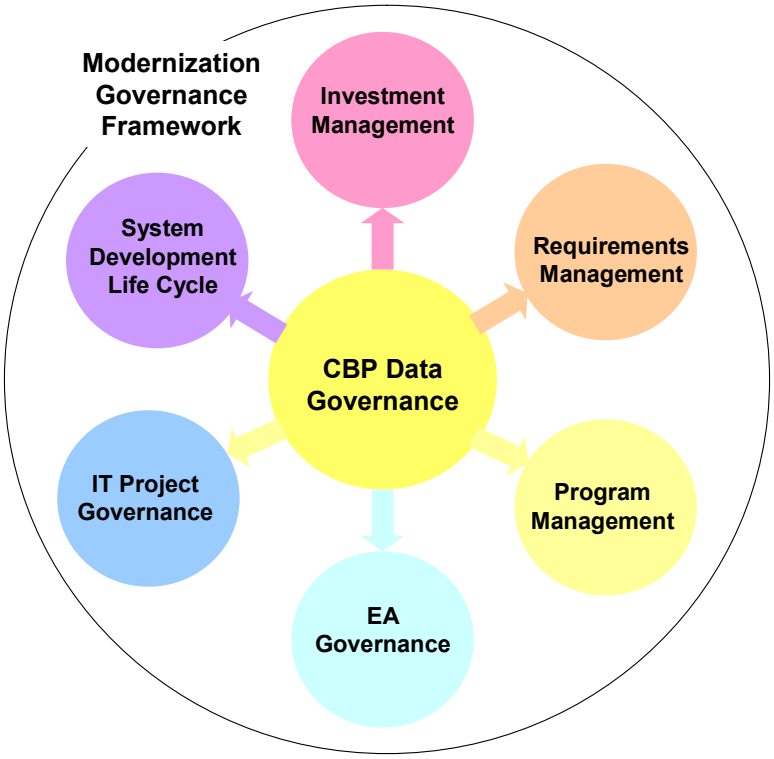


Figure 4-14. Integration of CBP Data Governance

CBP data governance is integrated with other management and governance programs within the Modernization program framework (see Figure 4-14 above). These programs include:

- Investment Management
- Requirements Management
- Program Management
- Enterprise Architecture Governance
- IT Project Governance
- System Development Life Cycle.

CBP measures the effectiveness of data governance using the following organizational indicators:

- Climate of trust
- High-level of transparent communication
- Streamlined decision-making
- Absence of organizational silos
- Performance-oriented culture.

CBP data governance has provided value to the Modernization program by enabling it to share information and provide a means to achieve high quality, integrated data. The

immediate benefit of such data is the reduction of costs and risks associated with overlapping and uncoordinated development efforts. Furthermore, governance has enabled CBP to be compliant with Federal EA legislation and initiatives.

The lessons learned shared by the EA Governance groups were as follows.

- Establish and promulgate information and data policy.
- Establish a strong partnership with the business areas by establishing and fostering a Data Stewardship program. Business accountability and responsibility for data management is achieved through formalizing this type of program.
- Establish and empower an enterprise-wide Data Decision Board that can make strategic decisions that will mitigate risk and further the mission.
- Incorporate data governance touch points into the investment management process and software development life cycle.
- Leverage the EDAWG to promote and incorporate data governance into its programs and projects.

4.4 Department of the Navy

4.4.1 Background

Forward-deployed naval forces capable of sustained combat operations against any adversary have always been a critical part of America's defense. The U. S. Navy has nearly 370,000 personnel and 290 ships to support this mission. In order to meet the changing threats to the United States in the 21st Century, the Department of the Navy (DON) has been at the forefront of leveraging technology to succeed at this mission.

The Secretary of the Navy tasked Functional Area Managers (FAM) to provide effective management of all the Navy IT applications and data. Using the migration to a new enterprise wide Navy Marine Corps Intranet (NMCI) as a catalyst for change, over 100,000 Navy applications have been inventoried, registered and reviewed. No application will migrate to the NMCI unless it passes rigorous compatibility testing and information assurance testing, receives approval from a FAM and is listed in the DON software portfolio. The FAM rationalization process is based on functional and technical criteria set in the Navy EA. Due to the efforts of the FAMs, over 30,000 applications have already been identified for elimination through the rationalization processes. The FAMs work closely with Functional Data Managers (FDMs) to identify opportunities to further reduce applications and its data requirements along with its associated costs.

4.4.2 Methodology Overview

DON EA development has been driven by a technology change, namely, the NMCI network installation. As the Navy has moved from a network of many geographic or organizational wide area networks into a single Navy- and Marine Corps-wide Intranet,

processes were put into place to determine which current applications and data would be allowed to migrate to the new network.

The position of the FAM was established in November 2001 by the Secretary of the Navy Instruction 5000.36 (SECNAVINST 5000.36) to oversee the migration, retirement or consolidation of the Navy's 100,000+ applications and databases. Once this is completed, the FAM would be responsible for managing the initial application portfolios. A major revision to that policy, SECNAVINST 5000.36A, contains detailed instructions that establish the roles and responsibilities of the FAM and of the FDM. Twenty-Four FAMs support all Navy and Marine Corps functional areas. Once the FAM position was established and organizations were designated the FAM role, the process of reviewing DON applications and databases began.

The process of reviewing applications and databases for migration consists of four iterations. Figure 4-15 illustrates the process. The first three iterations will reduce the 100,000+ applications to nearly 7,000, while the fourth iteration is the phase that the DON will use to manage the initial application portfolio.

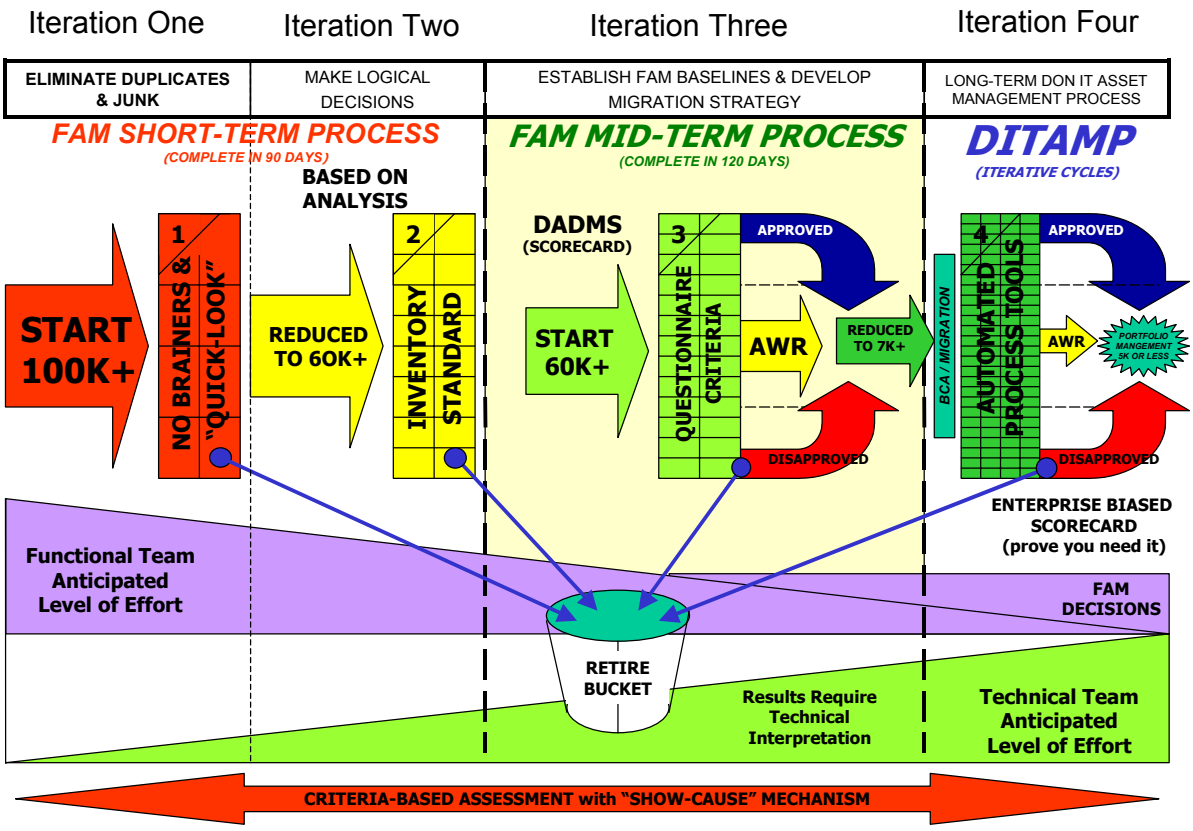


Figure 4-15. DON Application Rationalization Process

Iteration One was a short-term, 90 days, rationalization process that eliminated duplicate and outdated applications. This step reduced the number of applications to about 60,000. The second iteration used a high-level objective criterion in a 120-day process to reduce the

number of applications to nearly 7,000 (see Figure 4-16). Some of these applications are approved with restriction (AWR), which limits the application's use until it can be migrated to another solution that fully meets the DON application criteria.

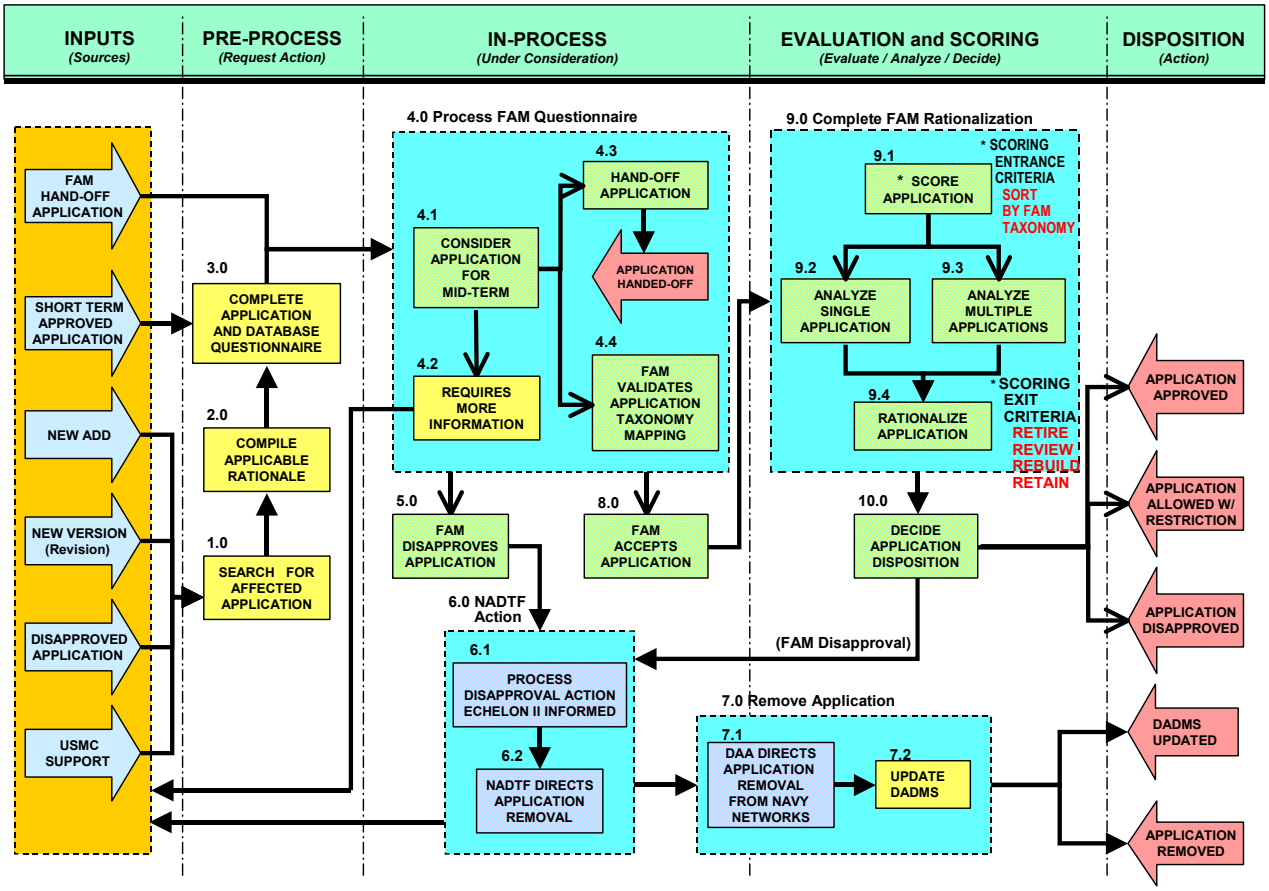


Figure 4-16. Iteration Two Application Rationalization Process Details

Application scoring exit criteria placed an application in one of four migration states: retire, rebuild, review or retain (see Figure 4-17). Applications that are not designated to be retired are evaluated in the next iteration, Iteration Three.

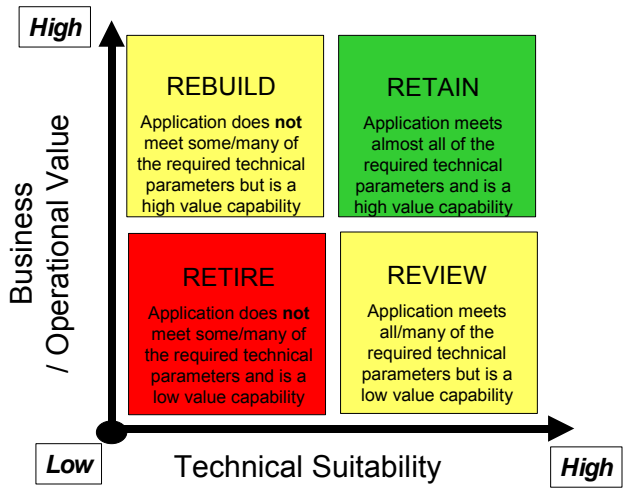


Figure 4-17. DON Basic Objective Decision Criteria

Iteration Three applies a business case analysis (BCA) filter and then builds migration plans for the applications that pass the BCA filter. This phase will result in the creation of the DON initial application portfolio of about 7,000 applications. Iteration Four represents the process the DON will follow in the management of this initial application portfolio, the DON Data Architecture.

During the DON application and database rationalization process, DON FDMs analyze databases within their functional area for its value in supporting DON missions. These DON missions, from 24 functional areas, are modeled into an operational activity taxonomy (see Figure 4-18). This top-down mission analysis provides the structure necessary for analyzing the as-is IT environment, as well as for mapping applications/databases to corresponding missions. This bottom up approach is the first step in the Navy's seven-step data management process to develop and manage a DON functional area data architecture (FADA).

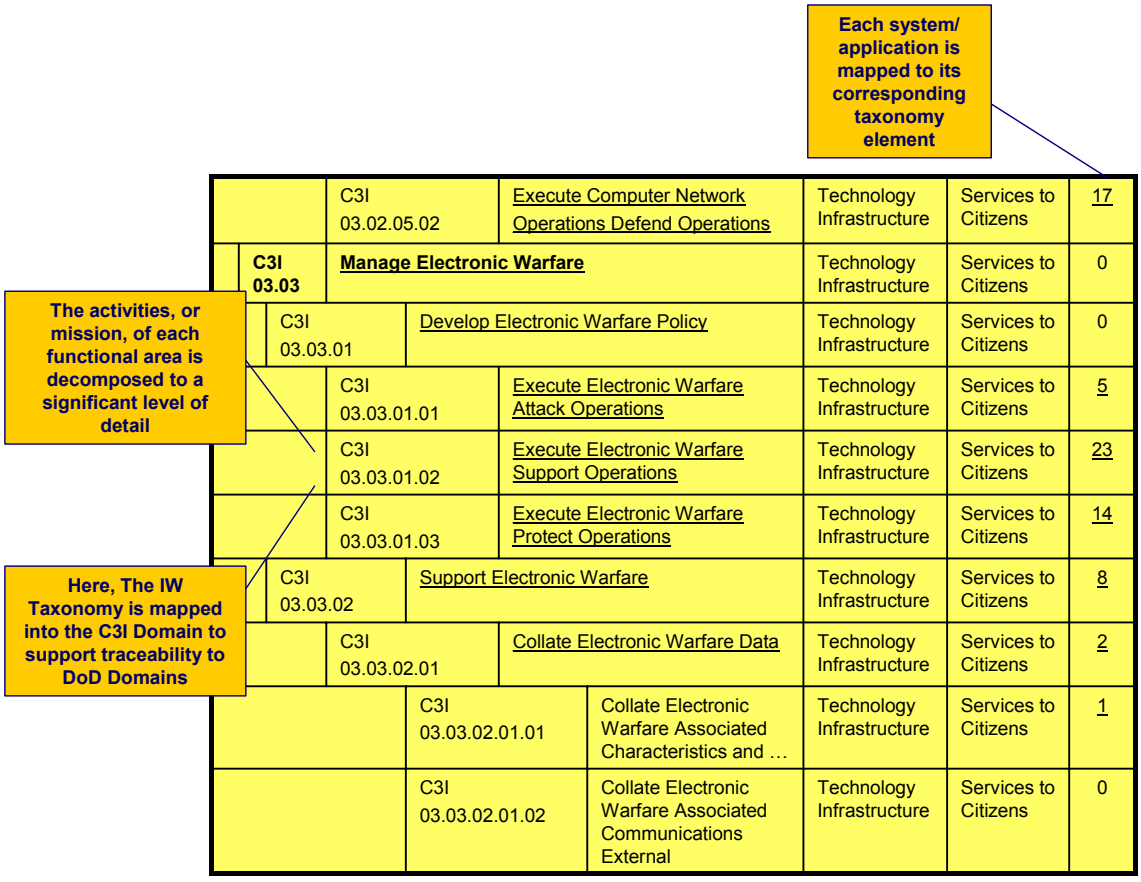


Figure 4-18. DON Operational Taxonomy Mapping

The DON seven-step data management process, which the FDMs use in their FADA development and management activities, is as follows.

1. Validate systems/applications-to-database associations made in the Application Portfolio
2. Oversee registration of new databases
3. Oversee completion of database questionnaires
4. Make initial database disposition decisions based upon questionnaire data
5. Oversee registration of applications/database schema (metadata)
6. Develop and maintain functional area data architectures
7. Manage the data architecture.

Figure 4-19 illustrates a more detailed view of the DON seven-step data management process. In the validation step, the FDM reviews the FAM approved applications that have database dependencies as indicated by the rationalization application and database questionnaire. Central Design Activities (CDA) is a designated organization or person that is responsible for maintaining or modifying applications software. The FDM determines if the database to application association is valid and establishes an initial application-to-

database baseline record in the DON Application and Database Management System (DADMS).

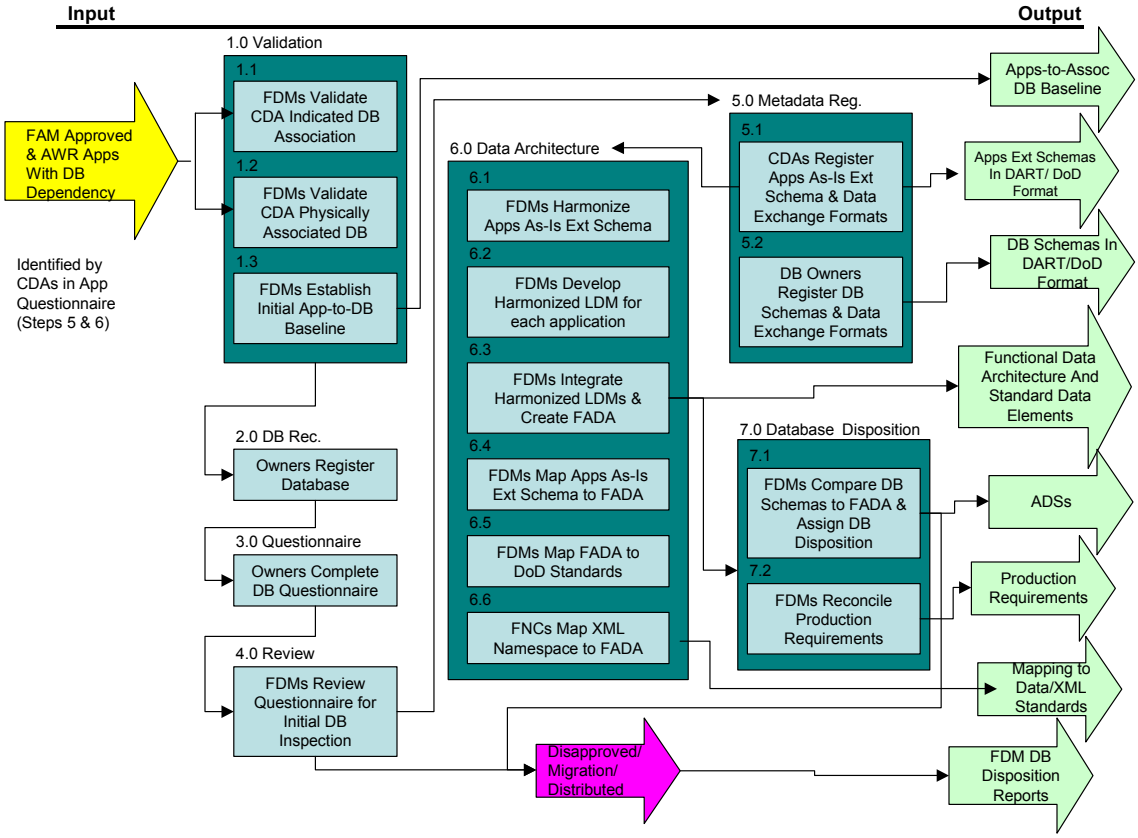


Figure 4-19. DON Seven Step Data Management Process

The application owner registers the application's existing database external schema and exchange formats in DADMS. The FDM then analyzes the database's external schema to develop a harmonized logical data model for the application. To build the FADA, the FDM integrates all of the harmonized logical models within a functional area to establish a consistent representation of the data objects. The FADA contains the mapping of application databases to the operational taxonomy. The FDM compares the database schemas to the FADA and assigns the database disposition, retained or retired. The outcome of this step determines the Authoritative Data Source (ADS).

4.4.3 Tools

The DON has a number of architecture tools to support the management of its IT systems. The most significant tool that supports its data architecture development is the Department of the Navy Application and Database Management System (DADMS).

4.4.3.1 Department of the Navy Application and Database Management System (DADMS)

The DADMS is a Web enabled registry of DON IT systems, its associated data structures and data exchange information, information assurance tools, EA documents and DON architecture artifacts (see Figure 4-20). It is the authoritative source for DON IT application and database portfolio management.

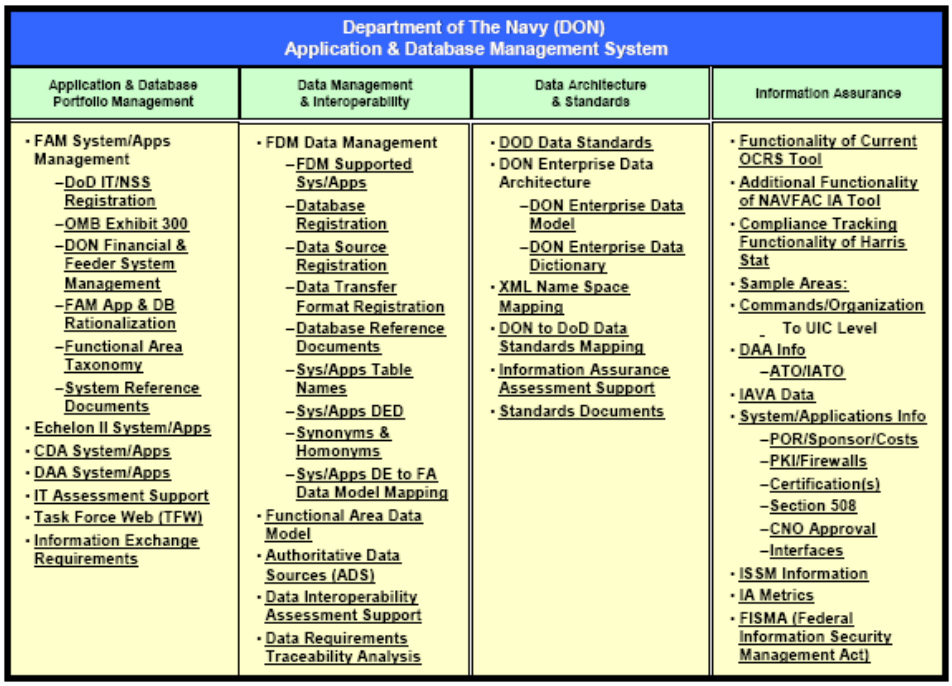


Figure 4-20. DON Application and Database Management System

DON FDMs use DADMS to register Authoritative Data Sources (ADS), functional area data architectures (FADA), metadata and data exchange formats (see Figure 4-21). This tool also provides the linkages between mission requirements and the ADSs. The Data Architecture and Standard module provides access to the DON and DoD data standards documents, the DON EA data model and the DON enterprise data dictionary.

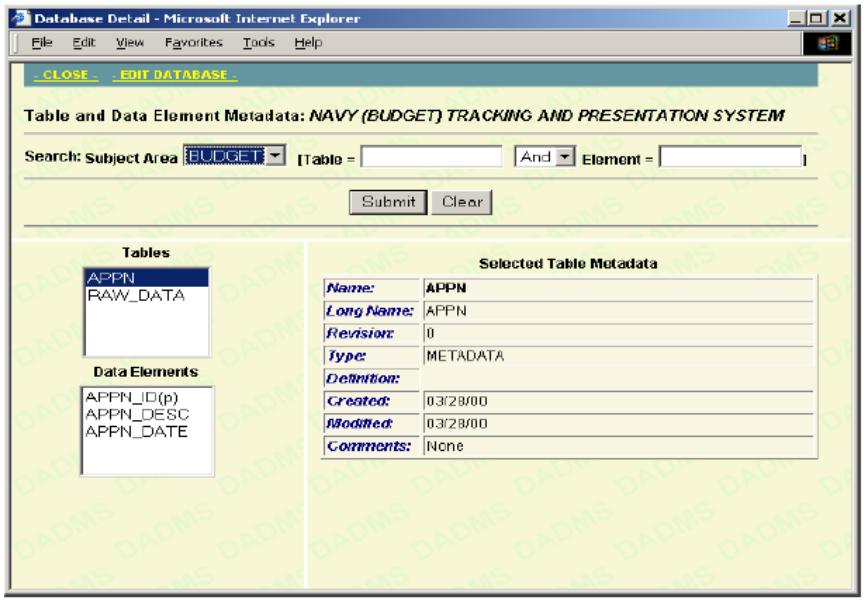


Figure 4-21. DADMS Table and Metadata Registration

4.4.4 Governance

Governance of the DON data management process is centered on the activities of the Functional Area Managers (FAMs) (see Figure 4-22). SECNAVINST 5000.36 defines the roles and responsibilities of the FAM and the FDM. A revised version of SECNAVINST 5000.36, SECNAVINST 5000.36A, further defines the roles and responsibilities of the FAMs and the FDMs. It also defines a new position of Functional Namespace Coordinators (FNCs).

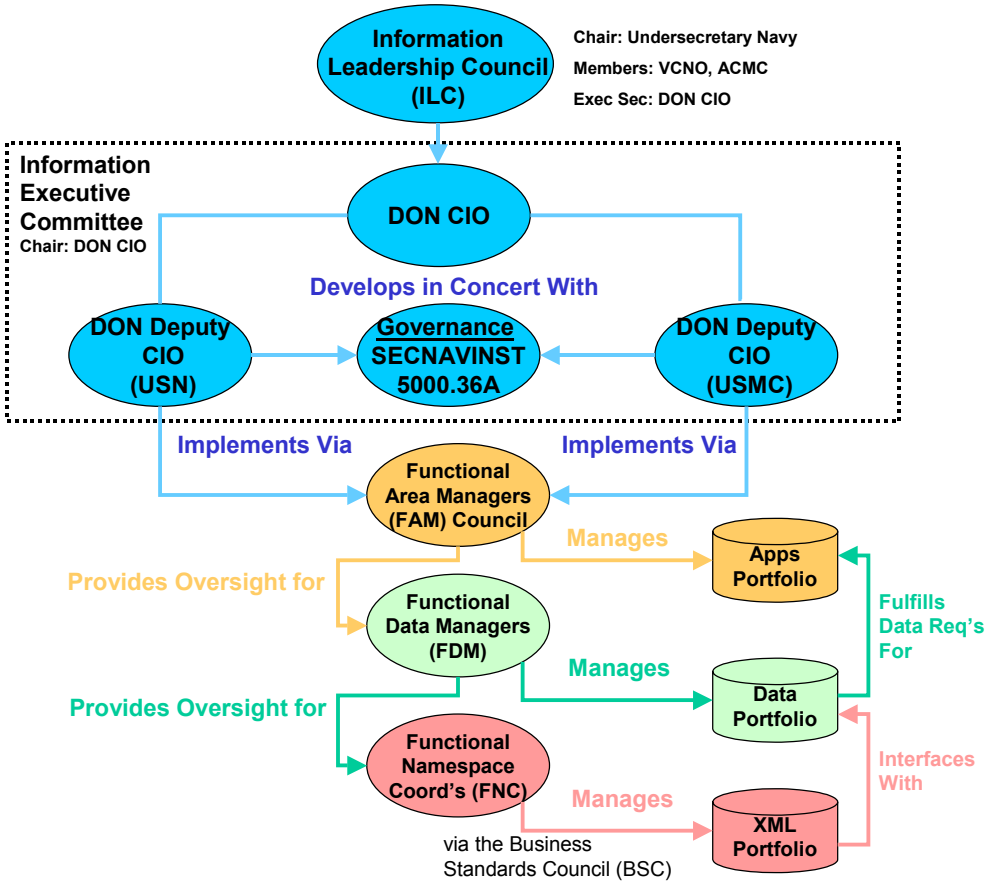


Figure 4-22. DON Governance Structure

The FAMs are responsible for determining which applications and databases are in the DON initial application portfolio. All legacy applications are analyzed by the FAMs for its business value before they can be migrated to the NMCI. All new software applications must be approved by the FAM, who will ensure that the application aligns with the functional area taxonomy and the FADA. They also are required to work with the DON CIO and the DON Information Executive Committee to ensure that DON IT/IM processes are followed consistently. The FAMs provide the strategic guidance and oversight for the FDMs.

DON FDMs are required to work closely with the FAM to eliminate duplicate databases in their functional area. They implement DON functional processes to produce and monitor use of data within and across DON functional areas. FDMs are responsible for the development and maintenance of the FADA, including the registering of application metadata and data exchange formats in DADMS. The FDMs are also required to develop new data standards for the Department of Defense (DoD) Metadata Registry and coordinate, with other DoD stakeholders, development of DoD-wide data architectures. The FDMs are required to review proposed DoD data standards for usability within the DON systems, and coordinate and implement the use of standardized data components through the DON Functional Namespace Coordinators (FNCs).

The DON FNCs manage the XML portfolio with other FNCs via the Business Standards Council (BSC). They harmonize their functional namespace with the other DON functional namespaces and are linked to the FADA. The FNCs coordinate with DoD Domain Owners to establish DoD enterprise XML components. They build DON XML standardized components for use by system developers for new DON applications.

4.4.5 Lessons Learned

The critical success factors identified from the work accomplished in the first three iterations of application rationalization process and in the development of the functional area data architectures were as follows

- **Have a catalyst for change**. The network NMCI drove DON to greater EA development.
- **Engage Senior-level management**. Management must be engaged in order to
  - Provide sufficient resources
  - Monitor metrics and initiate corrective action
- **Use a collaborate process to set polices.** Processes and policies will be better followed and understood if a collaborative process is used to create them.
- **Establish enterprise governance.** The DON established a governance process with a role-based hierarchy with clear roles and responsibilities that is outlined in SECNAVINST 5000.36A.
- **Have a goal and a way to get there.** The DON goal of reducing applications from 100,000 to 5,000 had an execution strategy, the iteration process, to reach it.
- **Communicate the execution strategy**. The DON communicated the execution strategy clearly and provided process training to ensure its success.
- **Execute a standard process**. For consistent, reliable results the DON used the application rationalization process and the data management seven-step process.
- **When practical, automate the process.** The DADMS tool organized and provided access to the information necessary for the application reduction and the building of the data architectures.
- **Keep pace with demands**. Provide the necessary funding and acquisitions in pace with the migration progress.
- **Make someone accountable for results**. The DON made the FAMs and FDMs responsible for DON data management.

4.5 Department of Defense Architecture Framework

4.5.1 Background

DoDAF, Version 1 was adopted in 2003 to replace the previous architecture framework, C4ISR Architecture Framework, Version 2.0. For the DoD, DoDAF defines a common approach for “DoD architecture description development, presentation, and integration for

both warfighting operations and business operations and processes. The Framework is intended to ensure that architecture descriptions can be compared and related across organizational boundaries, including Joint and multinational boundaries."[6]

The DoD uses the Framework to understand the DoD as an enterprise, identify operational requirements, rationalize IT investment decisions and improve interoperability among various systems.

4.5.2 Basic Principles

DoDAF's integrated architecture is comprised of three views and the interrelationships between them. These views include the Operational View, the Systems View and the Technical Standards View (Figure 4-23).

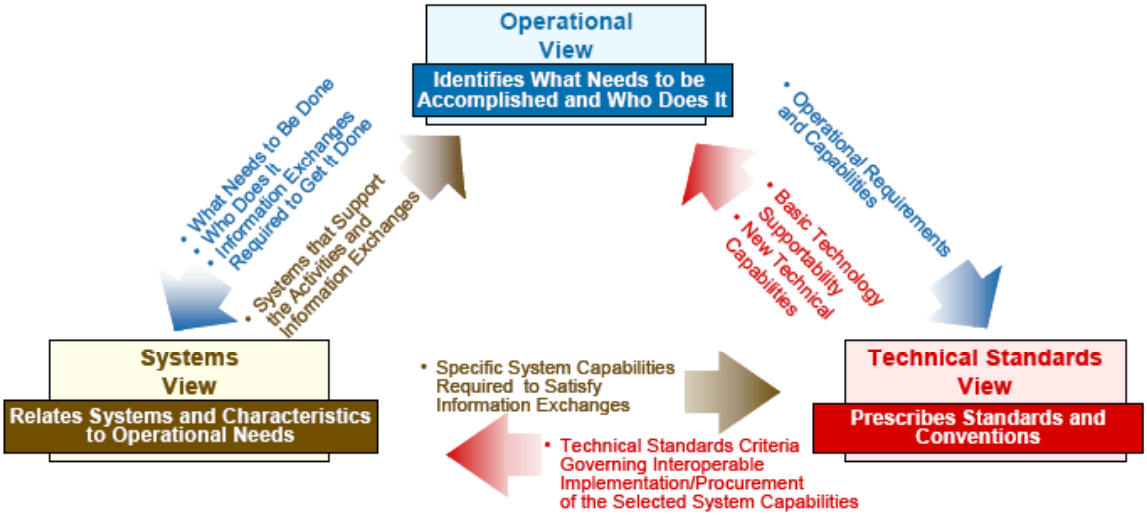


Figure 4-23. The Fundamental Linkages Among DoDAF Views

DoDAF describes a set of 26 interrelated work products that ensure uniformity and standardization in the documentation and communication of the architecture. The work products are designed to document the entire architecture from requirements analysis to implementation phase. The work products are categorized by the following DoDAF Views.

- **All Views (AV).** The AV captures aspects of architecture that relate to all three of the views. AV products set the scope and context of the architecture[7].

[6] : *DoD Architecture Framework Version 1.0, Volume I: Definitions and Guidelines,* (August 30, 2003), pg. ES-1.
[7] *DoD Architecture Framework Version 1.0, Volume I: Definitions and Guidelines,* (August 30, 2003), pg. 1-3.

- **Operational View (OV).** The OV is a description of the tasks and activities, operational elements, and information exchanges required to accomplish DoD missions[8].
- **System View (SV).** The SV is a set of graphical and textual products that describes systems and interconnections providing for, or supporting, DoD functions. The SV associates systems resources to the OV[9].
- **Technical Standards View (TV).** The TV is the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements. Its purpose is to ensure that s system satisfies a specified set of operational requirements[10].

4.5.3 Best Practices

The EDMG analysis of DoDAF identified a set of techniques and artifacts, which at a minimum should be considered for use in HUD's Segment Data Architecture development methodology. These work products are

- **Operational Node Connectivity Description (OV-2)**. The OV-2 graphically depicts the operational nodes (or organizations), the needlines between those nodes (or connectivity) and the information exchanged along those needlines. This diagram includes both internal and external nodes. For a segment architecture or LOB, the OV-2 would describe the internal and external key players (nodes) and the information exchanged between the key players to provide the overlying context for the segment and business functions.
- **Operational Information Exchange Matrix (OV-3)**. The OV-3 is a matrix which details the information exchanges identified in the OV-2. The matrix defines the information elements and relevant attributes of the exchange (e.g., producer node, consumer node, performance, security, etc.). The OV-3, or an augmented version, could be an effective format to document the information exchange details for a business processes. It could be documented to a level that can be used to validate the logical data model, and provide the specification for the development of the interface.
- **Logical Data Model (OV-7)**. The OV-7 describes the structure of the system data types within a domain of the architecture (entities) and the structural business rules that govern the system data (relationships). It also defines the data types, its attributes and its interrelationships. The OV-2 and OV-3 diagrams for a lower-level business processes or activities would align and provide input to the definition of the data types and structure of the OV-7 diagram.
- **System Interface Description (SV-1)**. The SV-1 graphically depicts the system nodes and systems that support an operational node. It could also include system interfaces that cross operational-node boundaries, referred to as key interfaces.

[8] *Ibid*.
[9] *Ibid.*
[10] *Ibid*.

The SV-1 links the SV to the OV by associating systems and key interfaces to operational nodes and needlines. A SV-1 diagram of both the baseline and proposed system architectures for a segment could be used to identify system data sources, analyze system interfaces and support transition planning.

4.6 Information Engineering Methodology

4.6.1 Background

The Information Engineering Methodology (IEM) developed by James Martin emerged in the early 1980s and was considered to be the most advanced and complete development methodology at that time. IEM was adopted to tackle enterprise-wide analysis projects in both the Federal and private sector because of its focus on analyzing the business requirements at the enterprise-level to build a cohesive collection of systems that effectively supported the overall mission of the enterprise. Other structured methodologies available at that time were system development methodology, which focused on design and implementation of a single system.

IEM is a comprehensive development methodology. It provides techniques for identifying and organizing business requirements at the highest possible level. Based on those requirements, it provides tools for building applications systems to meet them.[11] The two premises of IEM are 1) information is an enterprise asset and 2) the enterprise success is enhanced by effectively using information assets.

4.6.2 Basic Principles

The IEM is based on two principles, 'top-down' analysis and 'divide and conquer'. In its purest form, IEM has been categorized as the 'waterfall approach' because of its structured progression from one stage to the next until the bottom is reached. The outputs from one stage are further elaborated in the next stage (see Figure 4-24).

[11] *A Guide to Information Engineering Using the IEF,* (January 1990), pg. 1.

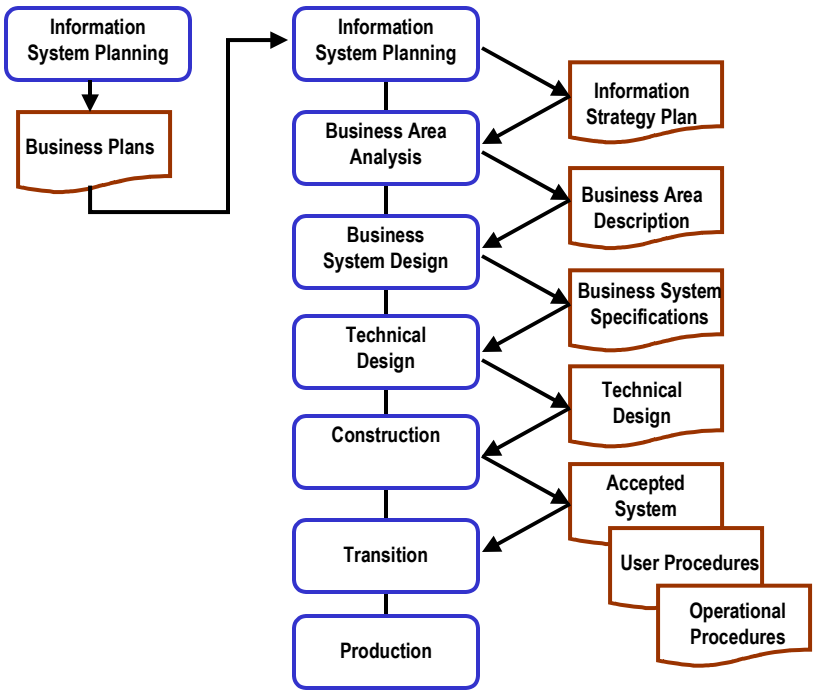


Figure 4-24 The Seven Stages of Information Engineering

The IEM follows a seven-stage approach to analyze business requirements at an enterprise level to implemented targeted systems that support business requirements. Information System Planning (ISP) and Business Area Analysis (BAA) are the stages that are the most relevant to the EDMG's analysis of best practices for segment data architecture development. ISP focuses on establishing a broad view of the business information requirements of the enterprise, and BAA performs a more detailed analysis on a particular segment of the enterprise, referred to as a business area.

The 'divide and conquer' principle is based on reducing the scope of the analysis and design effort into smaller components as the level of detail increases to ensure the task is a manageable size. The last step of each stage includes a process to analyze the artifacts and determine the scope and sequence for projects to progress on to the next phase. For example, the ISP stage focuses on information requirements at an enterprise-level, and the last step of that stage segments and sequences the enterprise into business areas for further detailed analysis.

4.6.3 Best Practices

Two of the premises of IEM -- information is an enterprise asset and incremental development -- were part of the EA approach used by the agencies the EDMG interviewed. The elements of IEM that the EDMG recommends HUD consider for use in the Segment Data Architecture development methodology are

- **Structured approach.** The method continuously refines and elaborates artifacts of a previous stage, and the progression and linkages between stages are well defined. At the end of each stage, the methodology recommends techniques to scope and sequence projects and governance reviews that should occur before proceeding on to the next phase.
- **Data and process alignment.** A technique, referred to as parallel decomposition, recommends decomposing both the data and activity architectures in parallel to ensure symmetry between the architectures. It has been effective in ensuring the resulting operations on data correlate with the data elements defined by the data model.
- **Identification of Business Data Stewards.** One of the last phases of both the ISP and BAA phases are to determine the 'CRUD' -- or the Create, Read, Update and Delete actions on the data -- and align them to business functions or processes that should perform them. At an ISP-level, CRUD can be used to identify programs offices that should be the Principal Stewards of the data and, at the BAA level, which processes should maintain this data. The "read" organizations and processes will be the Participating Stewards for this data.
- **Scope and sequencing business areas further development.** The IEM uses Affinity Analysis to identify the scope and sequence of projects to proceed to the next phase of development in the ISP and BAA phases. Affinity Analysis groups highly related data objects and process to organize and sequence them by CRUD. The results identify groups of highly related data elements and the associated processes that are sequenced by the life cycle of the data elements. This analysis provides the data and functional scope of a segment, determines the order in which these segments should be progressed and identifies the transitional issues.

SECTION 5. SEGEMENT DATA ARCHITECTURE BEST PRACTICES

5.1 **Introduction**

The EDMG studied the data architecture and governance practices of three Federal Agencies, as well as its proven methods for designing enterprise level data architectures. All of these agencies have very effective approaches that have resulted in successful data architecture programs. The EDMG identified eight best practices that were common among these agencies and methods that contributed to its program's EA success.

5.2 Best Practices

The eight best practices of a successful and effective data architecture are

- **Top-down and bottom-up analysis.** All the agencies established initiatives to build its enterprise data architectures using both a top-down and bottom-up approach. The top-down perspective produced the taxonomy to organize its enterprise-wide data architecture based on its business functions in its BRM. The bottom-up efforts served to decompose, detail and validate the data architecture with the as-is artifacts (e.g., data schemas). The approach also facilitated transition and implementation planning.

- **Incremental development.** In order to make the decomposition and definition of its enterprise data architectures more manageable, each agency developed strategic plans based on business priorities to incrementally develop data architectures for targeted business areas. The targeted business areas provided the scope for the analysis of both the target and baseline data architectures.

- **Alignment of data and business architectures.** Processes were implemented to ensure the decomposition of the data and process models retained alignment so that the artifact of the models could be mapped. This mapping served to 1) validate the synchronization of the data and business process models; 2) validate the information exchanges; 3) identify missing data elements and business processes; and 4) identify opportunities for data reuse and/or integration.

- **Communicate, coordinate and collaborate.** This expression was used by CBP within its recommendations for a successful enterprise data architecture program. The "3 Cs" concept is common; all the agencies in this analysis had established at least one working groups as a means to foster the concept across the enterprise. These working groups contribute the structure and definition of the enterprise data architecture, coordinate the alignment and harmonization of the functional data architectures with the enterprise data architecture, and foster governance within its respective organizations.

- **Business Data Stewardship.** All the agencies interviewed had a Business Data Stewardship program in place. DON and CBP had a formalized program comprised of members from the each of the enterprise business areas. DOI had a program in place that was comprised of volunteers, but the program is being formalized.

  The common view across the agencies was that Data Stewards were responsible for the definition and content of the data they govern. Each agency also shared unique views that pertained to the value of its stewardship program. For example, DOI uses the stewards as a point of contact to coordinate communication and information gathering. DON's business stewards (or functional data managers) were provided the authority necessary to ensure participation and compliance to data architecture policy and standards within their functional area. CBP uses its stewards to put the accountability and responsibility for the data architecture into the business organization.

- **Established and enforced data architecture governance.** Each agency stated that developing its enterprise-level data architecture would not have been successful without established policy, procedures and standards for architecture development and data management. Furthermore, the governance had to flexible enough to account for program or functional-area extensions. Established governance was not enough; it also had to be supported by senior-level management to ensure the data artifacts produced by the various areas adhered to the agency's policies and standards.

- **Architecture driven modernization efforts.** The agencies use its enterprise data architecture models to provide common semantics and structure for the physical data definition and specifications for information exchange. Furthermore, the taxonomy of the enterprise data architecture was used to identify system integration and replacement opportunities, data sharing opportunities and scope targeted areas for improvement.

- **Centralized and effective access to EA artifacts.** DOI and DON have an extensive centralized repository or application that enables enterprise-wide access to the artifacts of the data architecture and other EA models (e.g., technical, business). The centralized repository also provides the ability to register target and baseline architecture components and facilitates mapping data model artifacts to other EA models and as-is data schemas.

APPENDIX A. Department of the Interior (DOI) Data and Information Steward: Roles and Responsibilities

Department of the Interior (DOI)
Data and Information Stewardship:
Roles and Responsibilities

December 30, 2004

DOI Executive Sponsor - designates DOI Principal Stewards for the functional/subject areas within jurisdictional limits; ensures adequate funding for DOI Principal Stewards to effectively develop and maintain their respective functional/subject area view of the DOI Data Reference Model; and executes management responsibilities for the DOI Data Resource Management Program.

DOI Data Architect - provides overall direction on the development and implementation of DOI procedures for data standardization; provides support and direction to the DOI Principal Data Stewards and Bureau Data Stewards; and has a clear understanding of data management, compatibility and sharing, as well as business line outcomes and priorities across the Department.

DOI Principal Data Steward - takes direction from the DOI Data Architect; has a clear understanding of data management, compatibility and sharing, as well as business line outcomes and priorities across the Department; and is responsible for coordinating and integrating all data requirements for own subject area or business line.

Bureau Data Architect - takes direction from the DOI Data Architect and DOI Principal Data Stewards; is familiar with the business processes, data sets, business line outcomes and priorities of most Bureau programs; and ensures that business line data stored in the corporate database meets DOI and Bureau data standard requirements.

Business Data Steward - takes direction from the Bureau Data Architect; is familiar with the cost of operating and maintaining the Bureau's relational database management systems (RDBMS), as well as gathering, maintaining, and migrating internal or external data; and works closely with Bureau Subject Matter Experts to ensure the quality and accuracy of business line data stored in the corporate database.

Subject Matter Expert - ensures data integrity and quality control; manages user access to subject matter data sets; is familiar with Bureau business rules; and serves as the Bureau's expert on subject area processes, outcomes, outputs, data values, labels, definitions, and metadata information.

Database Administrator - implements logical and physical data models with appropriate security and access on a RDBMS; is usually an expert in describing data types and database schemas; and monitors security, data access and database system use.

I. DOI Executive Sponsor:

A. Designates DOI Principal Data Stewards for the functional/subject areas within their jurisdictional control or authority.

B. Ensures adequate and timely funding for DOI Principal Data Stewards to effectively develop and maintain their respective functional/subject areas of the DOI Data Reference Model.

C. Oversees and executes management responsibilities in support of the DOI Data Resource Management Program, including concurrence with decisions by the DOI Principal Data Stewards.

II. DOI Data Architect:

A. Develops and directs the implementation of DOI data resource management policies and standards.

B. Monitors and tests DOI data resource management policies and standards for compliance.

C. Maintains the DOI Data Reference Model and ensures its harmony, where practical, with the Federal Enterprise Architecture Data and Information Reference Model.

D. Establishes DOI Data Reference Model integration procedures and manages the integration of logical data models into the DOI Data Reference Model.

E. Establishes best practices and new standards for developing logical and/or physical data models.

F. Establishes and enforces procedures to be used by the DOI Principal Data Stewards in developing and submitting data requirements for their respective subject areas or business lines.

G. Establishes the criteria for the review of proposed DOI data standards and confirms their status prior to recording status changes in the DOI Data Repository.

H. Arbitrates and resolves data-related issues presented after a formal review.

I. Promotes the identification and protection of sensitive data associated with all DOI business lines that are designated "For Government Use Only," "Proprietary," or subject to the Privacy Act and/or applicable security classifications.

J. Serves as the functional proponent for the DOI Data Repository.

K. Maintains the DOI Data Repository and ensures its availability and continuous operation.

L. Conducts periodic assessments of DOI data standards contained in the DOI Data Repository and recommends retirement of data standards that are no longer of practical use to any business line.

III. DOI Principal Data Steward:

A. Works directly with the DOI Data Architect and Bureau Data Architects to review standards and business rules, and to establish DOI data standards in accordance with the DOI Data Reference Model, DOI Data Repository, and DOI Data Standardization Manual.

B. Promotes the implementation of best practices and new standards for developing logical and/or physical data models for own subject area or business line.

C. Works closely with the Bureau Data Architects and Business Data Stewards to coordinate and integrate all data requirements.

D. Provides guidance to Bureau Data Architects on existing policies, rules, regulations, and laws (i.e., the Privacy Act, Sarbanes-Oxley, Freedom of Information Act, Patriot Act, etc.).

E. Reviews and considers comments and recommendations submitted during formal reviews of DOI data standards.

F. Reviews and provides comments on data standards submitted by other DOI Principal Data Stewards to determine their potential impact.

G. Resolves issues on data standards associated with own subject area or business line with appropriate Bureau Data Architects and DOI Principal Data Stewards.

H. Final authority on all issues pertaining to own subject area or business line. Coordinates decisions on own subject area or business line with appropriate user communities.

I. Identifies and describes the attributes needed for the protection and proper release of sensitive data associated with own business line that is designated "For Government Use Only," "Proprietary," or subject to the Privacy Act and/or applicable security classifications.

J. Reviews and adopts recommendations on updating or retiring data standards associated with own subject area or business line.

IV. Bureau Data Architect:

A. Facilitates the timely development, review, modification, and/or establishment of DOI data standards and business rules with the DOI Data Architect, DOI Principal Data Stewards, Bureau Business Data Stewards, and other DOI Bureau Data Architects, in accordance with the DOI Data Reference Model, DOI Data Repository, and DOI Data Standardization Manual.

B. Facilitates the identification and leveraging of Bureau data standards as candidates for adoption as DOI data standards.

C. Implements best practices and standards for developing logical and/or physical data models for Bureau subject areas or business lines.

D. Coordinates and collaborates with others to integrate all data requirements for Bureau subject areas or business lines.

E. Works closely with the Bureau Business Data Stewards to review comments and recommendations presented during formal reviews of cross-Bureau data standards.

F. Facilitates the timely review of DOI data standards to determine their potential impact on Bureau subject areas or business lines.

G. Works directly with the DOI Principal Data Stewards and Bureau Business Data Stewards to resolve data standard issues.

H. Promotes the identification and protection of sensitive data associated with all Bureau subject areas or business lines that are designated "For Government Use Only," "Proprietary," or subject to the Privacy Act and/or applicable security classifications.

I. Promotes implementation of DOI data standards within the Bureau and ensures that standards are included in private sector contracts.

J. Makes recommendations on updating or retiring standards for the Bureau subject areas or business lines.

K. Coordinates the timely performance of data accuracy and quality assurance checks, formal reviews, and information exchange relevant to DOI data standards.

V. Business Data Steward:

A. Works directly with the Bureau Data Architect, Subject Matter Experts, and other Bureau Business Data Stewards to develop, review, modify, and/or establish DOI data standards for Bureau subject areas or business lines, in accordance with the DOI Data Reference Model, DOI Data Repository, and DOI Data Standardization Manual.

B. Implements best practices and standards for developing logical and/or physical data models for Bureau subject areas or business lines.

C. Reviews DOI data standards to determine their potential impact on Bureau subject areas or business lines.

D. Reviews and evaluates comments and recommendations presented during formal reviews of DOI data standards within the Bureau and the Department.

E. Works directly with the Bureau Data Architect, Subject Matter Experts, and other Business Data Stewards to resolve issues relevant to DOI data standards.

F. Identifies sensitive data associated with Bureau subject areas or business lines to ensure the appropriate designation, i.e., "For Government Use Only," "Proprietary," or subject to the Privacy Act and/or applicable security classifications.

G. Coordinates and promotes implementation of DOI data standards, accepted business rules, and the Life Cycle approach for all Bureau business line data.

H. Updates and maintains appropriate data standards for the Bureau's identified subject areas or business lines.

I. Identifies data quality metrics and coordinates data accuracy and quality assurance checks, formal reviews, and information exchange relevant to DOI data standards with the Bureau Data Architect, Subject Matter Experts, and other Business Data Stewards.

VI. Subject Matter Expert:

A. Works directly with the Business Data Steward to develop, review, modify, and/or establish data standards for Bureau's own subject areas or business lines, in accordance with the DOI Data Reference Model, DOI Data Repository, and DOI Data Standardization Manual.

B. Analyzes business requirements and/or logical/physical data models to ensure secure and appropriate interfaces and connections among Bureau systems, applications, and databases.

C. Evaluates comments and recommendations presented during formal reviews of proposed data standards within the Bureau to determine impacts on existing and planned systems.

D. Works directly with the Business Data Stewards and other Subject Matter Experts to resolve data standard issues and to implement DOI data standards, accepted business rules, and the Life Cycle approach for all Bureau business line data.

E. Suggests classification of sensitive data and regulatory authorities associated with Bureau subject areas or business lines that are designated "For Government Use Only," "Proprietary," or subject to the Privacy Act and/or applicable security classifications.

F. Identifies and verifies business rules for Bureau subject areas or business lines.

G. Works directly with the Business Data Stewards, Database Administrators, and other Subject Matter Experts to implement accepted business rules, best practices, data standards, quality control procedures, and security requirements for Bureau subject areas or business lines.

H. Implements DOI data standards and incorporates the Life Cycle approach for all Bureau business line data.

I. Assures the accuracy and quality of data definitions, data labels and metadata, including the specification of valid domain and data values.

J. Performs data accuracy and quality assurance checks, and conducts recurring (periodic) data quality reviews to ensure compliance with established DOI and Bureau data standards.

K. Documents quality assurance reviews and communicates all data-related changes with the appropriate Business Data Stewards and Subject Matter Experts.

VII. Database Administrator:

A. Develops and implements logical and/or physical data models within the Bureau's relational database management system (RDBMS).

B. Loads the approved data into the RDBMS as outlined in the logical and/or physical data model.

C. Designs, develops, and implements appropriate interfaces and connections among Bureau systems, applications, and databases, including the creation of database views, referential integrity constraints, and primary/secondary keys as outlined in the logical and/or physical data models.

D. Works directly with the Subject Matter Experts and Business Data Stewards to implement data standards, best practices, quality control procedures, and security requirements for Bureau subject areas or business lines as directed.

E. Updates and maintains data definitions for use in production environment.

F. Ensures specifications for valid domain and data values and fully implements accepted business rules in a consistent manner.

G. Implements data access and ensures that access is aligned with the security requirements specified by the Subject Matter Experts and Business Data Stewards.

H. Tunes the RDBMS to achieve maximum performance and ensures the day-to-day care, functionality, and utility of the RDBMS.