Enterprise Architecture For Federal Agencies

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1 Introduction

Enterprise Architecture is intended to provide a "big picture" of how business operations and IT solutions work together within a framework to support the organization. The goal is to generate value as reduced cost (increased efficiency) and improved performance (increased effectiveness) by way of improved managerial decision-making. Enterprise Architecture (EA) achieves this by facilitating coordination of the operational activities (i.e., Business Functions) an organization undertakes, the data exchanged and transformed by those activities, the systems used to automate those activities and mange the data, and underlying technologies, which support the systems. By aligning business functionality with relevant IT resources, EA helps an organization's business side better understand IT capabilities, while guiding the IT side to build systems that best support business operations. The expected result is more optimal IT investment.

An Enterprise Architecture (EA) is generally a living document or collection of documents or "artifacts". The artifacts help address such technical issues such as scalability, security, application modularization, performance, data handling, interface design, and so forth. These may include

- Frameworks,
- Functional Decompositions
- Performance Reference Model (PRM) and/or a framework within which progress against specific Goals and Objectives may be measured consistently.
- Guidance documents and best practices.

EA may represent the current "as-is" state as well as the evolution into a "to-be" future state in support of an organization's mission along with the transitional approach for implementing new technologies in response to changing mission needs. As such it should be accompanied and guided by an Enterprise Architecture Vision.

A useful and usable enterprise architecture must be situational and context-sensitive. Often, artifacts comprised in the enterprise architecture are developed without a tie to the mission of the enterprise. More importantly, *these artifacts fail to account for the character of the enterprise* – one that is determined by the culture of the organization, the organizational, the magnitude of the operation. Despite its transformational value, enterprise architecture cannot be the unique transformational element in an organization. It is an enabler that needs to be integral to organizational redesign, process engineering, and change management.

A Federal Agency's EA should be aligned with its' Department level EA and to the Office of Management and Budget's Federal Enterprise Architecture (OMB FEA). These mappings serve to align IT investments with a Department's EA and to document compliance with the OBM FEA as required for OMB budget submissions.

1.1 Major Components of an Enterprise Architecture

An EA Framework generally coordinates five major architectural aspects of a given organization as shown in Exhibit 1 below. The Business, Data, Application and Technical layers are described in greater detail in the later pages of this white paper.

Layer	Description
Business	Operational activity (Business Functions) undertaken to support organizational mandate and strategic goals
Data	Generated, transformed, exchanged, and stored via conduct of these Business Functions
Application	Systems used to automate these Business Functions
Technology	Serves as an underlying platform for these Systems
Security	Complies with federal mandates for protecting the agency's information assets

Exhibit 1: Enterprise Architecture Layers

2 Enterprise Architecture Vision

An Enterprise Architecture can have a transformational impact on an organization. But this requires the focus of the architecture to be on the 'enterprise' and not the information technology. The primary intent of an Enterprise Architecture Vision is to set a direction for enterprise architecture that is tied to the mission of an agency, its business constraints, and its nature. The Vision will serve to inform management of issues driving IT modernization and provides a roadmap for migration to better coordinated and unified services.

An EA Vision serves to establish the foundation for the IT architecture of an organization. This is referred to as the 'foundation for execution' and it represents the *realistic level of process 'digitization'* that an organization can accomplish given the nature and constraints of its environment.

The Enterprise Architecture vision (EA Vision) communicates an agency's strategic and transformational goals into institutional capabilities to be reflected in the formulation of all facets of the enterprise architecture (business, data, applications, technology). An EA Vision should ultimately support the goals and objectives established under an agency's mission as identified in its strategic plan. An EA Vision should enable an agency to evolve from predominantly tactical business activities (highly transactional activities with low value added due to the decomposition of the information across systems and data types) to strategic knowledge-driven decision-making capabilities. The goal is to move an agency to a level where routine activities are performed in 'automatic' mode reliably and with predictability. Once this is achieved, the organization can focus its attention on continued evolution towards further knowledge-acquisition and management.

The methodology for developing an Enterprise Architecture Vision includes a process that starts with establishing vision elements, then develops themes, uses the themes to develop operating models and finally results in the development of "Core Diagrams" which visualize the alignment of each line of business to data, services and technology.

2.1 Establish Vision Elements

Vision elements represent the institutional capability that is sought, and serve as the *blueprint of the EA Vision* – that is, *capabilities that can be accomplished* by implementing an enterprise architecture which is aligned with benefits, drivers, and guiding principles.

Vision Elements may also be thought of as an organization's "Aspirations". The aspirations may be business drivers, which come from

- Strategic Plan major initiatives,
- User Needs and ambitions as identified in discussions with a cross-section of stakeholders.

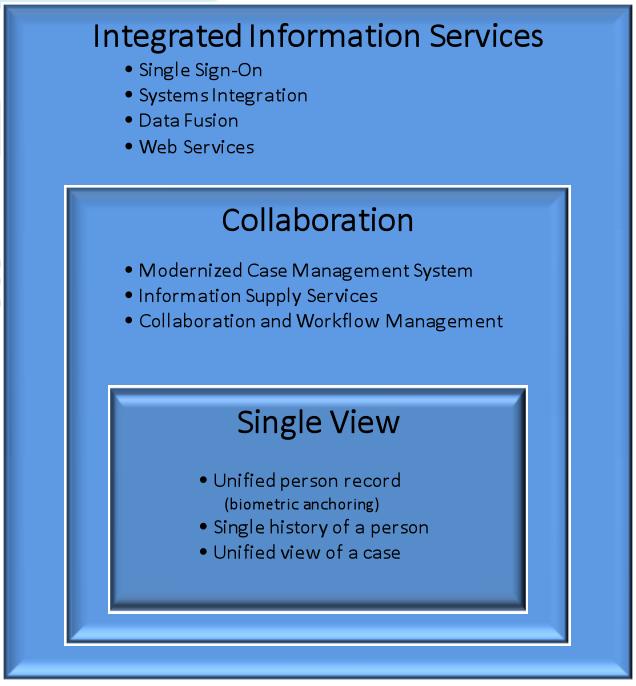
Aspirations are of a transformational nature and warrant concerted efforts in organizational redesign, process engineering, and change management. Information management and technology are key enablers provided they are properly aligned to the strategic ambitions of an agency.

Guiding principles should also be established – these capture the 'soul' of the organization (also known as the rules of the game). These principles transcend the organizational structure of an agency to illustrate the fundamental way of running business.

2.2 Establish Themes

A review of an Agency's Strategic Plan, major initiatives and users needs and ambitions as discovered through interviews with stakeholder should allow one to identify themes. For example, the following three themes may emerge as core to the 'foundation for execution':

- **Single View.** A common semantic language that enables the unification of persons' data (biographics, biometrics), their lifetime history, and the cases pertaining to them (and other type of entities involved in these cases). A 'single view' is equally sought by an Agency's mission support functions (administrative functions) to enhance governance through a single view of business assets (e.g., human capital, process assets, and linkages between strategic and tactical plans).
- **Collaboration**. Collaboration capitalizes on the 'Single View' theme to help facilitate the contextual exchange of information between stakeholders – within and outside of an agency. Information supply services and collaboration/workflow management services help automate the multilateral and multi-agency interactions while adhering to the unified views people, leads, cases, etc.



- **Integrated Information Services.** A standardized infrastructure creates a seamless environment with ubiquitous sharing of information via a series of services, including single sign-on to disparate systems, the integration of these systems, the ability to fuse throughout a common data model between these systems, and the availability of web services to support business activities.

The EA Vision integrates these themes into a single blueprint that unites the 'vision elements' that help accomplish the aspirations of an agency, in this case enhancing intelligence capacity.

2.3 Create Core Diagrams

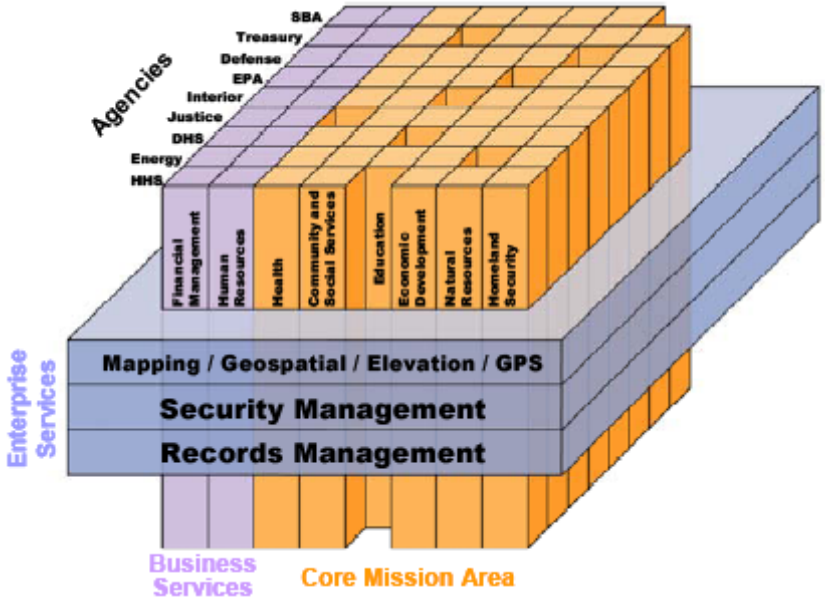
As discussed above, the core elements of an enterprise architecture (business processes, data, technology) must be derived from the nature of the organization (its character). This is represented in a '*core diagram'* – a high level view of the business processes that can be digitized, data shared by these processes, and the technologies to optimize them. A *core diagram* distills a business into its fundamentals to help IT architects develop plans, programs, and applications that respond to the true ambitions, needs and constraints of the entire enterprise.

3 EA Methodology: Segment Architecture

To organize the complex Enterprise Architecture effort into manageable pieces, Segment Architecture (SA) may be used to facilitate the EA analysis. The Segment Architecture becomes the "Blueprint" to guide the investment and implementation of information technology from the current environment to a future envisioned modern IT environment. The Blueprint may evolve over time to incorporate changing internal and external factors and increasing detail as the Segment Architecture matures.

The benefit of this segment type is that it permits identification and implementation of common services among highly related business lines and it supports local, or Administration-determined, project implementation techniques. This type of segment architecture is aligned with the FEA, as is its supported business lines (ref. Exhibit 4).

Exhibit 4. Example of Segment Architecture Alignment with FEA[1]



Investments at the application level, are mapped first to a Segment Architecture and then to a Core Mission Area and Business Function in accordance with FEA guidance.

[1] "Value to the Mission," FEA Practice Guidance, OMB, November 2007

4 Business Architecture Layer

An Enterprise Business Architecture (EBA) defines the core business functions, their relationships to all external entities and their core business functions, and the events that trigger instantiation (objects and events are defined in the Data Architecture of the EA). It is typically a definition of what the enterprise must produce to satisfy its customers, sustain operations, and care for its employees. Optimally, it is composed of architectures, workflows and events.

An Enterprise Business Architecture defines the formal link between the enterprise business strategy and the results predicted from supporting strategic initiatives. It is a single source and comprehensive repository of knowledge from which initiatives will evolve and link. The evolution occurs from a fully integrated enterprise model of the business to all IT, organizational, and security architectures. The EBA also provides integration capabilities for software development, packaged software configuration, and process improvement initiatives.

Moreover, as a link to the enterprise business strategy, the EBA is a manifestation of the EA Vision (which derives also from the business strategy). The EBA articulates the themes of the Vision into tangible business functions in accordance to the target operating model of the Vision.

Business functionality is supported by a host of IT applications, some of which evolved organically over time from legacy systems, and others which are integrated into an enterprise wide architecture and are based on commonly established enterprise standards. This broad diversity of systems must be closely monitored to ensure proper allocation of financial and human resources in accordance to the business value proffered by each application, and the value to support the strategic goals of the organization.

Business Architecture may be extended into the Applications layer including:

- Systems (including Applications, internal, and external IT Programs, networks, servers, databases, and data stores) identified and incorporated into the EA along with descriptions (where available), and mapped to relevant Organizations, as well as Business Functions.
- Proposed IT Services identified, incorporated into the EA along with descriptions and individually assigned to relevant Systems, Organizations and Business Functions.

5 Data Architecture Layer

The purpose of the Data Architecture is to provide an integrated global view of the enterprise data and information flows. The Data Architecture accomplishes this through the implementation of pictorial and textual blueprints of existing agency mission-critical application systems collectively known as the Enterprise Data Model (EDM). The Data Architecture is structured to provide alignment with a Department Data Reference Model (DRM). Within the Data Architecture are strategies and artifacts for data modeling, metadata management, and data sharing.

An important goal of the Data Architecture is to promote data standardization and data re-use throughout the organization's enterprise. More critically for the proper performance of the agency, the Data Architecture provides a means for sharing data with other federal, state, and local government agencies.

This section describes the various data models and their data standards that make up the Data Architecture Modeling component of the Enterprise Architecture. The data models included in the Data Architecture are; the Conceptual Data Model, the Logical Data Model (also known as the Enterprise Data Model), and the Physical Data Models.

The Data Architecture specifies the data required to support an agency's business processes; as such, it represents the 'objects of information' that a business cares about. It is comprised of several data models and assigns accountability for data integrity.

Data Models are products of the Data Architecture and are the logical representation of real-world objects and events with inherent properties that are independent of hardware, software or machine performance considerations. It includes subject areas, entities and their attributes. The data models show data attributes grouped into fully normalized[2] entities and the relationships among these entities.

The Data Architecture enforces the standardization of data naming conventions, data definitions, data representation structures, data types, and data sizes. The enforcement of these data standards within the Data Architecture helps ensure consistent data usage throughout the enterprise.

The Data Architecture also contains standards for data model diagramming and normalization. Three types of data models make up the Data Architecture: the Conceptual Data Model, the Logical Data Model, and the Physical Data Model. Each of these data models shows progressively higher levels of detail and targets a different audience, as illustrated in Exhibit 5.

Exhibit 5: Data Architecture Models

Data Model Type	Level of Detail	Contents	Target Audience
Conceptual Data Model	Limited level of detail	High level data objects representing major business functions connected by simple relationship lines.	Business stakeholders (staff, vendors, customers, etc), Business Managers, Data Stewards
Logical Data Model	Medium level of detail	Data objects with data attributes, key constraints, relationships with cardinality. Normalized – 3rd Normal Form.	Technical Architects, System Developers, Database Administrators, Data Stewards
Physical Data Model	High level of detail	Installable database objects with indices, key constraints, and integrity constraints. Generally 3rd Normal Form but some demoralization for performance benefits.	Database Administrators, System Developers, Data Stewards

[2] Normalization is the process of ensuring that the correct number of entities has been defined and that each attribute has been assigned to the proper entity.

6 Data Architecture - Metadata Management

The primary objective of Metadata Management is to provide a central facility for storage of all agency mission-critical systems metadata for their management and control. The benefits of the Metadata Management facility (Metadata Repository) is that it provides a single reference storage point to all logical and physical metadata. The Metadata Repository enables metadata discovery across the agency, enables impact analysis across the agency and facilitates SOA development efforts. The Metadata Repository also contains the mapping information between the Physical Data Model metadata and EDM.

Metadata management is a key component of the Data Architecture. Metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource. Metadata is key to ensuring that resources (data) will survive and continue to be accessible into the future. It is managed and stored in the Metadata Repository. Three types of metadata "data about data" should be created:

- *Content Description Metadata* describes a resource for purposes such as discovery and identification. It can include elements such as title, abstract, author and keywords.
- *Structural Metadata* indicates how compound objects are put together, for example, how pages are ordered to form chapters.
- *Administrative or Context Metadata* provides information to help manage data such as when and how it was created, file type and other technical information, and who can access it.

Sets of metadata elements or metadata schemas designed for a specific purpose such as describing a particular type of information resource should be created. Schemas specify names of elements and their semantics. The values given to metadata elements are the content. The schema should also specify content rules and content syntax.

7 Data Sharing Architecture

Data sharing is the practice of provisioning data from an information source to an information consumer in response to a business requirement. Data Exchange Architecture is a standard and repeatable pattern for sharing data.

Department-wide core and universal core data elements that need to be shared are being identified and standardized through COIs and other initiatives. The complete information chain for these data elements should be analyzed and all stakeholder, customer, and provider requirements defined. These core data elements will provide the initial components for the enterprise data model and subsequent repository. The key objectives of a data sharing architecture include:

- Message Definitions: Message exchanges between agencies shall be made as efficient and as uniform as possible. They should provide semantic definitions of the content in the exchanges to facilitate a common understanding of the purpose and intended use.
- Business Rules: Business rules shall be abstracted out of applications and reused to the greatest extent possible. Business rules are defined in a reusable manner that is not dependent on specific software technology. Such rules control the content model for the information and its use. Interoperability is facilitated through a common understanding of the business rules, their context and constraints.
- Data Transformation: Data shall be kept in its original form to the greatest degree possible, and transformed dynamically during data exchanges. Transformation services should seek to provide re-usable templates for when data transformations are required. Such templates should leverage

the business rule definitions to automate as much of the transformation logic as possible. Semantic information can also provide assistance in aligning like components during transformation and confirming those mappings are correct. Context mechanisms are also required to direct when and how transformations are needed.

The integration of underlying data models, is an essential precursor to any Service Oriented Architecture (SOA) implementation. The integration of data models focuses on the business requirements and abstracting system-and application- specific requirements where possible (Exhibit 6).

The integrated data model is the source of all data definitions and interface definitions required by the services; the process reveals duplication and redundancy to be resolved.

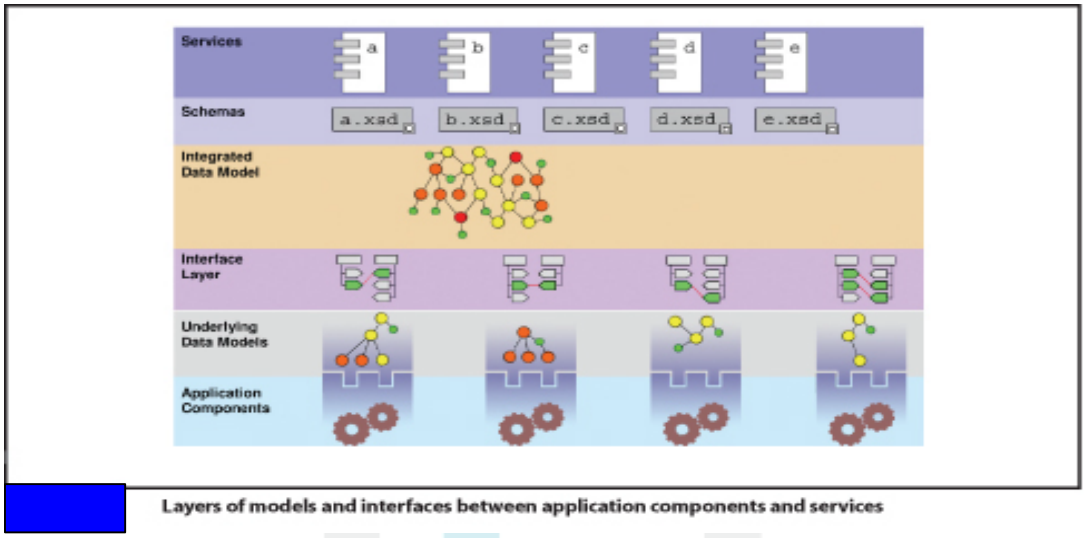


Exhibit 6 Data Model and SOA

The Data Architecture uses the EDM data taxonomy as the vehicle for implementing SOA within an agency. The Data Architecture contains the Physical Data Model and the EDM along with the mapping information between them. The mapping is performed at the attribute level. Each entity/attribute in the EDM may be mapped to one or more Physical Data Model table/columns. The EDM entity and attributes provide the data mapping by which SOA messages can be implemented. Since the data mapping in the EDM represents a common view of the data throughout the enterprise it is a primary candidate for the role of data dictionary in the strategy for implementing SOA for intra-agency messaging. SOA messages between one agency and other Government Agencies may use the National Information Exchange Model (NIEM)[3] if appropriate to the agency's mission.

[3] See http://www.niem.gov/

8 Application Architecture Layer

The Application Architecture provides a comprehensive blue print of an agency's applications to support end-to-end business processes. The Application Architecture supports the business architecture, uses data architecture to store and exchange information among systems, and is implemented according to the EA technical architecture (including platforms, technologies, and archtetypes).

Information provided by the Application Architecture includes the name of the application (system), its business purpose (and its linkage to the business architecture), the business owner (organizational), and its implementation technical architecture.

An Application Architecture is more than a list of applications (applications inventory). Its core value is to create a link between business functions, applications and their system architecture - including application technologies and design patterns.

9 Technical Architecture Layer

The technical architecture involves a range of different technologies running on different platforms, each relying on a range of heterogeneous legacy systems. Ensuring the security of these technologies while allowing business processes sufficient access to information.

The technical architecture describes the structure and behavior of the technology infrastructure of an enterprise, solution or system. It covers a range of different technologies, which may be running on different platforms each relying on a range of heterogeneous legacy systems. Alternatively it may prescribe operating systems and platforms for a future state. It covers the client and server nodes of the hardware configuration, the infrastructure applications that run on them, the infrastructure services they offer to applications, the protocols and networks that connect applications and nodes. It also addresses issues such as performance and resilience, storage and backup.

The Technical Architecture provides a number of different reference guides, which, when cross referenced with application requirements, serve to provide a target architecture utilizing standards and application infrastructure in place to support these requirements.

By leveraging existing resources and standards in this manner, a true and practical realization of an agency's EA can be recognized. Included in these reference guides are the Runtime Patterns, the Standards Profile, the Archetypes, and the Services Architecture. Each of these reference guides are described below at a high level. A technical architecture should be guided by the following constructs:

- The Runtime Patterns provides specific mappings of standards to existing and supported application hosting infrastructure, which is available for applications and programs to utilize. Utilization of pre-defined application runtime patterns provides for a well supported architecture and infrastructure.
- The Standards profile is the list of products and standards, which an agency currently supports. The Standards Profile is typically, but not always, a subset of the Department's Technical Reference Model (TRM).

10 Security Architecture

Security Architecture is a unifying framework and set of reusable services that implement policy, standards and risk management decisions. Together these focus on the confidentiality and integrity needs of an enterprise while addressing availability of services.

Risk management is comprised of an assessment of assets, threats, vulnerabilities and countermeasures. The risk management approach should allow the security architecture to be agile in responding to business needs ensuring that the enterprise's risk exposure is in line with risk tolerance goals.

Security policy & standards should describe both what is and is not allowed in the system. They should be a prescriptive guidance for people building and operating systems, and should be backed by reusable services wherever practical. Security policies and standards should be supported by a governance model that ensures they are in use and that it is practically possible to build, deploy, and operate systems based on their intent.

The Enterprise will ultimately use security services such as authentication and authorization, detection services, such as monitoring and auditing, and response services, such as incident response and forensics. These will be deployed across networks, hosts, applications and ultimately protect data. The architecture describes a way to identify security needs and map the appropriate security services to the needs.

11 EA's Relationship to Investment

A central tenet of the federal approach to IT investment management has been the select/control/evaluate model. This model was initially identified in the GAO Strategic Information Management (SIM) Executive Guide4, was expanded upon expanded in the Office of Management and Budget's IT investment guidance5, and then was refined in subsequent guidance published by the GAO6. It provides a systematic method for agencies to minimize risks while maximizing the returns of investments.

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[4] U.S. General Accounting Office, *Executive Guide: Improving Mission Performance through Strategic Information Management and Technology,* GAO/AIMD-94-115, (Washington, D.C.: May 1994).

[5] *Evaluating Information Technology Investments, A Practical Guide*, Executive Office of the President, Office of Management and Budget, November 1995.

[6] U.S. General Accounting Office, *Assessing Risks and Returns: A Guide for Evaluating Federal Agencies' IT Investment Decision-making,* GAO/AIMD-10.1.13 (Washington, D.C.: February 1997).

During the select phase the organization (1) identifies and analyzes each project's risks and returns before committing significant funds to any project and (2) selects those IT projects that will best support its mission needs. This process should be repeated each time funds are allocated to projects, reselecting even ongoing investments as described below. During the control phase the organization ensures that, as projects develop and investment expenditures continue, the project continues to meet mission needs at the expected levels of cost and risk. If the project is not meeting expectations or if problems have arisen, steps are quickly taken to address the deficiencies. If mission needs have changed, the organization is able to adjust its objectives for the project and appropriately modify expected project outcomes. During the evaluate phase, actual versus expected results are compared after a project has been fully implemented. This is done to (1) assess the project's impact on mission performance, (2) identify any changes or modifications to the project that may be needed, and (3) revise the investment management process based on lessons learned. However, the investment process does not end with the evaluation phase.

A project can be active concurrently in more than one phase of the select/control/evaluate model. After a project has been designated for initial funding in the select phase, it becomes the subject of evaluation throughout the control phase for the purposes of reselection. Re-selection is an ongoing process that continues for as long as a project is receiving funding. If a project is not meeting the goals and objectives that were originally established when it was selected, or if the goals have been modified to reflect changes in mission objectives—and corrective actions are not succeeding—a decision must be made on whether to continue to fund the project. Ultimately, "de-selection" can be one of the most difficult steps to implement, but it is necessary if funds can be better utilized elsewhere. Once projects are operating and being maintained, they remain under constant review for re-selection.

In accordance with the guidance of the GAO Strategic Information Management (SIM) Executive Guide, an agency should follow a comprehensive Investment Management process to manage programs that address IT requirements. This process includes all activities, beginning with the pre-select phase, where financial resources are requested, through the sustainment phase, where ongoing operation and maintenance activities are performed.

Investments may be differentiated into several categories:

- IT Portfolios which focus on the applications of the Segment Architecture defined above
- Major and Minor Investments
- Internal IT programs, projects, and support services
- Interfaces with and use of various IT aspects stewarded externally
- Other IT Elements (e.g. Servers, Networks, Databases, Data Stores, etc.)

11.1 IT Portfolio Management

Portfolio management (PfM) establishes EA target architectures for each portfolio identified as a high-value enterprise service. PfM aligns with guidance from OMB and the GAO IT Investment Maturity model for effective management of resources. It allows for managing risks, costs, schedule, and performance of critical IT assets at the Department level. The processes used and forums within which PfM applies include IT investments above certain threshold; Investment Review process; and Budget/CPIC processes. CIO review of IT investment budgets focuses on Component Exhibit 300s/53s. Department-wide investment review boards focus on individual reviews of major investments.

All IT investment initiatives must include a statement of need that clearly demonstrates the investment is needed to help meet the agency's strategic goals and mission. Further, investments should also support the President's Management Agenda (PMA). The President's Budget defines the guiding principles for the investments supporting the PMA. The Office of Management and Budget (OMB) portfolio review and

Budget process ensures IT investments support the strategy(ies) identified and ensures the Federal IT Investment Portfolio includes the most effective portfolio of investments to:

- Improve the management of programs to achieve better program outcomes;
- Ensure sound security of Federal information systems and appropriate protection of information held in those systems;
- Eliminate redundant or non productive IT investments through multi-agency collaboration;
- Support the Federal Enterprise Architecture (FEA);
- Support the Presidential initiatives and E-Gov strategy;
- Focus IT spending on high priority modernization initiatives;
- Manage major IT investments within 10% of cost, schedule, and performance objectives;
- Certify and accredit IT investments and systems; and
- Ensure privacy safeguards are implemented in electronic activities.[7]

OMB, Circular A-11 requires that federal capital requests must be captured and reported using standardized formats known as Exhibits 300 and 53. The capital asset plans and business cases (exhibit 300) and "Agency IT Investment Portfolio" (exhibit 53) demonstrate the agency management of IT investments and how these governance processes are used when planning and implementing IT investments within the agency. An individual agency's exhibit 53 is used to create an overall "Federal IT Investment Portfolio" published as part of the President's Budget. Each of these reports is submitted annually, and by completing an Exhibit 53, an agency meets the Clinger-Cohen Act of 1996 requirements to provide a full and accurate accounting of IT investments for the agency.

The overall goal of Exhibit 300 and 53 submissions is to ensure a strong business case for IT investments as well as proper alignment of these investments with the Department mission and objectives. The submission process can be lengthy and complex, requiring large amounts of data and strict adherence to OMB requirements that are frequently updated.

11.2 Internal Programs, Projects, and IT Support Services

The Investment category of “Internal Programs, Projects, and IT Support Services” accommodates IT aspects of this nature. Major programs should be decomposed into sub-programs. The purpose is to later associate Applications, Databases, etc. related to given Programs.

[7] OMB Circular No. A–11 (2008), Section 53

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