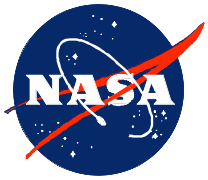

National Aeronautics and Space Administration

NASA Enterprise Architecture

Version # 3.0

August 8, 2004

NASA Enterprise Architecture

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Table of Changes

Date of Change	Section(s) Affected	Brief Description of Change	Change Made By	Organization
September 14, 2002		Final Version 1.0	NASA Office of the CIO	NASA Office of the CIO
September 22, 2003		Final Version 2.0	Chief Technology Officer, Code AO	NASA Office of the CIO
December 22, 2003	Sections 5.0 -> 12 Moved to Volume 4, Enterprise Architecture Strategy and Structure	Final Version 2.1	Chief Technology Officer, Code AO	NASA Office of the CIO
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August 8, 2004	Minor Editorial changes	Final Version 3.0	Chief Technology Officer, Office of the CIO	NASA Office of the CIO

Table of Acronyms

BAS	Basic Accounting System
CIO	Chief Information Officer
COAD	Commitment, Obligation, Accrual, Disbursement
CTO	Chief Technology Officer
DARTS	Dryden Accounting and Resources Tracking
EA	Enterprise Architecture
EAI	Enterprise Applications Integration
E-GOV	Electronic Government
FACS	Financial and Contractual Status
FAS	Financial Accounting System
FAS/T	Financial Accounting System
FEAF	Federal Enterprise Architecture Framework
FMS	Financial Management System
IBAS	Interactive Basic Accounting System
IFMP	Integrated Financial Management Program
IRM	Information Resources Management
IT	Information Technology
MARTS	Marshall Accounting and Resource Tracking System
NIITA	NASA Integrated Information Technology Architecture
NISSU	NASA's Information System Services Utility
NIST	National Institute of Standards and Technology

NITI	NASA Information Technology Infrastructure
NPD	NASA Policy Directive
NPR	NASA Procedural Requirements
ODIN	Outsourcing Desktop Initiative for NASA
OPAC	Online Payment and Collection
STARS	Staffing and Recruiting Systems
TCO	Total Cost of Ownership
TRM	Technical Reference Model
VPN	Virtual Private Network

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2 Executive Overview

Enterprise Architecture is a tool that links the mission and strategy of an organization to its Information Technology (IT) strategy. When complemented by strong governance processes, Enterprise Architecture can effectively guide the IT capital investment and planning processes and help an organization optimize the return on its IT investments. Identifying and defining common processes and functions, common information needs of different users, technology standards, and reusable common services that can be leveraged by multiple systems within the organization achieve this optimization.

A strong Enterprise Architecture facilitates the introduction and adoption of new technologies into an organization by separating an organization's processes and services: the "what," from the technologies, and the "how" that supports them. This separation allows the technologies, which evolve at a fast rate, to be changed independently from the process or service requirements, which usually evolve at a slower rate. The separation simplifies the introduction of new technologies into an organization.

The "Clinger-Cohen Act of 1996" requires each federal agency to develop an enterprise information technology architecture. To facilitate the consistent development of enterprise architectures across federal agencies, the Federal Chief Information Officer (CIO) Council developed and published the Federal Enterprise Architecture and the supporting reference models.

NASA's architectural development is an iterative and continuous process. The Agency is fully committed to working with the Office of Management and Budget (OMB), the General Accounting Office (GAO), and other entities within the federal government to identify opportunities to collaborate, consolidate, and leverage investments to reach the goal of overall government improvement. The NASA Enterprise Architecture is based on the Federal Enterprise Architecture and the associated supporting reference models. NASA has extended the Federal framework and reference models, where appropriate, utilizing commercial best practices.

This version of NASA Enterprise Architecture documents the complete Agency Enterprise Architecture, including the Office Automation, IT Infrastructure, and Telecommunications investment category and a representative set of elements from the Program Unique IT and Multi-Program / Project IT investment categories. NASA has determined that in order to continue to meet its mission effectively and efficiently, and to facilitate better program, project and information technology decision making, it is important to develop, communicate, and manage a consistent Agencywide Enterprise Architecture.

NASA has embarked upon a major Information Technology program, the Integrated Information Infrastructure Program, to support the transition from the current "as-is" state to the desired "to-be" state. The information technology segments documented here identify the current state of the NASA information technology environment and define the target state in terms of business, information, application, and technology architecture. In addition, it outlines the transition plan for each segment from the current state to the target state. This document will be updated to incorporate changes in implementation strategy and/or tactics.

3 Introduction

The NASA Enterprise Architecture (EA) focuses on leveraging the Agency's investment in legacy systems and driving the design on our emerging systems. The Enterprise Architecture leverages existing systems that NASA has in place, built separately by Centers and Programs over several decades. The NASA Enterprise Architecture and the associate reference models mold these systems into an integrated or federated infrastructure aligned with the Agency's mission and business needs. The model for the "to-be" state is based on a service-oriented architecture that allows for services provided by any of the following approaches:

- Locally managed and provisioned services
- Centrally managed and locally provisioned services
- Centrally managed and provisioned services

The NASA Enterprise Architecture provides a mission-driven approach to designing and implementing, partnering, or procuring new information technology systems and services. The true value of Enterprise Architecture is achieved when the architecture increases NASA's ability to deliver on our core missions. The NASA information technology systems and the Enterprise Architecture exist to support the vision presented in the NASA Strategic Plan and the three core missions and ten major goals of the Agency.

3.1 The NASA Vision

To improve life here,
To extend life to there,
To find life beyond

3.2 The NASA Mission

To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

3.3 Information Technology to support the NASA Vision

Enable NASA's missions and share the knowledge and excitement with the public through the effective use of information technology and systems.

3.4 Information Technology to support the NASA Mission

Provide the NASA workforce the information infrastructure and tools that adapt and evolve to support management, science, research, and technology programs.

Develop and implement unique and specialized IT systems to support mission planning and operations. Provide systems that disseminate information to the public and that preserve NASA's information assets.

3.5 NASA's Mission Goals

The NASA Strategic Plan identifies ten specific mission goals:

1. *Understand Earth's system and apply Earth-system science to improve the prediction of climate, weather, and natural hazards;*
2. *Enable a safer, more secure, efficient, and environmentally friendly air transportation system;*
3. *Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia;*
4. *Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space;*
5. *Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere;*
6. *Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics;*
7. *Engage the public in shaping and sharing the experience of exploration and discovery;*
8. *Ensure the provision of space access and improve it by increasing safety, reliability, and affordability;*
9. *Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery; and*
10. *Enable revolutionary capabilities through new technology.*

In addition to these specific mission goals, the Agency plan identifies five implementing strategies (IS) that provide the framework under which NASA conducts its business. These are:

IS-1. Achieve management and institutional excellence comparable to NASA's technical excellence.
IS-2. Demonstrate NASA leadership in the use of information technologies.
IS-3. Enhance NASA's core engineering, management, and scientific capabilities and processes to ensure safety and mission success, increase performance, and reduce cost.
IS-4. Ensure that all NASA work environments, on Earth and in space, are safe, healthy, environmentally sound, and secure.
IS-5. Manage risk and cost to ensure success and provide the greatest value to the American public.

3.6 Aligning NASA's Information Technology with the Agency Mission

NASA's Enterprise Architecture must support the unique science and research and technology missions of the Agency and the business processes and general-purpose infrastructure required to support the Agency's operations. The NASA Enterprise Architecture is structured into three major investment categories: Office Automation, IT Infrastructure, and Telecommunications (OAIT), including Program Unique IT and Multi-Program / Project IT. Detailed definitions for each component are provided in Section 8, Structure of the NASA Enterprise Architecture. This three-component structure allows the Agency to group items based on how they support NASA in achieving our overall strategic missions.

The goal of the enterprise architecture is to provide NASA with the essential information technology and information technology infrastructure required to support the NASA Strategic Plan and the three core missions of the Agency. The EA also supports NASA's participation in the expanded electronic government initiative (e-Gov) of the President's Management Agenda. As the e-Gov initiatives progress, the need to share services, information, and tools across the Agency and the entire federal government will continue to grow. NASA must be positioned to provide a secure and efficient interface to government agencies and/or application service providers that will deliver these services.

As an Agency, we must be prepared with an infrastructure that provides a consistent interface and eliminates the need for application owners and service providers to negotiate multiple agreements. The framework that the enterprise architecture provides will reduce the complexity of NASA's information systems by simplifying the implementation architectures and reusing common architectural, management, process, and technology components as appropriate. This enables effective and efficient deployment of new technologies to support the Agency's core missions.

The true value of Enterprise Architecture is realized as the architecture increases NASA's ability to deliver on our core missions. The NASA information technology systems and the Enterprise Architecture exist to support the NASA Strategic Plan and the three core missions of the Agency.

The NASA Enterprise Architecture is a transformation strategy for managing the Agency's IT infrastructure as an integrated architecture and providing an infrastructure that can evolve and adapt in concert with the Agency's strategy. The Enterprise Architecture provides a customer focus to the provisioning of common IT services across NASA and will also enable effective and efficient integration with federal e-Gov applications.

3.7 NASA Enterprise Architecture Release Schedule

Version 2 of the NASA Enterprise Architecture underwent quarterly revisions in FY 2004, and finished with Version 2.3. For FY 2005, NASA will publish EA Version 3.0 in September of 2004 and the EA update cycle will transition to a semi-annual release schedule. The document release schedule will be reviewed on a semi-annual basis and updated as required.

4 NASA's Information Resource Management Strategy

The NASA Chief Information Officer (CIO) has responsibility for ensuring that NASA's information assets are acquired and managed consistent with federal policies, procedures, and legislation and that the Agency's Information Resource Management (IRM) strategy is in alignment with NASA's vision, mission, and strategic goals. NASA's IRM plan has been developed as a mechanism for documenting the NASA CIO's strategy for fulfilling these responsibilities and to serve as a communication vehicle for sharing this strategy both internal and external to the Agency.

The IRM Strategic Plan is a companion document to the NASA Enterprise Architecture. It serves as an overall roadmap that will guide the Agency in using the EA as a framework for strengthening the management of NASA's information and technology resources through achievement of the following strategic goals:

1. Provide an infrastructure that can evolve and adapt to emerging technologies and service models;
2. Optimize investments in mission and program-unique IT systems by utilizing common infrastructure tools and services where practical;
3. Provide a customer focus to the provisioning of common IT services across NASA;
4. Protect and secure the Agency's information assets; and
5. Maintain an Agencywide IT investment portfolio in alignment with mission and business needs.

The plan includes the full spectrum of information resource management across the Agency, including business and administrative systems, mission specific systems, office automation, telecommunications, information technology (IT) infrastructure, security, and records management.

Within NASA, information technology has always been a critical enabling element of program development and management, as well as a pathway for improving business functions. Because IT is crucial to achieving NASA's strategic goals, IT projects must be aligned with the Agency's strategic direction and business plans in order to realize the value of each investment and take advantage of the opportunities that new information technologies promise. The IRM plan directly supports the Agency's Strategic Plan by clearly linking IRM strategies to the NASA vision, mission, strategic goals, and implementing strategies.

Not only must there be alignment with the Agency's mission, program, and business needs, there must be alignment with governmentwide architectures and standards, as well as alignment with our strategic and industry partners. This alignment provides for greater interoperability, efficiencies, and quality of service. It is essential that IT projects are planned and managed in a manner that integrates with mainstream Agency processes, including program/project management and budget processes.

The IRM strategic goals not only address direct support for mission goals through the development and operation of mission support and mission specific IT systems but also are key to the successful execution of the implementing strategies which are, in turn, key to the achievement of the mission goals. The criticality of IS-2, which specifically deals with information technology, in achieving these goals is demonstrated in Figure 1: The Importance of IT in Achieving NASA's Goals.

Figure 1: The Importance of IT in Achieving NASA's Goals

Achieving Agency Goals	Requires a Skilled Workforce Unencumbered by Physical Location	Enabled with the Right Capabilities	Provided by a Robust Tool Set	That can be used with consistent inter-operability	And Supported by a Strong IT Foundation	Built on Sound Investment Practices
Understand Earth's system and apply Earth-system science to improve the prediction of climate, weather, and natural hazards. Enable a safer, more secure, efficient, and environmentally friendly air transportation system. Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia. Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space. Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere. Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics. Engage the public in shaping and sharing the experience of exploration and discovery. Ensure the provision of space access and improve it by increasing safety, reliability, and affordability. Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery. Enable revolutionary capabilities through new technology.	Anywhere, anytime, access to information and people: • Virtual teaming • Collaboration • Mobile workforce	Device independent messaging Boundary-less access to resources for NASA and its partners. Knowledge capture, presentation sharing, and re-use	Electronic Work Environment (EWE) that includes: • Integrated email and calendaring; • email storage, search, and retrieval; • Instant messaging; • Secure messaging; • Wireless access; • File sharing: • Web-based conferencing; • Extensible Markup Language (XML) Repository	Consistent Network Security Perimeter (NSP): On demand secure connections between working groups across Centers and partners with: • Common data interchange formats • Common encription tools	WAN with guaranteed performance and reliability Agencywide Account Management: • Simplified log-in and password • Management—fewer passwords • Convenient and effective method for granting and removing resource access Identity Management System: • Agencywide directory	Standards and Architecture Capital Planning and Investment Control (CPIC) Program and Project Process Cost Schedule Performance Agreement (CSPA)

Figure 2 illustrates how each of the IRM strategic goals supports NASA's implementing strategies. The level of support is designated as high, medium, or low, depending on the extent to which achieving the IRM strategic goal is critical to the successful execution of the implementing strategy. The complete text and description of the Implementing Strategies, as documented in the NASA Strategic Plan and the IRM strategic goals, objectives, strategies, and performance measures, is contained in the *NASA Information Resource Management Plan.*

Figure 2: NASA IRM Strategic Goals

NASA IRM Strategic Goals	IS-1	IS-2	IS-3	IS-4	IS-5
1. Provide an infrastructure that can evolve and adapt to emerging technologies and service models	High	High	High	Low	High
2. Optimize investments in mission and program unique IT systems by utilizing common infrastructure tools and services where practical	Medium	High	High	Low	High
3. Provide a customer focus to the provisioning of common IT services across NASA	Medium	High	High	Low	Low
4. Protect and secure the Agency's information assets	High	High	High	High	High
5. Maintain an Agencywide IT investment portfolio in alignment with mission and business needs	High	High	High	Low	High
6. Ensure the viability of the Agency's IT workforce	High	High	High	High	High

5 The NASA Enterprise Architecture

The NASA Enterprise Architecture is a strategic tool that links NASA's mission, business and Information Technology (IT) strategies. The architecture provides the fundamental methodology and framework for defining how NASA's IT will be implemented and managed. Key elements of the architecture include a description of the current "as-is" state and a projection of the "to-be" state, a clear governance model, a Capital Planning and Investment Planning (CPIC) process, and information technology service delivery models.

The concept of One NASA encompasses how NASA decides to do those challenging projects that only NASA can, as well as how we actually accomplish them. A One NASA approach emphasizes a unified strategic plan, and a strong commitment to teamwork, tools and capabilities for greater collaboration. The NASA Enterprise Architecture provides the framework for NASA's Information Technology Programs and Projects. The information technology strategy provides both an overarching system of protection and removes many of the current barriers to One NASA caused by the disparate set of systems that are in place today. The Enterprise Architecture is decomposed into service elements, each of which integrates Agency-level services while retaining appropriate local-level operations. Through this approach NASA can put into place the information systems and technologies that enable anywhere, anytime access to information and people, can gain more effective use of its IT investments, and create the environment necessary to meet NASA's mission objectives.

5.1 Compliance with Federal and Agency Policy and Regulations

The NASA Enterprise Architecture is consistent and compliant with Federal laws, policies, and regulations. These include, but are not limited to, the following:

- President's Management Agenda
- Federal Information Security Management Act of 2002 (FISMA)
- Chief Financial Officers' Act of 1990
- Government Performance and Results Act of 1993
- Federal Acquisition Streamlining Act of 1994
- Paperwork Reduction Act of 1995
- Clinger-Cohen Act of 1996
- Government Paperwork Elimination Act of 1998
- Electronic Government Act of 2002
- Computer Security Act
- OMB Circulars and Bulletins
    - A-123, Internal Control Systems
    - A-130, Management of Federal Information Resources

As a part of NASA's Program and Project approval process (described in NPR 7120.5), all projects, including IT projects, are measured for compliance with the current approved version of the NASA Enterprise Architecture.

The NASA Enterprise Architecture references technical requirements developed and maintained by researching and evaluating current technologies, the appropriate federal regulations and standards, and the appropriate technical policies, procedures, and standards. These requirements and the Agency and Federal Policy guidance below are incorporated into every operational activity and new initiative:

Security – NASA policy and guidance is set out in:

NPD 2810.1, "NASA Information Security Policy"
NPR 2810.1, "Security of Information Technology"
Program and/or Project specific Security Plans

Software Engineering – NASA governing policies are:

NPD 2820.1, "NASA Software Policies"
NASA Standard 2100-91, "NASA Software Documentation Standard"
NASA Standard 2201-93, "Software Assurance Standard"
NASA Standard 2202-93, "Software Formal Inspection Process Standard"
NIST Standards

IT Asset Management – NASA's capital assets are valued at more than $60 billion. Because of their critical use and dollar value, the NASA Strategic Plan specifically calls out the goal of achieving excellence in the institutional management of capital assets, including implementation of best practices. Additional requirements are found in the following instructions:

NPD 4200.1, "Equipment Management"
NPR 4200.1, "NASA Equipment Management Manual"
NPR 4200.2, "Equipment Management Manual for Property Custodians"
NPD 8831.1, "Maintenance of Institutional and Program Facilities and Related Equipment"
NPR 8831.2, "Facilities Maintenance Management"

The following documents contain additional guidance and/or metrics that are used in the review process:
Management Guidance

NPR 7120.5, "NASA Program and Project Management Processes and Requirements"
NPD 2800.1, "Managing Information Technology"
NPR 2800.1, "Managing Information Technology"

Technical Standards

NASA Standard 2804, Minimum Interoperability Software Suite
NASA Standard 2805, Minimum Hardware Configurations
NASA Standard 2814, Technical Architecture – Volume 1, June 27, 2000
NASA Standard 2814, Considerations for Agencywide and Inter-Center Deployment of IT Services and Applications - Volume 2, June 27, 2000

Existing NASA Enterprise Architecture Documentation

NASA Enterprise Architecture – Version 2.3, July 2004

5.2 Alignment with Agency and Federal Strategic Goals

Within NASA, Information Technology has always been a critical enabling element of program development and management, as well as a pathway for improving business functions. Because IT is crucial to achieving NASA's strategic goals, IT projects must be aligned with the Agency's strategic direction and business plans in order to realize the value of each investment and take advantage of the opportunities that new information technologies promise.

Not only must there be alignment with the Agency's mission, program, and business needs, there must also be alignment with governmentwide architectures and standards, as well as alignment with other elements of the federal government and our strategic and industry partners. This provides for greater interoperability, efficiencies, and quality of service. It is essential that IT projects are planned and managed in a manner that integrates with mainstream Agency processes, including program/project management and budget processes.

5.3 External Drivers

The current Administration has taken an active role in improving the management of IT resources across the government. The President's Management Agenda provides the framework for improved management and coordination of IT and sets forth a number of actions, to include development of the Federal Enterprise Architecture, an evaluation process for IT activities, and a budget process that provides rigorous standards for determining the merits of IT investments.

Among the many other externally generated laws, policies, standards, and guidance, the following are key drivers of the direction of NASA's IT infrastructure:

- The Administration
  - President's Management Agenda
  - Agency Scorecard System
  - The E-government Initiatives
- Legislative Mandates
  - Chief Financial Officers' Act of 1990
  - Government Performance and Results Act of 1993
  - Federal Acquisition Streamlining Act of 1994
  - Paperwork Reduction Act of 1995
  - Clinger-Cohen Act of 1996
  - Government Paperwork Elimination Act of 1998
  - Electronic Government Act of 2002
  - Federal Information Security Management Act of 2002 (FISMA)
- Government and Industry Standards
  - National Institute for Standards and Technology (NIST)
  - HyperText Markup Language (HTML), Extensible Markup Language (XML), JAVA, Web services, etc.
  - Secure Socket Layer (SSL), Public Key Infrastructure (PKI), etc.

The President's Management Agenda has fostered the development of a set of federal-wide electronic government (e-Gov) initiatives. NASA is currently participating in 14 of the e-Gov initiatives including

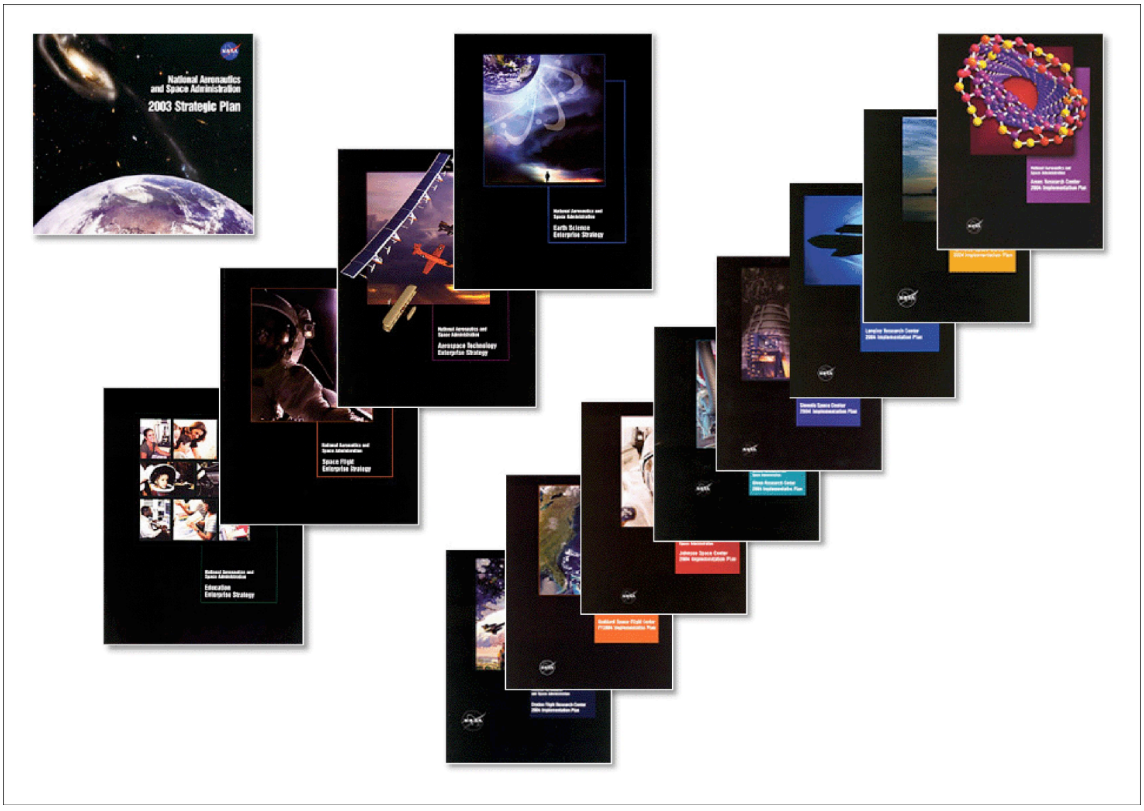
e-Travel, e-Payroll, e-Authentication and Integrated Acquisition. Federal Partners are developing the e-Gov initiatives. NASA is currently developing implementation and integration and test plans with the e-Gov partners. The detailed integration plans will be incorporated in later releases of the NASA Enterprise Architecture.

6 “To be” Directions

The Agency operating model requires increased capability to work across NASA Centers, generating IT requirements that, by their nature, are best met at the Agency level. To meet the changing requirements, NASA is shifting to a service-oriented architecture and evaluating the consolidation of like services when it makes economic sense and supports the successful achievement of NASA’s core missions. The shift in operating model is fundamentally changing the network traffic patterns and the architecture of the services provided. The shift in how information and knowledge is generated, used, and managed dictates a more holistic approach to providing information infrastructure services across NASA. Both the rate of change and the magnitude of change require a more shift away from a reactive planning and development model to a proactive, strategy driven planning and development model. The emerging services may be provided by outside vendors, outside federal Partners, or internally from centrally managed sites.

NASA continues to use the Agency’s strategic planning process for programs and projects to develop and refine potential elements for the integrated “to be” architecture. The items described in the “to-be” architecture are derived from the NASA Strategic Plan and support Mission Directorate and Center Documents. They constitute a candidate portfolio of new IT capabilities and upgrades to existing IT capabilities as required to achieve the NASA mission.

Figure 3: NASA Strategic Plan



As candidate new initiatives from this portfolio are validated by studies and business cases, decisions will be made regarding their funding, specific schedules and inclusion in this or future budget submissions.

NASA's IT systems and investments are necessarily driven by mission requirements that they are tested with every mission. NASA maintains an Agency-wide IT investment portfolio in alignment with mission and business needs, by addressing these key questions, in the order presented:

- What are the strategic objectives of the Agency?
- What information is needed to support the Agency?
- What applications are needed to supply the information?
- What technologies are needed to support the applications?

The details of the development process are presented in Volume 5 of the NASA Enterprise Architecture.

As an example, previous analyses of Agency requirements, technology directions, and perceived gaps led to identification of major initiatives for the OAIT investment area and the current definition of a reuseable component architecture. The Integrated Information Infrastructure Program defines the "to-be" targets for the Wide Area Network, Security, Enterprise Architecture, and the Electronic Work Environment. A more detailed description of the architectural development process and the "to-be" target for the Agency is provided in the NASA Enterprise Architecture Volume 5, NASA To-Be Architecture: Approach to Design and Implementation.

New initiatives that were defined and funded in FY 2004 include foundation improvements in IT security, integrated directory and account management, the Wide Area Network upgrade, and some integrated messaging, file sharing and collaboration services, as well as continuing improvements to the Web Portal, the XML registry and the Enterprise Architecture program itself. Network security improvements now in development include definition and implementation of an Agency Security Perimeter. The NASA Integrated Services Environment program will provide an integrated approach to Identity Management, physical access controls (SmartCard), a Cyber Identity Management capability (built upon a robust Agency level directory service), and a NASA Account Management System to automate and simplify computing and communications user accounts. A NASA Headquarters pilot to integrate e-mail, task management, calendaring and common file sharing and correspondence management services has completed its first phase.

As a result of 2 years of highly successful pilot services to support collaboration, the Agency recently decided to provide a virtual team meeting capability using an innovative provisioning model. The pilot included use of the WebEx Web-based virtual team-meeting tool under an Application Service Provider contract. The service will be moved into a full production mode as a seat-based service option on the NASA Outsourcing Desktop Initiative for NASA (ODIN) contract.

There are plans documented in the Wide Area Network Upgrade Program Plan to significantly upgrade the NASA WAN services. The Implementation details will be incorporated into the overall Enterprise Architecture as the detailed project tactical plan is developed. In particular, the technical and

marketplace status of Voice over IP and convergence of voice, video and data communications will be monitored.

NASA has completed a Local Area Networking Architecture document to define the roadmap to increase interoperability across the LANs. The LAN architecture presents the planned architectural changes to this component. The ideal "To be" condition for the Local Area networks is such that all outdated systems are replaced by state-of-the-art switches and wiring. The LAN end state will incorporate switches into the access level in a collapsed core and distributed/access architecture. Access switches will provide 100 Mbps to 1 Gbps of bandwidth per devices. A routing protocol supporting variable length subnet masking will be used to segment the network into IP subnet domains, which will allow for the reasonable use of voice and video over the shared infrastructure.

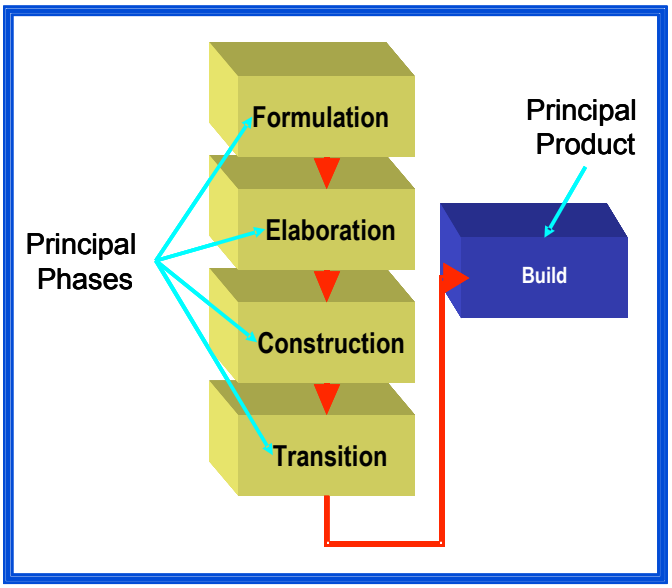
NASA is moving forward to advance the current state of Public Web Services. The highly successful deployment of the One NASA portal makes it easier for the public to find NASA information and for NASA to manage the content. The consolidated service delivery model provides for centralized content management. The external portal hosting services contract provides for a basic level of services and scales to meet demand. NASA is also investigating development of an InsideNASA portal for its employees. These initiatives will be included in the architecture as they mature.

The details of the “to-be” state of the overall NASA Enterprise Architecture are documents in Volume 5, NASA To-Be Architecture: Approach to Design and Implementation. Volume 5 will be updated with the details of the “to-be” state for the e-Gov initiative and will be defined in future releases of this document as NASA and the Managing Partners for each initiative develop detailed development and integration plans. The details of the IFMP “to-be” architecture and its integration points with the OAIT investment category will continue to be refined in future releases.

7 Policies and Procedures

The Enterprise Architecture program is implemented and managed according to a prescribed approach. Enterprise Architecture Volume 6: Policies and Procedures, details (a) the policies driving the EA program, and (b) the processes, products, roles, and responsibilities used by NASA to manage the EA. Volume 6 addresses broadly the entire enterprise life cycle, and describes in detail how the EA processes relate to enterprise engineering, program management, and capital planning and investment control processes.

The NASA process toward EA development and management employs a four-phase cycle . We define a phase as the span of time between two major process milestones in which a well defined set of objectives are met and artifacts are completed. Each phase is summarized below.



Formulation Phase - During this Phase, NASA establishes and validates the business case for the next cycle of the Enterprise Architecture program. The program requirements are determined and validated to delimit the program's scope. This includes success criteria, risk assessments, resource and cost estimates, a project plan with major milestones, and a view of the expected end product. Key tasks during this phase include business modeling, requirements engineering, environment definition, process development, and tool selection.

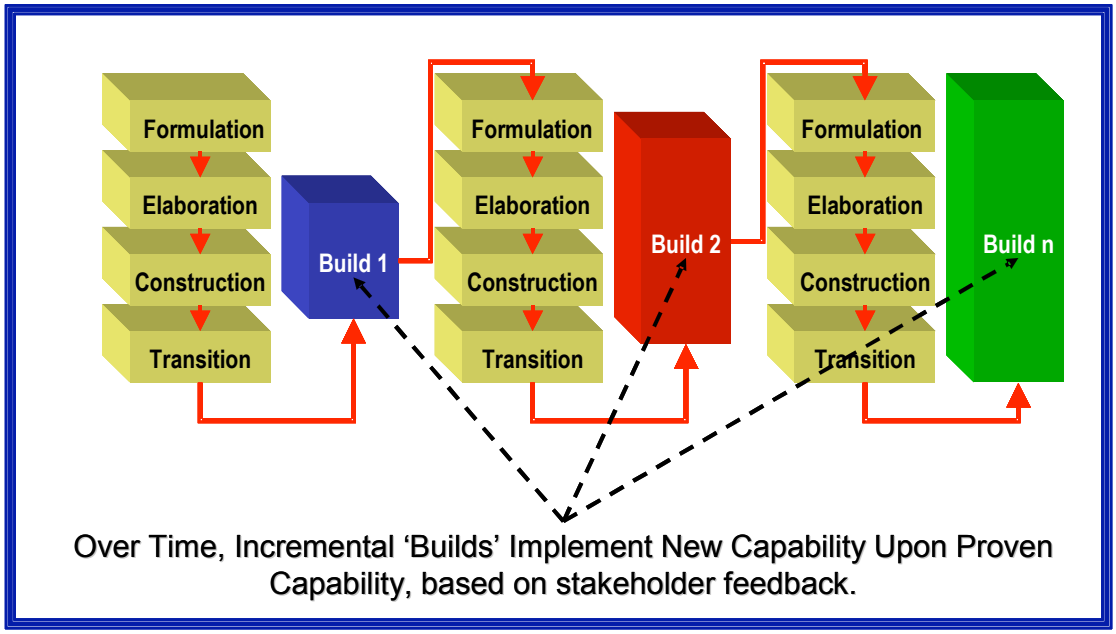
Elaboration Phase – During the Elaboration Phase, NASA analyzes the problem domain, refines the architectural foundation, develops a detailed project plan, and mitigates or eliminates the highest risk elements of the project. Architectural decisions are made with an understanding of the whole environment domain. System requirements must be fully documented during this Phase.

Construction Phase – During the Construction Phase, we iteratively and incrementally develop a complete product that is ready to transition to the user community. We fully describe the remaining requirements and acceptance criteria, complete the design, and complete the implementation and test of the environment. The product of this phase is a user-accessible information knowledgebase that will be transitioned to the user base.

Transition Phase – During the Transition Phase, NASA will deploy the information knowledge base to the user community. Once the knowledge base has been made available, issues often arise that require additional development in order to adjust the system, correct previously undetected problems, or finish some features that have been postponed. This phase typically starts with a beta release of the system, which is then replaced with the production system.

At the end of the Transition Phase, the Architecture Stakeholder Team decides whether the life-cycle objectives of the project have been met and determine if another development cycle should be initiated. We also document lessons learned on the project in order to improve our next development process, which will be applied to the next project.

Architecture Build – Finishing the four major phases completes a development cycle and results in a Build. The first pass through the four phases is the initial development cycle. Unless the life of the product stops, an existing product will evolve into its next generation by repeating the same sequence of phases. This is the evolution of the Build, so the development cycles after the initial development cycles are its evolution cycles.



8 Summary

NASA has made strong progress in developing and refining the Agency's Enterprise Architecture over the past 2 years. Our Agencywide EA team has compiled the current "As is" architecture and is continuing refinement of the "To-be" architecture. The overall architectural development and refinement process for development for the NASA EA is described in Volume 4.

NASA has adopted the major elements of the Federal Enterprise Architecture and is supporting the development of the Federal Enterprise Architecture. NASA will continue to engage with the CIO Council and the federal Architecture and Infrastructure Committee (AIC) and its subcommittees. As a part of the development of this document and our business cases for the OMB budget submissions, we mapped all of our OAIT and a representative subset of our program unique and multi-program specific IT investment to the Federal Enterprise Architecture reference models. We have extended the reference models to capture the unique elements of NASA science and research and technology missions.

NASA has defined a set of core Architectural Components for the OAIT investments of our general-purpose architecture and is using the common definition to focus and support our EA efforts. The set of components is being extended to include the elements of our program unique and multi-program/ project IT architectures.

The NASA Enterprise Architecture is a cohesive strategy for managing the Agency's IT infrastructure as an integrated architecture that support the One NASA strategy and the Agency's strategic plan, core missions and implementing strategies. The Enterprise Architecture provides a customer focus to the provisioning of common IT services across NASA. The Enterprise Architecture will evolve as required to support enable effective and efficient integration with Federal e-Gov applications and the President's Management Agenda.

The Enterprise Architecture will continue to undergo quarterly revisions. Starting with Version 3.0 scheduled for release in September of 2004, the Enterprise Architecture will transition to a semi-annual release schedule. The document release schedule will be reviewed on a semi-annual basis and updated as required.

9 Appendix A - Enterprise Architecture Roadmap

9.1 Introduction

The Clinger-Cohen Act assigns responsibility for developing, implementing, and maintaining enterprise architecture (EA) to Agency Chief Information Officers (CIOs). The EA is used to assure the integration of work processes with technology for achieving strategic goals. In past years, NASA has been involved with Office of Management and Budget (OMB) EA initiatives and worked on several EA compliance initiatives. These initiatives have ranged from development of the NASA Integrated Information Technology Architecture (NIITA), to the pilot NASA EA program through the Principal Center for Workgroup Hardware and Software (PCWHS), to the NASA Information Technology Initiative (NITI) study, and to various smaller projects such as the Data Mapping activity at JPL which addressed only the data portion of the entire EA focus. Each of these initiatives preceded the recently published reference models by the OMB (Performance, Business, Service, and Technology). NASA anticipates the maturity of Enterprise Architecture efforts within the federal government will increase rapidly.

In January 2003, the NASA Chief Technology Officer (CTO) began implementing a new Agency-wide Enterprise Architecture program that recognizes the new models and is intended to leverage the previous efforts into a sustained program. Appointed by the NASA CIO, the CTO is the officially recognized agency EA program executive. In this role, executive NASA management and all of the Mission Directorates endorse the CTO's EA approach. The Mission Directorates have directed mandatory participation at each of their program Centers. In turn, representatives from each NASA Center have been formally identified to contribute information, and an Agency working team has been established to communicate both understanding and approach for the Agency EA program.

NASA recognizes that these initial CTO EA activities are part of a larger program focus. Specifically, NASA views the EA program in two distinct life cycles:

- Life Cycle #1 – EA Program Development. Within this Life Cycle, architecture elements are characterized by "as-is," "to-be," and "transition" states. For example, today's "as-is" state focuses on information discovery, assimilation and analysis, information repository creation, and information assessment to establish a current enterprise architecture. An example of the "to-be" state is the One NASA model that includes the nine component categories for NASA OAIT investment management. An example of the "transition state" is the strategic alignment of IT investments that will evolve the architecture toward the "to-be" state.

- Life Cycle #2 – Architecture, Standards, and Technology Management. Within this Life Cycle, activities are focused on leveraging the architecture asset to more effectively manage technology changes. This includes activities such as assessment of new IT solutions against established architectural standards, IT portfolio management, exploration of emerging IT solutions, testing new and special-use solutions for integration with core infrastructure, and performing scalability assessments. A standard life cycle framework, such as one developed by Bell South, could provide a useful classification scheme for IT life cycle management.

The relationship between the two Life Cycles is Transition Management. Transition Management transforms the Enterprise Architecture from a logical framework into a robust operating entity where IT investments are delivering tangible returns against the programs they support.

The NASA EA Program is initially focused on forming and formalizing an ongoing and sustained process to manage these phases. The EA Program is envisioned to consist of a phased process of capturing and modeling both the "as-is" and "to-be" architectures, using modeling and repository tools to maintain the information, and establishing trained teams, processes, data, and analytic capabilities sufficient to deliver a continuing return on investment. Full development of the Lifecycle #2 elements and re-invigoration of the Standards and Technology Management will take place as the new program management process becomes firmly established.

9.2 Overview

NASA is a complex organization whose main lines of business are research, development and exploration. This mission is not entirely unique to the federal government, but it is a small segment of overall government activities. The services are significantly different from the requirements of most other government agencies (shared only with Energy, Transportation, and the NSF). OMB is developing a Federal Enterprise Architecture, including a Business Reference Model, that acknowledges the main lines of business of NASA, but which is also aggressively moving toward standardization of many government-wide services and standards. OMB has identified the following scientific research and development "Services to the Citizen" lines of business that NASA supports:

- Scientific Innovation
- Space Flight Innovation
- Technological Innovation

It is critical to NASA that an equally aggressive internal project be undertaken, so that as the overall government EA and standards are developed, and the requirements and architectural characteristics appropriate to meet NASA's mission needs are appropriately incorporated into the Federal EA Reference Models.

The NASA CTO is developing a distributed Civil Service support team that is trained and knowledgeable in EA tools, methods, and processes. The program is accomplishing this by using a small, but highly experienced, team to carry out both an initial EA knowledge base development and a training and education process across all the NASA Centers. This ensures the knowledgebase can be validated, accepted, maintained and utilized in an effective ongoing process. The EA will improve the quality of IT services across the Agency and enable a highly effective and cost conscious common infrastructure. A strong EA will help reduce the overlaps and redundancies of services and investments and engage the mission entities as willing and satisfied participants of the overall IT management process.

9.3 Interview and Data Gathering Plan

The interview and data gathering activity is structured iteratively across a 3-year period, but with actionable deliverables provided periodically along the way. The activity will address all Centers and

NASA Mission Directorates, all current and planned Agency level IT initiatives and selected key program missions, and all identified FEA Reference Models. Clearly, this is an ambitious undertaking, with a high degree of integration across several dimensions of the FEA model required, and it is believed that an iterative process is the only way to effectively proceed within the resource constraints that exist.

A significant amount of information has been leveraged for initial analysis and assessment. Examples include:

- NITI Study
- NIITA Standard
- ODIN Environment Descriptions
- Center Strategic Implementation Plans
- Center-specific Architecture Descriptions
- OMB Budget Submission Data
- NASA Strategic Plan and Mission Directorate Strategic Plans
- Center Strategic Implementation Plans

The data collection approach initially leveraged this information as a logical starting point. This assured an effective re-use of information yielding a higher return on the Agency's EA development efforts.

In year one, NASA Headquarters and one Center from each of the four primary Mission Directorates (Enterprises) were examined in depth (accomplished via visits to each Center of several weeks duration). Based on the data gathering exercises, both a draft knowledge base structure and data templates for future activities was developed and initially populated. The output formed the first draft of a fully integrated EA knowledge base, tested against the initial Centers and the Enterprises. This knowledge base addresses the OMB Business Reference Model, Service Reference Model, and Technical and Data Reference Model levels of the FEA. In effect, we developed the NASA-specific definitions of these Reference Models as relevant to the core NASA missions. An Agencywide workshop was held in July 2004 to share the data and knowledge base developed to date. The team has begun validating the process and templates with all the Centers and is beginning to form an Agencywide inherently governmental, distributed Civil Service team. The team reports to the NASA CTO and their planned full-time job will be to complete and maintain the EA and governance models and their use in investment analysis.

In year two, additional Centers will be visited, as well as repeat visits as required to year one Centers. During this phase, select Civil Service staff at each Center will begin training on the selected modeling tools and their use for data capture, modeling, and EA analysis. The target will be to have an 80 percent complete portfolio of Agency, Enterprise, Center, and Mission IT initiatives captured, templates defined, significant population of all levels of the EA, and trial exercises of analytical procedures for integrating all these views conducted. A second workshop near the end of year two will be conducted during which the 80 percent portfolio will be put through an evaluation, utilization, and review process to establish readiness for full NASA-wide implementation.

During year three, the process, tools, templates, models and analytic methods will be used in a semi-production mode. The balance of the Centers will be visited for final training and data gathering,

missing elements of the portfolio will be identified and captured, and the evaluation of the process and its payoffs will be finalized for ongoing utilization. The Civil Service team will be prepared to serve as the ongoing distributed EA team supporting the CTO and the CIO investment process.

The schedule of Center visits and content foci is provided in Figure 4: Schedule of Center Visits and Content Foci. The table also indicates the focus of interviews and data gathering for each Center. Although the schedule and subjects are subject to change at the direction of the CTO as events dictate, the particular schedule has been carefully selected with the iterative nature of the program in mind.

NASA has an excellent start on developing the key components of the overall FEA as defined by the OMB reference models. For example:

- NASA has a rigorous program and project management process (i.e., NPR 7120.5) defined and adhered to across all major programs and projects.
- NASA has established processes and documents relating to both a Technical IT Reference Model and an IT Governance process.
- NASA has a vigorous and healthy IT Security program in place.
- NASA JPL has initiated a Center-level Data Reference Model, and the NASA XML and Knowledge Management Teams can provide a leveraged start for a Data Reference Model appropriate to NASA.
- NASA's IFMP has evolved integration processes appropriate for enterprise applications and consolidated services.
- The NASA CIO has proposed an Electronic Work Environment initiative that would service all Centers and Enterprises.
- The NASA Chief Engineer is proposing an Advanced Engineering Environment to standardize how NASA does engineering.
- The NASA Space and Earth Sciences communities are well underway with various Center/Program specific Integrated Design capabilities.

Figure 4: Schedule of Center Visits and Content Foci

FOCI	Program Year 1					Program Year 2				Program Year 3		
	GRC	GSFC	KSC	JPL	HQ	ARC	JPL	LaRC	JSC	MSFC	DFRC	SSC
Center Desktop	x	x	x	x	x	x		x	x	x	x	x
Center Network	x	x	x	x	x	x		x	x	x	x	x
Center IT Security	x	x	x	x	x	x		x	x	x	x	x
NCCS	x									x		
IFM	x											
AEE	x	x	x	x		x		x	x	x	x	x
Collaborative Tools	x											
System Engineering	x											
IDAC	x											
Team Collaboration	x											
Project Management Working Group	x											
One Major Program	x	x	x	x		x	x		x	x	x	x
ODIN		x										
Integrated Mission Design Center		x										
EOSDIS		x										
Electronic Work Environment Initiative			x									
NASA Portal				x								
Design Center				x								
Information Map				x								
Enterprise Requirements					x							
CoSMO						x						
High End Computing						x	x	x				
IT Security Principal Center						x						
Architecture, Standards, and Testing	x											
Design Center update							x					
STI Program								x				
Engineering Tools									x	x	x	x
NACC										x		
Integrated EA Workshop	Time/Location TBD					Time/Location TBD				Time/Location TBD		

It is clear that the IFM application has plowed new ground and implemented one architectural driver that must be accommodated by the infrastructure. But it is equally clear that initiatives in Science, Engineering and general Electronic Work Environment are rapidly emerging as contenders for elements of the Service Model and new drivers to be added to the Data and Technical Reference models. It is proposed that the primary focus of attention should be on developing and integrating these emerging initiatives as components of the Business, Service, Data and Technical reference models for NASA so as to mitigate the possibility that the corresponding sponsors (the Mission Directorates and the CIO IT Infrastructure) are driven to develop stove-piped architectures. It is critical that the Science, Engineering, and Mission communities be proactively and positively engaged in the process.

9.3.1 Tool Selection

An Enterprise Architecture modeling tool is critical to the success of this program. It will become the primary mechanism for organizing information about the business and capabilities of NASA, and the principal tool for communicating the contents of the EA to Agency stakeholders and managers. Further, the tool will facilitate in the analysis of information by providing traceability between architecture components, such as the relationship between technology solutions and the business strategies they support.

In program year one, a study was performed to analyze the capabilities of market-available, visual modeling tools that integrate business, process, data, and technology components of the Enterprise Architecture. The selected tool from Adaptive, Inc., called Information Technology Portfolio Manager (ITPM), is capable of scaling to support a NASA-wide EA program.

9.3.2 Team Interaction

Frequent communication among EA team members and with the NASA CIO Board will help to assure a level of program commitment among participants, and will help drive program achievement. In addition, joint planning will help guide a common and consistent program scope. Project development has been communicated to the Agency EA team principally through weekly teleconferences.

The availability of a virtual team space will assure team member access to program information whenever they need access to it. "eRoom" is the software solution for virtual team spaces. 'eRoom' provides access to all program information through an accessible document repository, has helped coordinate schedules through an on-line event calendar, and is used to manage task priorities, to-do lists, and threaded discussions.

9.4 Methodology

Our enterprise architecture development process is architecture-centric and based on the principles of the Federal Enterprise Architecture (FEA) Model. It focuses on the early development and base-lining of a framework architecture to facilitate parallel development, minimize rework, and increase the probability of component reuse and eventual system maintainability. Our architecture will serve as a solid basis against which to plan and manage component-based development. By design, the FEA suggests that components of the overall architecture be developed modularly such that non-linear progress toward an overall blueprint can be attained without requiring a stop-all action to complete.

Our development process encourages ongoing quality control and risk management. Quality assessment is built into the process and in all activities, involving all participants. It is never treated as an afterthought or as a separate activity. Risk management is also built into the process, so that risks to the success of the project are identified and attacked early in the development process, when there is time to react.

Modeling is a central part of our knowledgebase development activities. Models communicate the desired structure and behavior of a system, so we build them to visualize the system. We also build

them to better understand the environment we are building, which often exposes opportunities for simplification and reuse. We also build models to manage risk. Finally, the use of Enterprise-scalable modeling tools allows for quantitative analyses to be conducted.

Our development activities emphasize the creation and maintenance of models rather than paper documents. Models – especially those specifically using the Unified Modeling Language (UML[i]) – provide semantically rich representations of the environment under development. They can be viewed in multiple ways, and the information represented can be instantaneously captured and controlled electronically. The focus on models rather than paper documents minimizes the overhead associated with generating and maintaining documents. This approach maximizes the relevant information content and allows for analytical capabilities to be applied.

Our development approach also supports object-oriented techniques. Each model is object-oriented, based on the concepts of objects and classes and the relationships among them, and they use the UML as its common notation.

Performing the data collection, analysis, and modeling activities discussed above requires a process that is widely proven and rigorous but that can help deliver quick results. Our approach is based on the Zachman framework but by design does not achieve an "excruciating level of detail." Instead, our methodology is scoped to focus initially on the top two rows of the Zachman framework and then completing that view so future iterations of detail can be built upon a solid understanding of the enterprise's capabilities. However, the tools and approach are intended to enable penetration and analysis down through the technical rows of the Zachman model as needed.

9.5 Deliverables and Benefits

This program provides a number of tangible deliverables and benefits for NASA. The deliverables break down into two classes:

(1) artifacts.
(2) a populated EA decision support tool and analysis capability.

The benefits include improving the quality of IT services across the Agency, enabling a highly effective and cost conscious common infrastructure, reducing the overlaps and redundancies of services and investments, and engagement of the mission entities as willing and satisfied participants of the overall IT management process. In addition, the analysis and integration process delivered will enable business case analyses to provide estimates of resources saved through the EA.

In the class of artifacts, the primary deliverable will be a populated knowledge base with templates for data gathering and analysis. Template creation and population will take place iteratively over the 3 years of the project and will include various stand-alone documents in addition to the knowledge base. In particular, NASA overview versions of the OMB mandated reference models (Business, Service, Data, and Technical) will be produced. The initial drafts of the documents and the knowledge base will be subject to review and ratification of the NASA CTO and the CIO Advisory Board.

In the class of a decision support tool and analysis capability, the primary deliverables will be:

- tool acquisition and population.

- a trained Civil Service EA team.
- both an EA and processes for maintaining it consistent with the OMB FEAPMO Reference Models.

The process of example development, review, and training of the Civil Service team is a critical deliverable if NASA is to make the EA an effective and fully functioning tool for the NASA CIO. The role of the Civil Servant team is critical, they are the key domain experts that have detailed knowledge of the Agency's key programs and enterprise Architecture. The EA must become a NASA owned and operated entity, and this program provides a means to accomplish that end.

9.6 Staffing and Team Approach

Two concurrent teams support the NASA Agency EA capability. The first team is a small EA Core Team directly supporting the CTO in the Lifecycle 1 portions of the program. The second team is a larger Extended Enterprise Architecture team distributed across the Centers and the programs who are the interfaces between systems architects for OAIT, Program Unique IT, and Multi-Program / Project IT investments in Life Cycle 2 portions of the Program.

The Core Team is comprised of a small contract staff of knowledge experts in enterprise architecture and modeling tools and who have demonstrated experience in implementing EA's and project coordination support. The contract is in direct support of the NASA CTO but is managed through a contract at the Glenn Research Center. The team consists of: a GRC Task Manager, a Senior Enterprise Architect and Program Manager, an Enterprise Architect, and three Enterprise Architecture Modelers. Other subject matter experts are used on an interim basis as necessary. This team will be responsible for tool acquisition and support, initial data harvesting and knowledge base population, development of models, templates, and analysis tools, proposing architecture and technology initiatives, and training and ongoing support and maintenance of the EA environment.

The Extended Enterprise Architecture team has representatives from: the NASA CIO Office, the NASA Mission Directorates, Center OAIT, Program Unique IT, and Multi-Program / Project IT investment service providers, and various standards-setting bodies supporting the NASA CIO. The team members are highly knowledgeable of the respective IT Service areas and/or NASA missions and requirements. This team is ultimately responsible for capturing, validating, and maintaining the NASA-level architecture information, for utilizing the repository and analytic tools to conduct architectural "what-if" studies and business cases, and for preparing architectural and implementation initiatives for review, approval, and funding by the NASA CIO. This team will likely be structured into sub-teams. A production version of this team is currently in place, and its full duties and membership will be augmented during FY05 to accommodate changing Agency initiatives and priorities.