27 INFRASTRUCTURE MANAGEMENT

Today's NAS infrastructure includes more than 30,000 air traffic control (ATC) systems. These infrastructure systems, which continue to increase in number faster than the Airway Facilities (AF) workforce that maintains them, include communication, surveillance, navigation and landing, weather sensors, and air traffic automation decision support systems (DSSs). NAS infrastructure systems support the air traffic operations carried out at air traffic control towers (ATCTs), terminal radar approach control (TRACON) facilities, air route traffic control centers (ARTCCs), airports, and other facilities. It is imperative that the performance of these systems be maintained to preserve the integrity of the NAS infrastructure and thereby avoid delays or disruptions in air traffic.

AF's greatest strength is the technical expertise of its workforce, its dedication to excellence, and the resulting level of public trust. The NAS infrastructure management (NIM) philosophy—which stresses decisionmaking alliances composed of AF elements and the AF customer base—has been initiated. AF operations business will be based on the NIM philosophy.

This philosophy embodies a strong customer orientation with an emphasis on cost-effectiveness and efficient and effective delivery of air traffic services. This concept, described in the *Airway Facilities Concept of Operations for the Future*, March 1995, represents a fundamental shift in the FAA's focus from the decentralized equipment maintenance performed today to centralized *service* management. The concept responds to anticipated changes in the NAS environment by promoting:

- Partnerships with organizations, both within and external to the FAA, to promote customer and stakeholder inclusion in setting strategic and tactical directions
- A strong customer orientation to ensure that AF is doing the right things, in a timely manner, to meet end-to-end customer service delivery needs
- A flexible, integrated information infrastructure to support the anticipation, identification, decisionmaking, and resolution of problems before service quality is affected
- A more expert workforce to exploit the full potential of emerging technologies and work "smarter" in meeting increased customer needs while maintaining workforce resources
- An emphasis on cost-effectiveness through a more businesslike approach to costs, measured performance, and focused resources.

A NIM capability combining technology, organizational changes, and reengineered processes will support the real-time information exchange essential to progress toward FAA/industry collaborative decisionmaking and the economics of implementing such concepts as Free Flight. NIM supports free flight through improved NAS service availability.

Implementing the infrastructure management philosophy will enable the FAA to provide more efficient and effective management of a growing NAS, reduce the NAS mean time to restore, and increase the productivity of the AF workforce, thereby improving air traffic services.

NIM implementation tools will be based on proven state-of-the-art systems management concepts in which functions are distributed among the central management servers, agents, and the managed resources themselves. NIM tools will use industry-standard computing platforms, information structures, and communication interfaces. The system technology will include commercial off-the-shelf (COTS) client/server platforms and applications that support industry standard management interfaces with open application program interfaces, standard data base technology, and interfaces for data sharing with other DSSs.

NIM tools build upon the remote maintenance monitoring system (RMMS) by leveraging existing assets and providing new automated management capabilities. Through NIM tools, the FAA will be able to remotely detect system faults and remotely resolve many faults. Collecting and analyzing more detailed fault and performance data will support proactive management of the NAS infrastructure. NIM capabilities will include remote monitoring and control; NAS modeling; and event, fault, maintenance, performance, resource, voice and data communications, and security management. The combination of new technology, organizational changes, and reengineered processes will enable the FAA to contain infrastructure maintenance costs while ensuring a consistently high level of service.

27.1 Infrastructure Management Architecture Evolution

The NIM phased implementation approach is based on the managed evolutionary development (MED) concept, which requires demonstrated performance before progressing to the next phase. Actual infrastructure management will be accomplished in four steps.

Step 1. Step 1 involved enhancing the RMMS by establishing remote monitor and control capabilities to nearly 4,000 remote NAS facilities. Initial stages of integration included development of a prototype NIM, which provided for a concept evaluation and investigated future development capabilities.

Step 2 (NIM Phase 1). During Step 2, an initial NIM capability will be incrementally deployed. Selected system service components (SSCs) (i.e., the National Operations Control Center (NOCC), operations control centers (OCCs), service operations centers (SOCs), national network control centers (NNCCs), work centers (WCs), and mobile system specialists capabilities) will be established during this time frame.

At the beginning of this step, NIM capabilities will be installed at four of the NIM SSCs, the NOCC, and the three OCCs. Prior to the beginning of final operational capability (FOC), resource management capabilities will be installed at all NIM SSCs. At this point, NIM will include new COTS-based resource management capabilities and legacy RMMS-based enterprise management capabilities. Full NIM resource and enterprise management capabilities will be operational at all SSCs by FOC.

Step 3 (NIM Phase 2). During Step 3, capabilities will be expanded and refined.

Step 4 (NIM Phase 3). Advanced NIM capabilities will be implemented, including intelligent fault correlation, reliability-centered maintenance, predictive maintenance, and NAS-wide information sharing.

27.1.1 Infrastructure Management Architecture Evolution—Step 1 (1996–1997)

The initial step in the evolution of infrastructure management consisted primarily of organizational changes, including consolidating management and maintenance facilities and acquiring and fielding advanced maintenance tools for operations support specialists. The RMMS is the primary automation system supporting NAS infrastructure operations during this step (see Figure 27-1). An integral part of the RMMS is the maintenance control center (MCC). AF's Maintenance Automation 2000 MCC operations concept focused on centralizing the management of maintenance operations for facilities at the sector level. These decentralized sectors operate and maintain equipment and facilities within their domain of responsibility based on local requirements and priorities. The MCC uses automation tools in a limited capacity to assess equipment performance, obtain real-time facility status information, perform remote facility certifications, and dispatch personnel as needed to accomplish facility/service restoration.

The heart of the RMMS network consists of 22 maintenance processor subsystems (MPSs) located within the ARTCCs. An additional MPS is located at the NIM premier facility (NPF) in Herndon, Va., which is co-located with the National Maintenance Control Center (NMCC), part of the ATC System Command Center. Using two resident software applications—the maintenance management system (MMS) and the interim monitoring and control system (IMCS)—maintenance personnel located in the MCCs remotely monitor the status of selected NAS subsystems, log maintenance actions, and report service and facility interruptions and equipment failures. The MPS also schedules preventive system maintenance actions and enables remote certification of facilities and equipment. Each MPS is capable of supporting up to four MCCs. The MPSs interface with NAS subsystems through a monitoring system function, which is either embedded or external to those subsystems. Some NAS subsystems provide their own monitoring/management and are known as element management systems.

Maintenance specialists at MCCs and at more than 300 work centers throughout the United

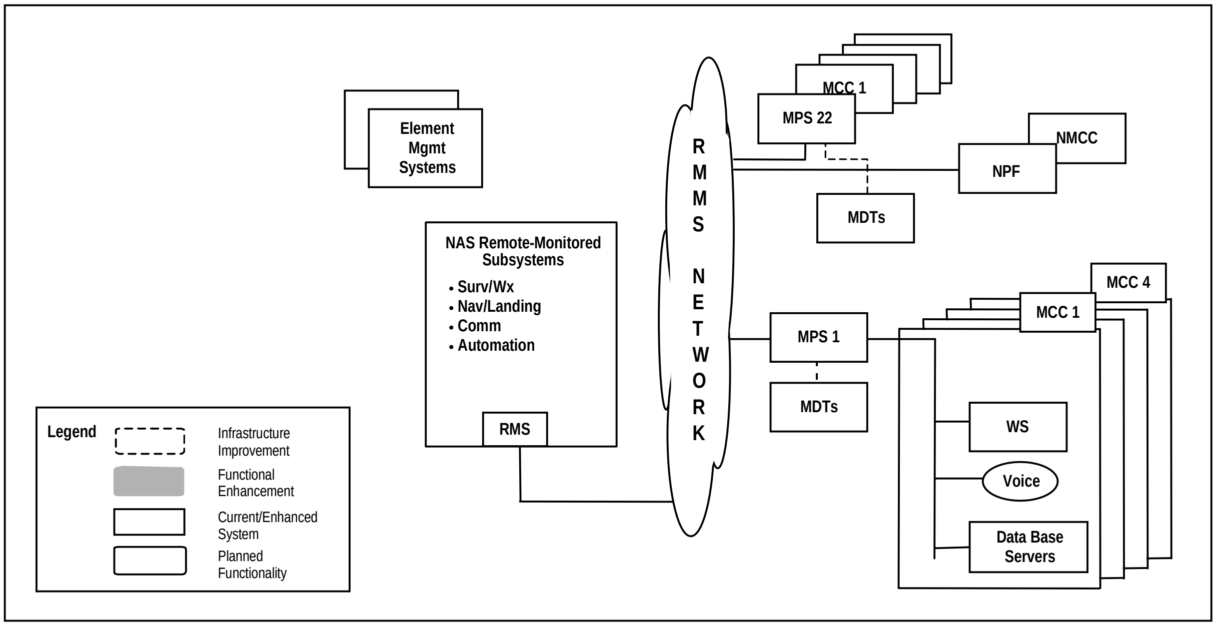

Figure 27-1. Infrastructure Management Architecture Evolution—Step 1 (1996–1997)

States have the primary responsibility for maintaining the NAS subsystems. Additionally, many remote facilities have permanent, onsite maintenance operations personnel due to their critical role in providing NAS services.

During Step 1, selected MCCs established prototype facilities for NIM concept evaluation and development capabilities.

27.1.2 Infrastructure Management Architecture Evolution—Step 2 (1998–2002)

The major activity at the beginning of Step 2, which is Phase 1 of the NIM implementation, was the opening of the NPF in June 1998. The NPF is used for demonstrations, training, and the development of new business processes, policies, and procedures. Initially, the NPF has demonstrated Build 1 and Build 2 of the NIM capabilities and will be able to continue the development of new business processes, policies, and procedures. In this step, the NPF will demonstrate the NIM Phase 1 initial operational capabilities that will be used at the NOCC, NNCCs, OCCs, SOCs, and WCs and by the mobile specialists. The major emphasis of NIM is on resource management. During this time frame, monitoring and control functions in the NPF will use the legacy system capabilities—the RMMS and element management systems.

The infrastructure management architecture for Step 2 (see Figure 27-2) is based on a three-tiered operations concept in which communications between tiers is provided via a local services network. NIM will consist of nodes located at one NOCC, two national network control centers (NNCCs), three OCCs, about 50 SOCs, and more than 300 WCs. The NOCC and OCCs will be responsible for centralized management of the NAS infrastructure.

NOCC. The NOCC is the operations control center that monitors the delivery of NAS infrastructure services to users and customers from a national perspective. It provides 24-hours-a-day, 7-days-a-week monitoring of infrastructure status and event response via OCC-reported information. The NOCC reports significant NAS infrastructure events to senior FAA management and coordinates transmittal of information to customers concerning events that could affect them. It monitors and assesses activities aimed at restoring services that have a critical affect on customers. Trend analysis such as the health of the NAS and NAS operational financial data will be available for FAA management analysis and reporting purposes at the NOCC.

OCCs. The primary role of each OCC is to manage the NAS infrastructure within its domain of responsibility. It directs the maintenance of NAS

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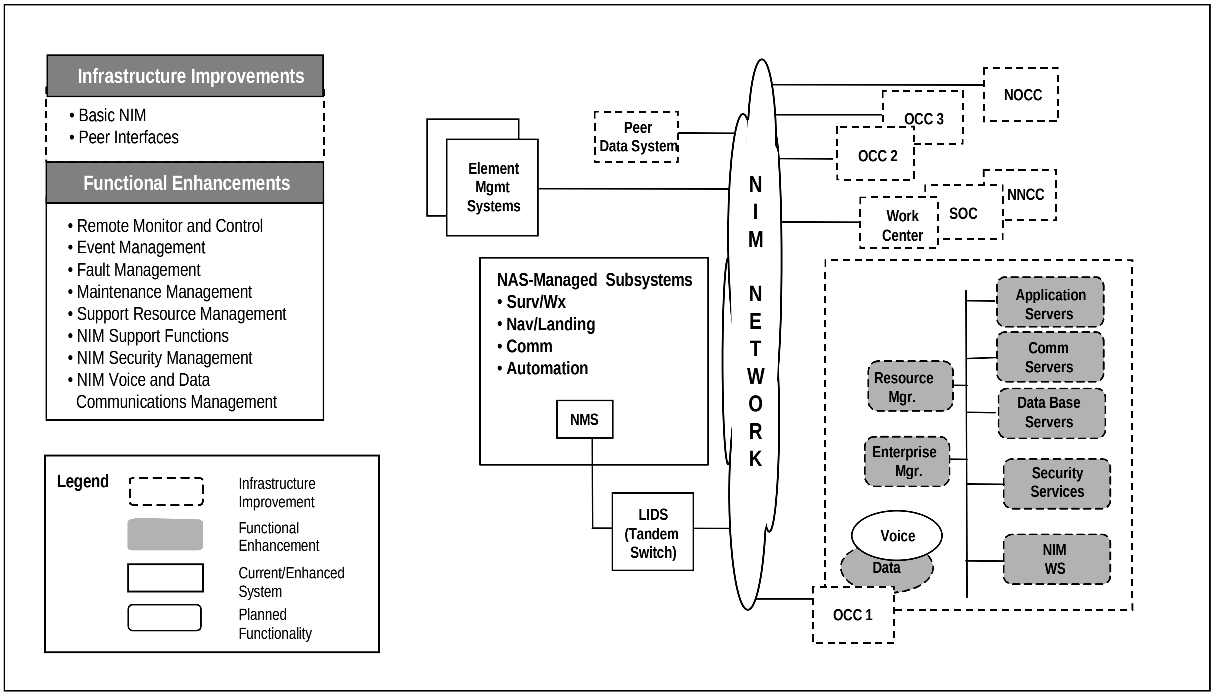

Figure 27-2. Infrastructure Management Architecture Evolution—Step 2 (1998–2002)

services and systems, providing active response and problem resolution. To accomplish this, each OCC operates 24-hours a day, 7 days a week, responding to faults and continuously monitoring the delivery of services and the status of the systems and equipment supporting those services. OCCs exercise operational control of their assigned domains of responsibility and oversee multiple work centers. Each OCC will be capable of assuming the responsibility of any other OCC that fails or is unable to provide services.

WC/SOC. The primary role of the WC is to maintain designated airways facilities. Each work center supervises its assigned workforce, ensures response to tasking, and is responsible for the equipment in specific geographic areas. SOCs are WCs that provide an AF presence at a high-impact facility when it has been determined that on-site coverage is necessary for efficient and effective delivery of service either to the facility or within a limited geographic area surrounding the facility. High-impact facilities include NNCCs, ARTCCs, large TRACONs, and ATCTs with significantly high numbers of operations. Operations support specialists will be provided with updated desktop and portable maintenance data terminals (MDTs). Cellular and satellite telephones and pagers will be used to supplement existing communications systems.

NNCCs. The primary role of the NNCCs is to monitor and control selected nationwide area telecommunications networks and to interface with the NOCC, OCCs, SOCs, and leased service providers to provide real-time operational status information. In addition, the NNCCs will interface with the appropriate OCCs for workforce and resource assignments during any planned or unplanned outages of NNCC-managed elements.

During Step 2, the MPS will transition to the Tandem switch, which is part of the legacy information distribution system (LIDS). RMMS functionality will be absorbed by the NIM resource manager located at the OCCs. Initially, IMCS functionality will transition to the maintenance automation system software (MASS) monitor and control function, which will reside in LIDS. By the end of Step 2, a COTS enterprise manager will be introduced. The interim and final enterprise managers will be capable of performing in an open operating system environment. The existing RMMS will be enhanced with an open system capability through LIDS. NIM tools and the enhanced RMMS will be collectively identified as NAS managed subsystems (NMSs). At the end of

Step 2, more than 6,000 NMSs will be automatically interfaced with the enterprise manager.

During Step 2, information from the logistics inventory system (LIS), corporate information management system (CIMS), regional information system (REGIS), and notice to airmen (NOTAM) will be available for NIM.

Basic functional capabilities included in Step 2 include:

- *NAS Modeling*: Define relationships between NAS elements, associate a criticality level to each resource, and provide tools to maintain a data base of the relationships
- *Remote Monitor and Control:* Remotely collect and process status information from NAS infrastructure resources, define authorized users, and establish access control to the commands
- *Event Management:* Classify and type events, and track NAS maintenance activities
- *Fault Management:* Generate alarms and alerts and manage actions to resolve the events that caused the alarms
- *Maintenance Management:* Match available maintenance resources with tasks that need to be completed
- *Support Resource Management:* Maintain information on the status of all resources required to support the NAS
- *NIM Support Functions:* Log, archive, and analyze NIM tool operational data
- *Security Management:* Protect NIM tool data via user identification, authentication, and access control mechanisms; support NAS-wide security management, such as detecting and logging NAS infrastructure security violations for reporting to FAA management
- *Manage NIM Voice and Data Communications:* Ensure appropriate communications capabilities at each user position.

27.1.3 Infrastructure Management Architecture Evolution—Step 3 (2003–2005)

Step 3 of the evolution, which is Phase 2 of the NIM implementation (see Figure 27-3), capitalizes and improves on the Phase 1 investment through the application of managed evolutionary development (MED). It will integrate existing element management systems, monitor environ-

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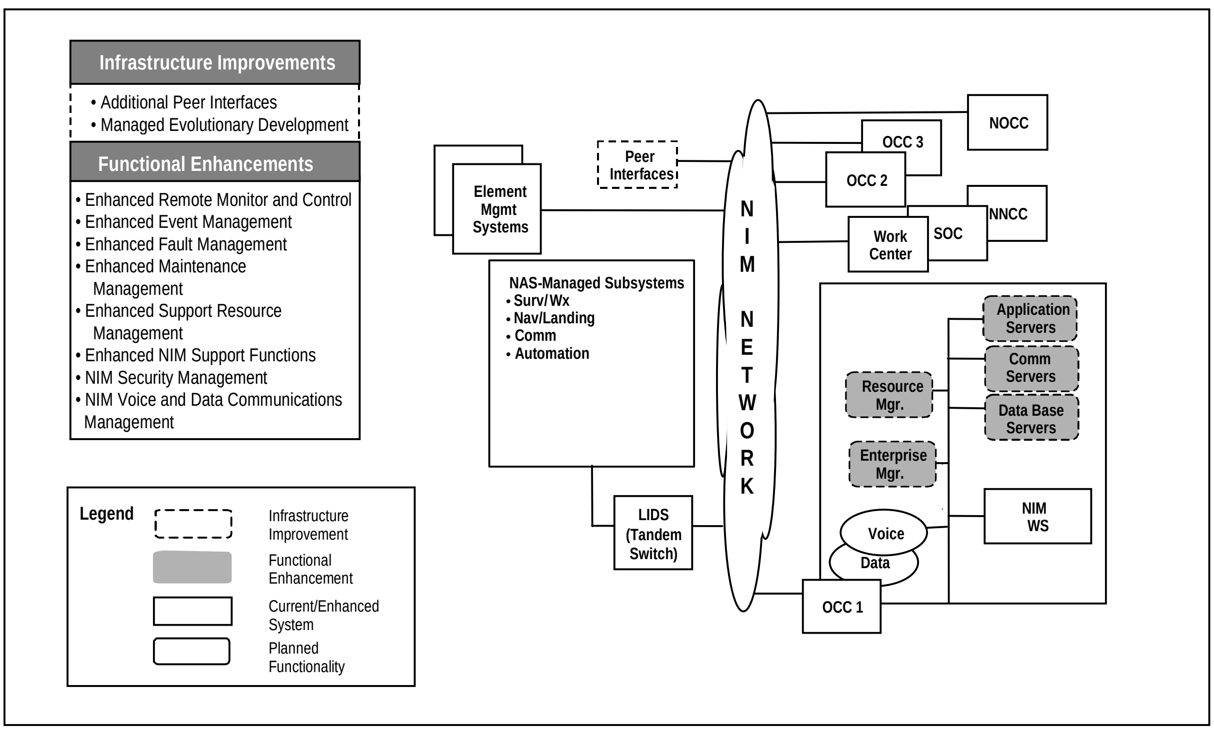

Figure 27-3. Infrastructure Management Architecture Evolution—Step 3 (2003–2005)

mental systems, and expand local information exchange services within the NAS.

The synergistic effect of integrating all resource management functions and the enterprise management function will result in seamless service management. Service management will improve services and reduce associated costs from both an individual or component service perspective and a multiservice perspective. The sum of multiple services forms the end-to-end service delivered to AF customers.

27.1.4 Infrastructure Management Architecture Evolution—Step 4 (2006–2015)

Step 4 of the evolution, which is Phase 3 of the NIM implementation (see Figure 27-4), will refine the capabilities provided in Steps 2 and 3 through continued application of MED. It will also initiate intelligent fault correlation, reliability-centered maintenance, predictive maintenance, enhanced information sharing with NIM tool internal and external users, and continued connection of new and legacy systems.

27.2 Summary of Capabilities

NAS infrastructure management development, through the process of MED, is leveraging the FAA's investment in the RMMS into a performance-based management system, which is focused on managing the NAS infrastructure so customer services are based on established performance standards, customer expectations, and business objectives. Following establishment of an initial RMMS capability in Step 1, each subsequent step in the evolution builds on the procurement of proven COTS products. Step 2 builds on the existing RMMS and establishes the three-tiered operations concept by:

- Establishing NOCC, OCC, and SOC/WCs
- Establishing a modern information infrastructure featuring resource and enterprise management, including security
- Establishing external interfaces with selected peer systems
- Increasing the number of remotely monitored and controlled NAS facilities
- Replacing technologically obsolete MDTs used by AF specialists
- Supplementing existing fixed communications capabilities with mobile communications equipment and services for AF specialists.

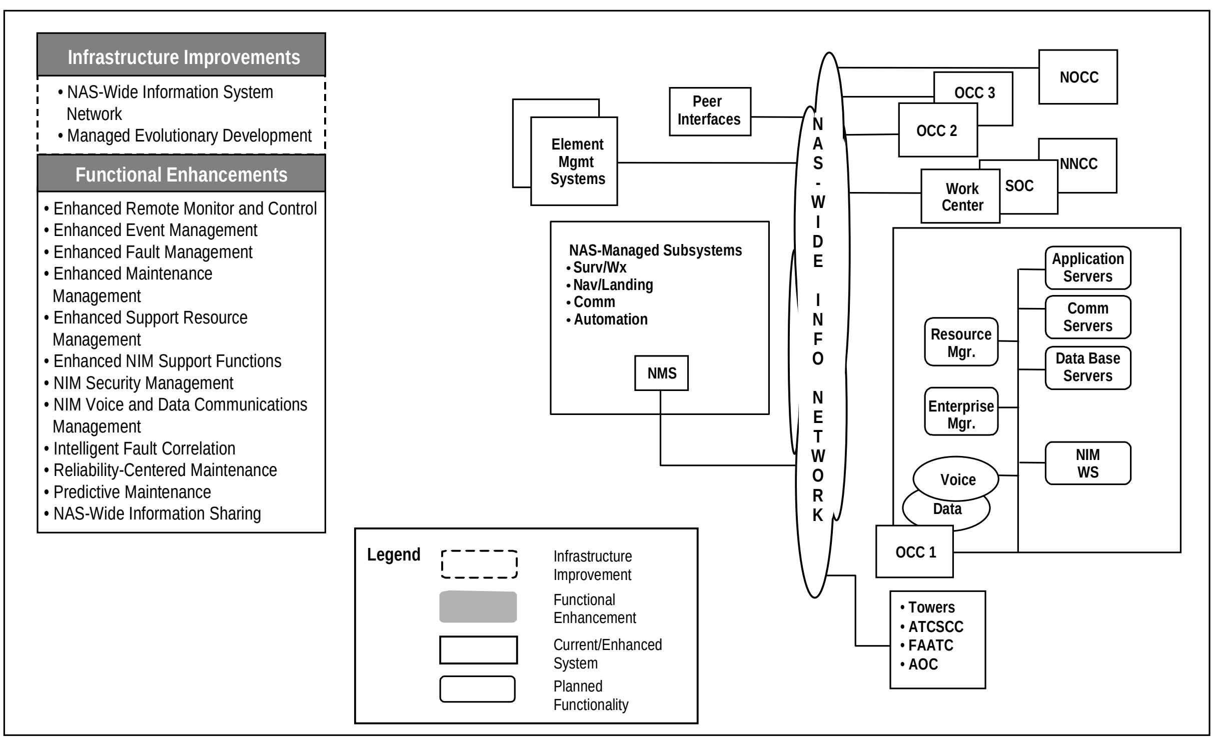

Figure 27-4. Infrastructure Management Architecture Evolution—Step 4 (2006–2015)

Step 3 continues the modernization and refinement of Step 2 capabilities while Step 4 initiates intelligent fault correlation (i.e., reliability-centered maintenance and predictive maintenance as well as enhanced information sharing). Step 4 also continues life-cycle modernization and refinement of NIM capabilities. As emerging technologies mature and become readily available, NIM will incorporate new functional capabilities yet to be identified throughout this final phase of its life cycle.

27.3 Human Factors

Human factors planning for NIM tools involve defining a process for incorporating human factors engineering into the development, acquisition, implementation, and operation of the control and work centers that comprise NIM, as well as for its associated equipment, capabilities, facilities, and personnel. For many years, the number of subsystem-specific interfaces technicians use in maintaining the NAS has steadily increased. These interfaces include diverse displays, keyboards, and controls with different computer-human interface (CHI) characteristics. NIM tools will incorporate a human-centered workstation design to enhance efficiency and effectiveness. The goal of NIM tool human factors engineering is to make the most effective use of human capabilities and to minimize the effects of human limitations and errors on the performance of the system.

The NIM will center on adapting and integrating components and subsystems that are developed using fast-track methods, including acquisition of COTS/nondevelopmental item (NDI) hardware and software products. The application of human factors criteria to subsystem selection will provide systems that better support users. As subsystem capabilities are developed, a subsystem's operational suitability will be determined through operational test and evaluation. The subsystem will be systematically assessed in terms of human factors requirements, criteria, measures, and procedures.

Because training provides people with needed knowledge and skills, it directly affects system performance and is a critical human factors issue that will be considered in detail. The training program must reduce training time through more efficient training methods and impart a wider scope of technical knowledge and skills to a reduced workforce. Because training can be very costly over a system's service life, and its delivery affects the availability of personnel for conducting operational tasks, it is considered to be an integral part of the system engineering design process. Traditional training will be augmented with other job performance aids.

NAS personnel requirements are determined by system equipment design, procedures, training, NAS workload, and other factors. Human resource tradeoff studies will be conducted to examine staffing requirements in relation to system productivity.

27.4 Transition

The schedule for the NIM implementation is shown in Figure 27-5. This schedule will be revised after requirements are stabilized.

27.5 Costs

The FAA estimates for research, engineering, and development (R,E&D); facilities and equipment (F&E); and operations (OPS) life-cycle costs for the infrastructure management architecture in constant FY98 dollars for 1998 through 2015 are shown in Figure 27-6.

27.6 Watch Items

Enforcement of FAA Order 6000.30. With the onset of user-intensive concepts such as Free Flight, maintaining the integrity of the NAS infrastructure while using such advanced technologies as NIM tools takes on added importance. However, liberal interpretation of FAA Order 6000.30 (Policy for Maintenance of the NAS Through the Year 2000) has resulted in many instances of noncompliance with the intended maintenance policy, thereby negating the benefits to be gained from NAS-wide implementation of an infrastructure management system. More stringent adherence to the AF CONOPS, with added emphasis on improving the integrity of the NAS infrastructure and the resulting benefits to the user community, is imperative.

Agreement on NIM Requirements. More work is needed to define requirements and operational procedures for using remote, automated control of NAS assets. Operational concepts need to be de-

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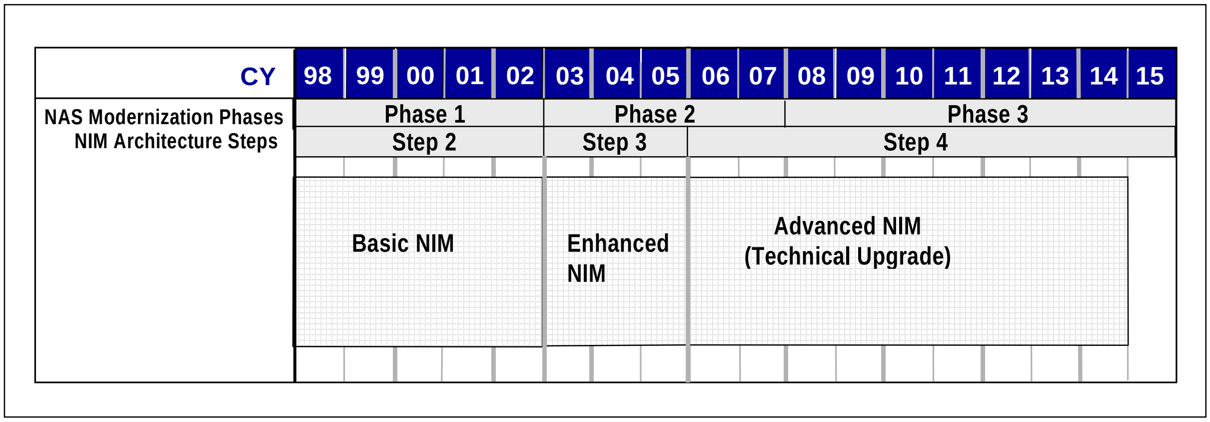

Figure 27-5. Infrastructure Management Transition

fined and modeled to assess workload improvements.

Implementation of NAS-Wide Security. NIM tools interface with all other NAS systems, and access to it must be restricted. For this reason, management and control of NAS security services is included in the NIM architecture. Within NIM tools, INFOSEC requirements are based on the NIM protection profile and vulnerability assessment. Adequate security is ensured for NIM tools by meeting requirements for service availability, access control, authentication, nonrepudiation, confidentiality, and integrity. In particular, appropriate security gateway services are available to provide proper access control between NIM tools and the NAS-wide information network. This reinforces consideration of NIM tools when it comes to planning for collection of NAS-wide subsystem security data for reporting and auditing purposes and to perform NAS-wide intrusion detection and key management.

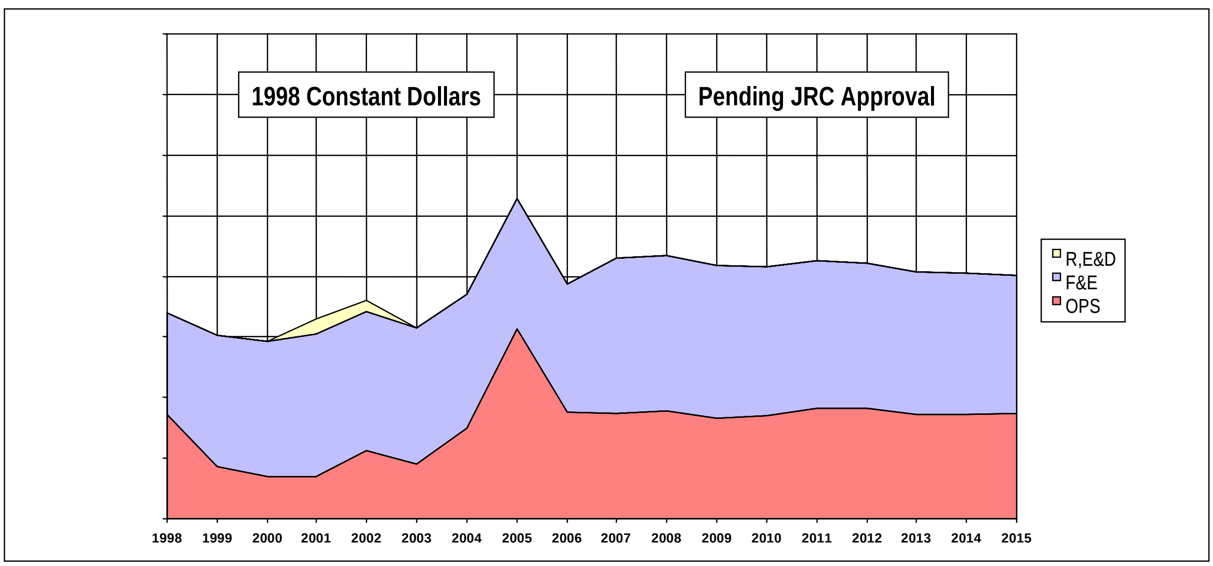

Figure 27-6. Estimated Infrastructure Management Costs