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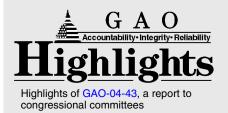
GAO

Report to Congressional Committees

November 2003

INFORMATION TECHNOLOGY

Architecture Needed to Guide NASA's Financial Management Modernization

G A O

Accountability ★ Integrity ★ Reliability

INFORMATION TECHNOLOGY

Architecture Needed to Guide NASA's Financial Management Modernization

Why GAO Did This Study

The National Aeronautics and Space Administration (NASA) is in the process of modernizing its financial management operations and supporting information technology systems. This modernization, known as the Integrated Financial Management Program (IFMP), is intended to provide NASA with an agencywide, integrated approach to performing critical business functions, such as contract management—an area that GAO first designated as high risk in 1990 and continues to do so today. GAO was requested to review various aspects of IFMP, and this report is one in a series on the program. The objective of this review was to determine whether NASA has been acquiring and implementing IFMP in the context of an enterprise architecture.

What GAO Recommends

GAO is making recommendations to the NASA Administrator for establishing an effective enterprise architecture management capability, ensuring the completeness of future releases of NASA's enterprise architecture, and minimizing its exposure to risk on IFMP caused by system component acquisition and implementation efforts that have proceeded to date in the absence of an enterprise architecture. NASA concurred with GAO's recommendations and described completed, ongoing, and planned actions to address them.

www.gao.gov/cgi-bin/getrpt?GAO-04-43.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Randolph C. Hite at (202) 512-3439 or hiter@gao.gov.

What GAO Found

To date, NASA has acquired and implemented significant components of IFMP without an enterprise architecture to guide and constrain the program. An enterprise architecture is an organizational blueprint that defines—in both business and technology terms—how an organization operates today and how it intends to operate in the future; it also provides a plan for transitioning to this future state. Using an enterprise architecture to guide and constrain systems modernization programs is a federal requirement and a recognized best practice of successful public and private organizations. In addition, GAO's research has shown that attempting major modernization programs such as IFMP without a well-defined enterprise architecture risks, among other things, building systems that are duplicative, are not interoperable, and do not effectively and efficiently support mission operations and performance.

During the course of GAO's work, NASA recognized the need for an enterprise architecture and has taken steps to develop one. For example, it has established an architecture program office, designated a chief architect, and selected an architecture framework to use. In addition, after GAO completed its audit work, NASA released an initial version of an enterprise architecture, which the chief technology officer stated was not yet complete and would be improved upon in future versions. However, the agency has yet to establish other key architecture management capabilities, such as designating an accountable corporate entity to lead the architecture effort, having an approved policy for developing and maintaining the architecture, and implementing an independent verification and validation function to provide needed assurance that architecture products and architecture management processes are effective. Moreover, the architecture products used to date to manage NASA's investment in IFMP did not provide sufficient context (depth and scope of agencywide operational and technical requirements) to effectively guide and constrain the program.

The chief technology officer agreed that NASA needs an effective enterprise architecture program and stated that efforts are under way to establish one. GAO's experience in reviewing other agencies has shown that not having an effective enterprise architecture program can be attributed to, among other things, an absence of senior management understanding and support, as well as cultural resistance.

NASA's current approach to acquiring and implementing IFMP outside the context of an architecture unnecessarily increases the risk that the program's system components will not effectively and efficiently support agencywide operations. The result will be costly system rework. It is critical for NASA to discontinue this approach and adopt the best practice of managing its IFMP system investments within the context of a well-defined enterprise architecture.

Contents

Abbreviations

ARC	Ames Research Center
CIO	chief information officer
CTO	chief technology officer
CRUD	create, read, update, and/or delete
DFRC	Dryden Flight Research Center
EAI	enterprise application integration
EA	enterprise architecture
FEAF	Federal Enterprise Architecture Framework
GRC	Glenn Research Center
GSFC	Goddard Space Flight Center
IFMP	Integrated Financial Management Program
IT	information technology
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
MSFC	Marshall Space Flight Center
NISSU	NASA's Information System Services Utility
NASA	National Aeronautics and Space Administration
OIG	Office of the Inspector General
OMB	Office of Management and Budget
SSC	Stennis Space Center
TRM	technical reference model

G A O
Accountability ★ Integrity ★ Reliability

United States General Accounting Office
Washington, D.C. 20548

November 21, 2003

The Honorable John McCain
Chairman
The Honorable Ernest F. Hollings
Ranking Minority Member
Committee on Commerce, Science
  and Transportation
United States Senate

The Honorable Sherwood L. Boehlert
Chairman
The Honorable Ralph M. Hall
Ranking Minority Member
Committee on Science
House of Representatives

To improve its ability to manage its contractors, which is an area that we designated as high risk in 1990, and continue to do so today,[1] the National Aeronautics and Space Administration (NASA) began its third attempt at modernizing its financial management systems in April 2000. This modernization effort, known as the Integrated Financial Management Program (IFMP), is expected to produce an integrated, NASA-wide business systems environment by acquiring and incrementally implementing commercial hardware and software components. Our research of successful public- and private-sector organizations shows that attempting a modernization program, like IFMP, without having and using a well-defined modernization blueprint, commonly called an enterprise architecture,[2] results in operations and systems that are duplicative, are not

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[1] In 1990, we began a special effort to review and report on the federal program areas that our work had identified as high risk because of vulnerabilities to waste, fraud, abuse, and mismanagement. We first issued our High-Risk Series in December 1992 and have since continued to include NASA's contract management as an area of high risk. See U.S. General Accounting Office, *High-Risk Series: NASA Contract Management*, GAO/HR-93-11 (Washington, D.C.: December 1992) and *High-Risk Series: NASA Contract Management*, GAO-03-119 (Washington, D.C.: January 2003).

[2] An enterprise architecture is a blueprint that defines, both in logical terms (including integrated functions, applications, systems, users, work locations, and information needs and flows) and in technical terms (including hardware, software, data, communications, and security), how an organization's information technology systems operate today, how they are to operate in the future, and a road map for the transition.

well integrated, are unnecessarily costly to maintain and interface, and do not effectively optimize mission performance.

In April 2003, we issued the first in a series of reports on the program, in which we concluded that NASA's approach to acquiring and implementing IFMP components had and would continue to introduce risk and increase the chances that the agency would fall short of meeting its program goal.[3] Because of the importance of IFMP to overall mission performance, you asked us to continue our review. Specifically, you requested that we determine whether (1) NASA has been acquiring and implementing IFMP in the context of an enterprise architecture, (2) the core financial module as implemented in June 2003 would satisfy NASA's key external reporting requirements, and (3) NASA's life-cycle cost estimate, program schedule, and funding reserves for IFMP were reasonable.

We are responding to the second two issues in separate reports,[4] as well as summarizing our findings on all three areas in an additional report.[5] This report addresses the first issue—whether NASA had and was using an enterprise architecture to acquire and implement IFMP. To accomplish this, we compared the architecture documents that NASA provided us, and represented as being used to manage IFMP, against published guidance governing the content of a well-defined architecture.[6] We also compared NASA's architecture development, maintenance, and implementation practices against our enterprise architecture management maturity

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[3]U.S. General Accounting Office, *Business Modernization: Improvements Needed in Management of NASA's Integrated Financial Management Program*, GAO-03-507 (Washington, D.C.: Apr. 30, 2003).

[4]U.S. General Accounting Office, *Business Modernization: NASA's Integrated Financial Management Program Does Not Fully Address Agency's External Reporting Issues*, GAO-04-151 (Washington, D.C.: Nov. 21, 2003) and *Business Modernization: Disciplined Processes Needed to Better Manage NASA's Integrated Financial Management Program*, GAO-04-118 (Washington, D.C.: Nov. 21, 2003).

[5]U.S. General Accounting Office, *Business Modernization: NASA Challenges in Managing Its Integrated Financial Management Program*, GAO-04-255 (Washington, D.C.: Nov. 21, 2003).

[6]See, for example, Office of Management and Budget, *Federal Enterprise Architecture Business Reference Model*, Version 1.0 (2002); Chief Information Officer Council, *A Practical Guide to Federal Enterprise Architecture*, Version 1.0 (February 2001); and Office of Management and Budget, *Management of Federal Information Resourc*es, Circular No. A-130 (Nov. 28, 2000).

framework.[7] Details on our objective, scope, and methodology are in appendix I.

Results in Brief

To date, NASA has acquired and implemented significant components of IFMP without an enterprise architecture, or modernization blueprint, to guide and constrain the program.[8] During the course of our review of this program, the agency recognized the need for an enterprise architecture and began efforts to develop one. For example, NASA established some important architecture management structures and process controls advocated by best practices and federal guidance, such as having an enterprise architecture program office; designating a chief architect; and using an architecture development methodology, framework, and automated tool. In addition, after we completed our audit work, the agency released an initial version of an enterprise architecture, which the chief technology officer stated was not yet complete and would be improved upon in future versions. However, NASA has yet to establish other key architecture management capabilities that are essential to having a mature, effective enterprise architecture program. Moreover, the architecture products that the agency has used to date in managing its $983 million IFMP investment[9] did not provide sufficient context (depth and scope of agencywide operational and technical requirements) to effectively guide and constrain the program. NASA's chief technology officer agreed that NASA needs an effective enterprise architecture program and stated that efforts are under way to establish one.

Our experience in reviewing other agencies has shown that not having an effective enterprise architecture program can be attributed to, among other things, an absence of senior management understanding and support, and cultural resistance to having and using one. Our experience also shows that attempting major modernization programs such as IFMP without having and using an enterprise architecture often results in system implementations that are duplicative, are not well integrated, and require

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[7]U.S. General Accounting Office, *Information Technology: A Framework for Assessing and Improving Enterprise Architecture Management*, Version 1.1, GAO-03-584G (Washington, D.C.: April 2003).

[8]NASA has acquired and implemented five of the nine planned major components of IFMP and is in the process of implementing the sixth component.

[9]GAO-04-118.

costly rework to interface. In the case of IFMP, this is occurring. Specifically, NASA's Office of the Inspector General (OIG) recently reported[10] that the agency would need to resolve several accounting and costing issues before the IFMP core system component provides full cost accounting capabilities. This means that the agency will now have to reconfigure the software for this component to reflect the issues' resolution. According to the chief technology officer, determining the need for additional rework of already implemented IFMP system components will be based on a future assessment of these components' alignment to an initial version of the agency's enterprise architecture that NASA first provided to us on September 24, 2003, which was after we had completed our audit work.

To assist NASA in its efforts to effectively and efficiently acquire and implement IFMP, as well as its recently launched efforts to develop and use a well-defined enterprise architecture, we are making recommendations to the Administrator related to establishing an effective enterprise architecture management capability, ensuring the completeness of planned future releases of its enterprise architecture, and minimizing its exposure to risk on IFMP caused by system component acquisition and implementation efforts that have proceeded to date without an enterprise architecture. NASA concurred with our recommendations, and described actions recently completed, ongoing, or planned to implement them.

Background

NASA's mission encompasses human exploration and development of space, the advancement and communication of scientific knowledge, and research and development of aeronautics and space technologies. Its activities span a broad range of complex and technical endeavors—from investigating the composition, evaluation, and resources of Mars; to working with the agency's international partners to complete and operate the International Space Station; to providing satellite and aircraft observations of Earth for scientific and weather forecasting purposes; to developing new technologies designed to improve air safety. NASA's workforce comprises over 19,000 civil service employees, primarily located at its headquarters and 10 major field centers, and more than 40,000 contractors and grantees, who collectively perform a wide range of roles

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[10]National Aeronautics and Space Administration Office of Inspector General, *Integrated Financial Management Program Core Financial Module Conversion to Full Cost Accounting*, IG-03-015 (Washington, D.C.: May 30, 2003).

and responsibilities. Table 1 describes the roles and responsibilities of NASA's headquarters and field centers.

Table 1: Overview of NASA's Organizational Components

NASA headquarters and field centers	Location	Roles/responsibilities
NASA Headquarters	Washington, D.C.	NASA headquarters manages the space flight centers, research centers, and other installations. It is responsible for determining programs and projects; establishing management policies, procedures, and performance criteria; evaluating progress; and reviewing and analyzing all phases of the aerospace program.
Ames Research Center (ARC)	Moffett Field, Calif.	ARC is a principal center for computational fluid dynamics, rotorcraft and powered-lift technology, artificial intelligence, and airborne sciences.
Dryden Flight Research Center (DFRC)	Edwards Air Force Base, Calif.	DFRC is the premier installation for aeronautical flight research.
Glenn Research Center (GRC)	Cleveland, Ohio	GRC, the lead center for aeropropulsion, is responsible for developing, verifying, and transferring aeropropulsion technologies to U.S. industry.
Goddard Space Flight Center (GSFC)	Greenbelt, Md.	GSFC is a major U.S. laboratory for developing and operating unmanned scientific spacecraft.
Jet Propulsion Laboratory (JPL)	Pasadena, Calif.	JPL is the lead U.S. center for robotic exploration of the solar system, with a primary focus on planetary exploration (e.g., missions to Mars) and environmental research (e.g., Shuttle Imaging Radar). The California Institute of Technology manages JPL for NASA.
Johnson Space Center (JSC)	Houston, Tex.	JSC is the primary center for designing, developing, and testing spacecraft and associated systems for human flight, selecting and training astronauts, and planning and conducting human space flight missions.
Kennedy Space Center (KSC)	Cape Canaveral, Fla.	KSC is primarily responsible for ground turnaround and support operations, prelaunch checkout, and launching of the space shuttle and its payloads, including NASA's International Space Station. KSC is the nation's spaceport—the liftoff site for all manned missions into space.
Langley Research Center (LaRC)	Hampton, Va.	LaRC is primarily responsible for basic research in aeronautics and space technology. It is the lead center for managing NASA's technology development programs for future high-speed civil transport, hypersonic vehicle concepts, and general aviation.
Marshall Space Flight Center (MSFC)	Huntsville, Ala.	MSFC is the premier organization for developing space transportation and propulsion systems and for conducting microgravity research.
Stennis Space Center (SSC)	Hancock County, Miss.	SSC is the primary center for testing large rocket propulsion systems for the space shuttle and future generation space vehicles.

Source: NASA.

Transcending NASA's organizational components are six strategic mission enterprises or business areas, each with a unique set of strategic goals, objectives, and implementation strategies focused on the requirements of the agency's customers. Each enterprise draws on the capabilities of

several centers so that each center contributes to multiple enterprises. Table 2 summarizes NASA's strategic enterprises and the contributing centers.

Table 2: Overview of NASA's Strategic Enterprises and the Contributing Centers

Strategic enterprise	Primary goal	Contributing NASA centers
Aerospace technology	Pioneer and develop advanced technologies that, in turn, improve the air transportation system, access to space, and science missions. Includes helping others use NASA technology for nonaerospace commercial purposes and developing technology partnerships with those in industry and academia that are outside of traditional aerospace fields.	ARC, DFRC, GRC, and LaRC
Biological and physical research	Offer a unique laboratory in which to study biological and physical processes. Experiments that take advantage of this environment extend from basic biology to quantum mechanics and from fundamental research to research with near-term applications in medicine and industry.	ARC, GRC, JPL, JSC, KSC, and MSFC
Earth science	Seek to understand and protect our planet by advancing Earth-system science with a near-term emphasis on global climate change through the use of Earth remote-sensing spacecraft, airborne observations, space shuttle missions, and ground-based measurements.	ARC, DFRC, GSFC, JPL, LaRC, MSFC, and SSC
Education	Inspire students to pursue the study of science and engineering, with the ultimate goal of having them choose careers in aeronautics and space at NASA.	ARC, DFRC, GRC, GSFC, JPL, JSC, KSC, LaRC, MSFC, and SSC
Space flight	Provide critical enabling capabilities that make possible the science, research, and exploration achievements of the rest of the agency.	ARC, GRC, JPL, JSC, KSC, and MSFC
Space science	Seek to answer fundamental questions about life in the universe: how it arose, what its mechanisms are, where in the solar system life may have originated or may exist today, and whether there are similar planetary environments around other stars where the signature of life can be found.	ARC, GSFC, JPL, KSC, and MSFC

Source: NASA.

To execute its mission responsibilities, NASA performs numerous management functions, such as contract management, financial management, and human capital management, relying heavily on information technology (IT) to assist it in performing these functions. For fiscal year 2003, the agency estimated that it would spend approximately $2.3 billion on IT systems and services. Of this amount, NASA anticipated spending $32.5 million on IT security and $11 million on enterprise architecture.

NASA Continues to Face Challenges in Managing Large Programs

In January 2003, we reported[11] that NASA faced challenges that threaten its ability to effectively run its largest programs. We also reported that because these challenges are rooted in NASA's culture and long-standing ways of doing business, the agency needed to make a major transformation. In particular, we identified the following four performance and accountability challenges facing the agency:

- **Strengthening strategic human capital management.** NASA is facing shortages in its workforce, which could likely worsen as the workforce continues to age and the pipeline of talent shrinks. This dilemma is more pronounced among areas crucial to NASA's ability to perform its mission, such as engineering, science, and IT. NASA is addressing this challenge through strategic planning, through a new workforce planning and analysis system, and by requesting additional personnel flexibilities, among other initiatives.

- **Controlling International Space Station costs.** Development costs for this project have soared to the point where NASA has had to cut back the program substantially, including reducing construction, the number of crew members, and scientific research. These cutbacks have raised concern among NASA's international partners, who have a large stake in the scientific research to be performed on the station. Although NASA is instituting management and cost-estimating reforms, it still needs to reach agreement with its partners on its planned cutbacks.

- **Reducing costs of space launches.** The administration submitted an amendment to NASA's fiscal year 2003 budget request, which (1) extends the life of the space shuttle and enhances its reliability, (2) funds the development of a new vehicle for ferrying crew to and from the space station, and (3) alters the time frame for a shuttle replacement. Accomplishing these and other goals related to space launches will be difficult and risky in light of the technology advances that NASA would like to pursue and the high degree of communication and coordination required among industry and government partners.

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[11]U.S. General Accounting Office, *Major Management Challenges and Program Risks: National Aeronautics and Space Administration*, GAO-03-114 (Washington, D.C.: January 2003).

- **Improving contract management.** NASA spends most of its funds on acquisitions.[12] Yet, for many years, the agency has been unable to oversee contracts effectively, principally because it lacked accurate and reliable information on contract spending and placed little emphasis on end results, product performance, and cost control. NASA has addressed many acquisition-related weaknesses and is beginning to tackle one of its most formidable barriers to sound contract management—the lack of a modern, integrated financial management system. Considerable work remains to be done since NASA is only in the early stages of designing and implementing this new system, and NASA reported that it is already facing challenges in terms of cost, interoperability, and security.

We also reported that NASA's ability to collect, maintain, and report the full cost of its projects and programs is weakened by diverse and often incompatible and nonintegrated center-level accounting systems; uneven and nonstandard cost-reporting capabilities; decentralized policies, procedures, and practices that are unique to its field centers; nonstandard data formats; and online financial information that is not readily available to program managers. Thus, it is difficult to ensure that contracts are being efficiently and effectively implemented and that budgets are executed as planned. This lack of integration and standardization also impedes the agency's ability to provide data required for external reporting purposes.

Recognizing the need for change, NASA's Administrator articulated a new vision for the agency—one that is science-driven, not destination-driven. To better enable NASA to fulfill this vision, the agency is taking on a major transformation aimed at eliminating stovepipes, becoming more integrated and results-oriented, and reducing risks while working more economically, efficiently, and effectively.

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[12]NASA spends 90 percent or $12.7 billion of its annual budget for aeronautical and space-related projects on the work performed by its contractors.

NASA Has Initiated a Large, Complex Systems Modernization to Address Financial Management Concerns

A key transformation effort is IFMP, which is NASA's third attempt in more than 12 years to modernize its financial management processes and systems. NASA spent about $180 million on its two prior failed efforts, and NASA's data indicate that the agency will spend approximately $983 million through 2010 for its current effort, IFMP, which it began in April 2000.[13] IFMP is expected to produce an integrated, NASA-wide financial management system by acquiring and incrementally implementing commercial software packages and related hardware and software components. The main objective of IFMP is to improve the financial, physical, and human capital management processes throughout the agency. According to NASA, once fully implemented, IFMP will reengineer NASA's business operations around industry "best practices" and use enabling technology to provide necessary management information to support implementation of the agency's strategic plan. To meet this objective and support these crosscutting activities, NASA has identified the following business drivers for the program:

- providing timely, consistent, and reliable information for management decisions;

- improving NASA's accountability and enabling full cost management;

- achieving increased efficiencies and operating effectively;

- exchanging information with customers and stakeholders in a timely and reliable way; and

- attracting and retaining a world-class workforce.

The IFMP system is to consist of nine modules supporting a range of functionality (see table 3).

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[13]GAO-04-118.

Table 3: Description and Status of NASA's IFMP System Modules

Module	Description	Reported status
Core financial	Support full cost management by providing agencywide standards for accounting and budget execution processes and financial reporting. Includes eight financial subprocesses: budget execution, purchasing, cost management, accounts payable, accounts receivable, fixed assets, standard general ledger, and federal reporting.	Operational as of June 2003.
Travel management	Streamline and unify the agency's employee travel system and improve traveler and vendor reimbursement. (According to NASA, this product has been integrated into the core financial module.)	Operational as of June 2003.
Executive financial management information system (Erasmus)	Provide budget, cost, and performance information for all major NASA programs and projects in a standardized format.	Operational as of July 2002.
Resume management	Enable applicants to search for matching NASA job listings and generate resumes online and allow NASA's human resources community to generate job listings while increasing efficiency and effectiveness.	Operational as of December 2001.
Position description management	Enable position descriptions to be rapidly generated and classified and associated documents to be automatically generated.	Operational as of early 2002.
Budget formulation	Enable the formulation of project, program, institutional, enterprise, and agency-level budget requirements. It will promote full cost management and real-time decision making.	Currently being implemented; to be operational at all locations in February 2004.
Integrated asset management	Enable financial reporting, physical inventory, maintenance, and liability reporting for the functional areas of aircraft, environmental, facilities, and logistics management.	Not yet initiated; no milestones set.
Procurement	Support the procurement, receiving, invoicing, and payment of materials. Will provide detailed and quantitative data to facilitate, economize, and expedite procurement processes.	Not yet initiated; no milestones set.
Human resources	Provide a human resources infrastructure that meets recordkeeping and process requirements while helping NASA managers fill positions with staff that possess the appropriate skill sets and career goals.	Not yet initiated; no milestones set.

Source: NASA.

As structured, NASA is the IFMP system integrator and thus is responsible for acquiring and integrating the multiple commercial components and ensuring that they collectively perform in a manner that meets the defined requirements. Table 4 describes the key IFMP program management positions/entities and their respective responsibilities.

Table 4: Summary of IFMP Management Structure

Management position/entity	Responsibilities
Program Executive	Manages, on a corporate level, program rollout, budget, performance, and schedule requirements; has decision authority over all program content, implementation schedules, and budget allocations; and provides leadership and accountability for top-level program requirements, implementation success criteria, overall performance definition, and strategic planning in the direction and operation of the Integrated Financial Management Program (IFMP).
Program Director	Implements IFMP according to specific guidelines (e.g., the program plan); reports to the Program Executive, and is under the oversight of the agency's Chief Financial Officer and the IFMP Steering Council.
Chief Financial Officer	Ensures that the program meets externally mandated requirements while satisfying internal customer needs in a cost-effective manner.
Steering Council	Acts as a forum for reviewing and approving the agencywide crosscutting facets of the program, including, for example, program strategy and budgets and expanding the scope of projects; resolves functional conflicts and ensures functional integration.
Project Manager (each NASA center has a Project Manager)	Plans and manages the implementation of each functional module approved by the program office; coordinates process team activities and supports the selection of software products, including updating requirements on the basis of the selected software's capabilities and the developed gap assessments, which identify differences between NASA's requirements and the software's capabilities.
Integration Project Manager	Establishes a viable technical infrastructure and ensures that the various functional module requirements are coordinated, ensures that each IFMP module is appropriately integrated/interfaced, minimizes redundant data, ensures that data definitions are consistent across modules, establishes life-cycle requirements, and performs configuration management.

Source: NASA.

Early Problems with IFMP Have Been Reported

In April 2003, we reported[14] that NASA was not following key best practices for acquiring and implementing IFMP. For example, the agency had not established an analytical capability to understand and proactively manage the dependencies among IFMP commercial components. Further, in implementing the core financial module component, NASA had deferred addressing the needs of key systems users and had not properly developed detailed system requirements. We concluded that the agency was at risk of making a substantial investment in a system that would fall far short of its stated goal of providing meaningful and reliable information to support effective program management and congressional oversight.

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[14]U.S. General Accounting Office, *Business Modernization: Improvements Needed in Management of NASA's Integrated Financial Management Program*, GAO-03-507 (Washington, D.C.: Apr. 30, 2003).

To address its problems, we recommended that NASA (1) develop and implement a short-term plan to identify and mitigate the risks currently associated with relying on already deployed IFMP commercial components and to expeditiously stabilize these components' operational capability and performance; (2) as part of the short-term plan, develop and properly document requirements, reengineer acquisition management processes, and fully engage stakeholders—including program managers, cost estimators, and the Congress—in the development of user requirements; and (3) develop a longer-term strategy for acquiring additional IFMP components that includes implementing a methodology for analyzing commercial system component dependencies. NASA concurred with the need for a short-term plan but disagreed with most of our findings and recommendations related to user needs and requirements and testing. NASA also agreed with the importance of having an approach for acquiring additional IFMP components, but stated that it already has an effective strategy in place.

In May 2003, NASA's OIG reported[15] that the core financial module software, which had been deployed at six NASA centers, had the capability to implement full cost accounting. However, before this implementation could take place, NASA needed to resolve several complex accounting and costing issues. These issues involved how to allocate service and general and administrative costs, civil service costs, and unassigned costs. Once these accounting and costing issues were resolved, the OIG reported that NASA would have to configure the IFMP software to reflect the changes. The OIG recommended that NASA revise the IFMP plans to include (1) time frames and milestones for completing steps to implement full cost accounting, including addressing and resolving the cost issues identified above; (2) identification of the personnel and other resources necessary to perform the steps within the established time frames; and (3) senior management approval and support of these additional procedures. IFMP officials concurred with the recommendations and plan to have all phases of full cost accounting implemented by October 1, 2003. (NASA reported that full implementation of the core financial module at all centers was completed in June 2003.)

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[15]National Aeronautics and Space Administration Office of Inspector General, *Integrated Financial Management Program Core Financial Module Conversion to Full Cost Accounting*, IG-03-015 (Washington, D.C.: May 30, 2003).

An Enterprise Architecture Is Critical to an Organization's Ability to Effectively Modernize Its Business Operations and Systems

Effective use of enterprise architectures, or modernization blueprints, is a trademark of successful public and private organizations. For a decade, we have promoted the use of architectures to guide and constrain systems modernization, recognizing them as a crucial means to a challenging goal: agency operational structures that are optimally defined in both business and technological environments. The Congress, the Office of Management and Budget (OMB), and the federal Chief Information Officer (CIO) Council have also recognized the importance of an architecture-centric approach to modernization. The Clinger-Cohen Act of 1996 mandates that an agency's CIO develop, maintain, and facilitate the implementation of architectures as a means for managing the integration of business processes and supporting systems. Further, OMB has issued guidance that, among other things, requires system investments to be consistent with these architectures.

An enterprise architecture provides a clear and comprehensive picture of an entity, whether it is an organization (e.g., federal department or agency) or a functional or mission area that cuts across more than one organization (e.g., financial management). This picture consists of snapshots of both the enterprise's current or "As Is" operational and technological environment and its target or "To Be" environment, as well as a capital investment road map for transitioning from the current to the target environment. These snapshots further consist of "views," which are basically one or more architecture products that provide conceptual or logical representations of the enterprise.

The suite of products and their content that form a given entity's enterprise architecture are largely governed by the framework used to develop the architecture. Since the 1980's, various frameworks have emerged and been applied. For example, John Zachman developed a structure or "framework" for defining and capturing an architecture.[16] This framework provides for six windows from which to view the enterprise, which Zachman terms "perspectives" on how a given entity operates: those of (1) the strategic planner, (2) the system user, (3) the system designer, (4) the system developer, (5) the subcontractor, and (6) the system itself. Zachman also proposed six abstractions or models associated with each of these perspectives: these models cover (1) how the entity operates, (2) what the

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[16]J.A. Zachman, "A Framework for Information Systems Architecture," *IBM Systems Journal* 26, no. 3 (1987).

entity uses to operate, (3) where the entity operates, (4) who operates the entity, (5) when entity operations occur, and (6) why the entity operates.

In September 1999, the federal CIO Council published the Federal Enterprise Architecture Framework (FEAF), which is intended to provide federal agencies with a common construct for their respective architectures, thereby facilitating the coordination of common business processes, technology insertion, information flows, and system investments among federal agencies. FEAF describes an approach, including models and definitions, for developing and documenting architecture descriptions for multiorganizational functional segments of the federal government. Similar to most frameworks, FEAF's proposed models describe an entity's business, data necessary to conduct the business, applications to manage the data, and technology to support the applications.

More recently, OMB established the Federal Enterprise Architecture Program Management Office to develop a federated enterprise architecture according to a collection of five "reference models:"

- The *Business Reference Model* is intended to describe the business operations of the federal government independent of the agencies that perform them, including defining the services provided to state and local governments.

- The *Performance Reference Model* is to provide a common set of general performance outputs and measures for agencies to use to achieve business goals and objectives.

- The *Data and Information Reference Model* is to describe, at an aggregate level, the types of data and information that support program and business line operations, and the relationships among these types.

- The *Service Component Reference Model* is to identify and classify IT service (i.e., application) components that support federal agencies and promote the reuse of components across agencies.

- The *Technical Reference Model* is to describe how technology is supporting the delivery of service components, including relevant standards for implementing the technology.

These various enterprise architecture frameworks differ in their nomenclatures and modeling approach. However, the frameworks consistently provide for defining an enterprise's operations in both (1) logical terms, such as interrelated business processes and business rules, information needs and flows, and work locations and users, and (2) technical terms, such as hardware, software, data, communications, and security attributes and performance standards. The frameworks also provide for defining these perspectives for both the enterprise's current or "As Is" environment and its target or "To Be" environment, as well as a transition plan for moving from the "As Is" to the "To Be" environment.

The importance of developing, implementing, and maintaining an enterprise architecture is a basic tenet of both organizational transformation and IT management. Managed properly, an enterprise architecture can clarify and help optimize the interdependencies and relationships among an organization's business operations and the underlying IT infrastructure and applications that support these operations. Employed in concert with other important management controls, such as portfolio-based capital planning and investment control practices, architectures can greatly increase the chances that organizations' operational and IT environments will be configured to optimize mission performance. Our experience with federal agencies has shown that investing in IT without defining these investments in the context of an architecture often results in systems that are duplicative, not well integrated, and unnecessarily costly to maintain and interface.[17]

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[17]See, for example, U.S. General Accounting Office, *DOD Business Systems Modernization: Improvements to Enterprise Architecture Development and Implementation Efforts Needed*, GAO-03-458 (Washington, D.C.: Feb. 28, 2003); *Information Technology: DLA Should Strengthen Business Systems Modernization Architecture and Investment Activities*, GAO-01-631 (Washington, D.C.: June 29, 2001); and *Information Technology: INS Needs to Better Manage the Development of Its Enterprise Architecture*, AIMD-00-212 (Washington, D.C.: Aug. 1, 2000).

IFMP Has Proceeded without an Enterprise Architecture, and NASA's Ongoing Architecture Management Efforts Are Missing Key Elements

NASA has thus far acquired and deployed IFMP without a sufficiently complete enterprise architecture to guide and constrain program investment decisions. During the course of our review of IFMP, NASA took steps to correct this situation by establishing key architecture management capabilities and undertaking the development of an initial version of an enterprise architecture that, according to the chief technology officer, will provide some missing contextual information (operational and technical). However, NASA has not established other key architecture management capabilities, such as designating an accountable corporate entity to lead the architecture effort, having an approved policy for developing and maintaining the architecture, and implementing an independent verification and validation function to provide needed assurance that architecture products and architecture management processes are effective. The chief technology officer agreed that NASA needs an effective enterprise architecture program and stated that efforts are under way to establish one. Based on our experience in reviewing other agencies, not having an effective enterprise architecture program is attributable to, among other things, limited senior management understanding and commitment and cultural resistance to having and using an architecture. The result is an inability to implement modernized systems in a way that minimizes overlap and duplication and maximizes integration and mission support.

The Architecture Products that NASA Has Used for IFMP Are Limited

As previously discussed, the various frameworks used to develop architecture products consistently provide for describing a given enterprise in both logical (e.g., business, performance, application, information) and technical (e.g., hardware, software, data) terms, and for doing so for the enterprise's current or "As Is" environment and its target or "To Be" environment; these frameworks also provide for defining a capital investment sequencing plan to transition from the "As Is" to the "To Be" environment. However, the frameworks do not prescribe the degree to which the component parts should be described to be considered correct, complete, understandable, and usable—essential attributes of any architecture. This is because the depth and detail of the descriptive content depends on what the architecture is to be used for (i.e., its intended purpose).

NASA's stated intention is to use an architecture as the basis for agencywide business transformation and systems modernization, including IFMP. This purpose necessitates that NASA's architecture products provide

considerable depth and detail, as well as logical and rational structuring and internal linkages. More specifically, it means that these architecture products should contain sufficient scope and detail so that, for example, (1) duplicative business operations and systems are eliminated; (2) business operations are standardized and integrated, and supporting systems are interoperable; (3) use of enterprisewide services is maximized; and (4) related shared solutions are aligned, like OMB's e-government initiatives.[18] Moreover, this scope and detail should be accomplished in a way that (1) provides flexibility in adapting to changes in the enterprise's internal and external environments; (2) facilitates its usefulness and comprehension by varying perspectives, users, or stakeholders; and (3) provides for properly sequencing investments to recognize, for example, the investments' respective dependencies and relative business value.

The architecture artifacts that NASA's chief technology officer provided to us and represented as those used to date in acquiring and implementing IFMP do not contain sufficient context (depth and scope of agencywide operational and technical requirements) to effectively guide and constrain agencywide business transformation and systems modernization efforts. More specifically, these artifacts do not satisfy the most basic characteristics of architecture content, such as clearly distinguishing between artifacts that represent the "As Is" and the "To Be" environments. The agency's chief technology officer agreed that these existing architecture products do not clearly distinguish between the two environments. Therefore, for purposes of our analyses, the chief technology officer told us to treat the architecture products as descriptive of the "To Be" environment, and to assume that any "As Is" content in these products represented capability intended for reuse in the future environment. This characterization is consistent with NASA contractual documents associated with developing these architecture products. On the basis of this characterization, we did not assess these artifacts for their "As Is" content and accepted the chief technology officer's acknowledgment

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[18]OMB has identified 24 e-government initiatives that are expected to support the goal of the President's management agenda and ultimately provide improved government services to citizens, businesses, and other levels of government. Examples of these initiatives include: (1) e-Grants, which will provide a single site intended to streamline the federal grants management process and allow customers of federal grants to find and apply for grants; (2) e-Payroll, which will simplify and integrate payroll systems across the federal government; and (3) e-Travel, which will streamline the government's travel administration by creating a governmentwide Web-based travel management service.

that this content was missing. Instead, we focused on the "To Be" content and the transition plan. To assess the "To Be" architecture products, we divided them into five architectural components similar to those in OMB's architecture reference models: the business, information/data, services/applications, technical, and performance components; we added security as a sixth component because of its recognized importance and relevance to the other five. We then compared architecture products NASA used to date for IFMP to relevant criteria[19] governing the content of key architectural elements for the transition plan and these six components of the "To Be" architecture. Based on this comparison, we determined whether the architecture products generally satisfied, did not satisfy,[20] or partially satisfied[21] each architectural element.

Overall, we found that NASA's "To Be" architecture products did not satisfy 18 of 35 (51 percent) key elements and partially satisfied the remaining 17 (49 percent), and its transition plan partially satisfied 1 (25 percent) of 4 elements and did not satisfy the remaining 3 (75 percent) (see fig. 1).

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[19]See, for example, Office of Management and Budget, *Federal Enterprise Architecture Business Reference Model*, Version 1.0 (2002); Chief Information Officer Council, *A Practical Guide to Federal Enterprise Architecture*, Version 1.0 (February 2001); Office of Management and Budget, *Management of Federal Information Resource*s, Circular No. A-130 (Nov. 28, 2000); M.A. Cook, *Building Enterprise Information Architectures: Reengineering Information Systems* (Prentice Hall Inc.: 1996); and National Institute of Standards and Technology, *Information Management Directions: The Integration Challeng*e, Special Publication 500-167 (September 1989).

[20]The architecture does not satisfy any aspects of this key architectural element.

[21]The architecture partially satisfies some aspects of this key architectural element but does not satisfy at least one significant aspect.

Figure 1: Summary of Extent to Which NASA's Architecture Products Satisfy Key Elements Governing Architectural Content

Source: GAO analysis of NASA data.

This means that the architecture products that NASA used to date in acquiring and implementing IFMP have not provided an adequate context in which to wisely invest in the program. In general, these products were limited to descriptions of (1) technology characteristics, which is one of many enterprise architecture elements, and (2) one of nine business operations (finance and accounting). Our specific analysis of "To Be" and transition plan products follows.

"To Be" Products: A "To Be" architecture is intended to capture the vision of future business operations and supporting technology. It should describe the desired capabilities, structures (e.g., entities, activities, and roles), and relationships among these structures at a specified point(s) in the future. The "To Be" architecture should show, for example, future business processes, information needs, and supporting infrastructure and be fiscally

and technologically achievable. According to relevant guidance,[22] the "To Be" architecture should contain, among other things, a description of (1) the future business operations that will be performed to support the organization's mission, including the entities or people that will perform the functions, processes, and activities, and the locations where the functions, processes, and activities will be performed; (2) the logical database model that is to be used to guide the creation of the physical databases where information will be stored; (3) the systems to be developed or acquired to support the business operations; (4) the physical infrastructure (e.g., hardware and software) that will be needed to support the business systems; (5) the organizations that will be accountable for implementing security and the tools to be used to secure and protect systems and data; and (6) the metrics that will be used to evaluate the effectiveness of mission operations and supporting system performance in achieving mission goals and objectives. By including these elements, the architecture would provide NASA with the necessary frame of reference for engineering business processes and systems in a manner that supports agencywide goals and objectives, such as ensuring that decision makers routinely receive timely, accurate, and reliable information.

The "To Be" architecture products used to date in acquiring and implementing IFMP provide minimal descriptive content. On the positive side, they contain a description of one future business operation (i.e., finance and accounting). However, they do not describe other future business operations (e.g., asset management and human resources). In addition, they do not describe (1) finance and accounting in terms of the entities or people who will perform the functions, processes, and activities and the locations where the functions, processes, and activities will be performed; (2) the logical database model to be used to create the physical databases; (3) the actual systems to be developed or acquired to support future business operations; (4) the physical infrastructure (e.g., hardware and software) that will be needed to support the business systems; (5) the organizations that will be accountable for implementing security and the

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[22]See, for example, Office of Management and Budget, *Federal Enterprise Architecture Business Reference Model*, Version 1.0 (2002); Chief Information Officer Council, *A Practical Guide to Federal Enterprise Architecture*, Version 1.0 (February 2001); Office of Management and Budget, *Management of Federal Information Resourc*es, Circular No. A-130 (Nov. 28, 2000); M.A. Cook, *Building Enterprise Information Architectures: Reengineering Information Systems* (Prentice Hall Inc.: 1996); and National Institute of Standards and Technology, *Information Management Directions: The Integration Challeng*e, Special Publication 500-167 (September 1989).

tools to be used to secure and protect systems and data; and (6) the metrics that will be used to evaluate the effectiveness of mission operations and supporting system performance in achieving mission goals and objectives. Without this information, the organization will not have a common vision and frame of reference for defining a transition plan to guide and constrain the transformation of business operations and associated capital investments and, thus, will be unable to effectively leverage technology to orchestrate logical and systematic change and optimize enterprisewide mission performance. Detailed results of our analysis are provided in appendix II.

Transition Plan Products: According to relevant guidance and best practices,[23] the transition plan should provide a temporal road map for moving from the "As Is" to the "To Be" environment. An important step in developing a well-defined transition plan is a gap analysis—comparison of the "As Is" and "To Be" architectures to identify differences. Other important steps include analyzing technology opportunities and marketplace trends, as well as assessing fiscal and budgetary realities and institutional acquisition and development capabilities. With the use of such analyses and assessments, options are explored and decisions are made regarding which legacy systems to retain, modify, or retire and which new systems to introduce on a tactical (temporary) basis or to pursue as strategic solutions. Accordingly, transition plans identify legacy, migration, and new systems and sequence them to show, for example, the phasing out and termination of systems and capabilities and the timing of the introduction of new systems and capabilities, and they do so in light of resource constraints, such as budget, people, acquisition/development process maturity, and associated time frames.

The transition plan artifacts that NASA relied on in acquiring and implementing IFMP generally do not possess these attributes. Specifically, they do not (1) provide a gap analysis identifying the needed changes to current business processes and systems; (2) identify all of the systems that will not become part of the "To Be" architecture, as well as the time frames for phasing out these systems; (3) show a time-based strategy for replacing legacy systems, including identifying intermediate (i.e., migration) systems

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[23]See, for example, Office of Management and Budget, *Federal Enterprise Architecture Business Reference Model*, Version 1.0 (2002); Chief Information Officer Council, *A Practical Guide to Federal Enterprise Architecture*, Version 1.0 (February 2001); and Office of Management and Budget, *Management of Federal Information Resources*, Circular No. A-130 (Nov. 28, 2000).

that may be temporarily needed; and (4) define the resources (e.g., funding and staff) needed to transition to the target environment. The result is that NASA has not had a meaningful and reliable basis for managing the disposition of its systems or for sequencing the introduction of modernized business operations and supporting systems. Detailed results of our analysis appear in appendix II.

The chief technology officer agreed that the architecture products used to date to acquire and implement IFMP do not provide sufficient scope and content to constitute a well-defined enterprise architecture. Based on our experience in reviewing other agencies, not having an effective enterprise architecture program is attributable to, among other things, limited senior management understanding and commitment and cultural resistance to having and using an architecture.

Our experience with federal agencies has shown that attempting to define and build major IT systems without first completing an enterprise architecture often results in IT systems that are duplicative, are not well integrated, are unnecessarily costly to maintain and interface, and do not effectively optimize mission performance. In fact, NASA's OIG recently reported[24] that the agency would need to resolve several accounting and costing issues before the IFMP core financial module, which is to implement NASA's finance and accounting business process, would be able to provide full cost-accounting capabilities as envisioned. To accomplish this, the agency will have to reconfigure the IFMP software to reflect these changes, resulting in system rework and additional associated costs that could have been prevented.

Beyond this known rework, additional corrective action could be necessary to address any misalignment between already implemented IFMP system components and NASA's just-released initial version of an enterprise architecture. Specifically, the chief technology officer provided us with an initial version of a NASA enterprise architecture on September 24, 2003, which was after we completed our audit work. According to this official, although this initial version of the architecture is incomplete, it does provide some of the missing contextual information (operational and technical) that we had identified during our review. The official also stated

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[24]National Aeronautics and Space Administration Office of Inspector General, *Integrated Financial Management Program Core Financial Module Conversion to Full Cost Accounting*, IG-03-015 (Washington, D.C.: May 30, 2003).

that future versions of the architecture are to be issued quarterly through June 2004 and semiannually thereafter, and that plans are currently being developed for assessing IFMP's alignment with the architecture. The IFMP deputy program manager affirmed these plans for assessing IFMP's alignment. In the likely event that any misalignment is found, NASA will be faced with additional system rework demands.

NASA Does Not Have Key Capabilities in Place for Effectively Managing Its Recently Launched Enterprise Architecture Effort

As NASA proceeds with its enterprise architecture effort, it is critical that it employs rigorous and disciplined management practices in doing so. Such practices form the basis of our architecture management maturity framework,[25] which specifies by stages the key architecture management controls that are embodied in federal guidance and best practices, provides an explicit benchmark for gauging the effectiveness of architecture management, and provides a road map for making improvements. Each of the five stages is described below.

1. *Creating enterprise architecture awareness.* The organization does not have plans to develop and use an architecture, or it has plans that do not demonstrate an awareness of the value of having and using an architecture. While stage 1 agencies may have initiated some architecture activity, these agencies' efforts are ad hoc and unstructured, lack institutional leadership and direction, and do not provide the management foundation necessary for successful architecture development.

2. *Building the enterprise architecture management foundation.* The organization recognizes that the architecture is a corporate asset by vesting accountability for it in an executive body that represents the entire enterprise. At this stage, an organization assigns architecture management roles and responsibilities and establishes plans for developing enterprise architecture products and for measuring program progress and product quality; it also commits the resources necessary for developing an architecture—people, processes, and tools.

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[25]U.S. General Accounting Office, *Information Technology: A Framework for Assessing and Improving Enterprise Architecture Management*, Version 1.1, GAO-03-584G (Washington, D.C.: April 2003).

3. *Developing the enterprise architecture.* The organization focuses on developing architecture products according to the selected framework, methodology, tool, and established management plans. Roles and responsibilities assigned in the previous stage are in place, and resources are being applied to develop actual enterprise architecture products. The scope of the architecture has been defined to encompass the entire enterprise, whether organization-based or function-based.

4. *Completing the enterprise architecture.* The organization has completed its enterprise architecture products, meaning that the products have been approved by the architecture steering committee or an investment review board, and by the CIO. Further, an independent agent has assessed the quality (i.e., completeness and accuracy) of the architecture products. Additionally, evolution of the approved products is governed by a written architecture maintenance policy approved by the head of the organization.

5. *Leveraging the enterprise architecture to manage change.* The organization has secured senior leadership approval of the enterprise architecture products and a written institutional policy stating that IT investments must comply with the architecture, unless granted an explicit compliance waiver. Further, decision makers are using the architecture to identify and address ongoing and proposed IT investments that are conflicting, overlapping, not strategically linked, or redundant. Also, the organization tracks and measures architecture benefits or return on investment, and adjustments are continuously made to both the architecture management process and the enterprise architecture products.

For stage 2, our framework specifies nine key practices or core elements that are necessary to provide the management foundation for successfully launching and sustaining an architecture effort. Examples of stage 2 core elements are described below.

- *Establish a committee or group representing the enterprise that is responsible for directing, overseeing, or approving the enterprise architecture.* This committee should include executive-level representatives from each line of business, and these representatives should have the authority to commit resources and enforce decisions within their respective organizational units. By establishing this enterprisewide responsibility and accountability, the agency

demonstrates its commitment to building the management foundation and obtaining buy-in from across the organization.

- *Appoint a chief architect.* The chief architect should be responsible and accountable for the enterprise architecture, supported by the architecture program office, and overseen by the architecture steering committee. The chief architect, in collaboration with the CIO, the architecture steering committee, and the organizational head, is instrumental in obtaining organizational buy-in for the enterprise architecture, including support from the business units, as well as in securing resources to support architecture management functions, such as risk management, configuration management, quality assurance, and security management.

- *Use a framework, methodology, and automated tool to develop the enterprise architecture.* These elements are important because they provide the means for developing the architecture in a consistent and efficient manner. The framework provides a formal structure for representing the enterprise architecture, while the methodology is the common set of procedures that the enterprise is to follow in developing the architecture products. The automated tool serves as a repository where architectural products are captured, stored, and maintained.

- *Develop an architecture program management plan.* This plan specifies how and when the architecture is to be developed. It includes a detailed work breakdown structure; resource estimates (e.g., funding, staffing, and training); performance measures; and management controls for developing and maintaining the architecture. The plan demonstrates the organization's commitment to managing architecture development and maintenance as a formal program.

- *Allocate adequate resources.* An organization needs to have the resources (funding, people, tools, and technology) to establish and effectively manage its architecture. This includes, among other things, identifying and securing adequate funding to support architecture activities, hiring and retaining the right people, and selecting and acquiring the right tools and technology to support activities.

Our framework similarly identifies key architecture management practices associated with later stages of architecture management maturity. For example, at stage 3, the stage at which organizations focus on architecture

development activities, organizations need to satisfy six core elements. Examples of these core elements are discussed below.

- *Issue a written and approved organization policy for development of the enterprise architecture.* The policy defines the scope of the architecture, including the requirement for a description of the baseline and target architecture, as well as an investment road map or sequencing plan specifying the move between the two. This policy is an important means for ensuring enterprisewide commitment to developing an enterprise architecture and for clearly assigning responsibility for doing so.

- *Ensure that enterprise architecture products are under configuration management.* This involves ensuring that changes to products are identified, tracked, monitored, documented, reported, and audited. Configuration management maintains the integrity and consistency of products, which is key to enabling effective integration among related products and for ensuring alignment between architecture artifacts.

At stage 4, during which organizations focus on architecture completion activities, organizations need to satisfy eight core elements. Examples of these core elements are described below.

- *Ensure that enterprise architecture products and management processes undergo independent verification and validation.* This core element involves having an independent third party—such an as internal audit function or contractor that is not involved with any of the architecture development activities—verify and validate that the products were developed in accordance with architecture processes and product standards. Doing so provides organizations with needed assurance of the quality of the architecture.

- *Ensure that business, performance, information/data, application/service, and technology descriptions address security.* An organization should explicitly and consistently address security in its business, performance, information/data, application/service, and technology architecture products. Because security permeates every aspect of an organization's operations, the nature and substance of institutionalized security requirements, controls, and standards should be captured in the enterprise architecture products.

At stage 5, during which the focus is on architecture maintenance and implementation activities, organizations need to satisfy eight core elements. Examples of these core elements are described below.

- *Make the enterprise architecture an integral component of the IT investment management process.* Because the road map defines the IT systems that an organization plans to invest in as it transitions from the "As Is" to the "To Be" environment, the enterprise architecture is a critical frame of reference for making IT investment decisions. Using the architecture when making such decisions is important because organizations should approve only those investments that move the organization toward the "To Be" environment, as specified in the road map.

- *Measure and report return on enterprise architecture investment.* Like any investment, the enterprise architecture should produce a return on investment (i.e., a set of benefits), and this return should be measured and reported in relation to costs. Measuring return on investment is important to ensure that expected benefits from the architecture are realized and to share this information with executive decision makers, who can then take corrective action to address deviations from expectations.

Table 5 summarizes our framework's five stages and the associated core elements for each stage.

Table 5: Summary of the Maturity Stages and Core Elements of GAO's Enterprise Architecture (EA) Management Framework

Stage	Core elements
Stage 1: Creating EA awareness	• Agency is aware of EA.
Stage 2: Building the EA management foundation	• Adequate resources exist. • Committee or group representing the enterprise is responsible for directing, overseeing, or approving EA. • Program office responsible for EA development and maintenance exists. • Chief architect exists. • EA is being developed using a framework, methodology, and automated tool. • EA plans call for describing the "As Is" environment, the "To Be" environment, and a sequencing plan. • EA plans call for describing the enterprise in terms of business, information/data, application/service, and technology. • EA plans call for business, performance, information/data, application/service, and technology descriptions to address security. • EA plans call for developing metrics for measuring EA progress, quality, compliance, and return on investment.
Stage 3: Developing EA products (includes all elements from stage 2)	• Written and approved organization policy exists for EA development. • EA products are under configuration management. • EA products describe or will describe the enterprise's business, performance, information/data, application/service, and the technology that supports them. • EA products describe or will describe the "As Is" environment, the "To Be" environment, and a sequencing plan. • Business, performance, information/data, application/service, and technology descriptions address or will address security. • Progress against EA plans is measured and reported.
Stage 4: Completing EA products (includes all elements from stage 3)	• Written and approved organization policy exists for EA maintenance. • EA products and management processes undergo independent verification and validation. • EA products describe the "As Is" environment, the "To Be" environment, and a sequencing plan. • EA products describe the enterprise's business, performance, information/data, application/service, and the technology that supports them. • Business, performance, information/data, application/service, and technology descriptions address security. • Organization chief information officer has approved current version of EA. • Committee or group representing the enterprise or the investment review board has approved current version of EA. • Quality of EA products is measured and reported.
Stage 5: Leveraging the EA for managing change (includes all elements from stage 4)	• Written and approved policy exists for IT investment compliance with EA. • Process exists to formally manage EA change. • EA is integeral component of IT investment management process. • EA products are periodically updated. • IT investments comply with EA. • Organization head has approved current version of EA. • Return on EA investment is measured and reported. • Compliance with EA is measured and reported.

Source: GAO.

The state of NASA's implementation of key enterprise architecture management practices, conditions, and structures currently places the agency at stage 1 of our maturity framework. Specifically, it has satisfied all but one of the core elements associated with building the architecture management foundation—stage 2 of our framework—but only about 23 percent (5 of the 22) of the core elements associated with stages 3, 4, and 5. According to our framework, effective architecture management is generally not achieved until an enterprise has a completed and approved architecture that is being effectively maintained and is being used to leverage organizational change and support investment decision making; having these characteristics is equivalent to having satisfied all stage 3 core elements and many stage 4 and 5 elements.

Regarding stage 2 core elements, NASA has, for example, recently established a program office, assigned a chief architect, and selected a framework (Zachman) and automated tools (e.g., the Rational Rose by Rational Software Corporation/IBM Software Group). However, the agency has not satisfied a stage 2 core element that is critical to effective architecture management. Specifically, a committee or group representing the enterprise has not yet been established to guide, direct, or approve the architecture. Instead, the CIO is guiding the architecture development effort. Having such a corporate entity is critical to overcoming cultural resistance to using an enterprise architecture. Without such an entity to lead and be accountable for the architectural effort, there is increased risk that the architecture will not represent a corporate decision-making tool and will not be viewed and endorsed as an agencywide asset.

Concerning stage 3, NASA has not satisfied three of six core elements. For example, the agency does not have a written and approved policy for architecture development, which is a stage 3 core element. Without such a policy that, for example, identifies the major players in the development process and provides for architecture guidance, direction, and approval, NASA will be challenged in overcoming cultural resistance to using an enterprise architecture and achieving agencywide architecture commitment and support.

The agency also has yet to implement numerous stage 4 and 5 core elements. For example, NASA has not (1) documented and approved a policy for architecture maintenance, (2) implemented an independent verification and validation function that covers architecture products and architecture management processes, and (3) made the architecture an integral component of its IT investment management process. (The

detailed results of our assessment of NASA's satisfaction of each of the stages and associated core elements are provided in app. III.)

According to the chief technology officer, the agency recognizes the importance of having rigorous and disciplined architecture management controls and is in the process of establishing them. Our research of successful organizations and experience in reviewing other agency enterprise architecture efforts shows that not having these controls is, among other things, a function of limited senior management understanding of and commitment to an enterprise architecture and cultural resistance to having and using one. Until such barriers are addressed, and effective architecture management structures and processes are established, it is unlikely that any agency will be able to produce and maintain a complete and enforceable architecture or implement modernized systems in a way that minimizes overlap and duplication and maximizes integration and mission support.

Conclusions

NASA's acquisition and implementation of six major IFMP system components outside the context of an enterprise architecture was not a prudent decision. Such a systems modernization approach unnecessarily increases the risk that system components will not effectively and efficiently support agencywide operations, which in turn leads to costly system rework. It is critical for NASA to discontinue this approach and adopt the best practice of managing its IFMP system investments within the context of a well-defined enterprise architecture. In order to do so, it is important for NASA to establish an effective means for developing and implementing an architecture, which includes gaining top management understanding and support to lead the way in overcoming any cultural resistance. It is equally important that the agency ensure that the architecture contains sufficient depth and scope, quickly determine whether existing and planned IFMP component systems align with initial and subsequent versions of the architecture, and limit further investment in these systems until such determinations are made. To do less risks introducing additional system rework to that already facing the agency on already implemented system components.

Recommendations for Executive Action

To ensure that NASA has the necessary agencywide context within which to make informed IFMP and other systems modernization decisions, we recommend that the NASA Administrator demonstrate an institutional

commitment to developing and using an enterprise architecture by establishing a NASA enterprise architecture policy and designating a NASA architecture board, or comparable body, that is made up of agency executives who are responsible and accountable for developing and maintaining the architecture.

In carrying out its responsibility, we recommend that the Administrator direct the architecture board, in collaboration with the CIO, to ensure that the architecture content requirements identified in this report are satisfied by first determining the extent to which NASA's initial release of an enterprise architecture satisfies these content requirements and then developing and approving a plan for incorporating any content that is missing.

We further recommend that the Administrator direct the IFMP Program Executive Officer to appropriately limit acquisition and implementation activities until the agency ensures that the program's plans are aligned with the initial and subsequent versions of the enterprise architecture. In addition, we recommend that the Administrator direct the architecture board, in collaboration with the CIO, to immediately map already implemented IFMP components to the agency's enterprise architecture and report to the Program Executive Officer any instances of misalignment, the associated risks, and proposed corrective actions. Moreover, we recommend that the Administrator direct the Program Executive Officer to develop corrective action plans, as appropriate, that include specific milestones, cost estimates, and detailed actions to be taken to align the program with the enterprise architecture.

To further assist NASA, we recommend that the Administrator direct the board, in collaboration with the CIO, to ensure that the best practices involved in stages 3 through 5 of our enterprise architecture management maturity framework are implemented. More specifically, we recommend that the board and the CIO (1) establish a written and approved policy for architecture development, (2) place enterprise architecture products under configuration management, and (3) ensure that progress against architecture plans is measured and reported.

In completing the architecture, we recommend that the board and CIO (1) establish a written and approved policy for architecture maintenance; (2) ensure that enterprise architecture products and management processes undergo independent verification and validation; (3) ensure that architecture products describe the enterprise's business and the data,

application, and technology that supports it; (4) ensure that enterprise architecture products describe the "As Is" environment, the "To Be" environment, and a sequencing plan; (5) ensure that business, performance, data, application, and technology descriptions address security; (6) ensure that the CIO approves the enterprise architecture; (7) ensure that the steering committee and/or the investment review board has approved the current version of the enterprise architecture; and (8) measure and report on the quality of enterprise architecture products.

In implementing the architecture, we recommend that the board and CIO (1) establish a written and approved policy for IT investment compliance with the enterprise architecture, (2) ensure that the enterprise architecture is an integral component of IT investment management processes, (3) ensure that IT investments comply with the enterprise architecture, (4) obtain Administrator approval of each enterprise architecture version, (5) measure and report enterprise architecture return on investment, and (6) measure and report on enterprise architecture compliance.

Agency Comments and Our Evaluation

In written comments on a draft of this report signed by the Deputy Administrator (reprinted in app. IV), NASA concurred with our recommendations and described recently completed, ongoing, or planned efforts to address them. For example, the agency stated that it has developed a 3-year plan for refining the latest version of its architecture, as well as a plan to guide the agency in using the architecture to achieve NASA's strategic goals. In addition, the agency stated that it has adopted our architecture management maturity framework and is currently working to satisfy the framework's core elements, including establishing architecture policies and a function for independently verifying and validating architecture artifacts and management practices. Additionally, it stated that it plans to continually validate IFMP against its architecture on a quarterly basis.

NASA also stated that its CIO board, which is chaired by NASA's CIO and composed of the CIOs from the agency's six major lines of business and its ten field centers, serves as the NASA architecture board or steering committee. While we support CIO representation on an architecture steering committee, recognized best practices and our maturity framework both advocate that architecture ownership and accountability be vested with an enterprise's business owners. Thus, we state in our framework that the architecture steering committee should be composed of executive-level representatives from each line of business and that these representatives

should have the authority to commit resources and enforce decisions for their respective organizational units. Without such an entity to lead and be accountable for the architectural effort, there is increased risk that the architecture will be viewed solely as an IT tool and not represent a corporate, business-driven decision-making tool and will not be viewed and endorsed as an agencywide asset. Accordingly, it is important for NASA to ensure that its architecture board's membership includes business owner representation.

As agreed with your offices, unless you announce its contents earlier, we will not distribute this report further until 30 days from its date. At that time, we will send copies to interested congressional committees as well as to the NASA Administrator and the Director of OMB. We will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-3439 or hiter@gao.gov. Key contributors to this report are acknowledged in appendix V.

Randolph C. Hite
Director
Information Technology Architecture
  and Systems Issues

Objective, Scope and Methodology

To determine whether the National Aeronautics and Space Administration (NASA) had and was using an enterprise architecture to guide and constrain its investment in its Integrated Financial Management Program (IFMP), we requested all NASA enterprise architecture artifacts and related documentation that had been used to date to guide and constrain IFMP and, based on what we were provided by NASA's chief technology officer,[1] compared them to relevant guidance.[2]

In doing so, we first segmented our analysis of artifacts and guidance into the three primary component parts of any architecture: the "As Is" architecture, the "To Be," and the transition plan. We then further divided the "As Is" and "To Be" architectures into five architectural components similar to the Office of Management and Budget's architecture reference models: business, information/data, services/applications, technical, and performance. We also added security as a sixth component because of its recognized importance in the various architecture frameworks and relevance to the other five architectural components. Because NASA had not clearly distinguished between its "As Is" and "To Be" environments, the chief technology officer told us to treat the architecture products provided as the "To Be" environment and assume that any "As Is" content would be intended for reuse in the future environment. As a result, we did not analyze whether NASA's architecture products satisfied relevant "As Is" guidance; instead, we accepted the chief technology officer's acknowledgment that NASA did not have any "As Is" artifacts.

To augment our documentation reviews and analyses of architecture products used to date in acquiring and implementing IFMP, we also interviewed various officials, including the chief information officer and chief technology officer, to determine, among other things, the agency's plans to develop an enterprise architecture. Specifically, we inquired as to NASA's basis for selecting already acquired IFMP commercial products and

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[1]We reviewed technology architectures and an enterprise architecture for the IFMP core financial module.

[2]See, for example, Office of Management and Budget, *Federal Enterprise Architecture Business Reference Model*, Version 1.0 (2002); Chief Information Officers Council, *A Practical Guide to Federal Enterprise Architecture*, Version 1.0 (February 2001); Office of Management and Budget, *Management of Federal Information Resources*, Circular No. A-130 (Nov. 28, 2000); M.A. Cook, *Building Enterprise Information Architectures: Reengineering Information Systems* (Prentice Hall Inc.: 1996); and National Institute of Standards and Technology, *Information Management Directions: The Integration Challenge*, Special Publication 500-167 (September 1989).

its plans for selecting future IFMP modules, including whether the agency had developed an enterprise architecture to guide and constrain its future investment in IFMP.

We also requested information on ongoing efforts to develop the initial version of NASA's enterprise architecture, such as detailed program plans, updated policies and procedures, and the architecture itself, but this information was not provided until September 24, 2003, which was after we had completed our audit work. As a result, our review did not include an assessment of the initial version of NASA's enterprise architecture, which the chief technology officer stated addressed some, but not all, of the limitations discussed in this report.

To determine whether NASA's initial and subsequent versions of its enterprise architecture were supported by effective management structures and processes, we used our Enterprise Architecture Management Maturity Framework,[3] which describes the five stages of management maturity, and determined the extent to which NASA has adopted key elements of architecture management best practices embodied in the framework. To make this determination, we reviewed program documentation, such as program policies and procedures, an IBM report[4] on the agency's efforts to implement management processes and controls over its architecture development activities, and the architecture products used to date in acquiring IFMP system components, and we compared them to the elements in our framework. We did not independently validate the cost and budget information provided by the chief technology officer.

We conducted our work at NASA headquarters in Washington, D.C. We performed our work from June to mid-September 2003 in accordance with generally accepted government auditing standards.

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[3]U.S. General Accounting Office, *Information Technology: A Framework for Assessing and Improving Enterprise Architecture Management*, Version 1.1, GAO-03-584G (Washington, D.C.: April 2003).

[4]IBM, *NASA Enterprise Architecture: Roadmap for Building and Sustaining Business Value Through an Integrated EA*, Sept. 6, 2002.

Detailed Results of GAO's Analyses of Architecture Products Used to Date by NASA to Acquire and Implement IFMP

Detailed Analysis of NASA's "To Be" Architecture Products

Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
Business				
A description of the overall architectural vision and strategic goals that define what an organization wants to achieve.			X	The available architecture products contain a high-level description of the agency's OneNASA vision, which focuses on how technology will be managed to improve services (e.g., providing secure and highly interoperable information systems in support of all NASA operations). It lists mission statements for both the agency and the lines of business. The architecture also lists business architecture drivers, which can be considered business goals. However, the available architecture products do not contain a description of the strategic goals, objectives, missions, and implementing strategies established to support NASA lines of business. In addition, the architecture products do not explain what the OneNASA vision encompasses since it appears to be technology-centric, as opposed to business-centric (i.e., it addresses business, information/data, services/applications, and technology).
A business strategy, which defines how the enterprise's strategic goals and objectives will be achieved.			X	The available architecture products list business strategies, such as implementing the Integrated Financial Management Program (IFMP). However, they do not describe how these strategies will be implemented.
Common (standard and agencywide) policies, procedures, and business and operational rules for consistent implementation of the architecture.		X		
A description of key business processes and how they support the agency's mission, including the organizational units responsible for performing the business processes and the locations where the business processes will be performed. This description should provide for the consistent alignment of (1) applicable federal laws, regulations, and guidance; (2) agency policies, procedures, and guidance; (3) operational activities; (4) organizational roles; and (5) operational events and information.			X	The available architecture products contain a description of the finance and accounting processes (i.e., the processes to be supported by the IFMP core financial module). This description also identifies the subprocesses within these processes and includes detailed diagrams of process flows. However, these products do not identify the organizational units responsible for performing the finance and accounting business processes nor the locations where they will be performed. Moreover, the architecture products do not contain a description of other business processes, such as asset management, human resource management, and budget.

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Detailed Results of GAO's Analyses of
Architecture Products Used to Date by NASA
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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A description of the operational management processes to ensure that the agency's business transformation effort remains compliant with the business rules for fault, performance, security, configuration, and account management.		X		
A listing of opportunities to unify and simplify systems or processes across the agency.			X	The available architecture products recognize the need for an implementing strategy to streamline financial operations and identify IFMP as that strategy. However, the products do not describe specific opportunities for improving weaknesses in the "As Is" financial systems or processes or how IFMP will be implemented to achieve this unification/simplification.
A description of the organizational approach (processes and organizational structure) for communications and interactions among business lines and program areas for (1) management reporting, (2) operational functions, and (3) architecture development and use (i.e., how to develop the architecture description, implement the architecture, and govern/manage the development and implementation of the architecture).			X	The available architecture products contain a description of the management reporting lines for the agency's chief information officer (CIO) organization as it relates to managing the architecture products and standards. However, they do not describe the roles and responsibilities of other organizations. For example, these products do not have a model for roles and an organization chart that shows the lines of communication and reporting responsibilities for financial management operations.
Information/data				
A description of data management policies, processes, procedures, and tools (e.g., CRUD matrix[a]) for analyzing, designing, building, and maintaining databases in an enterprise architected environment.	X			
A description of the business and operational rules[b] for data standardization to ensure data consistency, integrity, and accuracy, such as business and security rules that govern access, maintenance, and use of data.			X	The available architecture products contain a description of technical standards currently being used. However, these products do not state whether these standards are still relevant or will need to be updated to reflect changes to the current environment. In addition, the architecture products do not identify data standards upon which business rules can later be developed.[c]
A data dictionary, which is a repository of standard data definitions for applications.	X			

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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A conceptual data model that describes the fundamental things/objects (e.g., invoices, financial statements, inventory) that make up the business, but without regard for how they will be physically stored. It represents the consolidated structure of business objects to be used by business applications.		X		
A logical database model that provides (1) the data structures that support information flows and (2) the basis for developing the schemas for designing, building, and maintaining physical databases.[d]		X		
A metadata[e] model that specifies the rules and standards for access to information.[f]		X		
A description of information flows and relationships between organizational units, business operations, and system elements.		X		
Services/applications				
A description of the end-user services to be provided by the application systems.		X		
A list of application systems (acquisition/development and production portfolio)[g] and their relative importance to achieving the agency's vision based on business value and technical performance.		X		
A description of the policies, procedures, processes, and tools for selecting, controlling, and evaluating application systems to enable effective IT investment management.		X		
A description of the enterprise application systems and components and their interfaces.[g]			X	The available architecture products contain a description of an enterprise application system that supports finance and accounting (IFMP core financial module) functions. They also identify legacy systems that interface with this application system. However, this description is limited to this one system.

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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A description of the common technical approach, policies, and procedures for developing/acquiring application systems throughout their life cycle, including requirements management, design, implementation, testing, deployment, operations, and maintenance. The common technical approach should also describe the process for integrating legacy systems with the systems to be developed/acquired.			X	The available architecture products list several architectural principles for system development and acquisition (e.g., modular design, open system approach) and identify a strategy (i.e., a hub-spoke configuration) for integrating legacy systems. They also identify a minimum set of technical standards for hardware and software. In addition, the architecture products contain policies and guidance for implementing systems. However, these products do not describe a common technical approach. In addition, the products did not state whether the existing policies and procedures are common, complete, and sufficient to effectively implement the architecture. They do recognize the need to revise existing policies and procedures.
Technical				
A list of infrastructure systems and their relative importance to achieving the agency's vision based on business value and technical performance.		X		
A description of the policies, procedures, processes, and tools for selecting, controlling, and evaluating infrastructure systems to enable effective IT investment management.		X		
A description of the technical reference model (TRM[h]) that describes the enterprise infrastructure services,[i] including specific details regarding the functionality and capabilities that these services will provide to enable development of application systems.			X	The available architecture products recognize the need for a TRM and contain a generic description of the TRM. These products also note that technology services needed to support the application portfolio should be defined and identify several of these services. However, according to NASA's chief technology officer, the TRM is incomplete and flawed. In addition, the list of technology services identified is incomplete.
A description in the TRM that identifies and describes the technical standards[j] to be implemented for each enterprise service.			X	The available architecture products note that these standards should be identified and documented. They also contain a list of specific standards. However, the architecture products do not state whether these standards are for the current or future environment. In addition, the architecture products do not identify the technical standards to be implemented for specific enterprise services, such as query processing.

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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A description of the physical IT infrastructure needed to support the developed and/or acquired systems, including the relationships among hardware, software, and communications devices.			X	The available architecture products contain a high-level description (i.e., diagrams without supporting narrative) of the IFMP core financial network, OneNASA network backbone, and NASA's Information System Services Utility (NISSU[k]) network architecture. However, these networks do not encompass the entire enterprise, but rather a subset of activities.
Common policies and procedures for developing infrastructure systems throughout their life cycle, including requirements management, design, implementation, testing, deployment, operations, and maintenance. These policies and procedures should also address the integration of applications, including legacy systems.			X	The available architecture products contain a list of policies and procedures for implementing systems. However, the products do not state whether these policies and procedures are common, complete, and sufficient to effectively implement the architecture.
Security				
A description of the policies, procedures, goals, strategies, and requirements relevant to information assurance and security and how they (the policies, procedures, goals, strategies, and requirements) align and integrate with other elements of the architecture (e.g., security services).			X	The available architecture products contain a high-level description of security goals and strategies and identify some security requirements. They also note that an "Information Assurance Trust Model" is needed and will be developed. The architecture products do not contain a description of security policies and procedures. They also do not identify important security requirements (e.g., availability and access control), nor do they link identified security requirements to security services. Moreover, the architecture products do not define the "Information Assurance Trust Model" or address plans for its completion. Finally, regarding the strategies, they do not identify and summarize the agency's most significant security risks. According to NASA's chief technology officer, a clear computer security policy does not exist within the agency, and there is a lack of understanding as to how such a policy could be integrated into the network infrastructure.
Definitions of security and information assurance related terms.			X	The available architecture products contain definitions for some security-related terms (e.g., authentication, confidentiality, and intrusion detection); however, they do not define other key terms listed (e.g., integrity, physical security, and encryption services). In addition, the definitions for these terms are inconsistent with the definitions shown in current standards (e.g., firewalls).

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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A listing of accountable organizations and their respective responsibilities for implementing enterprise security services. Organizational relationships are important to show in an operational view because they illustrate fundamental roles (e.g., who conducts operational activities) and management relationships (e.g., what is the command structure or relationship to other key players), and how they influence the operational nodes.		X		
A description of operational security rules that are derived from security policies.		X		
A description of enterprise security infrastructure services (e.g., identification and authentication) that will be needed to protect the agency's assets, and the means for implementing such a service (e.g., firewalls and intrusion detection software). This description should also address how these services will align and integrate with other elements of the architecture (e.g., security policies and requirements).			X	The available architecture products contain high-level descriptions of enterprise security services; however, in most instances, these products describe the technology components that will be implemented to provide the security service, and not the security service. For example, the architecture products classify "Audit Logs" as a security service; however, audit logs are generally the function/component within an "Auditing Service." The architecture products also do not link the security services to security policies, procedures, goals, strategies, and requirements.
A description of the security standards to be implemented for each enterprise service. These standards should be derived from security requirements. This description should also address how these services will align and integrate with other elements of the architecture (e.g., security policies and requirements).			X	The available architecture products contain a description of various security standards, but it is unclear if these standards are relevant to the "As Is" or "To Be" environment or both. In addition, the architecture products do not contain a traceability matrix that links goals, strategies, requirements, and services to the security standards and security products (e.g., SmartCard). They also do not clearly state whether the list of security standards for enterprise services is complete.

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Architecture Products Used to Date by NASA
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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A description of the protection mechanisms that will be implemented to secure the agency's assets, such as firewalls and intrusion detection software, including a description of the relationships among these protection mechanisms.			X	The available architecture products contain a high-level description of protection mechanisms (e.g., firewalls). However, they do not describe the level of protection needed and the types of services the protection mechanisms will provide to protect IFMP applications that access information/data, business services/applications, and the various networks. In addition, the architecture products do not contain a traceability matrix that links goals, strategies, requirements, and services to the security standards, so it is unclear whether this is the definitive list of protection mechanisms.
Performance				
A description of the processes for establishing, measuring, tracking, evaluating, and predicting business performance regarding business functions, baseline data, and service levels.		X		
A description of customer-focused measurable business goals and outcomes for business products and services through the execution of financial and financial-related business activities.		X		
A description of measurable technical goals and outcomes for managing technology products and services for the "To Be" architecture that enable the achievement of business goals and outcomes.		X		

Source: GAO analysis of NASA data.

[a]A CRUD (create, read, update, and/or delete) matrix shows the specific business functions and applications that create, read, update, and/or delete specific data elements, which enables the organization to develop applications.

[b]Business and operational rules define specific constraints for the data, such as security needs (e.g., confidentiality and accessibility of data) and actions that should or should not occur, such as updating or deleting data.

[c]The framework that NASA is using for architecture development does not identify a work product that supports the creation of business rules.

[d]Although the framework that NASA is using identifies a logical database model as a work product, the available architecture products do not include such a model, and there was contradictory evidence in the architecture products that stated that NASA considered this model to be nonessential. As a result, it is unclear whether the agency plans to produce a logical database model as part of its architecture description.

[e]Metadata is "data about data" that enables automation and consistent management and use of information, such as rules and standards.

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[f]The framework that NASA is using does not identify the metadata model as a type of work product nor does the agency's action plan address the development of a metadata model for later inclusion in the architecture description.

[g]While the framework that NASA is using does identify the application portfolio as a type of work product, the agency's action plan does not address the development of this portfolio for later inclusion in the architecture description.

[h]The technical reference model (TRM) describes how technology is supporting the delivery of service components, including relevant standards for implementing the technology. The TRM is a generally accepted representation of the generic components of an information system. It allows designers, developers, and users to agree on definitions, have a common understanding of the services to be provided, and identify and resolve issues affecting such requirements as interoperability, portability, reliability, scalability, and serviceability.

[i]Examples of enterprise services include application services, such as Web services, and collaboration services, such as instant messaging and video conferencing.

[j]Technical standards are strict rules and protocols governing how a given enterprise service is to be implemented.

[k]NISSU was initially established to support the deployment of the IFMP core financial module. However, NASA is now considering using this technical infrastructure to support the deployment of other enterprise applications that have yet to be identified.

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Detailed Results of GAO's Analyses of
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Detailed Analysis of NASA's Transition Plan Artifacts

Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	No	Partially	
Transition plan				
Analysis of the gaps between the baseline and target architecture for business processes, information/data, and services/application systems to define missing and needed capabilities.		X		
A high-level strategy[a] for implementing the enterprise architecture, including specific time-phased milestones for acquiring and deploying systems, performance metrics, and financial and nonfinancial resource needs.				
This strategy should include:				
• A listing of the legacy systems that will not be part of the "To Be" environment and the schedule for terminating these systems.			X	The transition plan identifies only the core financial legacy systems that have been or will be retired. It does not identify all legacy systems or provide a schedule for terminating these systems.
• A description of the training strategy/approach that will be implemented to address the changes made to the business operations (processes and systems) to promote operational efficiency and effectiveness. This plan should also address any changes to existing policies and procedures affecting day-to-day operations, as well as resource needs (staffing and funding).			X	The transition plan provides a high-level description of a training strategy and references a change management strategy for IFMP. It also identifies a business driver for improving human capital management within the organization. However, the architecture does not (1) address training needs for nonfinancial business operations, (2) contain training plans, (3) identify changes to existing policies and procedures, or (4) estimate resource needs. Moreover, this generic strategy was developed without the benefit of a gap analysis.
• A list of the systems to be developed/acquired/modified to achieve business needs and a description of the relationship between the system and the business need(s).			X	The transition plan notes that there is a list of project development initiatives, such as core financial and travel manager, but it does not provide a complete list of systems to be developed or acquired to achieve business needs (e.g., human resources and budget).
• A strategy for employing enterprise application integration (EAI) plans, methods, and tools to, for example, provide for efficiently reusing applications that already exist concurrent with adding new applications and databases.			X	The transition plan contains a description of an EAI strategy for IFMP applications. However, the transition plan does not state whether this strategy would be applied to other agencywide application systems.

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Key architectural element	Element satisfied?			Explanation of partially satisfied
	Yes	**No**	**Partially**	
A technical migration plan (systems, infrastructure, and data) that shows:				
(a) the transition from legacy to replacement systems with explicit "sunset" dates and intermediate systems that may be temporarily needed to sustain existing functionality during the transition period;		X		
(b) an analysis of system interdependencies, including the level of effort required to implement related systems in a sequenced portfolio of projects that includes milestones, timelines, costs, and capabilities; and		X		
(c) a cost estimate for the initial phase(s) of the transition and high-level cost projection for transition to the target architecture.		X		
A description of the architecture governance and control structure and the integrated procedures, processes, and criteria (e.g., investment management, security) to be followed to ensure that the agency's business transformation effort remains compliant with the architecture.		X		

Source: GAO analysis of NASA data.

[a]Acquisition/business strategy is a plan or action for achieving a specific goal or result through contracting for software products and services.

Assessment of NASA's EA Management Efforts against GAO's Architecture Management Maturity Framework

Stage	Core element	Satisfied?	Comments
Stage 1: EA awareness	Agency is aware of EA.	Yes	In December 2002, the CIO issued a memorandum stating the agency's intent to develop and use an EA.
Stage 2: Building the EA management foundation	Adequate resources exist (funding, people, tools, and technology).	Yes	According to the chief technology officer (CTO), the agency has adequate program funding. NASA estimates that it will cost $750,000 to develop its EA for fiscal years 2001 through 2003. Further, the agency reports that it has skilled staff (government employees and contractors) for its architecture program. In addition, NASA is using automated tools and technology, such as Rational Rose by Rational Software Corporation/IBM Software Group.
	Committee or group representing the enterprise is responsible for directing, overseeing, or approving the EA.	No	NASA has not assigned responsibility for directing, overseeing, or approving the EA to a committee or group comprising representatives from across the agency.
	Program office responsible for EA development and maintenance exists.	Yes	In December 2002, NASA established a program office that is responsible for EA development and maintenance.
	Chief architect exists.	Yes	In January 2003, NASA designated the CTO as the chief architect.
	EA is being developed using a framework, methodology, and automated tool.	Yes	The EA is being developed using the Zachman framework. According to the CTO, the agency is also using a defined methodology to develop the EA.[a] In addition, NASA is using automated tools, such as Rational Rose by Rational Software Corporation/IBM Software Group, to build the EA.
	EA plans call for describing both the "As Is" and the "To Be" environments of the enterprise, as well as a sequencing plan for transitioning from the "As Is" to the "To Be."	Yes	According to the CTO, the plans[b] for the EA provide for describing both the "As Is" and the "To Be" environments and a sequencing plan.
	EA plans call for describing both the "As Is" and the "To Be" environments in terms of business, performance, information/data, application/service, and technology.	Yes	According to the CTO, the plans[b] for the EA provide for describing both the "As Is" and the "To Be" environments in terms of business, performance, information/data, application/service, and technology.
	EA plans call for business, performance, information/data, application/service, and technology descriptions to address security.	Yes	According to the CTO, the plans[b] for the EA provide for addressing security for the "As Is" and "To Be" environments.
Stage 2: Building the EA management foundation	EA plans call for developing metrics for measuring EA progress, quality, compliance, and return on investment.	Yes	According to the CTO, the plans[b] for the EA provide for developing metrics to measure progress, quality, compliance, and return on investment.

**Appendix III
Assessment of NASA's EA Management
Efforts against GAO's Architecture
Management Maturity Framework**

(Continued From Previous Page)

Stage	Core element	Satisfied?	Comments
Stage 3: Developing EA products (includes all elements from stage 2)	Written/approved organization policy exists for EA development.	No	According to the CTO, the agency is revising its existing policy to require the development of an EA. As written, the policy requires the CIO to develop an information technology (IT) architecture, which is one aspect of an EA.
	EA products are under configuration management.	No	According to the CTO, EA products are not currently under configuration management.
	EA products describe or will describe both the "As Is" and the "To Be" environments of the enterprise, as well as a sequencing plan for transitioning from the "As Is" to the "To Be."	Yes	According to the CTO, the plans[b] for the EA products provide for describing the "As Is" and the "To Be" environments, as well as a sequencing plan.
	Both the "As Is" and the "To Be" environments are described or will be described in terms of business, performance, information/data, application/service, and technology.	Yes	According to the CTO, the plans[b] for the EA provide for describing both the "As Is" and "To Be" environments in terms of business, performance, information/data, application/service, and technology.
	Business, performance, information/data, application/service, and technology descriptions address or will address security.	Yes	According to the CTO, the plans[b] for the EA provide for the business, performance, information/data, application/service, and technology descriptions addressing security for the "As Is" and "To Be" environments.
	Progress against EA plans is measured and reported.	No	According to the CTO, the agency is measuring and reporting progress against EA plans; however, NASA was unable to provide evidence of these reports.
Stage 4: Completing EA products (includes all elements from stage 3)	Written/approved organization policy exists for EA maintenance.	No	There is no written/approved policy for EA maintenance.
	EA products and management processes undergo independent verification and validation.	No	According to the CTO, management processes are independently verified and validated, but EA products do not undergo independent verification and validation. According to the CTO, EA products will be subject to independent verification and validation in the future.
	EA products describe both the "As Is" and the "To Be" environments of the enterprise, as well as a sequencing plan for transitioning from the "As Is" to the "To Be."	No	According to the CTO, the plans[b] for the EA provide for describing both the "As Is" and the "To Be" environments of the enterprise, as well as a sequencing plan for transitioning from the "As Is" to the "To Be." However, the initial version of NASA's EA was not provided to us in time to determine if its products address this core element. Therefore, our analysis is based on the products that were used to date to guide and constrain IFMP.

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Efforts against GAO's Architecture
Management Maturity Framework**

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Stage	Core element	Satisfied?	Comments
Stage 4: Completing EA products (includes all elements from stage 3)	Both the "As Is" and the "To Be" environments are described in terms of business, performance, information/data, application/service, and technology.	No	According to the CTO, the plans[b] for the EA provide for describing both the "As Is" and "To Be" environments in terms of business, performance, information/data, application/service, and technology. However, the initial version of NASA's EA was not provided to us in time to determine if its products address this core element. Therefore, our analysis is based on the products that were used to date to guide and constrain IFMP.
	Business, performance, information/data, application/service, and technology descriptions address security.	No	According to the CTO, the plans[b] for the EA provide for the business, performance, information/data, application/service, and technology descriptions addressing security. However, the initial version of NASA's EA was not provided to us in time to determine if its products address this core element. Therefore, our analysis is based on the products that were used to date to guide and constrain IFMP.
	Organization CIO has approved current version of EA.	No	The CIO approved the initial version of the EA. However, the initial version of NASA's EA was not provided to us in time to determine if its products address this core element. Therefore, our analysis is based on the products that were used to date to guide and constrain IFMP.
	Committee or group representing the enterprise or the investment review board has approved current version of EA.	No	According to the CTO, the plans[b] for the EA do not provide for approval by a committee or group representing the enterprise or the investment review board.
	Quality of EA products is measured and reported.	No	According to the CTO, the quality of EA products is not measured and reported.
Stage 5: Leveraging the EA for managing change (includes all elements from stage 4)	Written/approved organization policy exists for IT investment compliance with EA.	No	There is no written/approved policy requiring IT investment compliance with the EA. The current policy requires the CIO to ensure that new IT investments are in alignment with technology architectures, which are one aspect of an EA. According to the CTO, this policy is being revised.
	Process exists to formally manage EA change.	Yes	According to the CTO, there is a process for formally managing EA change.
	EA is integral component of IT investment management process.	No	Since the EA is currently being developed and has not been used to date in acquiring and implementing IFMP, it is not part of the investment management process.
	EA products are periodically updated.	Yes	According to NASA, it plans to update the EA quarterly through June 2004, and semiannually thereafter.

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Assessment of NASA's EA Management
Efforts against GAO's Architecture
Management Maturity Framework

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Stage	Core element	Satisfied?	Comments
Stage 5: Leveraging the EA for managing change (includes all elements from stage 4)	IT investments comply with EA.	No	Since the EA is currently being developed and has not been used to date in acquiring and implementing IFMP, it is not part of the investment management process.
	Organization head has approved current version of EA.	No	The organization head has not approved the current version of the EA.
	Return on EA investment is measured and reported.	No	Metrics and processes for measuring EA benefits have not been developed, and an initial version of the EA has not been completed, thus precluding return-on-investment measurement.
	Compliance with EA is measured and reported.	No	Metrics for measuring EA compliance have not been developed, and an initial version of the EA has not been completed, thus precluding measuring and reporting on compliance.

Source: GAO analysis of NASA data.

[a]According to NASA, its methodology is from the following: Melissa A. Cook, *Building Enterprise Information Architectures: Reengineering Information Systems*, Prentice Hall Inc. (1996).

[b]We requested NASA's architecture program plan, but NASA did not provide it.

Comments from the National Aeronautics and Space Administration

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

October 31, 2003

Mr. Randolph C. Hite
Director
Information Technology and Systems Issues
United States General Accounting Office
Washington, DC 20548

Dear Mr. Hite:

Enclosed is the National Aeronautics and Space Administration's (NASA) response to the General Accounting Office (GAO) Draft Report, "Architecture Needed to Guide NASA's Financial Management Modernization," (GAO-04-43). The Agency concurs with your recommendations for corrective action. Please find enclosed our detailed comments on each individual recommendation.

My point-of-contact for enterprise architecture is Dr. John McManus, Chief Technology Officer, Office of the Chief Information Officer (CIO). He may be contacted by e-mail: jmcmanus@nasa.gov or by telephone at (202) 358-1802.

Cordially,

Frederick D. Gregory
Deputy Administrator

Enclosure

Enclosure

**NASA Response to Draft General Accounting Office's (GAO) Report:
"Architecture Needed to Guide NASA's Financial Management Modernization,"
(GAO-04-43)**

1. <u>GAO Recommendation:</u> **The Administrator establish a NASA Enterprise
   Architecture Policy and designate a NASA Architecture Board that is made up of
   Agency executives who are responsible and accountable for developing and
   maintaining the architecture.**

<u>NASA Response to GAO Recommendation 1:</u> <u>Concur.</u> The NASA enterprise
architecture policy guidance is contained in NPG 2800.1, *Managing Information Technology*.
NPG 2800.1 is currently being updated; the next version is due for release in the first quarter
of FY 2004. The updated NASA enterprise architecture policy will address the General
Accounting Office's recommendations on the issue.

The NASA Chief Information Officer (CIO) is responsible and accountable for developing
and maintaining the enterprise architecture. The NASA 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 and enterprise architecture are in alignment with NASA's vision, mission, and
strategic goals.

The NASA CIO Board serves as the NASA Architecture Board. The NASA CIO Board is
chaired by the NASA CIO and includes as members the CIO's from each of the 6 major
NASA enterprises and the 10 Field Centers.

In March of 2003, the NASA CIO established a NASA Enterprise Architecture Working
Group to develop and maintain future releases of the NASA Enterprise Architecture. The
NASA Enterprise Architecture Working Group is led by the NASA CIO's Chief Technology
Officer (Chief Enterprise Architect) and has representation from the 6 major NASA
enterprises and the 10 Field Centers. The NASA Enterprise Architecture Working Group
reports directly to the NASA CIO.

NASA's architectural development is an iterative and continuous process. NASA 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.

2. <u>GAO Recommendation:</u> **The Administrator direct the architecture board, in
   collaboration with the CIO, to ensure that the architecture content requirements
   identified in this report are satisfied by first determining the extent to which**

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NASA's initial release of an enterprise architecture satisfies these requirements, and then developing a plan for incorporating any content that is missing.

NASA Response to GAO Recommendation 2: Concur. On September 22, 2003, NASA delivered version 2.0 of the NASA Enterprise Architecture. NASA incorporated preliminary comments and suggestion from GAO in the drafting of Version 2.0 of the enterprise architecture. Version 2.0 meets the content requirements outlined in the draft GAO report. NASA also delivered a revised Information Resources Management Strategic Plan and an updated Capital Planning and Investment Control Process.

Version 2.0 of the NASA Enterprise Architecture documents the complete Agency enterprise architecture, including the Infrastructure, Office Automation and Telecommunications segment, a representative set of elements from the Mission Specific Information Technology (IT) segment and the Financial Architectural Segment. 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 made strong progress in developing and refining the Agency's enterprise architecture over the past year. The Agency enterprise architecture team has compiled the current "As-Is" architecture and is continuing refinement of the "To-Be" architecture. NASA has developed a detailed 3-year plan for continued refinement of the NASA Enterprise Architecture. The plan is described in Appendix A of Version 2.0 of the NASA Enterprise Architecture.

NASA has adopted the GAO architecture maturity framework and is currently in the selection process phase for an outside organization which would provide annual Independent Verification and Validation (IV&V) capability for our Enterprise Architecture and annual assessments on NASA's progress against the GAO architecture maturity framework.

In the near-term (development stage), the NASA Enterprise Architecture will undergo quarterly updates for 1 year, starting with the September 22, 2003, release of version 2.0. Version 2.1 will be released in December 2003, version 2.2 will be released in March 2004 and version 2.3 will be released in June 2004. Starting with version 3.0, scheduled for release in September 2004, the NASA 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. The details of the "To-Be" state for the President's Management Agenda Electronic Government (E-Gov) initiatives will be defined in versions 2.1, 2.2, and 2.3 of this document, as NASA and the Managing Partners for each initiative develop detailed development and integration plans.

3. GAO Recommendation: The Administrator direct the architecture board, in collaboration with the CIO, to ensure that best practices involved with stages 3 through 5 of the GAO architecture maturity framework are implemented.

    a. Establish a written and approved policy for architecture development.
    b. Place enterprise architecture products under configuration management.
    c. Ensure that progress against the architecture plan is measured and reported.

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NASA Response to GAO Recommendation 3: Concur. NASA has adopted the GAO
architecture maturity framework. Furthermore, NASA has made significant progress in
developing and refining its Enterprise Architecture over the past year. NASA is currently
interviewing potential vendors to provide an annual Independent Verification and Validation
of the NASA Enterprise Architecture artifacts and annual assessments against the GAO
architecture maturity framework.

NASA is also updating its published enterprise architecture development policy guidance,
contained in NPG 2800.1, *Managing Information Technology*. NPG 2800.1 is currently in
revision; the next version is due for release in the first quarter of FY 2004.

NASA placed all enterprise architecture products under configuration control and
management in August 2003. All of the enterprise architecture artifacts are stored in a
central repository managed by the NASA CIO's Chief Technology Officer (Chief Enterprise
Architect) and the NASA Enterprise Architecture Working Group.

Over the past year, NASA developed a 3-year plan for continued refinement of the NASA
Enterprise Architecture. The plan is described in Appendix A of Version 2.0 of the NASA
Enterprise Architecture document. The detailed enterprise architecture plan established the
NASA roadmap for progressing forward in the GAO architecture maturity framework. The
NASA CIO's Chief Technology Officer (Chief Enterprise Architect) will provide quarterly
updates on the progress against the architecture plan in FY 2004 and semi-annual reports
starting in FY 2005.

4. GAO Recommendation: The Administrator directs the architecture board and the
CIO:
   a. Establish a written and approved policy for architecture maintenance.
   b. Ensure that enterprise architecture products and management process
      undergo an independent verification and validation.
   c. Ensure that architecture products describe the enterprise's business and the
      data, application(s) and technology that supports it.
   d. Ensure that the enterprise architecture products describe the "As Is"
      environment, the "To Be" environment and a sequencing plan.
   e. Ensure the business, performance, data, application, and technology
      descriptions address security.
   f. Ensure the CIO approves the enterprise architecture.
   g. Ensure the steering committee and/or the investment review board has
      approved the current version of the enterprise architecture.
   h. Measure and report on the quality of the enterprise architecture products.

NASA Response to GAO Recommendation 4: Concur. As stated in our response to the
first and third recommendations, the NASA enterprise architecture policy guidance is

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contained in NPG 2800.1, *Managing Information Technology*. NPG 2800.1 is currently in revision; the next version is due for release in the first quarter of FY 2004.

The NASA Enterprise Architecture is a strategic tool linking 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 Control Process, and Information Technology service delivery models. NASA has adopted the GAO architecture maturity framework and is currently interviewing potential vendors to provide an annual Independent Verification and Validation (IV&V) of the NASA Enterprise Architecture and annual assessments on NASA's progress against the GAO architecture maturity framework.

The NASA Enterprise Architecture is a central element in the Agency's cohesive strategy for managing the Agency's IT infrastructure as an integrated architecture that supports 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 NASA 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 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 NASA 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.

NASA has adopted the major elements of the Federal Enterprise Architecture and is supporting the ongoing development of the Federal Enterprise Architecture. As a part of the development of the revised NASA Enterprise Architecture document, NASA mapped all general purpose and a representative subset of mission specific IT investments to the Federal Enterprise Architecture reference models. NASA has also extended the Federal Enterprise Architecture reference models to capture the unique elements of NASA science and research and technology missions.

NASA's Information Resources Management Strategic 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

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the Agency. The Information Resource Management Strategic Plan is a companion document to version 2.0 of the NASA Enterprise Architecture and serves as an overall roadmap that guides the Agency in using the NASA Enterprise Architecture as a framework for strengthening the management of NASA's information and technology resources through achievement of the Agency's strategic goals. The Information Resources Management Strategic Plan and the NASA Enterprise Architecture include the full spectrum of information resource management across the Agency, including business and administrative systems, mission specific systems, office automation, telecommunications, information technology infrastructure, security, and records management.

NASA recognizes that 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 broader alignment provides for greater interoperability, efficiencies, and quality of service. It is essential that NASA IT projects are planned and managed in a manner that integrates with mainstream Agency processes, including program/project management and budget processes.

5. **GAO Recommendation:** **The Administrator directs the architecture board and the CIO:**
    a. **Establish a written and approved policy for IT investment compliance with the enterprise architecture.**
    b. **Ensure that the enterprise architecture is an integral component of the IT investment management process.**
    c. **Ensure that IT investments comply with the enterprise architecture.**
    d. **Obtain Administrator approval of each enterprise architecture version.**
    e. **Measure and report enterprise architecture return on investment.**
    f. **Measure and report on enterprise architecture compliance.**

NASA Response to GAO Recommendation 5: **Concur.** As written earlier in our responses to the first and third recommendations, the NASA enterprise architecture policy guidance is contained in NPG 2800.1, *Managing Information Technology*. NPG 2800.1 is currently in revision; the next version is due for release in the first quarter of 2004. NPG 2800.1 and the revised Capital Planning and Investment Control Process, released on September 22, 2003, provide guidance for compliance with the NASA Enterprise Architecture and ensure that the NASA Enterprise Architecture is an integral component of the IT investment management process.

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 Information Resources Management Strategic Plan directly supports the NASA Strategic Plan by clearly linking information resources management strategies to the NASA vision, mission, strategic goals, and implementing strategies.

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The NASA Chief Information Officer (CIO) is responsible and accountable for developing and maintaining the NASA Enterprise Architecture. The NASA 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 resources management strategy and enterprise architecture are in alignment with NASA's vision, mission, and strategic goals. Based on these responsibilities, accountabilities and authority, the NASA CIO signs each version of the NASA Enterprise Architecture. Future versions will be routed to the NASA Administrator for approval before release.

The NASA CIO's Chief Technology Officer (Chief Enterprise Architect) has established enterprise architecture metrics for return on investment and compliance and will provide quarterly updates on the progress against the architecture plan in FY 2004 and semi-annual reports starting in FY 2005.

6. GAO Recommendation: The Administrator directs the architecture board in collaboration with the CIO, to:
   a. Immediately map already implemented IFMP components to the agency's enterprise architecture.
   b. Report to the IFM Program Executive Officer any instances of misalignment, the associated risks and proposed corrective actions.

NASA Response to GAO Recommendation 6: Concur. The alignment between the current and planned IFMP architecture and the current NASA Enterprise Architecture was validated as an integral phase of the development of version 2.0 of the NASA Enterprise Architecture. The IFMP Business Architecture is an integral element of the NASA Enterprise Architecture that was submitted to OMB by the NASA CIO on September 22, 2003. The NASA Enterprise Architecture Working Group will continue to work closely with the NASA CIO, the NASA CIO's Chief Technology Officer (Chief Enterprise Architect) and the IFM Program Executive Officer.

7. GAO Recommendation: The Administrator directs the IFM Program Executive Officer to appropriately limit acquisition and implementation activities until the agency ensures alignment of the program's plans with the initial release and subsequent versions of the enterprise architecture

NASA Response to GAO Recommendation 7: Concur. At this time, there are no outstanding alignment issues between the current and planned IFMP architecture and the current NASA Enterprise Architecture. The IFMP Business Architecture has been evaluated as a part of the development of the current release of the overall NASA Enterprise Architecture. The IFMP Business Architecture is an integrated element included in the NASA Enterprise Architecture that was submitted to OMB by the NASA CIO on September 22, 2003. NASA concurs that alignment of the IFMP program plans and the NASA Enterprise Architecture is critical to the success of the IFM Program. As a part of NASA's continuing enterprise architecture refinement process, and the IFM Program Management Plan, NASA has validated the alignment of IFMP with the NASA Enterprise Architecture. The NASA Enterprise Architecture Working Group will continue to work closely with the NASA CIO, the NASA CIO's Chief Technology Officer (Chief Enterprise Architect) and the IFM Program Executive Officer.

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GAO Recommendation: The Administrator directs the IFM Program Executive Officer to develop corrective action plans, as appropriate, that include specific milestones, cost estimates, and detailed actions to be taken to align the program with the enterprise architecture

NASA Response to GAO Recommendation 8: Concur. Although at this time, there are no alignment issues between the current and planned IFMP architecture and the NASA Enterprise Architecture. NASA concurs that ongoing alignment of the IFMP program plans and the NASA Enterprise Architecture is critical to the success of the IFMP Program. As part of NASA's continuing enterprise architecture refinement process and the IFM Program Management Plan, NASA will continue to validate, on a quarterly basis, the alignment of IFMP with the NASA Enterprise Architecture. If, in the future, any misalignment should occur the IFM Program Executive Officer will direct the IFM Program to develop corrective action plans which would include, as appropriate, specific milestones, cost estimates, and detailed actions to be taken to align the program with the NASA Enterprise Architecture. The NASA Enterprise Architecture Working Group will continue to work closely with the NASA CIO, the NASA CIO's Chief Technology Officer (Chief Enterprise Architect) and the IFM Program Executive Officer.
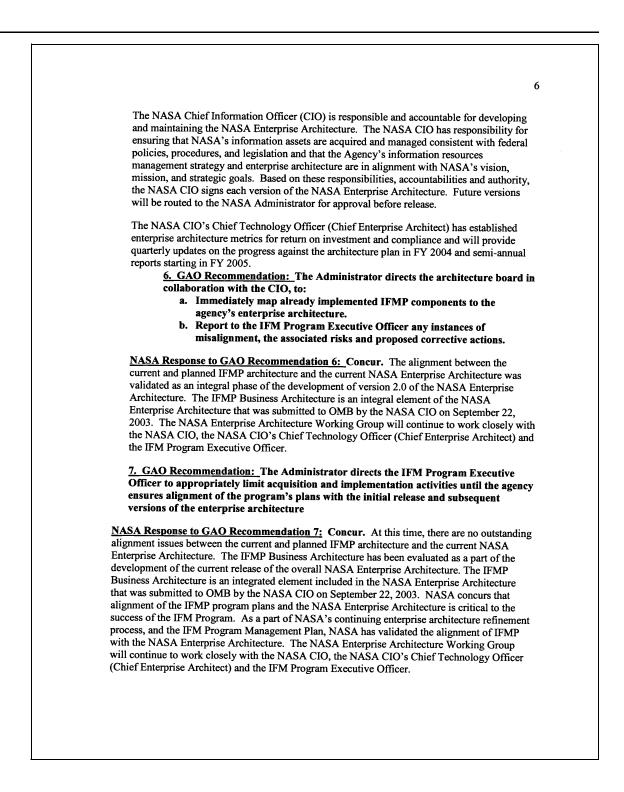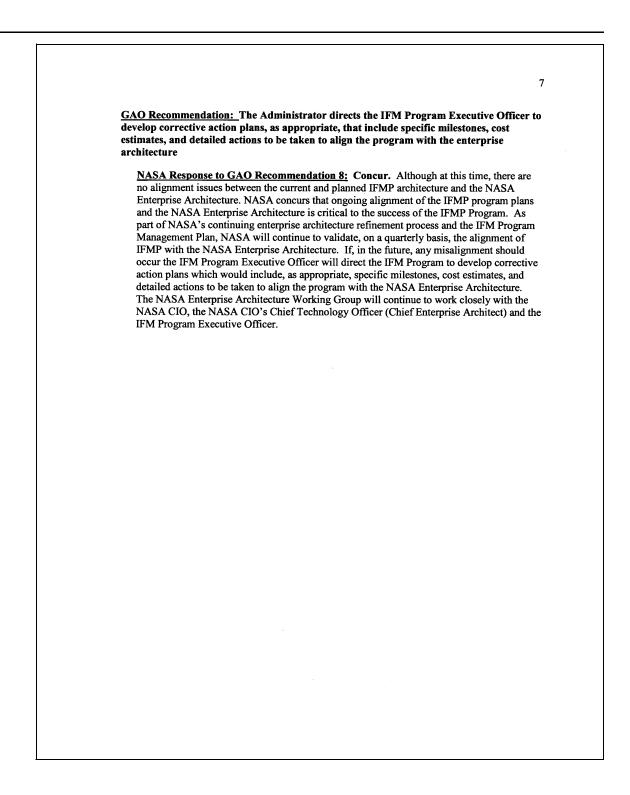
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Cynthia Jackson, (202) 512-5086

Acknowledgments

Staff making key contributions to this report were Sophia Harrison, Anh Le, Randolph Tekeley, William Wadsworth, and Lillian Whren.

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