Civilian Application of the DOD C4ISR Architecture Framework: A Treasury Department Case Study

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Abstract

This case study presents a recent effort to apply architectural precepts from the Department of Defense (DOD) in the environment of a civilian Federal agency. The end of the Cold War affords us the opportunity to devote time, attention, and interest to the concept of adapting the structured DOD architectural processes and best practices to the non-military sector at Federal, department, and bureau levels of the U.S. Government.

This paper describes how two department leaders in the application of architectural principles and practices—the DOD and the Department of the Treasury (Treasury)—design, establish, and apply architectural frameworks. Their two frameworks are separate, but similar. DOD uses the C4ISR (Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance) Architecture Framework, which predates the Federal Enterprise Architecture Framework (FEAF). Treasury relies on the Treasury Information Systems Architecture Framework (TISAF), which also predates the FEAF. Treasury is supporting one of its largest bureaus, U.S. Customs Service (Customs), in applying the more prescriptive C4ISR architectural precepts and practices via the TISAF for development of the modernized Customs Enterprise Architecture (EA).

Lastly, the paper discusses additional opportunities to apply the guidance of the C4ISR Architecture Framework within international, coalition environments.

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1.0 Introduction

Due to the nature of its mission, the DOD possesses some of the most structured processes and mature practices in the Federal Government. The DOD was one of the first Federal agencies to embrace the use of architectural principles and practices in the management of information technology and its return on investment (ROI). Consequently, the DOD is recognized as the source of many processes that can be applied throughout the public and private sector.

Traditionally, organizations have scrutinized their information technology investments more for cost than benefits. With increased budgets for information technology, organizations are now questioning the benefits of these investments more closely. The clear trend, at present and for the future, is that benefits and outcomes will be the major concern for information technology investments. Enterprise architecture (EA) is a vital candidate for this scrutiny and planning.

EA, as a discipline and practice, should address the linkage between an organization's strategic plan and its implementation of information technology. An EA is more than simply a plan that optimizes existing information technology and ensures its alignment with strategic goals. EA adds a crucial element of control, ensuring the proper integration of changes in corporate practices or new or advanced technologies into an agency's architecture. Properly designed, the EA provides in one framework a coherent presentation of all the policies, standards, and procedures, as well as evaluation and oversight tools, necessary to enforce the mandates of the Clinger-Cohen Act of 1996.

As a group, architects tend to look for success stories and valuable lessons learned from their efforts to establish standards and guidelines for design, implementation, and management. In the last 10 years, the prevailing belief was that if one built the architecture, the owners and operators would come. History has shown, however, that few organizations actually "operationalized" the architecture—and the owners and operators did not come. The inherent flaw from the beginning was the lack of a standard framework or methodology that allows the architecture to be inserted into the decision making process.

1.1 *Foundation for Architectural Models*

Guided by priorities of the Clinger-Cohen Act, the Federal CIO Council Strategic Plan (January 1998) directed the development and maintenance of a Federal Enterprise Architecture to maximize the benefits of information technology within the Federal Government. From the outset, the Federal CIO Council agreed to employ the widely accepted National Institute of Standards and Technology (NIST) architecture model and expand its foundation to meet the organizational and management needs of a Federal Enterprise Architecture. Promoted as a management tool within the Federal Government, the NIST model illustrates the interrelationship of enterprise business, information, and technology environments.

Federal departments and agencies are using architectural disciplines to improve systems acquisition and technology insertion practices, increase return on information technology investment, and guide systems migration. Although executive directives and recent legislation direct the use of architectures, Federal agencies vary widely in their approach to architecture

development and implementation. They apply the FEAF in different ways and for varying purposes, with diverse results.

1.2 *Application of Architectural Models*

Enterprise architects and engineers have used models as their primary descriptive methodology. John Zachman and Dr. Steven Spewak are two of the many recognized leaders in architecture conceptualization and EA planning. Figure 1 shows the hierarchy of architectural frameworks—from the Federal to department to bureau levels—and the influences of Zachman, Spewak, and the DOD C4ISR Architecture Framework. The FEAF is built on the foundation of the well-known Zachman Framework, with Spewak's Enterprise Architecture Planning overlaid onto the rows of the first two perspectives (Planner, Owner). The architectural guidance flows from the seminal frameworks to the Customs EA (formerly known as the Blueprint) and to its product, a Functional Architecture for the Automated Commercial System (ACS)—the central system within the Customs trade compliance mission area.

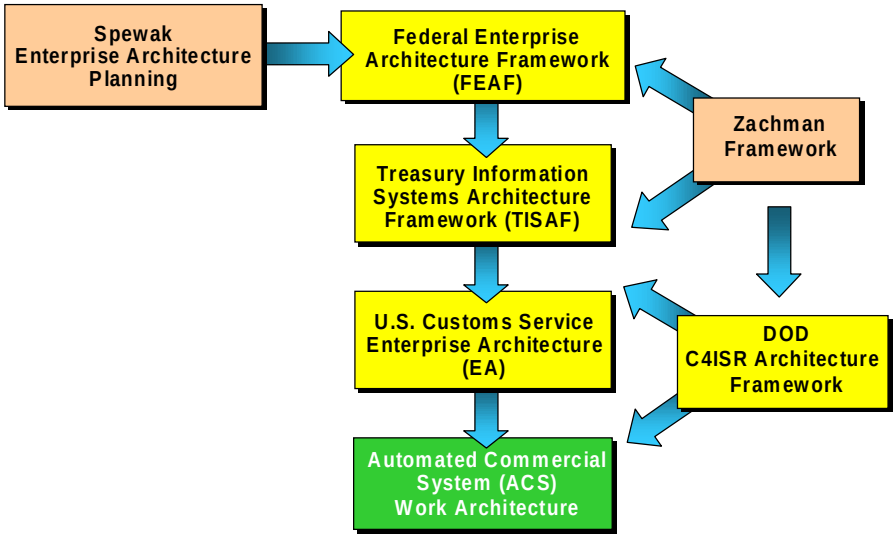


Figure 1. Hierarchy of Guidance Architectural Frameworks

The C4ISR Architecture Framework delineates three architectural views: (1) the operational architecture view, (2) the systems architecture view, and (3) the technical architecture view. The framework also identifies descriptive "products" or models to be developed as components of each view. These products are deemed either essential or supporting. Although the C4ISR Architecture Framework predates FEAF, it is completely compatible with and reflects many of the same fundamental precepts.

By contrast, the TISAF delineates four architectural views: (1) the work architecture view, (2) the information architecture view, (3) the functional architecture view, and (4) the infrastructure view. The TISAF is not as exacting as the C4ISR Architecture Framework in specifying what constitutes the components of the individual architectural views. However, the Treasury Architecture Process Document does provide a list of key aspects of each view and prescribes a

set of "possible methods and techniques" [TISAF, 1997]. As employed by the bureaus within Treasury, TISAF is one interpretation of the principles of the FEAF.

The Treasury CIO Council has endorsed additional guidance that builds upon TISAF, creating a Treasury Enterprise Architecture Framework (TEAF). TEAF incorporates some of the prescriptive elements of the C4ISR Architecture Framework. These modifications include the addition of essential and supporting products, individualized guidance for subordinate agencies and bureaus, and a temporal component—adding time-phased architectural views, from "As-Is" through migration phases to the "To-Be" architecture. This adaptation of the C4ISR Architecture Framework for Federal civilian agency use is part of the Customs EA development for the bureau's Modernization Program.

1.3 *New Enterprise Architecture Efforts within the U.S. Customs Service*

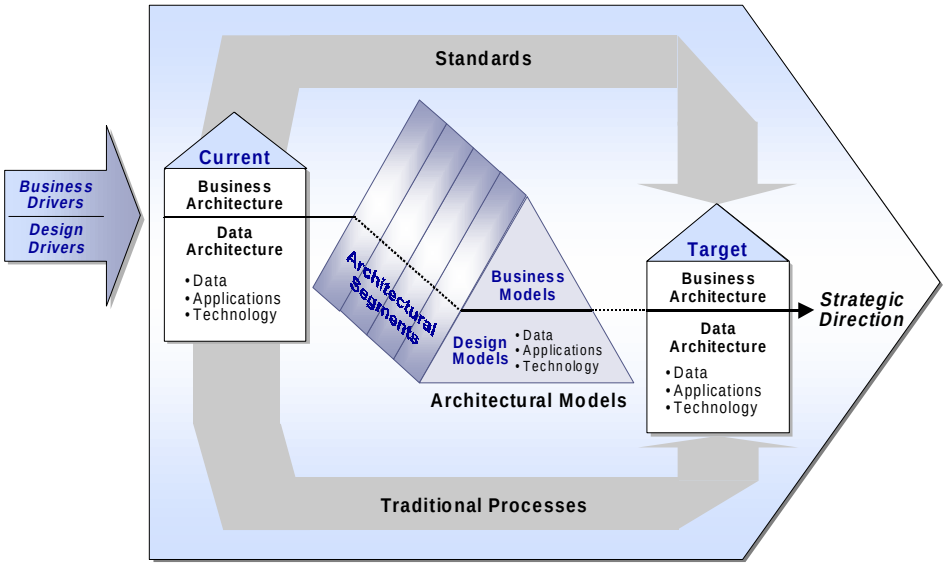
The Customs modernization of ACS presents one opportunity to leverage the DOD architectural experience in a civilian agency environment. ACS tracks, controls, and processes all goods and merchandise imported into the U.S., and manages tariff accounts, protests, and summonses to court. This information system supports the Customs trade compliance mission. It currently interacts with more than 2,500 trade users/stakeholders (importers and brokers), other Customs systems, and other Federal Government and non-Government agencies. Using the precepts of TISAF, C4ISR Operational Architecture products, and guidance from FEAF, Customs architects are developing a preliminary functional architecture for ACS. The effort is integrating prescribed DOD products to graphically illustrate architectural views into the TISAF and the ACS Functional Architecture.

2.0 The Federal Enterprise Architecture Framework and Pilot Demonstration

The Federal CIO Council seeks to develop, maintain, and facilitate the implementation of a top-level EA—predicated upon the FEAF—for the Federal Enterprise. This architecture will serve as a reference point to facilitate the efficient and effective coordination of common business processes, information flows, systems, and investments among Federal agencies.

2.1 *Federal Enterprise Architecture Framework*

In September 1999, the Federal CIO Council published the *Federal Enterprise Architecture Framework, Version 1.1*. The FEAF provides an enduring standard for developing and documenting architecture descriptions of high-priority areas. It builds on common business practices and designs that cross organizational boundaries. The FEAF provides guidance in describing architectures for multi-organizational functional segments of the Federal Government. These Federal architectural segments will collectively constitute the Federal Enterprise Architecture.



Source: Federal Enterprise Architecture Framework, Version 1.1, September 1999

Figure 2. Structure of the Federal Enterprise Architecture Framework Components

As shown in Figure 2, the FEAF partitions a given architecture into Business and Design models. The Business model is further partitioned into architectural views to include Data, Applications, and Technology aspects.

2.2 *Pilot Demonstration of the Federal Enterprise Architecture Framework*

The Federal CIO Council has sponsored a pilot demonstration to test the utility of FEAF guidance in demonstrating a degree of interoperability across selected Federal architectural segments, improving internal-segment integration, and investigating the level of interoperability across all Federal architectural segments. The pilot supports the activities of the Council's Emerging Information Technology and Interoperability Committee. It contributes to the Committee's near-term vision: increased interoperability of business processes to achieve a cost-effective, value-added contribution to the efficiency of the Federal enterprise.

Unlike the C4ISR Architecture Framework, the FEAF does not include product descriptions and definitions. Accordingly, it is not possible to test the value that FEAF might contribute to interoperability between Federal architectural segments. To ensure that interoperability is tested in the pilot demonstration, DOD products have been mapped to the FEAF structure. (It is necessary to understand the basic "questions" that need to be asked, the associated data, and the DOD products that reflect that data.) If one or two Federal architectural segments complete one or more specified products, then it is possible to make determinations about interoperability and what must be done to achieve it.

Although the DOD products do not mesh exactly with the Zachman Framework perspectives—the Planner, Owner, Designer, Builder, and Subcontractor Views, the DOD products used in the pilot are sufficient to help understand the dynamics of interoperability.

Now underway, the pilot effort will develop architecture descriptions for two high-priority, cross-agency business lines or Federal architectural segments. The FEAF provides very high-level text descriptions of the models that should be built to fulfill the cells of the modified Zachman matrix. The two functional segments tentatively selected are Grants and International Trade. These narrow-scope architecture segments can generate lessons learned for further development or improvement of the FEAF. Selected product templates from the C4ISR Architecture Framework will be used to populate the appropriate matrix cells of the Zachman Framework.

For this pilot, the C4ISR Architecture Framework products will provide the common frame of reference. Figure 3 illustrates the products that will be used as templates for populating the Framework cells used in the pilot. By asking each Federal architectural segment the same question at the same level of detail, this should develop comparable answers that facilitate achieving the desired degree of integration.

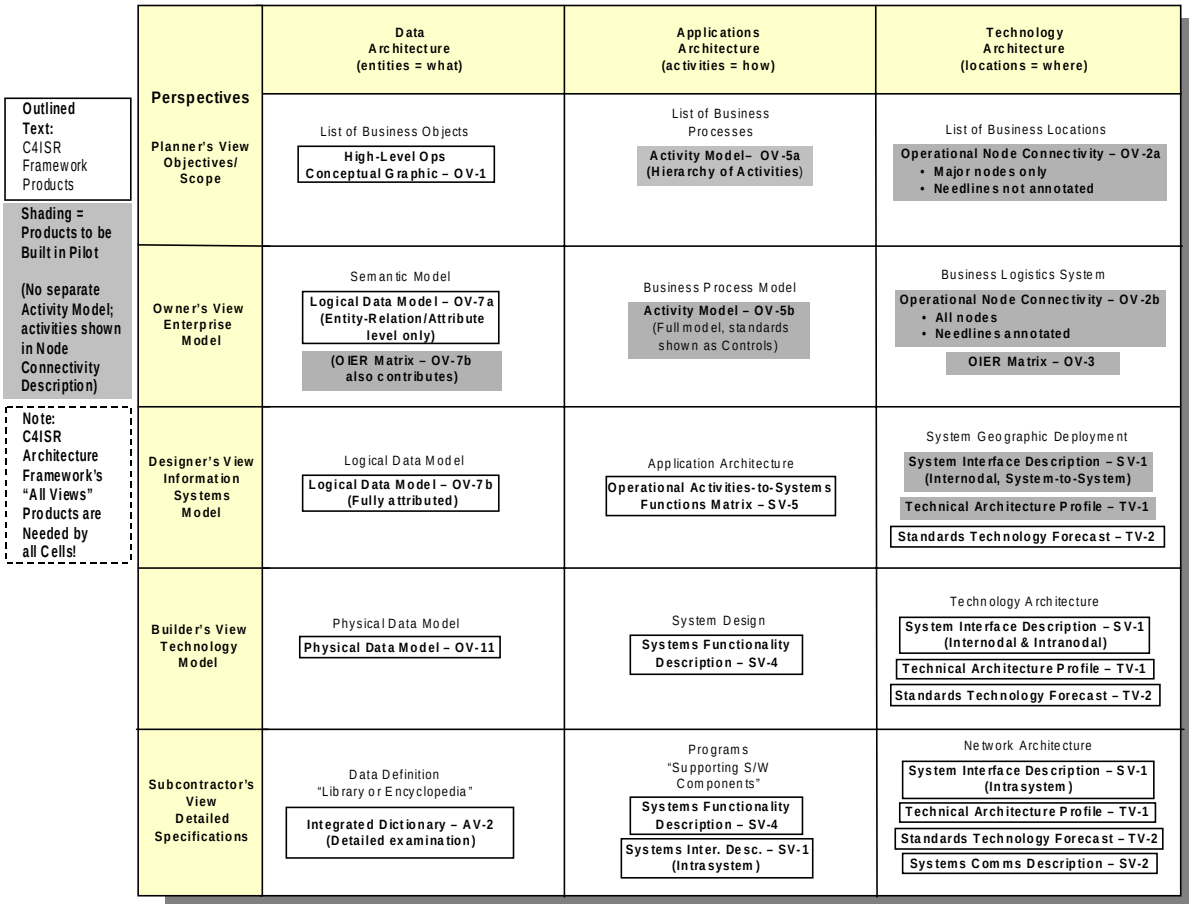


Figure 3. DOD C4ISR Architecture Framework Products Mapped to the Federal Pilot Architecture Models

3.0 Defense and Treasury Frameworks

Each Federal organization has instituted EA in its own unique and fundamental manner. To service the strategic needs and set guidance for a diverse set of Federal agencies and departments, the FEAF provides a structure to develop, maintain, and implement top-level operating environments and supporting information technology systems. The DOD and Treasury are leaders in the application of EA.

Both DOD and Treasury have developed in-depth architectural frameworks to guide the generation and use of architectures throughout their large and diverse organizations. The DOD has unique requirements: the framework must apply to, and be relevant for, all branches of the armed services (Army, Navy, Air Force, and Marines). This includes the numerous major and subordinate commands, field organizations, and task forces within each service geographically dispersed around the world. Similarly, the Treasury framework must be germane and applicable to each of its 13 subordinate bureaus and agencies.

As leaders in the use and implementation of architectural precepts, DOD and Treasury continue to modify and revise their frameworks. Currently, the DOD is upgrading version 2.0 of the C4ISR Architecture Framework by refining architectural products and realigning the essential and supporting aspects of its direction. The DOD is also considering a name change to reflect the Framework's wider relevance to all DOD mission areas. For its part, Treasury has transformed the descriptive 1997 TISAF to a more prescriptive and directive instrument, the TEAF.

3.1 *C4ISR Architecture Framework*

Many current and evolving DOD efforts focus on the common goals of interoperability, integration, and cost-effective investments. Various reference models and information standards provide source documentation for guidelines and attributes, and must be consulted in building architecture products. The C4ISR Framework cites several of these reference models.

The most essential aspect of the Framework guidance is that the purpose for building the architecture description should be clearly understood and articulated at the outset. The purpose will influence the choice of what information to gather, what products to build, and what kinds of analysis to apply.

Development of C4ISR architectures is a distributed process. Because there has been no uniform guidance governing architecture development, DOD organizations describe their respective architectures using disparate perspectives, formats, and terminology. It has been virtually impossible to interrelate or compare one architecture with another. Therefore, the architect and program management must conduct an integration process in order to identify interoperability issues and to find opportunities for technology leveraging and sharing. By using the C4ISR Framework over time, system architects can dovetail architectures and develop opportunities to identify and enhance interoperability, integration, and cost effectiveness.

3.1.1 *C4ISR Architecture Views*

The C4ISR Architecture Framework defines the operational, systems, and technical views of any given architecture. Figure 4 illustrates these three views and their relationships.

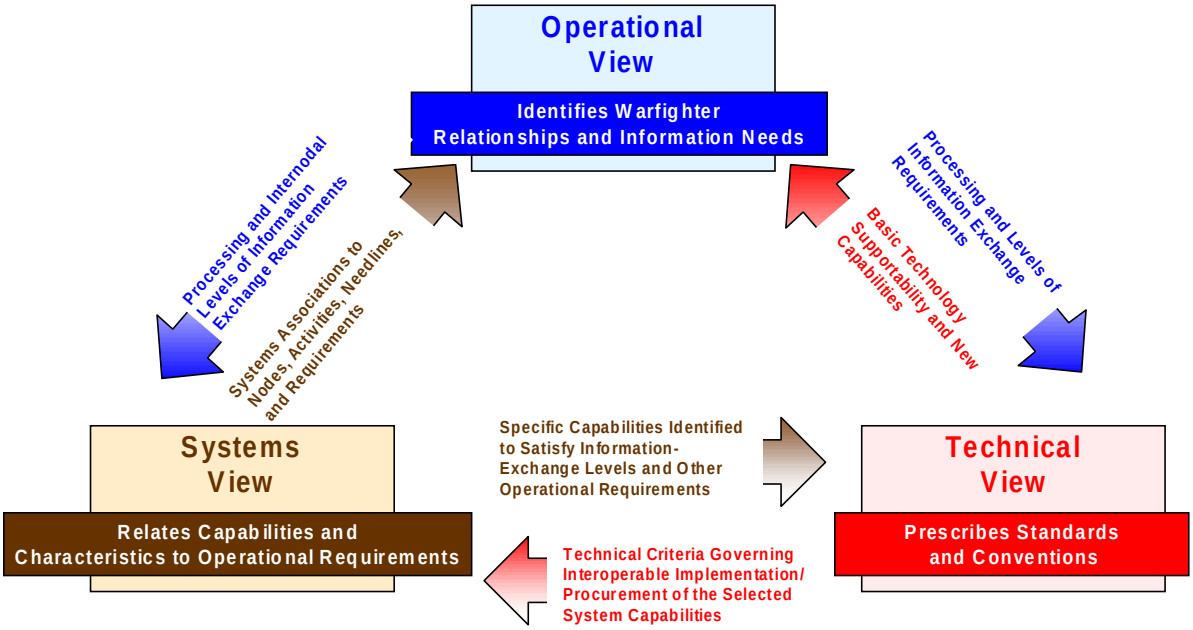


Figure 4. C4ISR: One Architecture, Three Views

The *operational view* describes the tasks and activities, operational elements, and information flows required to accomplish or support an operation. It specifies the nature of each needline's information exchange in sufficient detail to determine the required interoperability. The *systems view* identifies which systems support the requirement. It translates the required degree of interoperability into a set of needed system capabilities, and compares current/postulated implementations with needed capabilities. The *technical view* articulates criteria that govern the implementation of each required system capability. To be consistent and integrated, an architecture description must provide explicit linkages among its various views.

3.1.2 *C4ISR Architecture Products*

Products are the representation formats, and the required data, that all DOD organizations use to describe their C4ISR architectures. The essential products are those that every architecture description must contain, provided the subject view is included in the architecture. The supporting, or optional, products are those that will be needed for some architecture descriptions, depending on the purpose. For example, in the operational architecture view, four of the products are considered supporting or optional (Organizational Command Relationships Chart, Activity Model, Operational Rules Model, and a Logical Data Model) [C4ISR, 1997].

There are three essential, or mandatory, products in the *operational view*:

- The **High-level Operational Concept Graphic** is the most general of the architecture-description products. Its main utility is to facilitate high-level communication and is intended for presentation to decision makers. This kind of diagram can also be used as a means of orienting and focusing detailed discussions.
- The **Operational Node Connectivity Description** describes the operational nodes and elements, the needlines between them, and the characteristics of the information exchanged.
- The **Operational Information Exchange Matrix** displays the Information Exchange Requirements (IER) among the operational nodes. The IER identifies *who* exchanges *what* information with *whom, why* the information is needed, and in *what* manner. IERs identify the elements of information used in support of a particular activity and between any two activities, along with relevant attributes of the exchange. [C4ISR, 1997].

There is just one essential product in the *systems view:* the System Interface Description. To accommodate the range of detail that may be required by individual architectures, this product can be shown in three perspectives: *internodal* (with two levels of detail), *intranodal*, and *intrasystem* (system component). The System Interface Description links the operational and systems architecture views and depicts the assignments of systems and their interfaces to the nodes and needlines described in the Operational Node Connectivity Description. It identifies the interfaces between systems nodes, between systems, and between the components of a system, depending on the needs of a particular architecture.

The *technical view* also has one essential product: the Technical Architecture Profile, which references the technical standards that apply to the architecture and how they need to be, or have been, implemented.

3.2 *Treasury Information System Architecture Framework*

The TISAF provides (1) guidance to the Treasury bureaus concerning the development and evolution of information systems architecture; (2) a unifying concept, common principles, technologies, and standards for information systems; and (3) a template for the development of the EA.

The TISAF describes an enterprise information system architecture in terms of four architectural views. These views are:

- A **Work Architecture** that specifies the decentralization of the business, the distribution of the work organization to business locations, and the communication and coordination between these locations. It also describes the major operations performed by work organizations in support of functions and the types of work in terms of the type of workers and types of work locations.
- A **Functional Architecture** that identifies, defines, and organizes the business functions, processes, or activities that capture, manipulate, and manage the business information to support business operations. It also describes the logical dependencies and relationships among business functions.

- An **Information Architecture** that identifies, defines, and organizes all of the information needed to perform the enterprise business operations and the relationships among that information. The data elements or entities needed to support business functions are captured in this view.
- An **Infrastructure View** that specifies the hardware, software, telecommunications components, management tools, security services, and distributed computing services required to support the functional and information architectures.

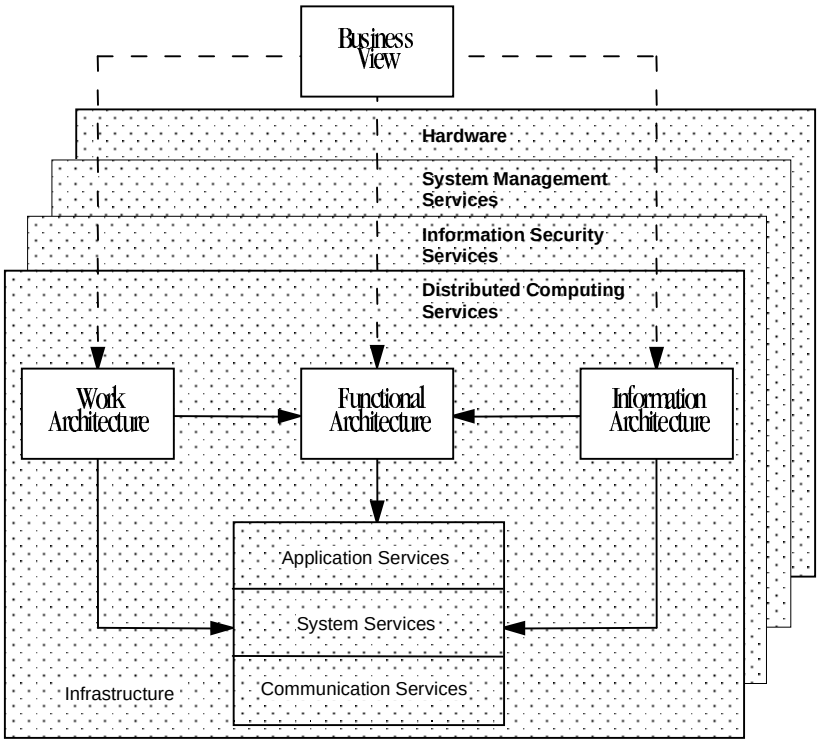


Figure 5. Architectural View Relationships in the TISAF

The enterprise is composed of multiple business operations. The work, functional, and information architecture views collectively model the organization's business operations. This grounds the architecture in the business of the organization, while the business view defines the core business procedures and processes of the enterprise. By providing explicit models, the architecture enables the identification and reasoning of enterprise- and system-level concerns and investment decisions.

The TISAF describes an architectural framework that supports Treasury's business processes. This framework guides the development and redesign of the business processes for various bureaus in order to meet the requirements of recent legislation in a rapidly changing technology environment. While not as prescriptive as the C4ISR Architecture Framework, the TISAF does provide guidelines for characterizing each of the architectural views. Although the document recommends a succinct approach to describe the current state of computer-based automated support for its business operations, Treasury has produced the TEAF to prescribe a set of artifacts, graphics, and models to portray the various views for all bureaus.

3.3 *Supplementing the TISAF with DOD Precepts*

Treasury understands that, in its commitment to standardization of architectural products, "one size does not fit all." Consequently, by supplementing TISAF with the TEAF, Treasury is attempting to broaden the audience for the framework and reduce the burden on many bureaus to fit a particular mold.

TEAF builds upon TISAF. It addresses the scope or scale of architectures, the different architectural views, linkage between architectures, definition of terms, and the application of architectural principles across several bureaus. A set of models or products provides a solution pattern with templates for common use among agencies within Treasury. The new framework makes a concerted effort to ground the architecture development process in business operations, mapping artifacts and models to business activities, functions, and missions.

Treasury has improved the guidance and rationale for producing enterprise-wide architectures through these efforts. In recognition of the integral role of information technology investment management in architecting, TEAF also introduces metrics to measure the levels of interoperability and information technology ROI.

4.0 Applying the TEAF

TEAF provides a unifying concept, common terminology and principles, common standards and formats, a normalized context for strategic planning and budget formulation, and a universal approach for resolving policy and management issues.

The TEAF calls for an EA comprised of four architectures or views: functional, information, organizational, and infrastructure. The TEAF describes in detail the enterprise information system architecture and its components, including the architecture's purpose, benefits, characteristics, and structure. The TEAF introduces various architectural views and delineates several modeling techniques. Each view is supported with graphics, data repositories, matrices, or reports.

Using the more prescriptive and directive guidelines provided by the C4ISR Architecture Framework, it is now possible to develop specific elements or components of the TEAF views. Thus, the EA becomes a model of how information technology will meet and support organizational goals and user requirements. In addition, the individual views make the structure more understandable, complete, consistent, traceable, and integrated.

4.1 *The Customs Enterprise Architecture*

Customs is pursuing an enterprise-wide modernization effort. One of the initial goals of the Modernization Program is to develop an EA that benefits from the increased prescriptive guidance of the TISAF and TEAF. Many information systems within Customs mission areas are, or will be, candidates for reengineering, redesign, or replacement. One of the first

candidates is the highly visible Automated Commercial System within the nationally critical trade compliance mission area.

The Customs trade compliance systems are essential for importation of goods and merchandise into the U.S. They ensure the collection of fair and equitable duties and fees, enforcement of trade laws and regulations, compliance with international trade agreements, and aggressive interdiction of drug trafficking across our borders.

Customs has designated ACS, now 16 years old, as one of the first legacy systems to be modernized. ACS is a system-of-systems that controls and monitors the entry and release of merchandise into the U.S., collection of duties, and maintenance of all associated records and statistical data. In advance of its selection of a prime contractor for the Customs Modernization Program, Customs is developing a sound and accurate "As-Is" Functional Architecture for ACS. This functional architecture will identify current business activities, processes, and practices; capture the organizational and operational nodes; document the current information exchanges and flow; and establish overall operational sequences. As one of its first tasks under the Modernization Program, the prime contractor will generate a "To-Be" (target architecture) for the modernized environment, which must build upon and transition from the "As-Is" architecture.

The Customs EA is a strategic information asset base. It defines the mission, the information necessary to perform the mission, the technology needed to conduct the operations, and the transitional processes for inserting and implementing new technologies in response to changing needs. There are four basic elements to build the Customs architecture management capability: strategy, processes, approaches, and an information asset.

The *architecture strategy* identifies why the organization needs an architecture, what the current control issues are, and what information technology management principles apply. The *processes* determine how the architecture will be managed, how the staff will use the architecture, and what information or added value the architecture provides. The *approaches* outline how the architecture will be developed, how data will be collected to build the architecture, how models will be constructed and organized, and the depth and breadth of the architecture. The *information asset* delineates how the information will be presented in a usable format, how the framework is populated, and how to ensure the architecture has achieved its stated purpose and goals [Blueprint, 1999].

The Customs EA framework depicted in Figure 6 provides a structure for organizing resources and for defining and managing EA activities. The TEAF-compliant views within the current Customs framework are functional, information, organizational, and infrastructure. Typical architecture views captured in the framework include data, applications, technical and security. The key linkages established within the framework run from the business processes to application systems and from application systems to the technology infrastructure [TEAF, 2000].

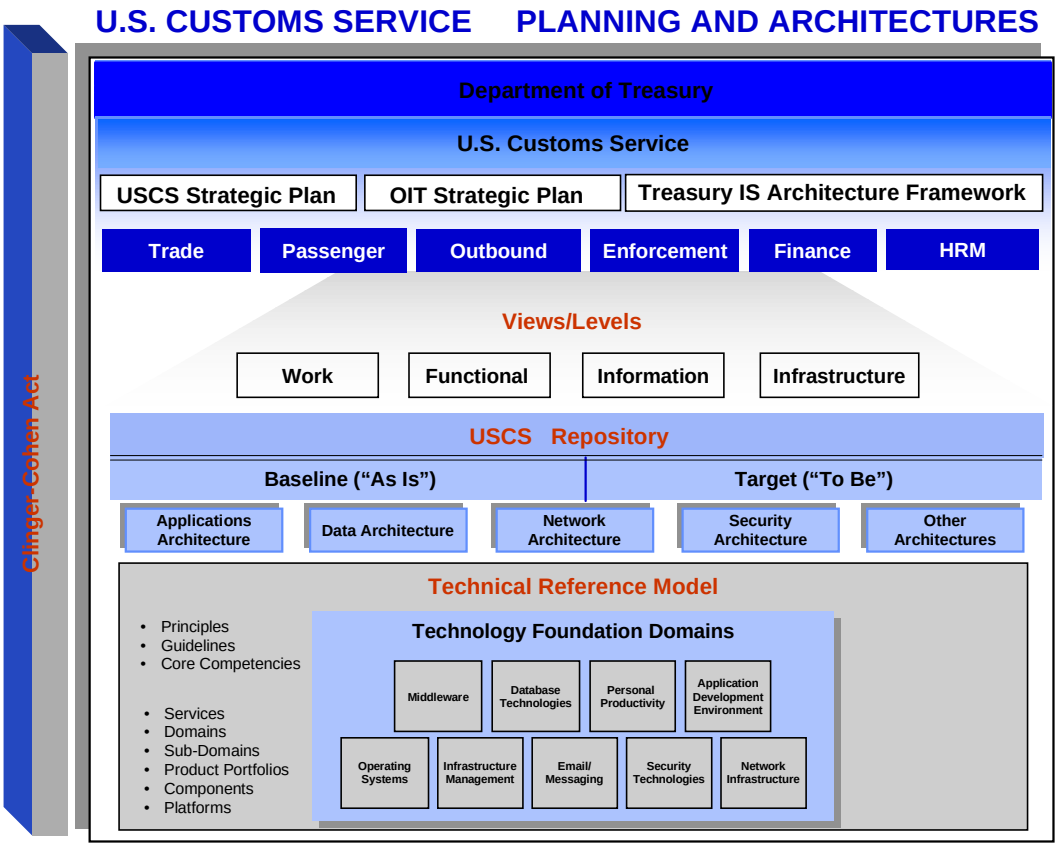


Figure 6. Customs Enterprise Architecture Framework

The Customs EA strategy exists as the collection of objectives, purposes/goals, major policies, principles, and guidelines that are used to direct the development of the strategic information asset. Customs has grounded its strategic planning and architecture development in Federal legislation and Treasury Department precepts. The Customs EA enables the agency to make sound technology investment decisions and to measure its ROI.

The Customs EA accomplishes this by aligning the business requirements of the six mission areas (Trade, Passenger, Outbound, Enforcement, Finance, and Human Resources) to a foundation of technology domains through architectural views and a technical reference model. The model supports information technology growth by illustrating the systems migration and integration needs from the existing baseline, or "As-Is" architectural view, to the target or "To-Be" view. To succeed in this endeavor, the overall EA must be a compilation of architectural views for all the systems that support the Customs missions and business practices. The next section illustrates one such architectural view for Customs ACS.

4.2 *The ACS Functional Architecture*

The ACS Functional Architecture incorporates the best practices and features of both the C4ISR Architecture Framework and the TISAF, which are now available in the TEAF. Working within the scope of the TISAF, Customs architects are using some of the essential products of the C4ISR Operational Architecture to portray the ACS Functional Architecture. These products

(shown in Figure 3) are the High-level Operational Concept graphic (OV-1), the Node Connectivity diagrams (OV-2), the Information Exchange Matrix (OV-3), and the Activity Tree or Model (OV-5). Using these products in the development of an "As-Is" Architecture creates a solid foundation for the eventual generation of a "To-Be" Architecture. Customs intends the ACS "As-Is" Functional Architecture to establish the foundation for substantial, long-term efforts over the course of the enterprise-wide Modernization Program.

The ACS Functional Architecture is grounded in Customs business processes and activities. These are captured in the ACS Operational Concept Graphic and the Activity Tree, Figures 7 and 8, respectively.

The ACS Operational Concept Graphic is the most general of the architectural products and the most flexible in format. Its main purpose is to facilitate discussions and is an important presentation graphic for high-level decision makers.

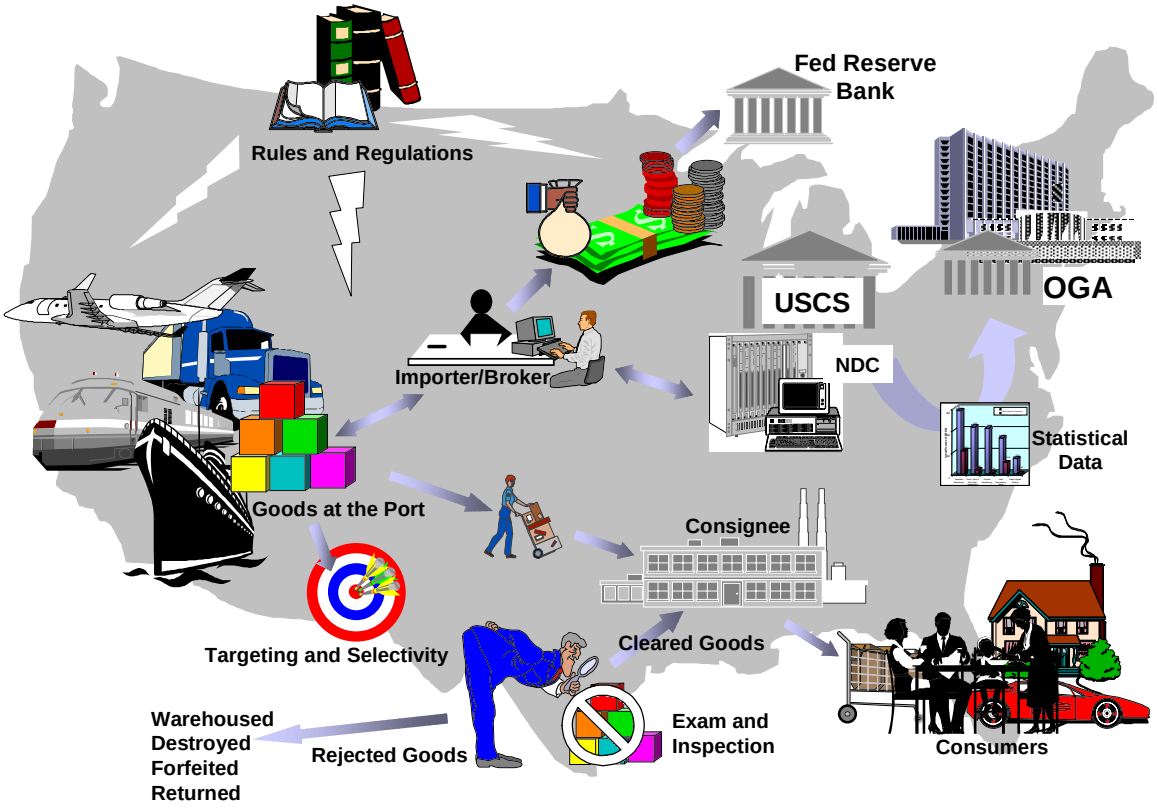


Figure 7. ACS Operational Concept Graphic

The ACS Activity Tree describes the applicable business functions or tasks and the hierarchical relationship among the business entities. Together these products make a valuable contribution to the definition, understanding, and scope of the enterprise under investigation or development. They are the starting points for the subsequent generation of operational sequence and node connectivity diagrams and the associated information exchange database.

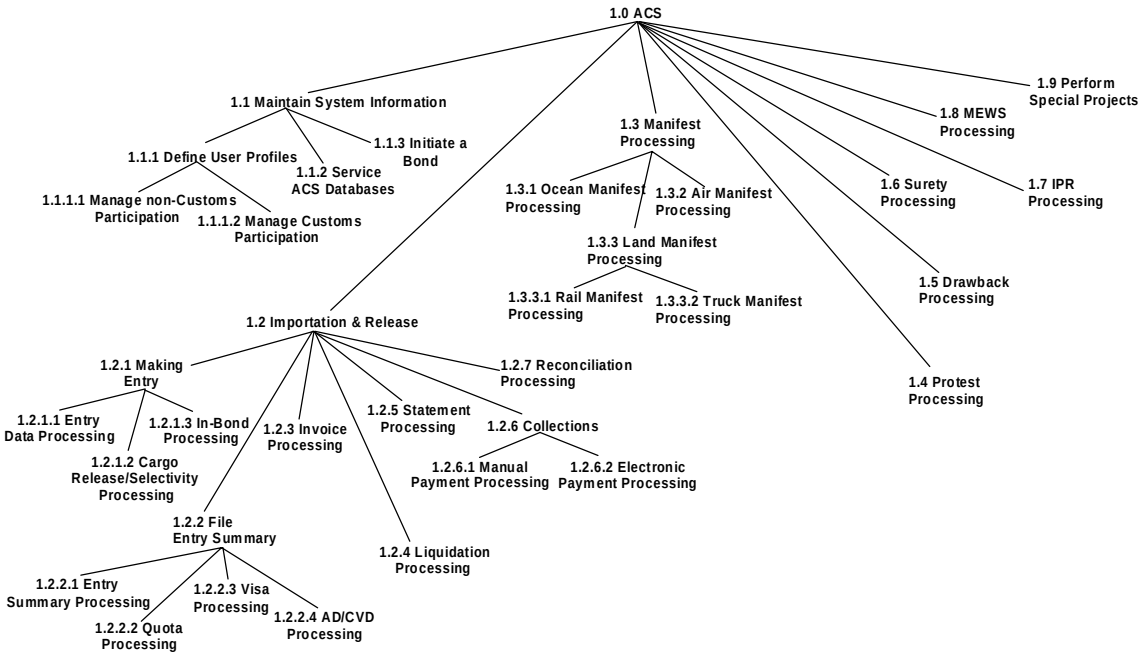


Figure 8. ACS Activity Tree

From the Activity Tree, it is possible to determine each of the base functions or activities that the organization must perform to accomplish the agency's mission. Operational Sequence Diagrams (OSDs) represent the next step of detail in the development of a functional architecture. OSDs illustrate the passage of time in the vertical axis and the flow of information between nodes along the horizontal axis. Using the OSD format, the architecture team captured the time-ordered sequence of processes and communications for each of these activities—the exchange of information—among and between operational nodes. Figure 9 presents a representative OSD (Monitoring of Import Quota on particular commodities into the U.S. from specific countries) from this effort.

The architect can construct a set of node connectivity diagrams from the sum collection of all OSDs. These diagrams illustrate those stakeholders or players in the business process who communicate with one another (i.e., "who talks to whom"). The node connectivity diagram may be drawn for individual activities, classes of information users, specific mission areas, and/or an overall enterprise-wide perspective. The node connectivity diagrams show the minimum mission-essential information flow required to accomplish the organization's roles and responsibilities within the enterprise.

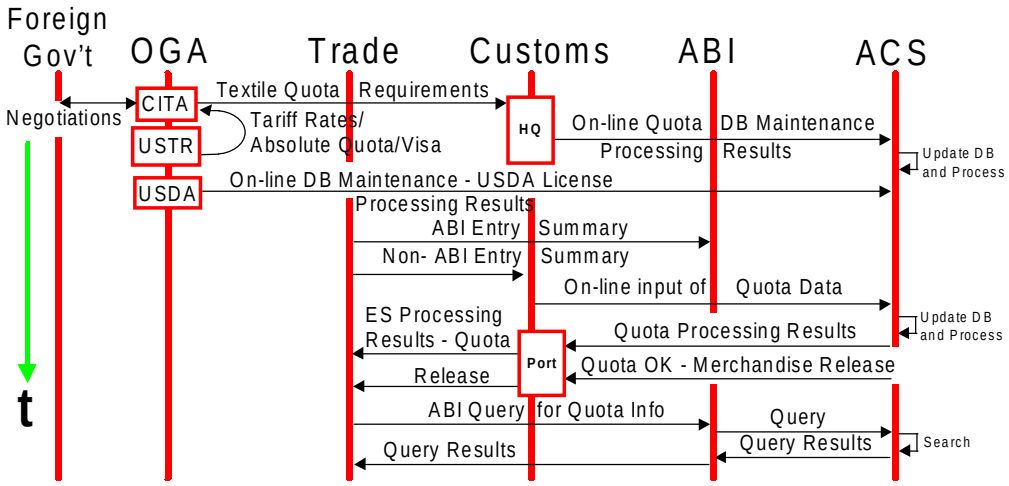


Figure 9. Representative ACS Functional Architecture Operational Sequence Diagram

Figure 10 shows the node connectivity diagram developed for the interfaces and information exchanges between the Customs ACS and other government agencies (OGA). These interactions are essential to the flow of goods and commodities across U.S. borders. In the diagram, the Customs Inspector or Import Specialist represents a number of other Federal agencies at border crossings. Customs collects statistical data on all imports and exports and disseminates this information to the appropriate Federal organizations. This node connectivity diagram, like all of the connectivity charts, was generated from the appropriate OSDs, coupled with information gathered during extensive interviews with stakeholders and players.

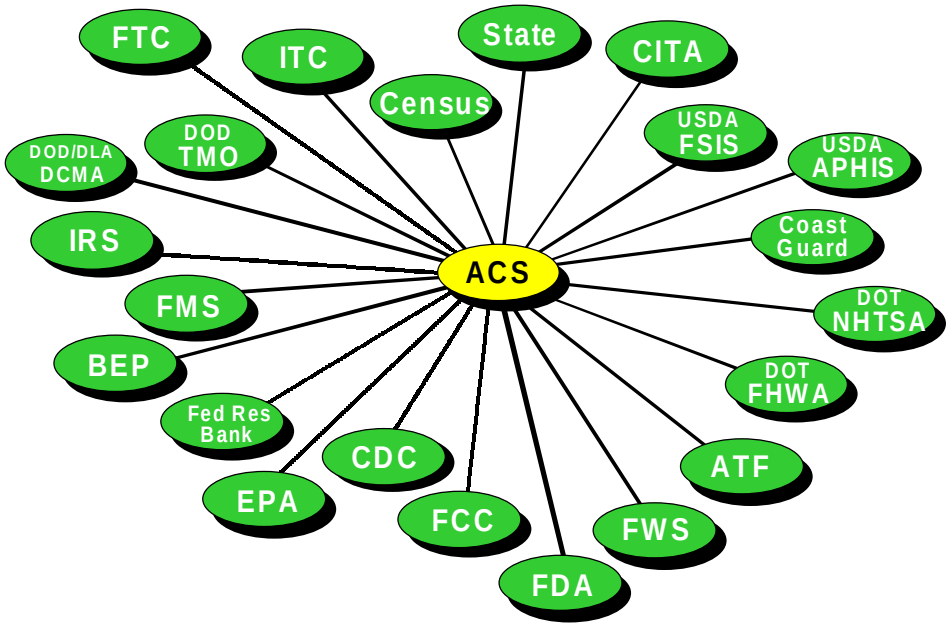


Figure 10. ACS-to-OGA Connectivity Diagram

The last, and probably most important, product of the functional architecture is the Information Exchange Matrix. It is this matrix—or database—that contains the essence of the functional architecture. The Information Exchange Matrix captures the attributes or characteristics associated with each interface—the more detail required, the more attributes collected and stored. The matrix is maintained throughout the entire functional architecture effort, and is populated and updated when data is collected and synthesized. For the ACS Functional Architecture, the Information Exchange Matrix holds the following data for each node connection:

- Interface number
- Source of the information
- Destination of the information
- Business activity supported
- Actual information content
- Communications media
- Level of Information Systems Interoperability (LISI)
- Source automated information system, if applicable
- Destination automated information system, if applicable
- Event trigger
- Frequency of transmission
- Interoperability issues.

The ACS Functional Architecture is but one example of the potential and successful adaptation of C4ISR Architecture Framework and its architectural products to a Federal civilian agency. We have discovered that, while DOD activities may be very different from those of other organizations, the methodology applied is compatible with and appropriate for use by other Federal civilian agencies or commercial organizations.

5.0 International, Coalition Implications

A major feature of current U.S. and Allied planning is the development of an architecture for an integrated, coalition response to international situations. Orchestrating a concerted and balanced response in the battlespace (air, land, and sea) is still a central, essential issue. It becomes even more important with the growing diversity of Allied capabilities, because no two participating nations share totally similar, integrated, or compatible technology, equipment, services, or even languages.

The effectiveness and ability of the entire coalition force is only as good as its weakest link or its least technically capable component. There is a digital divide between certain Allies: the “have-nots” are excluded from applying the advantages and benefits derived from new, innovative technologies. One viable solution to the problem of technology harmonization and operational integration is to plan for and employ multinational-oriented Concepts of Operations derived from operational and systems architectures.

The civilian agency use of DOD C4ISR Architecture Framework precepts shows that application of architecture-based systems ensures an enterprise-wide engineered environment of integrated

parts. Through architecture-based planning, it is possible to achieve node connectivity and interoperability of communications, even across national boundaries. This is contingent upon the willingness of all players to compromise and integrate national interests for the betterment of the whole. All parties need to play a role in the architecture development and the subsequent tailoring of plans, and then equip for deployment appropriately.

6.0 Conclusions

Architectures have been defined as structures of components, the relationships among components, and the principles and guidelines that govern their design and evolution over time. Architectures offer a reliable mechanism for understanding and managing complexity, bringing order to diverse organizations, and portraying the enterprise in a structured model. As engineering tools, architectures also provide functional traceability, business process reengineering, user requirements definition, systems migration analysis, information technology investment management, and enterprise-wide strategic planning.

Across the Federal landscape, enterprise architecture frameworks ensure uniformity and standardization in migrating and integrating information systems. The potential for a global constancy—the ability to compare architectures—is accomplished only when the frameworks are applied consistently across the multitude of departments, bureaus, and agencies that make up the Federal Government. Consequently, compliance with the Federal Enterprise Architecture Framework is a paramount requirement.

As advocates of a Federal Enterprise Architecture Framework, the Federal CIO Council, the DOD, and Treasury have complemented their architectural endeavors. These organizations have developed and tailored their EA frameworks to ensure parallel precepts, principles, and methodologies. Although first captured on the Federal level in the DOD C4ISR Architecture Framework, many of the fundamentals of enterprise architecting are now found in the FEAF and TEAF.

The DOD C4ISR Architecture Framework illustrates a detailed set of products (or artifacts) that constitutes an EA. While originally designed for a defense environment, these products can be employed at Federal civilian agencies, within corporate America, and throughout our international alliances. These architectural products are useful in characterizing an organization’s operations, regardless of mission or line of business.

The use of similar architectural products across organizational boundaries, at agencies with disparate cultures and missions, demonstrates the applicability and flexibility of this approach. This case study and the Federal pilot effort are the first of many future architectures that will establish roadmaps to high levels of interoperability through innovative technology insertion and successful systems migration. Understanding both internal and external organization information flows and usage will be critical success factors in enterprise architecture development and business process reengineering. These efforts suggest the potential for a valid architecture success story.

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Acronyms

ABI	Automated Broker Interface
ACS	Automated Commercial System
AD/CVD	Anti Dumping/Countervailing Duties
APHIS	Animal and Plant Health Inspection Service
ATF	(Bureau of) Alcohol, Tobacco, and Firearms
AV	All Views
BEP	Bureau of Engraving and Printing
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CDC	Centers for Disease Control and Prevention
CIO	Chief Information Officer
CITA	Committee for the Implementation of Textile Agreements
CMC	Customs Management Center
DB	Database
DCMA	Defense Contracts Management Agency
DLA	Defense Logistics Agency
DOD	Department of Defense
DOT	Department of Transportation
EA	Enterprise Architecture
EPA	Environmental Protection Agency
ES	Entry Summary
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FEAF	Federal Enterprise Architecture Framework
FHWA	Federal Highway Administration
FMS	Financial Management Service
FSIS	Food Safety and Inspection Service
FTC	Federal Trade Commission
FWS	Fish and Wildlife Service
HQ	Headquarters
IER	Information Exchange Requirement
IPR	Intellectual Property Rights
IRS	Internal Revenue Service
ITC	International Trade Commission
MEWS	Mail Entry Writing System
NDC	Newington Data Center
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
OGA	Other Government Agencies
OSD	Operational Sequence Diagram
OV	Operational View
ROI	Return on Investment
SV	Systems View
TEAF	Treasury Enterprise Architecture Framework

TISAF	Treasury Information System Architecture Framework
TMO	Traffic Management Office
TV	Technical View
U.S.	United States
USCS	United States Customs Service
USDA	U.S. Department of Agriculture
USTR	U.S. Trade Representative