An IT Enterprise Architecture Process Model

Ira Grossman
Systems Acquisition Office, Systems Engineering Staff
James Sargent
National Marine Fisheries Service, Office of Management and Information

Department of Commerce, National Oceanic and Atmospheric Administration
1315 East West Highway Silver Spring, MD 20910 USA

Abstract: This paper describes the authors' experiences using a process to develop IT Enterprise Architectures. An IT Enterprise Architecture is a blueprint that explains how all the IT and Information Management elements work together as a whole. The IT Enterprise Architecture is characterized by four views: Work and Location, Information Sets, Applications, and Technology Infrastructure. The IT Enterprise Architecture Process is based on a seven step model.

1. What Is an IT Enterprise Architecture?

An Information Technology (IT) Enterprise Architecture is a blueprint that explains how all the IT and Information Management elements work together as a whole. It is the underlying framework that defines and describes the IT infrastructure required by an Agency to reach its objectives and goals, and to reach its prescribed working vision. The IT Enterprise Architecture takes into account an organization's IT issues, principles and guidelines to promote the continual flexibility and modularity needed to improve IT functionality over time.

The IT Enterprise Architecture is characterized along four key components or views: Work and Location, Information Sets, Applications, and Technology Infrastructure. (DoD, 1996)". Thus, an IT Enterprise Architecture describes:

- The way **Work** activities are organized and the **Locations** where the work is carried out
- The **Information Sets** needed to perform the work
- The **Applications** that capture and manipulate the information sets
- The **Technology Infrastructure** (hardware, networks and communications) needed to run the applications.

Other definitions of an IT Architecture include:

"The structure and relationship among the components of a system. The system architecture may also include the systems interface with its operational environment. (A system is defined as "A collection of people, machines, and methods organized to accomplish a set of a specified function." (IEEE, 1996).

"The fundamental and unifying system structure defined in terms of system elements, interfaces, processes, constraints, and behaviors." (INCOSE, 1998)

"An integrated framework for evolving and maintaining existing IT, and for acquiring new IT. The IT Architecture is a means to achieve Federal strategic and IT goals by integrating the work processes and information flows with technology. The architecture specifies standards that enable information exchange and resource sharing." (Federal CIO Council, 1998).

"An integrated framework for evolving or maintaining existing information technology and acquiring new information technology to achieve the agency's strategic goals and information resources management goals." (Public Law 104-106, Sec 5125(d), 1996).

The authors encourage a "principles-based" and "standards-based" approach to its IT Enterprise Architecture process. This approach incorporates a number of elements that may not appear in a traditional IT Architecture, as defined above. These components include:

- IT principles, which are statements of preferred Architecture direction or practice
- Definitions of generic components and work practices
- Set of open system standards that permit a migration strategy from proprietary

standards to open de jure and de facto standards.

A de jure standard is an official standard with legal status. It is usually produced by a national or international organization which has no specific (biased to any one company) commercial interests. A de facto standard is an informal standard, that is developed by a single vendor or a group of vendors and generally arise from innovative products that appeal to most people or producers who then decide to use the product. De facto standards do not go through an official standards-setting process. (Senn, 1995), (Shnier, 1996).

Open system standards are encouraged as the desired building blocks for the IT Architecture. The voluntary use of national and international open system standards is the preferred practice by the Federal government. When open system standards do not exist or prove not to be practicable, best practices are encouraged to be used.

Finally, the IT Enterprise Architecture must be derived from the organization's strategic plans and business requirements. It must enable the organization to rapidly adapt to ever quickening changes in technology and applications. In 1980, it took an IT staff three to five years to develop a new IT business process. Today, an IT staff is required to develop new IT business process in six to eighteen months because of accelerating technological advances, newer and faster communication and transmission methods, and changes in the economy and in the competition (DeBoever, 1997).

2. Why Is an IT Enterprise Architecture Important for Federal Agencies?

IT is essential for a Federal Agency to achieve its strategic goals. All Federal Agencies are mandated by the Clinger/Cohen Act to develop and maintain an IT Architecture. Specifically, the law requires "The Chief Information Officer (CIO) of an executive agency shall be responsible for...developing, maintaining, and facilitating the implementation of a sound and integrated information technology architecture." (Public Law 104-106, Sec 5125(b)(2) 1996)).

On October 25,1996, Director of the Office of Management and Budget (OMB), Franklin O. Raines issued a memorandum defining eight decision criteria that are to be used in the evaluation of major information system investments within the federal government. These eight criteria have become to be known as "Raines Rules". The fifth criterion establishes the critical link between planning and information architecture implementation. It states, that "Investments in major information systems should... be consistent with Federal, agency, and bureau information architectures which integrate agency work processes and information flows with technology to achieve the agency's strategic goals...." For all new IT initiatives this question must be addressed and documented. (OMB, 1996).

The Beneficial results of going through the IT Enterprise Architecture process include the following:

- Facilitates flow of information and data through an Agency
- Improves an Agency's ability to communicate and work with collaborators and constituents
- Facilitates support for budget approval through OMB
- Ensures that IT provides direct support for an Agency's strategic goals
- Makes certain that the IT Infrastructure works and continues to work with emerging technologies.
- Streamlines IT acquisitions, lowers upgrade expenses, and reduces IT support and long term maintenance costs
- Helps achieve Agency buy-in for IT activities.

3. An IT Enterprise Architecture Seven-Step Process Model

The IT Enterprise Architecture Process is comprised of the following seven steps:

1. Define the IT Vision, Objectives and Principles
2. Characterize the IT Baseline
3. Create the IT Target Architecture
4. Identify the Immediate and Future Opportunities and Perform a Gap Analysis
5. Develop Migration Options
6. Implement the IT Target Architecture
7. Continuously Review and Update IT Enterprise Architecture.

Figure 1 is a model of the IT Enterprise Architecture Process. The model is derived from a DoD model that is defined and explained in the Technical Architecture Framework for Information Management (TAFIM). The authors have used the Seven Step Process for over three years and have

modified the DoD model based on our experiences with developing IT Enterprise Architectures. The contribution of our work is our emphasis on implementation, and continuously reviewing and updating the IT Enterprise Architecture. In addition, the process has evolved into a Principles - Based as well as a Standards - Based IT Architecture. IT principles are requisite rules and guidelines that are stable statements of the essential constitution of the IT Enterprise Architecture. The IT Principles remain constant as the Architecture incorporates technology and process improvements.

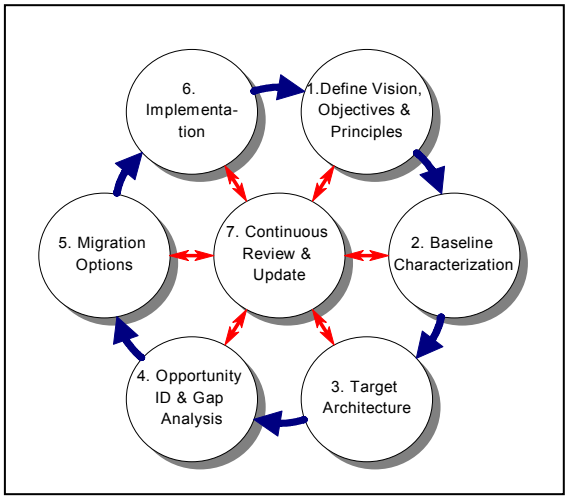

Figure 1 IT Enterprise Architecture Process

Each of the seven steps of the IT Enterprise Architecture Process Model is described below as they have evolved and have been carried out.

1. Define the IT Vision, Objectives and Principles
The first phase initiates the IT Enterprise Architecture by establishing the process, teams and budget. The initial IT vision and objectives, as well as the structure and the critical success factors of the process are established during this phase. The Agency's strategic drivers are reviewed and developed. In addition, a Business Context Diagram is constructed during this phase to align the IT Architecture with the Agency's Strategic Plan and Mission. The Business Context Diagram describes the market forces, the suppliers, the customers and other external factors that affect the business entity and its functions. Finally, a set of IT Principles is developed, usually in workshops and/or during interviews to establish what are believed to be good IT Enterprise Architecture requirements and practices for the Agency.

2. Characterize the IT Baseline The second phase establishes a baseline or starting point for IT Architecture development. The first phase helps provide an effective means for organizing this review and presenting the current status. This phase demonstrates, architecturally, where the Agency is currently situated. The Baseline Characterization phase results in a picture of the existing Architecture along its four views: Work and Location, Information Sets, Applications, and Technology Infrastructure. The term "characterization" is used because the data gathering and analysis are not exhaustive. Only enough detail is gathered to allow informed decisions to be made with regard to the desired Target Architecture. The views may be modified or expanded for to fit the scope of a particular IT Enterprise Architecture.

When appropriate, interviews are conducted to obtain baseline information. Other information gathering techniques include written surveys and workshops. The authors suggest that information gathered be compiled into a database and be condensed into a summary report. The IT Baseline is determined by analyzing the results of the information gathered.

3. Create the IT Target Architecture This is the heart of the process. The four views of the IT Enterprise Architecture are modeled in terms of a desirable Target Architecture. The process consists of defining the architectural components and the relationships between them. The result is an organized set of definitions and models which reflect the different views of the Architecture.

Each of the four views is modeled separately. The four views are then synthesized into a comprehensive Target Architecture. The key IT Issues and IT Principles are used to define the components for each of the views. As part of the Target Architecture, a Standards Profile is also created. The Standards Profile reflects a set of standards and guidelines that are used by the Agency in acquiring technology and in developing applications.

4. Identify the Immediate and Future Opportunities and Perform a Gap Analysis This phase moves the IT Enterprise Architecture out of the conceptual world into one where the practical realities govern implementation. In this step, short-term immediate opportunities are identified which, once implemented, can demonstrate the value of the IT Architecture and provide immediate benefits to the Agency. In addition, all projects that are necessary to achieve the Target Architecture are identified and are

actualized in some detail. Immediate Opportunities are initially identified during Step Three of the process and are verified during this stage as low cost quick-win projects.

The Gap Analysis is developed during this phase to identify all projects that are necessary to achieve the Target Architecture. The analysis is accomplished by comparing the IT Baseline with all four views of the Target Architecture. Holes in the Target Architecture are discovered as a result of the Gap Analysis, and the necessary projects to bridge the gaps are identified and project plans are developed.

5. Develop Migration Options This phase links the current reality with the desirability of the Target Architecture by establishing one or more plateaus. Plateaus represent practical migration stages and are defined as short, medium and long range objectives and priorities. Projects identified in the previous steps are prioritized over time, based on inter-project dependencies and cost/benefit analyses. During the development of the Migrations Options various alternative analyses are performed. The best technical design is not always chosen, because of political, agency, technological and budgetary constraints.

6. Implement the IT Target Architecture This phase implements the first plateau of the migration effort. It constitutes the first wave of projects that establish the groundwork for each successive plateau of the Target Architecture implementation. The first plateau contains projects that are short term in nature and are linked generally to the next stage in the Migration Plan. Responsibilities are established to ensure that the projects are carried out and that the Migration Plan is properly updated. Also, during this stage the Standards Profile is released as a product of the IT Enterprise Architecture.

7. Continuously Review and Update IT Enterprise Architecture. This phase is intended to keep the Architecture alive and well by continuously improving it. This phase reflects the need to adjust the IT Enterprise Architecture decisions in accordance with unforeseen changes in business directions or in technology advances or its availability. It is also used to make adjustments based on experience and ensure that modifications in standards and supporting processes reflect a realistic approach. This continuous review process can cause a reentry into the process at any point depending on the area to be adjusted or updated.

4. Implementing an IT Enterprise Architecture

The basic steps for implementing an IT Enterprise Architecture is listed below:

- Create IT Architecture team
- Get management's support and commitment to the IT Architecture process
- Take a snapshot (baseline) of what currently exists
- Determine where the Agency wants to be in the next three to five years
- Determine the gaps between the current baseline and the future vision
- Identify and accomplish early success projects that will create buy-in
- Develop a plan and budget for bridging the gaps and reaching the IT goals
- Develop a blueprint that explains how all the IT and elements work together as a whole.
- Update annually to accommodate strategic and budget plans.

Based on the authors' experiences, an initial IT Enterprise Architecture may take six months to three years to complete depending on the scope and complexity of the IT Enterprise Architecture. Factors in determining the process schedule include the following:

- Scope of effort
- Staffing resources available to assist in the development
- Available funding.

The scope includes all aspects of the Enterprise that may have an impact on the future use and deployment of IT, the work of the Enterprise, and the way IT may be used to support it. The resources required to develop an IT Enterprise Architecture involves varying levels of participation. At the basic level, a Core Architecture Team (CAT) of three to five people is recommended. The CAT should be led by a full time staff member from the primary organization. An Architecture Working Group (AWG) assists the CAT and provides valuable technical insight and direction to the core team. The AWG also helps in research and analysis. The AWG should be made up of IT representatives from all the key organizations and locations of the Agency. Also, a Management Decision-Making Board is needed to review and approve the analysis and recommendations of the CAT and the AWG. The management board should be comprised of managers from all the key organizations and locations of the Agency. Funding is determined by the scope and resources required to develop the Architecture.

Funding may come from the Enterprise's headquarters or it may be obtained from various operating units of the organization.

5. Case Study - An IT Enterprise Architecture for NOAA's National Marine Fisheries Service

The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) supports the domestic and international conservation and management of living marine resources. NMFS provides services and products to support domestic and international fisheries operations, fisheries development, trade and industry assistance activities, enforcement, protected species and habitat conservation operations, and the scientific and technical aspects of NOAA's marine fisheries program. NMFS by its very nature is information driven and IT is an indispensable tool. To support NMFS products and services, the NMFS National Information Management Board (NIMB) decided to implement an IT Enterprise Architecture in the summer of 1996. When asked about what improvements the Architecture could provide, staff eagerly responded that they needed the following:

- Better connectivity and bandwidth
- Better access to NMFS information
- Training
- More comprehensive IT support
- Workplace automation
- Better IT tools, planning and administration.

NMFS decided to use the Enterprise Architecture process to develop an integrated framework for evolving or maintaining existing IT and acquiring new IT to achieve the Agency's strategic goals and information resource management goals. The objectives of the project were to describe the functions, elements, and performance requirements, and to define the most effective approach to meet current and future IT system needs. An integral part of the process was a new team approach which involved all NMFS ten regional offices in planning, developing and implementing the Architecture. At the core was an AWG chaired by the IT Architecture project leader from Headquarters. The AWG consisted of 14 members and met every three months in person and every two weeks by videoconference, when necessary. The AWG developed a plan based on the seven step model described in this paper. The AWG scaled down the original DoD process in scope and complexity to meet NMFS' needs. The AWG also determined that the IT Enterprise Architecture process should use a "principles-based" as well as a "standards-based" approach.

The AWG conducted interviews to ascertain Agency IT Objectives and Vision, and to obtain Baseline Characterization information. The interviews were conducted at all levels of the Agency from the Directors and Administrators to the scientists, technicians and office administration support staff using a standardized questionnaire. Approximately 40 percent of the Agency's total workforce was interviewed. A set of standard non-directive questions was used to ascertain the Agency's current and future IT requirements; its strengths, weaknesses in IT; its constituents, collaborators and partners; and its long-term IT visions and objectives. Each respondent was also asked what feature of the IT Architecture would predicate a success for them personally. IT hardware and software information was also collected using a survey template. This template was sent to NMFS's ten Regional IT Coordinators for completion. Information gathered was compiled into an IT Enterprise Architecture databases and condensed into summary reports. The IT Baseline was determined by compiling and analyzing the results of the information gathered.

The AWG focused on establishing IT Principles rather than hard and fast policies. Changes or additions to NMFS IT Principles will require formal review and acceptance by the NIMB. The resulting set of IT principles were aligned with the Architecture views and as shown:

Meta Principles: Architecture Compliance, Cross-Functionality, IT Standards, Measurement, Return on Investment, Security, Interoperability, Training, Ease of Learning and Use, Information Management Administration, Technology Change Management, and Metadata

Work and Location Principles: System Ownership, Electronic Enterprise, Electronic Work Processes, One-time Only Data Capture, and Remote/Mobile Office

Application Principles: Common User Interface, Cross-Functional Opportunities, Build or Purchase, Systems Development Process and Methodology, and Reusability

Information Sets Principles: Multiple Types of Information, Data Standardization, Data as an Agency Asset, Direct Accessibility of Information, and Legacy Data Retention

Technology Infrastructure Principles: Interchangeable Components, Network Connectivity, Network Interfaces, Network Services, Information Access, Multiple Information Types Transmission, and Minimally Disruptive Transitions.

Products developed during the first phase included a statement of IT principles, and a series of regional reports, which summarized the interviews conducted in each of NMFS ten regions. A Baseline Characterization document was developed during Phase Two.

During Phase Three, four Target Architecture Teams were created and involved a total of over 40 Agency personnel. There was one Target Architecture Team for each view. The following products were developed for each of the four views during Phase Three by the teams:

Work and Location View: Descriptions of Business Processes or Logical Operating Units (LOUs), User Classes, and Logical Locations

Information Sets View: Lists of Logical Information Sets, Security Categories, Access, and Data Types

Applications View: Lists of Off-the-Shelf Software Types and Developed Target Applications

Technology Infrastructure View: Target Network Diagrams of Wide Area Network (WAN) and Communications Network, and a List of IT Services.

A Standards Profile for NMFS was also developed during Phase Three and was based on a model created by the Forrester Research, Inc (Deutsch, 1996). The Standards Profile defined, classified, and categorized technologies and applications as follows:

Foundation Technology - A Foundation Technology standard is used enterprise-wide and has a high impact on Agency activity. Implementation, support and training are sponsored nationally. Examples include: E-Mail, TCP/IP and Financial Systems.

Building Block Technology - A Building Block Technology impacts the individual business functions differently. Using standards in this category allow technical flexibility. Implementation, support and training are sponsored by the individual business function. Examples include server configuration software, Internet browsers and, Desktop Operating Systems.

Watch List Technology - A Watch List Technology includes standards for emerging or specialized technologies. The technologies included in this category change rapidly and have scattered use throughout the Agency Implementation, support and training are sponsored by the local business unit. Examples include Linux, Java development tools, and multidimensional databases.

Obsolete Technology - Standards are classified obsolete when the support and training for the technology may be limited. Obsolete technologies are recommended for phasing out.

The primary document that was developed during Phase Three was a plan, ***Fisheries Information Technology for the 21st Century (FIT 21)***. The plan is made up of the following four components:

Stable IT Administration - FIT 21 Administration will focus on an IT Principle-centered Architecture that will be directed by national decision making board and will be implemented by regional IT experts. It will be supported by consistent IT Principles, a Standards Profile and an Architecture Web Page to keep the staff informed.

Empowered Workforce - The NMFS workforce will be empowered with web-based training, with IT support using national and regional help desks, and with a national web-based reference library. Software tools will include a full suite of Off -the-Shelf and custom developed software including automated workflow and collaboration, and electronic tracking systems with electronic signatures. The workforce will be further supported with the IT Principles, methods and procedures.

Virtual Information Center (VIC) - The VIC includes an Information Portal which will provide web-based access to fifty-five categories of NMFS information. The information will be available to NMFS staff and selected NOAA staff using security certificates over an Intranet, to collaborative partners using an Extranet and to the public over the Internet.

IT Infrastructure - The NMFS IT infrastructure will consist of an agency-wide Virtual Private Network (VPN) and an Enterprise Network in which any staff member can log-on to his or her work space from any computer in the system or from home.

In Phases Four and Five, NMFS identified ten Immediate Opportunities to implement during Fiscal Year 1999, drafted a three-year Migration Options

Plan and is currently budgeting to implement the Migration Plan.

6. Lessons Learned from Existing IT Enterprise Architecture Efforts

The following are some of the lessons learned from using the IT Enterprise Architecture process for the past three years:

- The IT Enterprise Architecture phases requires continuous review and update.
- An orderly and systems approach must be used to develop the IT Enterprise Architecture.
- Great flexibility and creativity are required to modify the process so that it works for your organization. The process will be anything but smooth.
- Each organization must determine the scope of its IT Architecture efforts.
- The IT Enterprise Architecture must be in alignment with the Agency's strategic plan and mission requirements.
- There must be a shared and mutual vision with senior managers and executives on the mission and strategic role of the IT Enterprise Architecture.
- An IT Architecture is defined by IT Principles and Standards. An IT Architecture is not just the selection of hardware and software products.
- It was invaluable to do the Architecture using in-house staff and to take the lead ourselves.
- It is important to involve as many IT and business staff in the process, as practicable. The more you involve the end user, the more they feel a part of and take an active role in the process.
- The process must begin with a clear definition and understanding of the Agency's vision, IT principles and business context
- It is critical to learn about IT requirements, and IT successes and failures from all levels of the Agency
- Multi-organizational collaborative efforts are very effective and successful.
- The IT Enterprise Architecture process is much more important than the IT Architecture plan. Technology and business drivers can rapidly change.

Disclaimer: The opinions expressed in this paper are solely those of the authors are not those of the Department of Commerce, the National Oceanic and Atmospheric Administration or the National Marine Fisheries Service.

REFERENCES

DeBoever, L. R., *Enterprise Architecture 'Boot Camp' & Best Practices: A Workshop*, META Group, The Enterprise Architecture Conference, Orlando, FL, December 1, 1997.

Department of Defense (DoD), *Technical Architecture Framework for Information Management (TAFIM), Volume 4: DoD Standards-Based Architecture Planning Guide*, Version 3.0, 30 April 1996. http://www-library.itsi.disa.mil/tafim.html

Department of the Navy, *Information Technology Standards Guidance (ITSG)*, Version 98-1.1", 15 June 1998. http://www.doncio.navy.mil/itsgpublic/

Deutsch, H. W., Leuchtenburg, C. M., and Allen, N. H., "Sinking the IT Iceberg", *The Forrester Report, Computing Strategies*, Volume 13, Number 5, March 1, 1996.

Federal CIO Council, *Federal Information Technology Architecture Conceptual Model*, Draft, June 25, 1998. http://cio.gov/new.htm

Grossman, Ira, McCloy, Mark, and Sargent, Jim, *NOAA Information Technology Enterprise Architecture*, Department of Commerce IT/Acquisition Management Conference, Williamsburg, VA, May 21, 1998.

IEEE Std 100 - 1996, *IEEE Standard Dictionary of Electrical and Electronics Terms*, Sixth Edition, The Institute of Electrical and Electronics Engineers, 1996.

International Council of Systems Engineers (INCOSE), Systems Architecture Working Group, *Systems Architecture Working Group Definitions*, August 8, 1998. http://www.incose.org/cmtes/sawg.html.

Office of Management and Budget (OMB) Memorandum, Subject: Funding Information Systems Investments, dated October 25,1996 http://cio.gov/raines.htm

Public Law 104-106 (S.1124), "National Defense Authorization Act for Fiscal Year 1996, Division E--

Information Technology Management Reform Act of 1996" (Clinger/Cohen Act). http://cio.gov/s1124_en.htm

Senn, Ann, *Open Systems for Better Business, Something Ventured, Something Gained*, Van Nostrand Reinhold, New York, 1995

Shnier, Mitchell, *Dictionary of PC Hardware and Data Communications Terms - Online Resource*, O'Reilly & Associates, 1996. http://www.oreilly.com/reference/dictionary/

BIOGRAPHIES

Mr. Ira Grossman has been a member of the Systems Engineering Staff of NOAA's Systems Acquisition Office for seven years. He has 27 years of experience in Systems Engineering, Information Technology, Systems Architecture. Acquisition Management, Logistics, and Configuration Management. Mr. Grossman has been involved in developing IT Enterprise Architectures for NOAA for the past three years. Mr. Grossman has a Bachelors of Mechanical Engineering degree from the City College of New York and a Masters of Business Administration degree from the College of William and Mary.

Mr. James Sargent is Senior Computer Specialist for the Office of Management and Information of NOAA's National Marine Fisheries Service. Mr. Sargent is the Project Leader for the NMFS IT Systems Architecture. He has over 30 years experience in IT Systems Development, Software Engineering Management, Strategic Planning and IT Architecture. He has a Bachelors of Arts degree in Mathematics from State University of New York at Buffalo and has completed graduate work towards a Masters degree in Engineering Management at Northeastern University.