DRAFT

NAS Information Architecture Evolution

January 1998

Produced by:

Federal Aviation Administration
Architecture and Systems Engineering Division, ASD-100
NAS Information Architecture Team

Abstract

This paper expands on the concept of a NAS Information Service (NIS) and Local Information Services to serve facility-based information needs and NAS users. A concept for the evolutionary transition of existing information services to the NIS is described that emphasizes the parallel development of services at NAS-wide, local facility, and system levels. Recommendations are made for transitioning and implementing NIS.

KEYWORDS: air traffic control, information architecture, data standards, data model, transition, information services, information sharing, information exchange, collaboration, NAS, NIS

Table of Contents

List of Figures

List of Tables

Section 1

NAS Information Architecture Supplement

1.1 NAS-wide Information Services for Collaboration and Information Sharing

Collaboration. The newly adopted Concept of Operations describes a NAS environment (illustrated in Figure 1-1) in which multiple decision makers, each with access to similar, current operational data, use those data in real and near-real time to make decisions about aircraft separation (safety) and traffic flow (efficiency). This collaborative view requires coordination and cooperation among the decision makers using high quality information services distributed throughout the NAS based on commonly applied data standards and structures. In the future, collaborating decision makers will see the same (i.e., consistent) information at the same time.

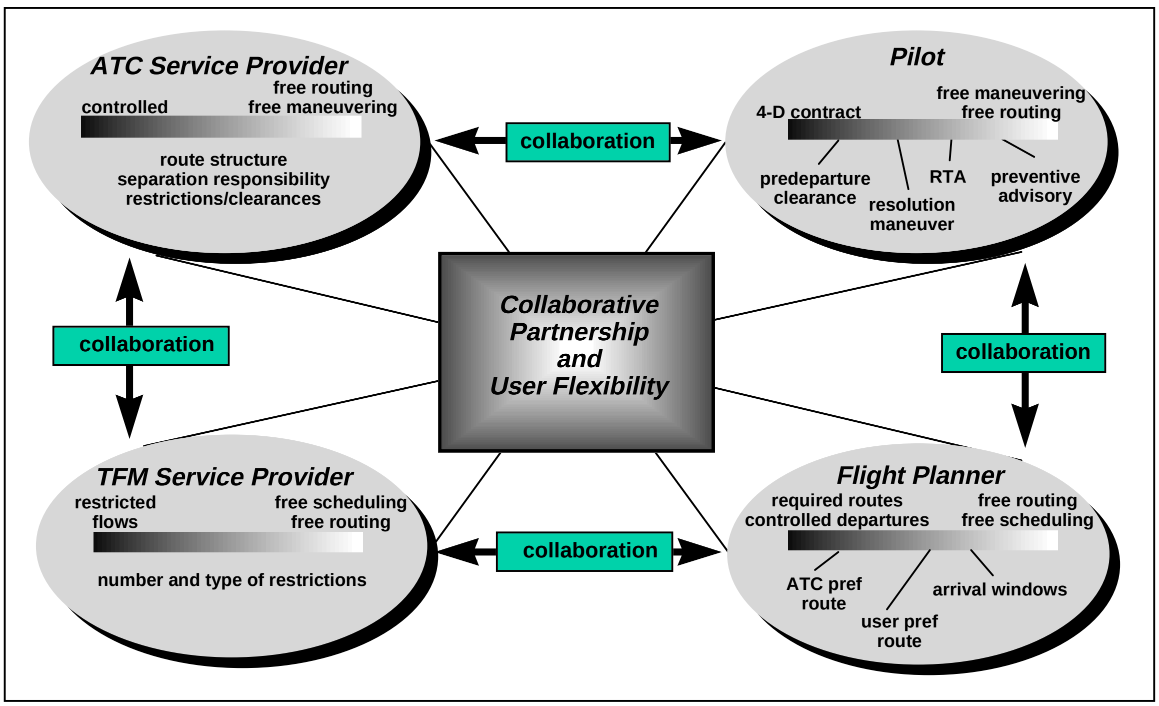

Figure 1-1. The Roles of Key Decision Makers in the Future NAS

The level of collaboration envisioned in the Concept of Operations is quite complex and consists of processes that are now being jointly explored by the FAA and the user community. Collaboration will evolve as experience is gained in the early phases of developing these processes. The information services supporting these collaborative processes will evolve from basic forms of information exchange to the view of information collaboration that is envisioned in the Concept.

The user community has proposed[1] an evolution of information exchange as illustrated in Figure 1-2. The figure illustrates three levels of collaboration between the FAA and NAS users, each of which becomes more sophisticated and useful, starting from pure data exchange between independent processes to collaboration based on common processes. The goal of an evolving approach is to get an early start on the development of such a collaborative process.

Information Sharing. As emphasized in the Concept of Operations, information is key to the safe and efficient operation of a NAS serving the flying public. Air-to-ground exchange of information is at the core of maintaining safe separation of controlled flights. Air-to-air exchange of information is increasingly important to flight safety as well. Ground-to-ground exchange of information is essential for the coordination of safe end-to-end flight operations. The generation, processing, and distribution of information is an integral part of the NAS Architecture. As depicted in Figure 1-3, each of the architecture elements, in the NAS either generates, uses, or transfers some form of NAS information.

Conceptually, each element has a common understanding of shared information used in other domains. The center of the figure displays the types of data generated, used, and transferred among these elements. The remainder of this section focuses on how the information needs of these elements can be efficiently and effectively managed. A NAS-wide Information Service (NIS) is outlined that defines common information services that are tailored to meet the information management requirements of the many different types of users across the NAS. Three levels of information sharing services are identified within the NAS: NAS-wide common information services, local (or facility)-based information services, and system (or application)-specific information services. At present, most NAS information is managed at the application system level and lacks a level of standardization needed FAA-wide, NAS-wide, and collaboratively.

---

1 Beatty, Roger and Ron Martin, "Collaborative Decision Making (CDM) and ATC - Traffic Flow Management," ATCA Annual Meeting, 2 October 1997.

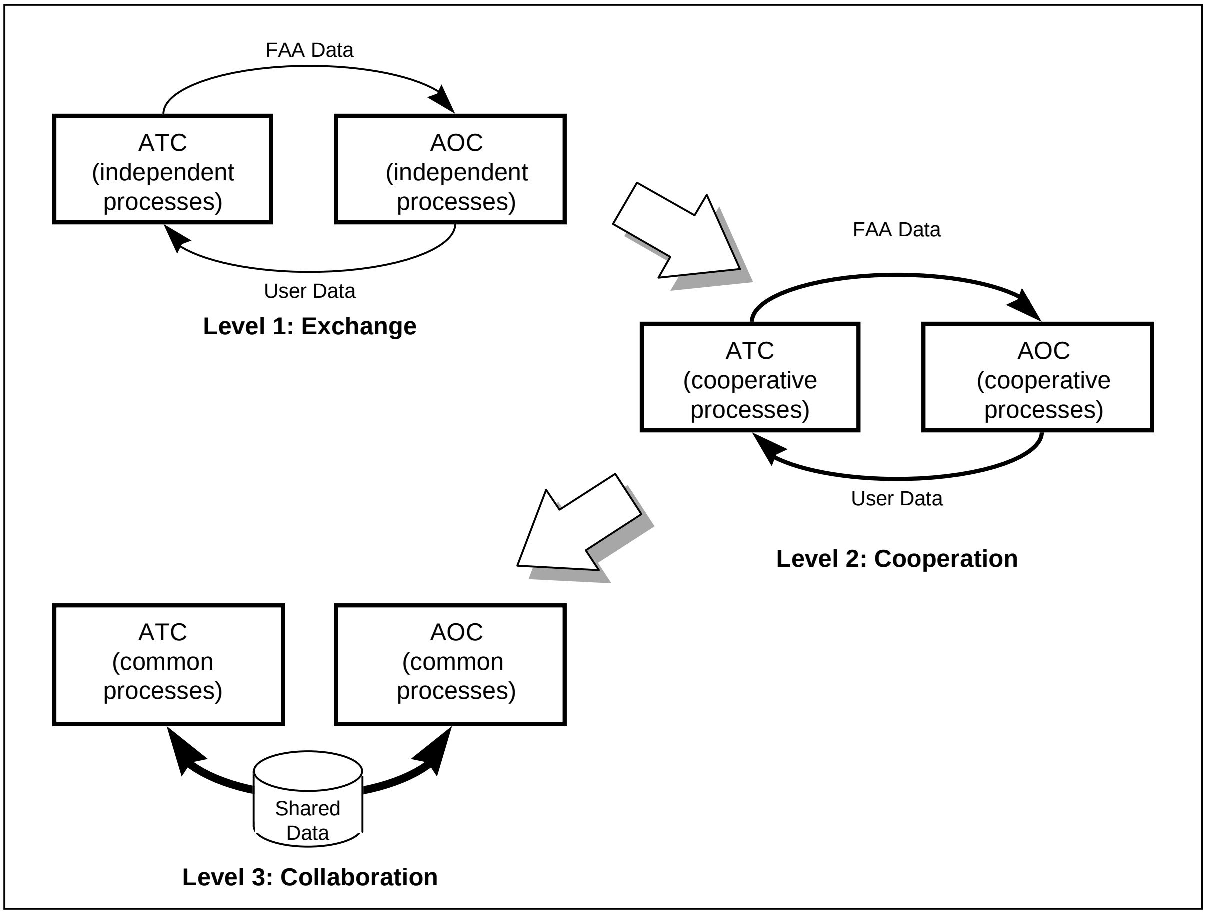

Figure 1-2. The Evolution of Collaboration and Information Exchange

The use of NAS data varies by a number of user classes. Table 1-1 presents three types of NAS data interactions (system-to-system, human-to-system, human-to-human) for three basic types of data (i.e., real-time operational, archival operational, and system metadata). Traditionally, the FAA system development organizations (IPTs) and the system engineering organization (ASD) have focused on the real-time (and near-real-time) system-to-system exchange of operational data shown in the upper left cell in the matrix. Much of these data—flight data and surveillance (radar) data—originate in the Host.

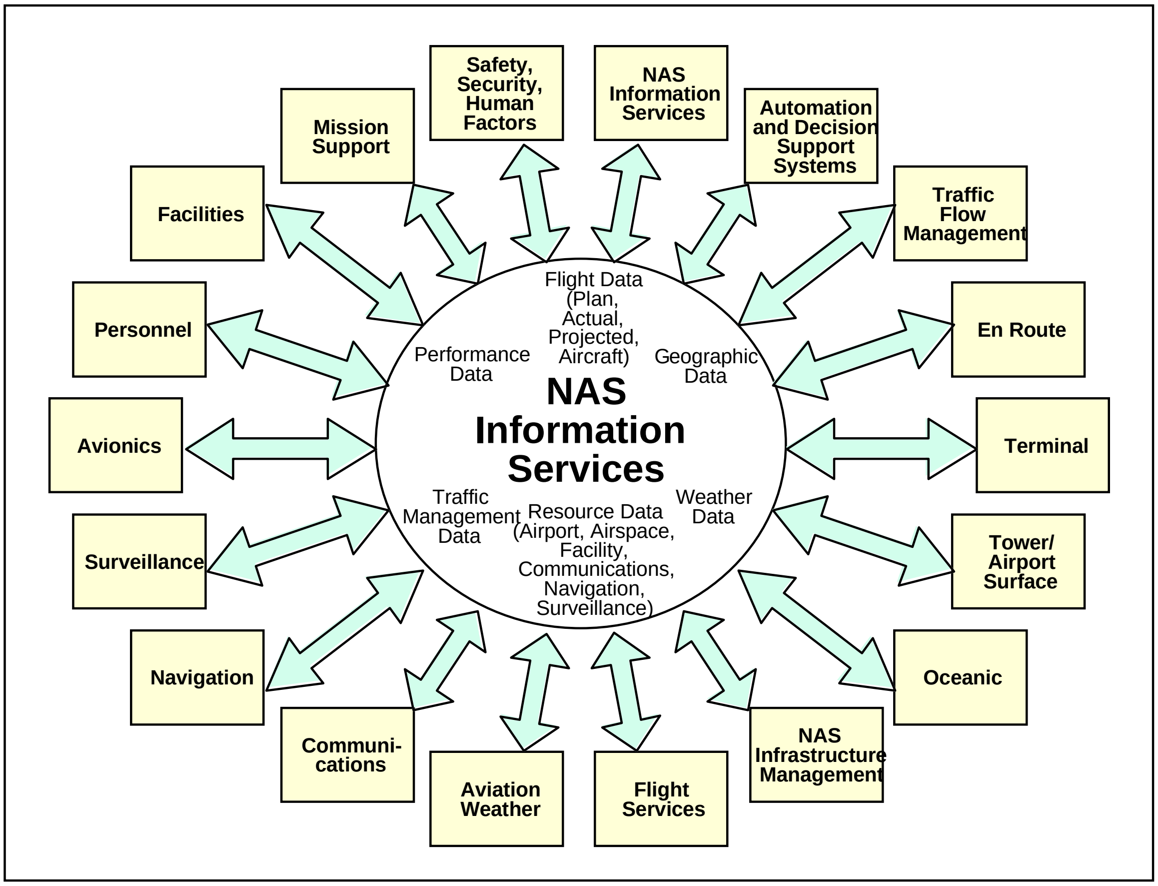

Figure 1-3. NAS-wide Information Services in the NAS Architecture

However, there are many other types of interactions involving NAS information, and these are represented in the other eight cells. One of the goals of a re-engineered NAS Information Architecture is to improve data access and data quality for each of these interactions via better information management using information technology and automation. At present, substantial automation is provided to support real-time, system-to-system interactions while more automation is needed for the other eight types of interaction represented by the matrix.

Table 1-1. Types of NAS Data Compared with Types of Interaction

Data Type	Interaction Type: System-to-System	Human-to-System	Human-to-Human
Real-Time Operational Data	Host←→ETMS	TMC←→ NAS Status	Collaborative TFM (multi-Center)
example →	Messages: current and forecast aircraft position	Ad hoc query: runway capacity, delay status, weather status	Voice: Common view of severe weather re-routing; numerous safety issues
Non-Real-Time Operational Data (Archive)	Archive ←→ Ground Delay Program	Archive (DataMart) → Command Center specialist	Command Center specialist ←→ ARTCC controllers ←→ AOCs ←→ pilots
example →	System performance: Delay statistics by airport, carrier, and time of day	System performance: Delay statistics departing LAX for 1997 during the morning departure 'rush'	History/analysis of weather patterns over JFK between 4-6 pm in early summer; view of current weather
Metadata (Data Structure and System Engineering Data)	Engineering Repository ←→ New system development (e.g., CTAS, Build 2)	System Developer ←→ Engineering Repository	System developer ←→ Investment analyst
example →	Flight Information Object (FIO) definition and structure	Sources of flight information, e.g., all systems, NAS users, to build modified conflict probe capability	Estimating the size and cost of storing full, graphical weather images for the 50 major airports in one hour increments

Architectural Drivers. A number of new *operational*, *technical*, and *fiscal* drivers have recently emerged that require a more structured approach to the way information will be managed in the future NAS to support various user classes.

Operational drivers include:

a) New operational views represented by the developing Concept of Operations[2] and the Collaborative Decision Making (CDM) initiative. These require a more consistent, flexible and fluid sharing of information between FAA service providers and NAS users, supported by an enhanced information management process, as indicated by this statement from the Concept of Operations:

"The NAS in 2005 takes a human-centered approach to maximize the efficient delivery of air traffic services to users. Thus, system processes and workstations are designed to expedite the exchange of information between NAS information systems, service providers, and users."

b) The need for better airspace design and post-event analysis to determine the causes and cures for delay and congestion and the equitable allocation of user fees

c) Data consistency across NAS domains to improve operational decision making. This view is also recognized by the European aviation community. In their view of the future, described by their European Air Traffic Management System (EATMS), they state that,

"There should be a higher level of gate-to-gate and ground-to-ground integration. Open, interoperable flight data bases and information systems are essential to optimise the ATM processes, support cooperative decision making between Airports, Airline Operations, and ATM, and to offer freedom of movement to the greatest possible extent." [3]

d) The need to improve system interoperability by implementing common, flexible system and user interfaces; the need to extend interoperability to key NAS users communities, such as the air carriers, general aviation (GA), the military, and the international aviation community, and not only among FAA-developed systems

---

2 "A Concept of Operations for the National Airspace System in 2005," FAA, 27 June 1997.

3 From a description of the European Air Traffic Management System (EATMS).

Technical drivers include:

e) The growing complexity of the NAS with the introduction of new capabilities and new systems and their integration into a coordinated NAS Information Architecture spanning logical (e.g., domain/phase of flight) and physical (e.g., facility) boundaries.

f) The increasing importance of government and industry technical standards, such as the Technical Reference Model (TRM) and its equivalents, as mandated by the Office of Management and Budget (OMB), the General Accounting Office (GAO) and Congress as common development frameworks for governmental systems.

g) The availability of cost-effective Commercial-off-the-Shelf (COTS) information technologies (e.g., database management systems (DBMSs), geographical information systems (GIS), query tools, data warehousing) to manage information and to deliver NAS information faster and cheaper than customized systems over the system life-cycle and with greater information quality to many classes of decision makers.

Fiscal drivers include:

h) Budget constraints. The size of the FAA budget relative to the tasks that need doing; the high cost of building new systems and of re-engineering existing systems; the high current cost of achieving system interoperability across FAA systems and between FAA and NAS user systems; the high current cost of maintaining proprietary automation systems having widely varying data structures.

i) Acquisition process. The need to build new systems and re-engineer existing systems faster and cheaper and to make their internal data structures more consistent NAS-wide for more efficient system maintenance and to add future enhancements with relative efficiency.

Table 1-2 associates the operations in various NAS operational areas with the type of NAS data involved and indicates whether the area is a user, supplier, or pass-through of that information. The matrix illustrates how multiple operational systems share an interest in broad categories of data that include: flight, resource, weather, and other data. The use and generation of flight data (including aircraft-related data) are shared by FAA decision support systems (DSS) with NAS users just as the avionics suite on-board the aircraft brings flight data to the pilot. NAS resource data are also an area of common interest in that the NAS DSS use and generate resource-related data while

NAS users are interested primarily in receiving selected resource status information. Weather data are used in some form by most NAS systems but only a small subset of participants are responsible for generating them. NAS users can have weather data input via pilot reports (PIREPs), aircraft sensing (e.g., wind, air temperature and pressure), and by staff meteorological weather assessment.

Table 1-2. Information Use by Operational Area

	Information Categories													
	Flight				Resources						WX	Other		
Operational Areas	Flight Plan	Flight Actual	Flight Projected	Aircraft	Airport	Airspace	Facility	Communications	Navigation	Surveillance	Weather	Traffic Management	Performance	Geographic
NAS Users	source/user	source/user	source/user	source/user	source/user	user	source/user	user	user	user	source/user	source/user	source/user	user
NAS Information Services	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	source/user	pass through
Traffic Flow Management DSS	source/user	source/user	source/user	source/user	source/user	source/user	source/user	user	user	user	user	source/user	source/user	user
En Route DSS	source/user	source/user	source/user	source/user	user	source/user	source/user	source/user	source/user	source/user	user	source/user	source	user
Terminal DSS	source/user	source/user	source/user	source/user	user	source/user	source/user	source/user	source/user	source/user	user	source/user	source	user
Tower / Airport Surface DSS	source/user	source/user	source/user	source/user	source/user	source/user	source/user	source/user	source/user	source/user	user	source/user	source	user
Oceanic DSS	source/user	source/user	source/user	source/user	user	source/user	source/user	source/user	source/user	source/user	user	source/user	source	user
NAS Infrastructure Management					source/user		source/user	user	user	user		user	source/user	user
Flight Services	source/user	source/user	source/user	source/user	user	user	user	user	user	user	user	source/user	source	user
Aviation Weather					user	user	user				source/user		source	user
Navigation				source/user	user	user	user	source/user	source/user	source/user			source	user
Communications	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	source	pass through
Surveillance					source/user	user	source	source/user	source/user	source/user		user	source	user
Avionics	source/user	source/user	source/user	source/user	user	user	user	source/user	source/user	source/user	source/user	pass through		user
Personnel	user	user	user	user	user	user	user	user	user	user	user	source/user	source/user	user
Facilities					source	user	source/user	user	user	user	user		source	user
Mission Support	source/user	source/user	source/user	source/user	source/user	source/user	source/user	user	user	user	user	source/user	source/user	user
Safety, Security, Human Factors	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	pass through	source	pass through

- information user
- information source
- information pass through

Traffic management data cover control actions required for safe separation of aircraft and the orderly flow of traffic. The growth of collaborative decision-making implies an increasing role for NAS users as generators of data in this category. Most operational systems will be providing inputs about system performance primarily through the NAS Infrastructure Management System (NIMS). Finally, geographic data include physical data on the NAS environment that is not FAA-specific, such as terrain

data, maps, and political boundaries. Most of these data are likely to be generated outside the NAS and hence no sources are indicated for this category in the matrix.

1.2 A NAS-wide Information Service (NIS)

At present, most NAS information is managed at the application system level, with some facility-based information management, and very little NAS-level information management. To improve information management across the NAS, the NIS will be implemented as a NAS-wide, service-oriented capability among all three levels of information services. The NIS provides an integrated NAS-wide perspective for the management of information common to and shared across many facilities and users of the NAS. As part of the NIS, local information services provide an integrated perspective of information shared within a facility, such as an ARTCC or TRACON.

By the nature of these (information) services—operating at the NAS level through the local (i.e., facility) level to the application system level—the NIS is not a single, bounded system that can be specified and acquired like a traditional application system. Rather, the core of the NIS is a set of information services specified in the information architecture and distributed across other systems and components of the NAS. The result is integrated logically into a single information system as illustrated in Figure 1-4.

The roles of the NIS are to define and manage consistent data structures and standards; provide universal data access (with appropriate access controls); streamline the use of multiple, overlapping data sources by systems; improve cost efficiencies for information management; and provide a cohesive methodology for sharing data among systems and users. One goal of the NIS is to improve overall system performance, including system interoperability, and coordinate information management in cooperation with NAS users. It also intends to improve the interfaces between 'like' systems across the FAA/NAS users boundary.

The NIS will also provide information services supporting the new Concept of Operations, featuring collaborative decision-making with convenient, widespread, and standards-based information exchange between the FAA and NAS users. It will manage all types of NAS data (i.e., real-time operational, archival operational, metadata) but will emphasize the core types of operational data: flight data, surveillance (radar) data, NAS resource data, and weather data. Both static (i.e., descriptive) and dynamic (i.e., NAS resource status) data will be shared, and operational data will be applied to both real-time safety and traffic flow decision making as well as to pre-and post-event analysis to improve operational performance using structured data archives, or data warehouses.

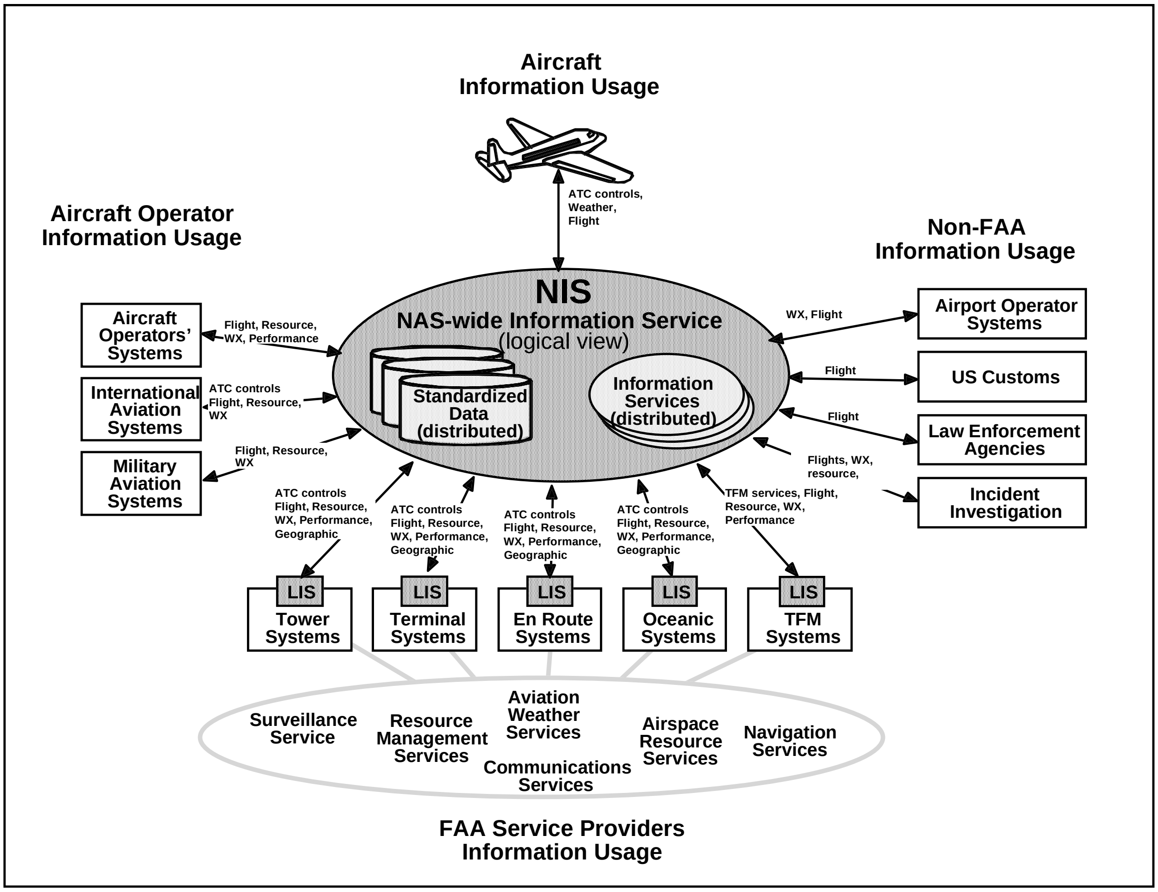

Figure 1-4. Proposed Information Services and Information Flow in the NAS

The NIS will address aviation data standards such as those from the FAA and the International Civil Aviation Organization (ICAO) in applying information standards such as the Structured Query Language (SQL) from the American National Standards Institute (ANSI).

The 3-Level NIS Operational Concept. As shown in Figure 1-5, information flowing throughout the NAS will support several categories of information end users. Future NAS information services will be allocated, tailored, and integrated across the following three levels of the NAS:

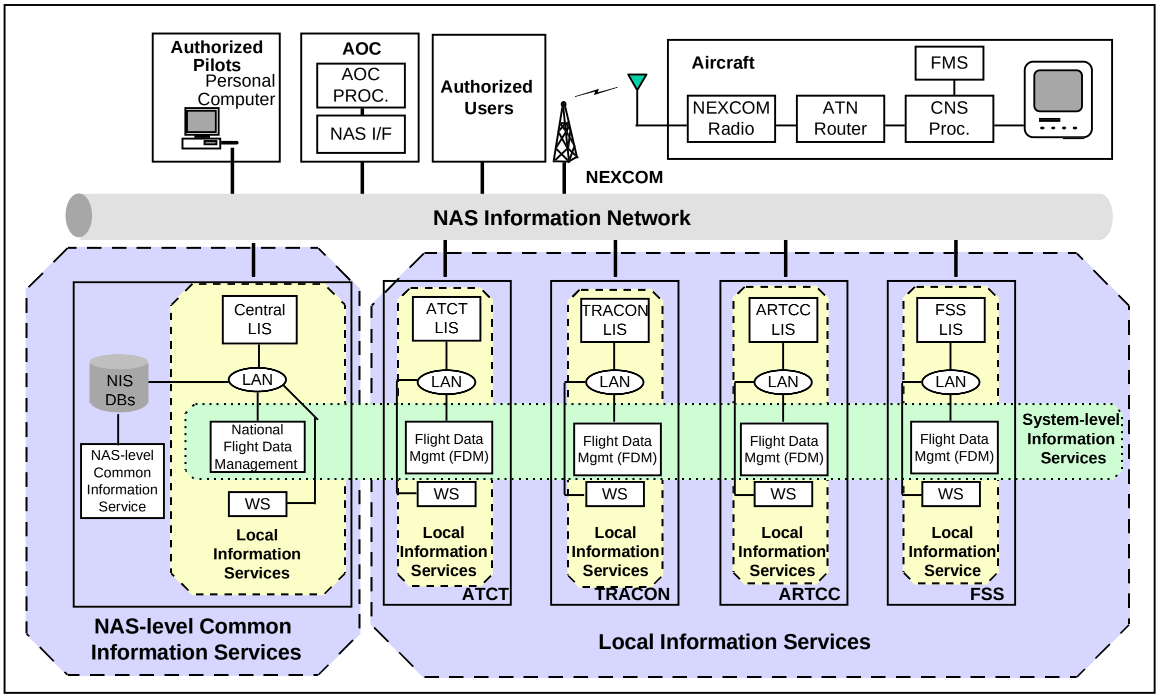

Figure 1-5. A High-Level View of the NAS

- **NAS-level Common Information Services**
  - **Manages an integrated NAS-wide perspective of information management across all local facility types.**
  - **Coordinates NAS-wide data standards and guidance.**
  - **Implements limited NAS common data management capabilities.**
  - **Embeds NAS-level standards and processes in facility and domain information systems.**

- **Local (Facility)-level Information Services**
  - **Integrates facility-wide perspective of information management across all domain systems within a facility using database and datamart technology.**
  - **Implements limited facility common data management services.**
  - **Implements NAS data standards and guidance in a facility.**
  - **Embeds local common services in system information systems.**
  - **Defines facility standards within NAS-level standards.**

- **System (Application)-level Information Services**
  - **Integrates a system-based perspective of information management across all components and systems supporting a (phase of flight) domain, such as en route, so that the same information in the same structures is managed and shared across application systems.**
  - **Implements NAS-level and facility data standards guidance in domain systems.**
  - **Defines standards compatible with NAS-level and facility-level guidance.**

Figure 1-5 illustrates how the NIS will tie together NAS-wide functional activities through common information management at the NAS-level with more specific services at local/facility and system levels. For example, flight data management (FDM) will be based on structured flight information that will span several facilities and numerous application systems and will be consistent across them.

Information Structure and Services. The four categories of information services shown in Figure 1-6 in bold will be operational at the three levels: NAS-level, Local-level, and System-level.[4] The implementation of the NIS within a 3-level information service requires a clear delineation of the varieties of NAS data and their structures.

The information architecture services pictured in the lower portion of Figure 1-6 are a representative set stemming from the four information service categories pictured in the upper portion of the figure.[5] Each of the main categories is described as follows:

- **NAS Data Services contain both the organization, or structure, of NAS data and also the data themselves. These services manage data classification and require NAS user involvement since a significant amount of NAS data originates with them. How these data structures and databases are managed in the NAS is a system engineering issue.**

---

4 This discussion does not mean to imply that some or all of these services are not now available. It does mean to imply that these services are available for some FAA systems but are not consistent or coordinated among all systems.

5 A complete representation would contain many more such services, and, in addition, each of these services would be decomposed into a set of more detailed, lower level services. Such a detailed decomposition will be addressed in version 4.0 of the NAS Architecture.

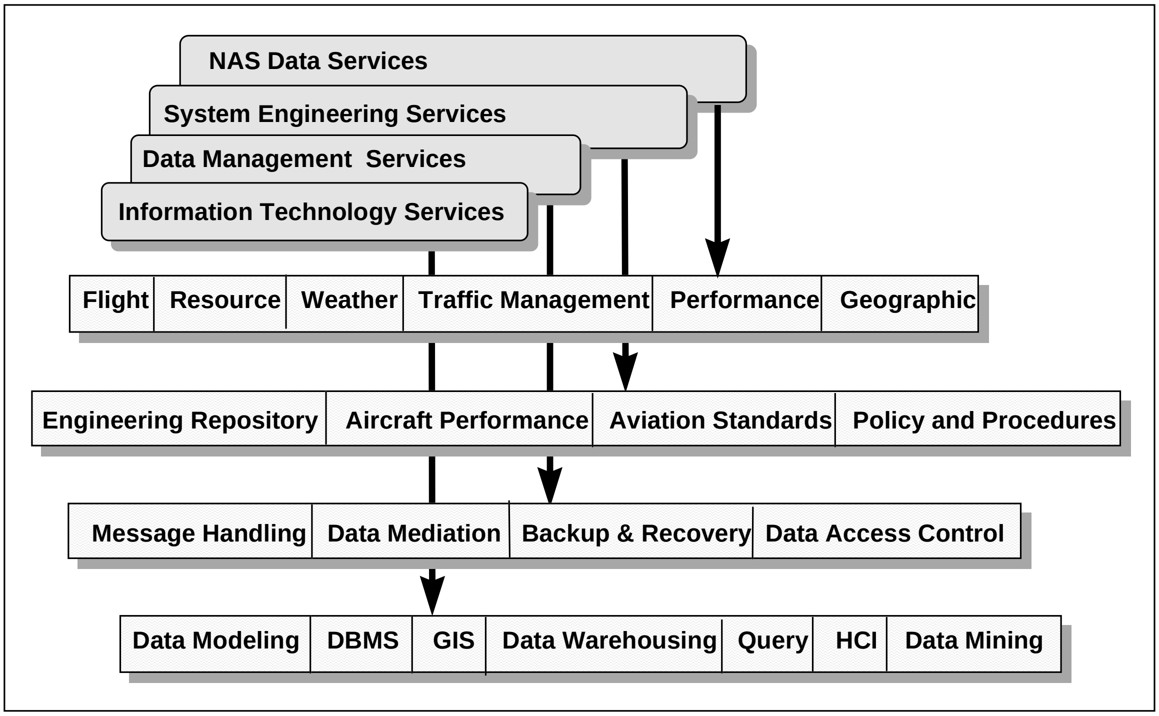

Figure 1-6. NAS-wide Information Services Categories

- **System Engineering Services are information services that include repositories to manage system engineering data, such as an engineering repository describing application system data, function, implementation and interaction with other systems; aircraft performance data and standards; information architecture standards; airspace policies and procedures. These information services will include a full picture of the NAS from a system engineering viewpoint.**
- **Data Management Services may include a variety of information services, such as multi-system message, data mediation to resolve data semantics among differing data views, backup and recovery services (whether application-supported or DBMS/COTS-based), and data access controls to ensure that only properly authorized persons may see or change NAS data. These services will serve system-to-system needs, human-to-system needs, and NAS user-to-NAS system needs.**
- **Information Technology Services include an array of information technologies, primarily in the form of COTS products that range from basic database management (DBMS) services to data warehousing to data mining. In addition,**

of particular to NAS operations are geographical information systems (GISs), which depict tabular airspace data in geographical form for improved data visualization leading to more effective operational, tactical, and strategic decision making.

1.3 An Information Architecture-Based NAS

NAS-wide Information Service (NIS) Goals. The development of the NIS is based on meeting four important goals, all of which are directed toward accomplishing the business goals and mission of the FAA. These are:

- **Data Quality and Access: Supporting the information needs of the many NAS role players with timely, accurate, and complete information via system-to-system, human-to-system, and human-to-human information access**
- **Interoperability: Providing for the exchange of commonly defined data with numerous NAS organizations, systems, and users**
- **Cost Effectiveness: Delivering information in a cost-effective manner and emphasizing information reuse. The NIS offers an opportunity to significantly reduce the cost of managing information, especially in the areas of acquisition (F&E) and system maintenance and reuse (O&M)**
- **Responsiveness, Flexibility and Scalability: Responding to new functional needs quickly and efficiently.**

An Information Architecture is that part of a System Architecture that manages a system's information. It consists of standards, technologies, data management processes, and their implementation. It also includes the distribution of these services across an organization as well as the roles of management and control required to deliver consistent and accurate information across an organization.

Although there are many variations in the details, there is a generally accepted view of what constitutes a Technical Architecture and an Information Architecture, as described in the TRM initiated by the National Institute of Standards and Technology (NIST) and implemented by the Department of Defense (DOD). In addition, the OMB and the GAO have encouraged the use of a common TRM throughout government, and several agencies have already applied this model to their system development efforts.[6] OMB's view of information systems development is found in the following statement

6 These agencies include the Department of Defense (DoD), Department of Energy (DoE), and the Department of Commerce's (DoC) Patent and Trademark Office (PTO).

issued by that organization in October, 1996.[7] It requires that, *"agency investments in major information systems should be consistent with Federal, agency, and bureau Information Technology Architectures (ITAs)."*

Section 3 of this Supplement contains a detailed description of several agencies' responses to this OMB directive in defining their Information Architecture as well as additional material from the OMB circular.

In a recent report evaluating the FAA's Version 2.0 NAS Architecture, the GAO described its view of a system architecture, as shown in Figure 1-7, which is modified here to highlight those parts of the architecture that are information-based. Based on this view and the one from NIST's TRM, the NIS will be developed within a technical architecture framework, as represented in Figure 1-8. The view presented below in this figure is that of a layered information model moving from principles (e.g., standards) at the bottom, to technology, to services, and to system interfaces at the top.

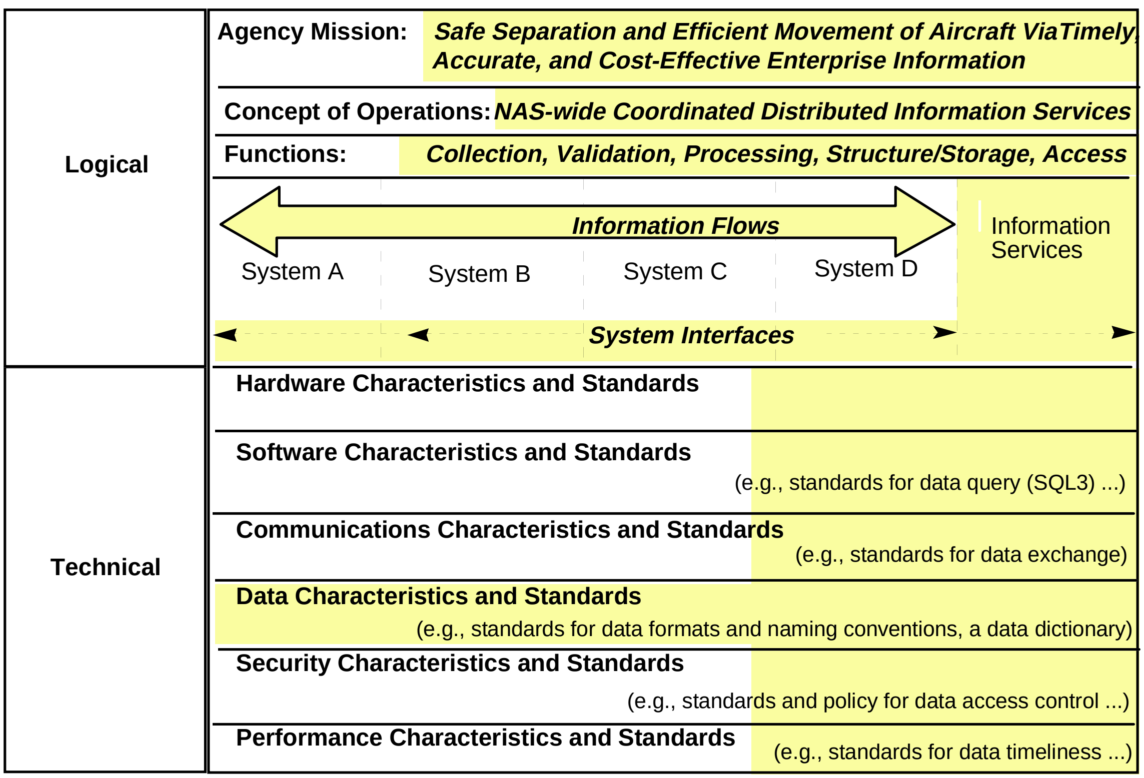

Figure 1-7. An Information-Based View of GAO's System Architecture Structure

7 OMB Memorandum 97-02 "Funding Information Systems Investments," 25 October 1996.

Two key layers in Figure 1-8 are: (a) the information services layer, containing a system engineering repository (data structures and systems engineering data), data models (including definitions of data classes, data relationships, and business rules), and data translation services, and (b) the logical layer, that manages domain and system information services and interfaces between and among FAA application systems.

Building a NIS using guidance from the NIST, GAO, and NAS Technical Architecture models offers a solid framework for achieving the information goals state above.

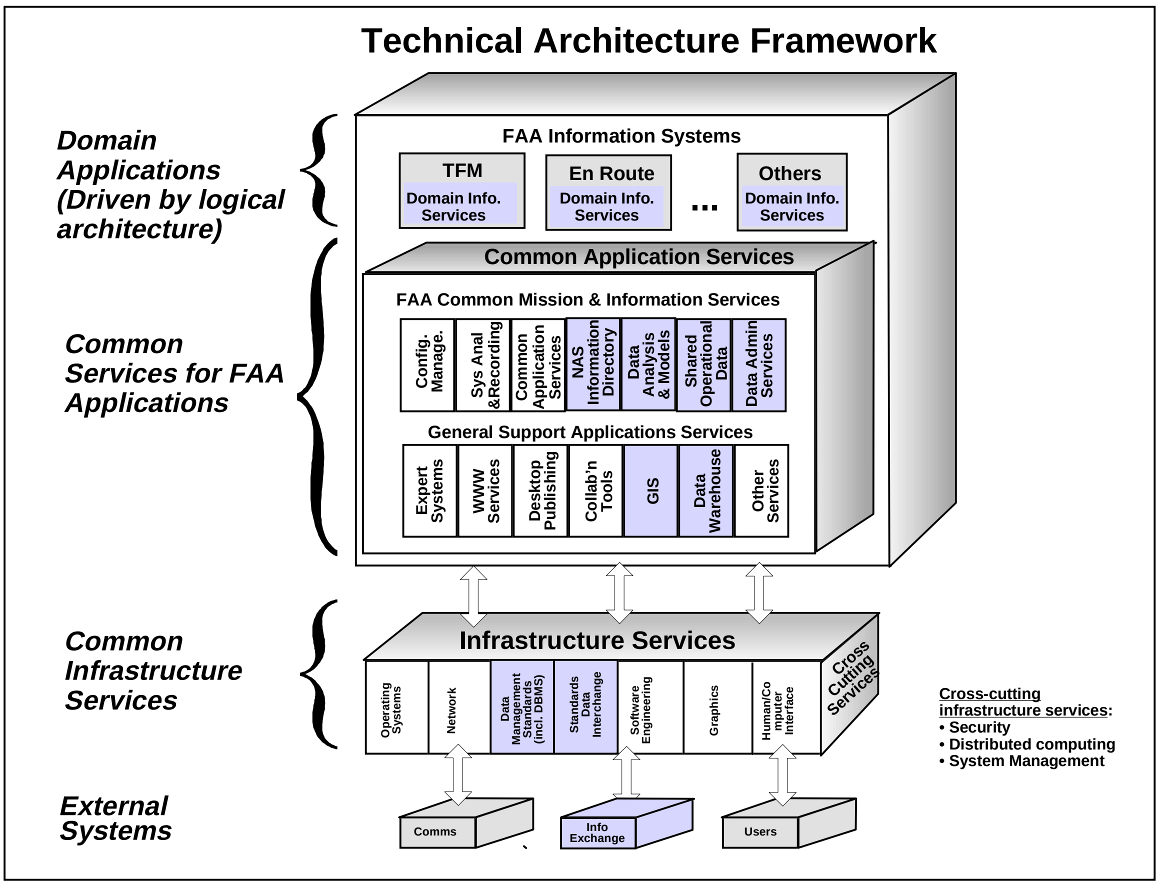

Figure 1-8. NAS Information Architecture Within a Technical Architecture Framework

A NAS-wide Information Service. The NIS is a collection of standards-based information and data processes and functions that will perform or support the general information flow in the NAS and will manage the following data related processes at the appropriate level of the NAS:

- **Data Collection. Acquisition of raw or processed data or information from an original or secondary sources**
- **Data Validation. Comparison of the values and format of the acquired data against a specific definitive standard**
- **Processing and Transformation. Conversion of the acquired data into a format consistent with the storage structure defined for it and with the needs of the application programs that require the data**
- **Structure and Storage. Creation of the data structures used to store the acquired, validated, and parsed data (these structures should reflect the logical relationships among the data); the insertion of these data into the data structures; the management of these data while in storage**
- **Access and Sharing. The means by which all users who require the data can access it (human access); the means by which the system responsible for the data can send it to other systems that require it (system access); the process by which data are sent between users, sites, processes, systems, and organizations.**

Figure 1-5 above illustrates how the NIS will tie together NAS-wide functional activities through common information management at the NAS-level with more specific services at local/facility and system levels. In fact, since domain systems, such as the Enhanced Traffic Management System (ETMS) [Traffic Flow Management], User Request Evaluation Tool (URET) [En Route], Standard Terminal Arrival System (STARS) [Terminal/TRACON], and Dynamic Ocean Track System (DOTS) [Oceanic] operate in multiple facilities and in multiple facility types, the system-level information service is both inter-facility and intra-facility in scope, as shown in the figure. For example, as shown implicitly in that figure, flight information processing spans several facilities and numerous application systems.

Whereas Figure 1-5 illustrates a high-level view of the NIS, showing its three levels, Figure 1-9 is a functional (logical, in GAO terms) view of the NIS that illustrates activity at the local/facility level in terms of system functions and provides a more detailed view of the information functionality at each of the three levels of the NIS: NAS level, local level, and system level.

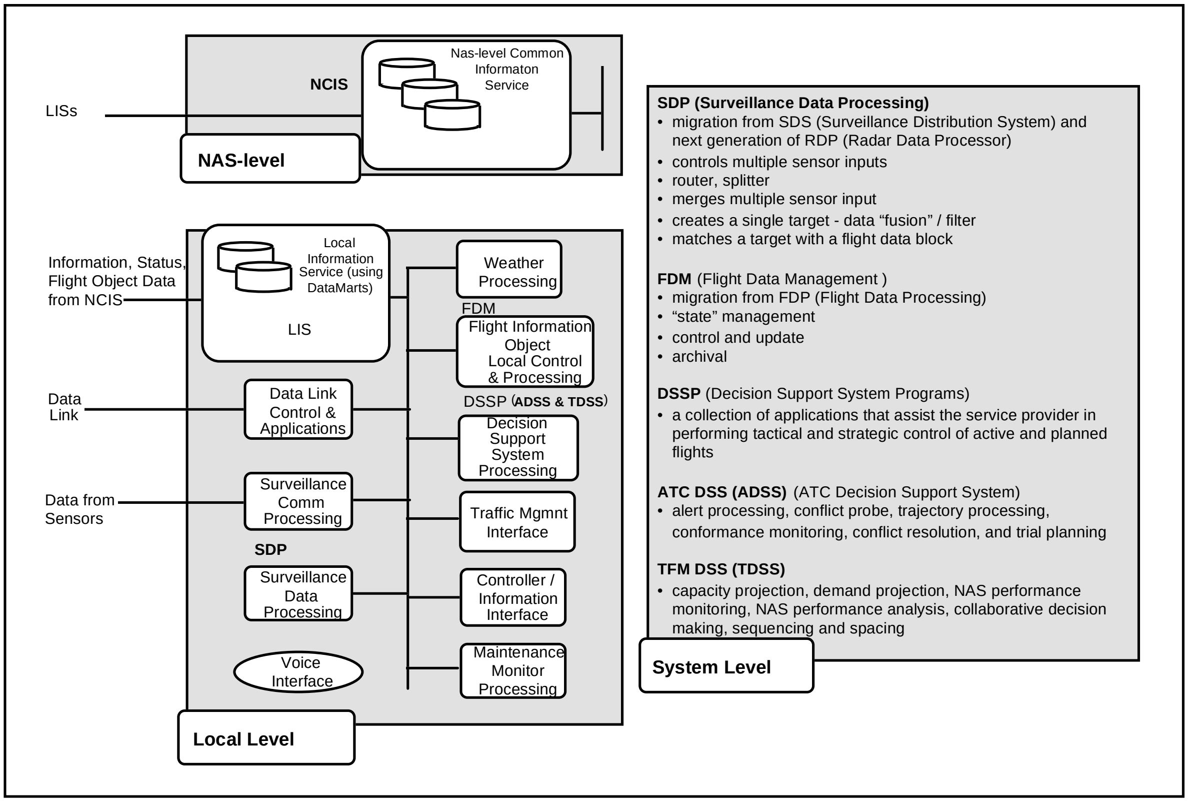

Figure 1-9. Three-level Functional Overview of NAS Processing

The following three figures describe the information services per level to support this functionality. Figure 1-10 describes a set of information services with a NAS-wide perspective that would not be distributed across local or application systems. Information services at this level will be managed using a NAS-wide Engineering Repository to collect, store, and disseminate system engineering and data structure information about NAS objects (e.g., flights, system resources, performance standards). In concept, the NAS-level will also manage an archive of operational data. The extent of the archive will be decided as detailed design and implementation decisions draw nearer.

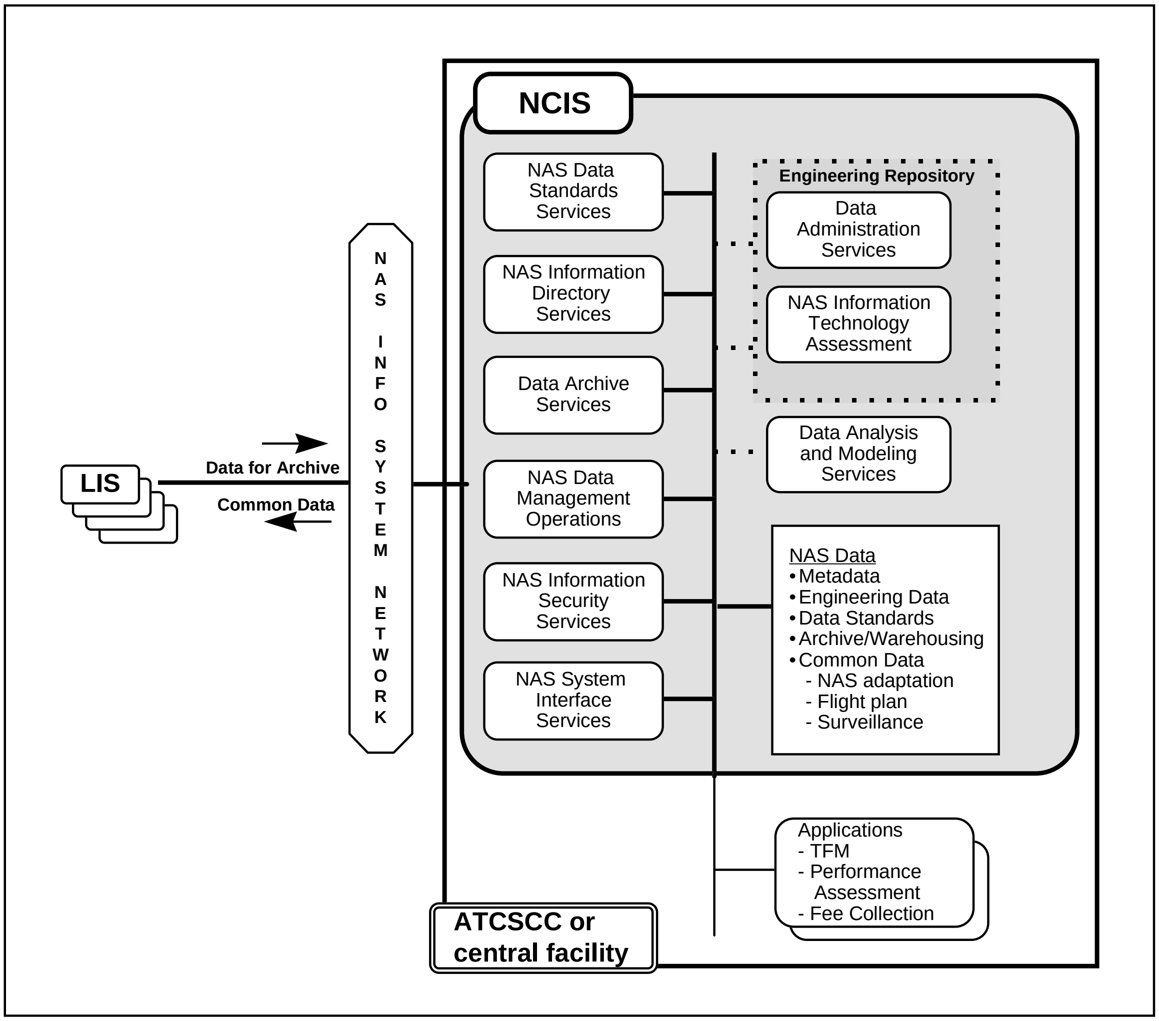

Figure 1-10. NAS-level Information Services

Figure 1-11 illustrates the complementary information services at the local (facility) level. These local information services are built upon and implement the NAS-level information services and standards that have been augmented to meet intra-facility information exchange requirements. Database technology will be used to integrate NAS data at the local level, using data repository, DBMS and data warehousing technology (in the form of datamarts) to organize NAS information across the multiple domains at this level in coordination with the NAS-level Engineering Repository.

Figure 1-12 distinguishes the basic set of information services by each of the three levels.

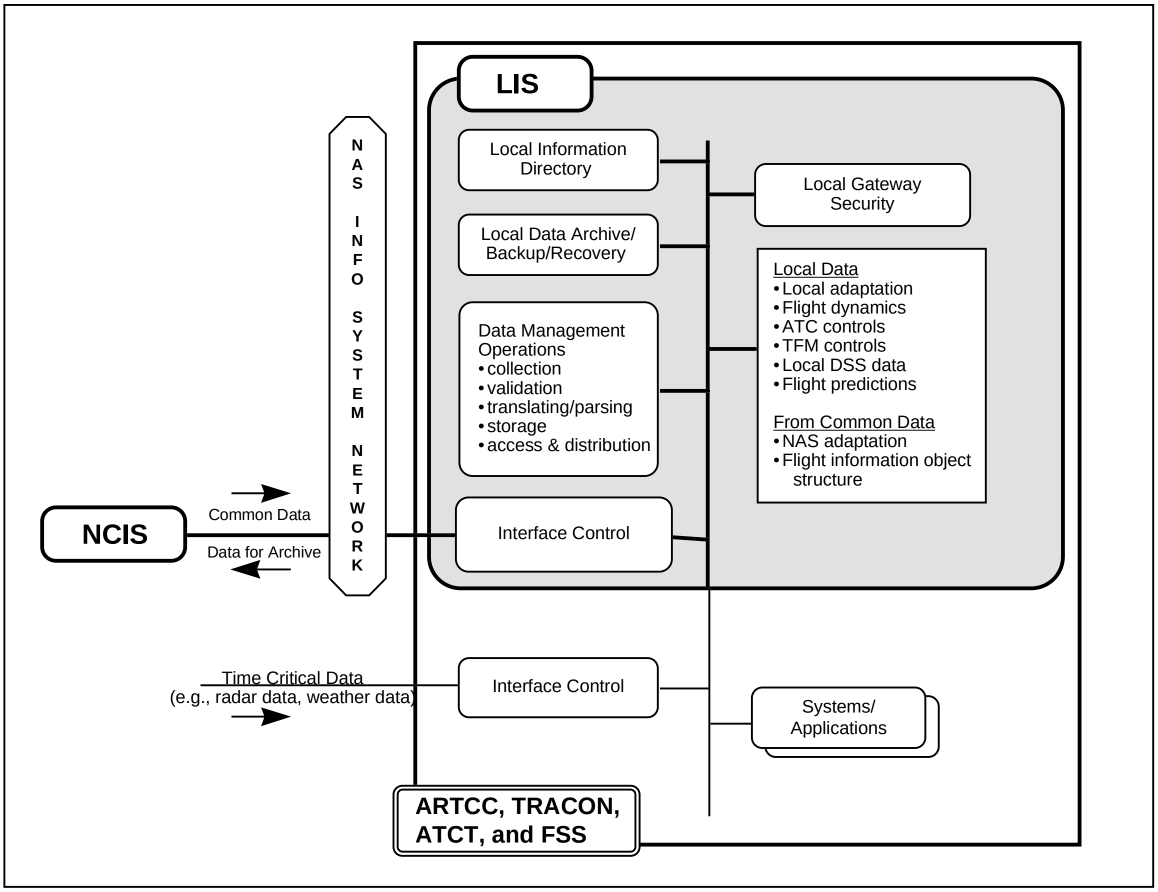

Figure 1-11. Local-level Information Services

1.4 Transition to the NIS

NIS implementation requires the following activities:

- **Introduction of common NAS-level data standards and structures, including coordinated system interfaces, along the lines described in NIST's and DOD's TRM and as supported by the OMB and GAO.**
- **Establishment of NAS-wide oversight for a re-engineered information architecture with coordinated information management at the NAS level, local (facility) levels, and at the (application) system level.**

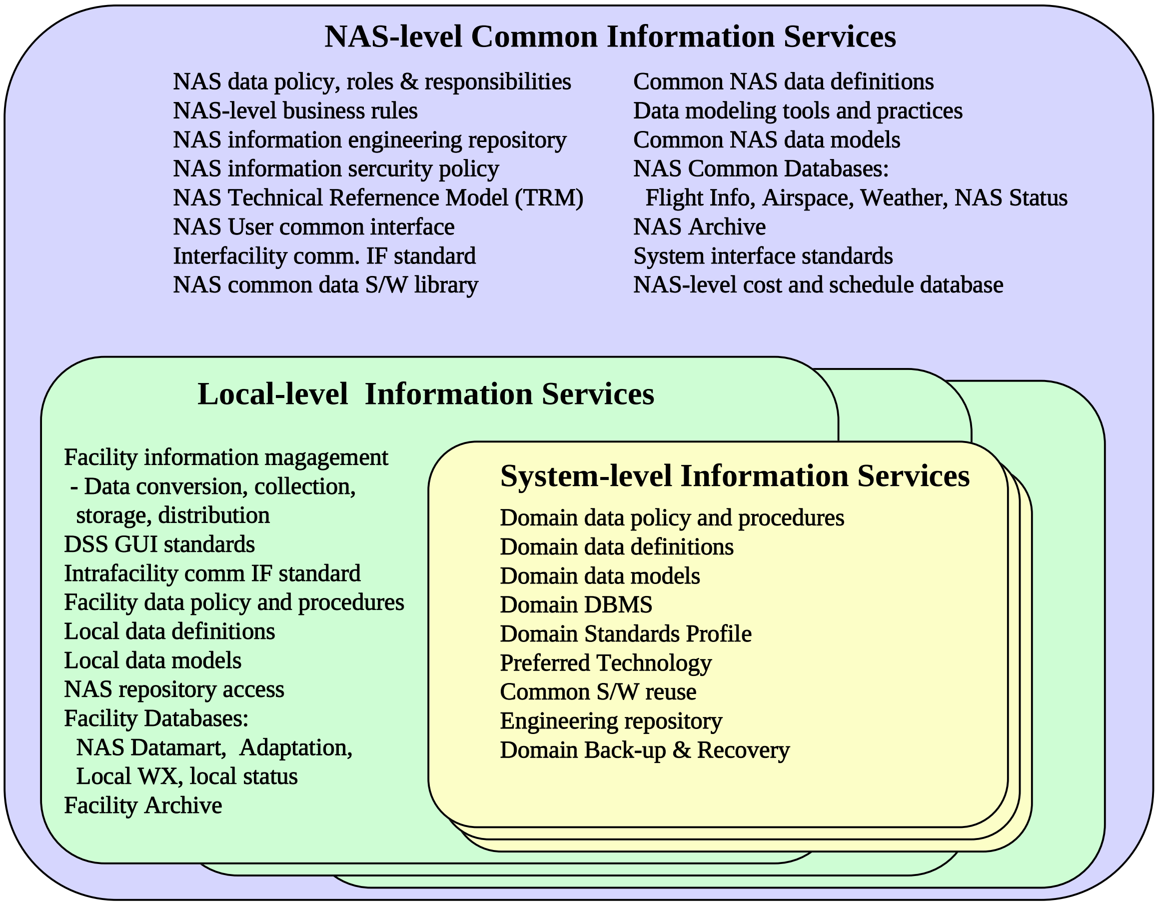

Figure 1-12. Three-level Distribution of NAS Information Services

- **Establishment of coordinated interfaces between the FAA and NAS user systems for the exchange of the three basic types of data: real and near-real-time operational data, archival operational data, and system engineering data (metadata).**

As one example of information standardization, the FAA has already begun to think about implementing an integrated view of flight information as the agency prepares to use an expanded data set defined in the ICAO flight plan. Ongoing efforts in the ATM IPT and other IPTs are moving to structure and standardize TFM and other domain related data elements around a common view of flight data. Future work, as specified

in the NAS Architecture, Version 3.0, will develop the full details of a flight object and its related functionality.

In the NAS Architecture, Version 3.0, the project segment entitled 'Develop Information Standard' (segment 592)[8] beginning in 2000 and the Flight Information Object Specification segment (segment 594) will provide the foundation and details for the FIO's scope and structure. The FDM Prototype Development (segment 535) will provide an environment for testing, evaluating and refining the FIO before it is fully deployed in the FDM National Development segment (536) beginning in 2007.

The addition of information services with a NAS-wide perspective and a local/facility perspective will take time to implement, but the transition for all three levels will begin in parallel. The parallel transition of information services at all levels provides development of services that are tailored to support the differences of information scope and implementation detail required at each level. Neither a top-down nor bottom-up approach alone are sufficient to transition to an improved information management environment. There must be coordinated development at all levels with the flexibility to adapt as the process moves forward.

One aspect of transition is building systems using data standards and data models and the use of COTS information technology. Options for transitioning NAS legacy systems to common information services are depicted in Figure 1-13. Legacy application transition steps include:

- **Introducing standardized common data definitions and data structures**
- **Introducing standards-based database management services**
- **Introducing common data access and distribution services as part of application upgrades and re-engineered systems**

The NIS will transition incrementally along with the NAS operational concept and the infrastructure supporting these operations. Increasingly, information services, along with the infrastructure, will be based on information and technical standards, as depicted in Figure 1-14. These standards are a key part of the TRMs that will be coordinated across all levels of the NAS and with NAS users. As NAS information services are implemented to collect, process, and distribute common data shared by multiple systems, individual local and domain systems will be relieved of or share many data management activities. Legacy systems that depend on existing data exchange

8 The 3-digit numbers in parentheses are references to segments of the proposed FAA budget for the NAS Architecture.

formats will acquire common data via translation services until they are upgraded (or replaced) to include common data elements and to take advantage of common data management services. More uniform data services will be

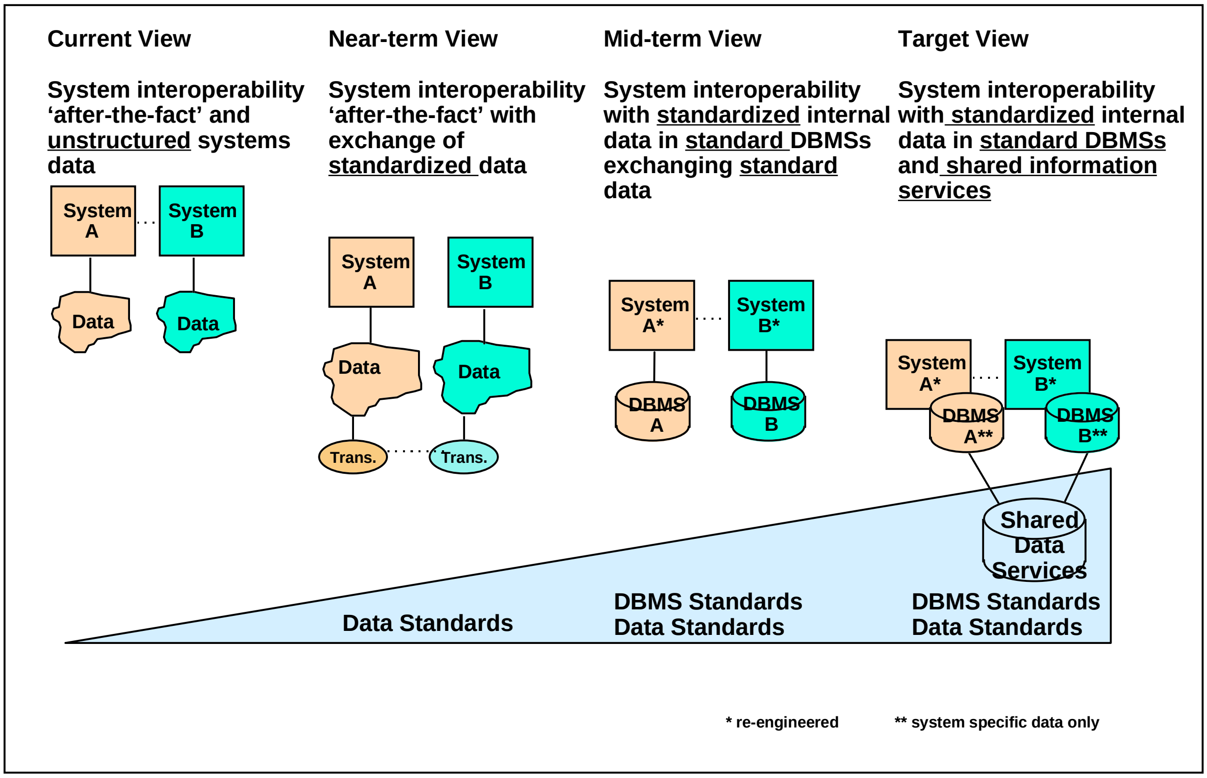

Figure 1-13. Transitioning Legacy Applications to Common Information Services

implemented at local NAS facilities (e.g., ATCSCC, ARTCC, TRACON, and Airport/Tower) to deliver accurate, up-to-date, and relevant information needed by a wide variety of decision makers.

NAS development will increasingly be based on coordinated data service standards (infrastructure, software, communications, security standards) developed from a NAS-wide perspective. Within the context of the such standards, local information services will be based on standards that focus on ensuring interoperability of systems and applications within a facility. For domains with multiple systems and applications, domain standards will be constructed within the context of NAS-wide and local standards. Shared data services will reduce cost, improve interoperability, and speed the fielding of systems and applications that take advantage of common data services.

The incremental development of a systems engineering repository with easy accessibility will facilitate and enhance NAS development efforts. As NAS information services are fielded, NAS domain capability developers will spend less time and resources developing the information management components of a system and focus on development of needed functionality.

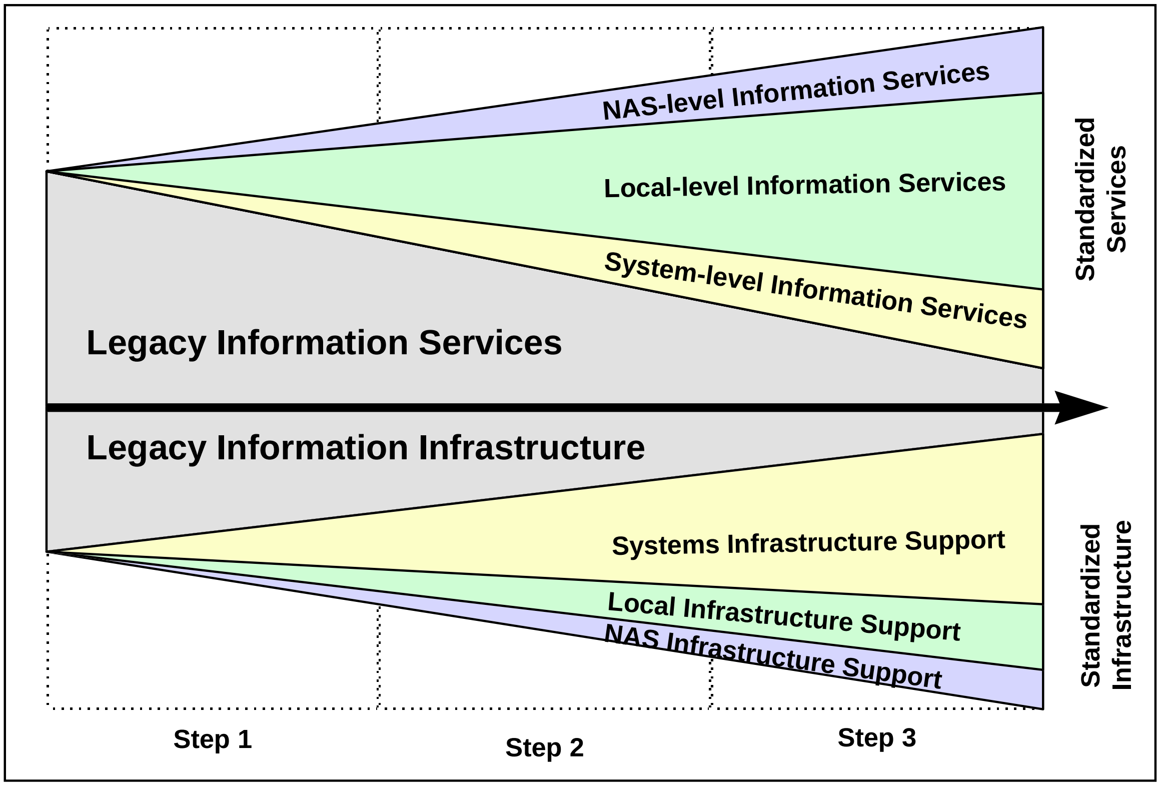

Figure 1-14. Transition to a Standards-Based NAS-wide Information Service (NIS)

Parallel Transition of NAS-wide Common, Local, and System-level Services. The parallel transition of information services at all three levels provides development of services that are tailored to support the differences of information scope and implementation detail required at each level. The information services transitions at all levels will involve some form of the following activities:

- **Documenting legacy and future information services**
- **Selecting data to be standardized**
- **Introducing data standardization services**
- **Introducing data management of standardized data**
- **Upgrading and re-engineering applications to use common data and information technology**

Tables 1-3, 1-4, and 1-5 provide an overview of the broad transition steps for implementing NAS-level common, local, and system-level information services. The information services needed to support the target Concept of Operations at each level are listed in the first column. Steps for an incremental implementation of the services are identified in the next three columns. Italicized entries in the chart identify segments that were used for costing purposes in the NAS Architecture, Version 3.0. These segments may provide increments in many of the services across multiple levels.

Table 1-3. NAS-level Common Services Transition Steps

Services	Step 1	Step 2	Step 3
NAS Data Administration Policy	**Establish the roles of Data Administration (DA) and Database Administration (DBA).**	**Assign responsibility for policy development, review, and enforcement; review organizational structures.**	**Update policy and organizations as required to enhance information services delivery.**
NAS Common Data Standards	***Develop Information Standard [592]*** **Develop flight information object, facility status, and static airspace data standards.**	**Add dynamic airspace, archive development, and surveillance to flight information object, facility, and static airspace data standards.**	**Add weather, to dynamic airspace, surveillance, flight information object, facility, and static space standards.**
NAS Common Data Structures	***Flight Information Object Specification [594]*** **Complete a data model of flight information object, facility status, and static airspace data.**	**Add models of dynamic airspace, archive, and surveillance data to model of flight information object, facility status, and static airspace data.**	**Add models of weather data to models of dynamic airspace, archive, surveillance, information object, facility status, and static airspace data.**
NAS Information Directory	**Evaluate standards-based information directory tools.**	**Initiate directory for NAS flight information and resource data.**	**Maintain directory for all NAS common data.**
NAS Data Archive	**Coordinate, upgrade, and standardize existing archives.**	**Use data warehousing technology to integrate archives for FAA access.**	**Develop datamarts to support analysis; for controlled access to NAS operational data.**

Table 1-3 (concluded)

Services	Step 1	Step 2	Step 3
NAS Information Security	**Include information security policy in NIAC policy drafts; provide NAS guidance to facilities & domains.**	**Assign responsibility for data information security policy development, update, and enforcement.**	**Update information security policy and procedures; coordinate with facility and domain security work.**
NAS Technical Reference Model	**Adapt NIST TRM with focus on infrastructure and general support applications services.**	**Expand initial TRM to complete FAA common mission and information services standards.**	**Update and maintain TRM with common application and infrastructure standards.**
NAS Common Database Management	**Identify common data requirements; prototype flight information object (flight plans and dynamic flight parameters).**	**Initiate database management of flight information object (flight plans) and airspace (adaptation) data.**	**Provide NAS databases for flight information object, adaptation , NAS status, and selected operational archives.**
NAS Information Systems Engineering Repository	***Information Systems Requirements [593]*** **Prototype an engineering repository for standards, requirements, use and services.**	**Provide intranet access to existing and planned systems engineering data, standards, data usage, data structures, and application data requirements.**	**Add controlled NAS user and NAS contractor access; add software engineering data.**
NAS/User Interface Standards	**Coordinate NAS user interface activities.**	**Draft and coordinate user interface standards with joint FAA and user team; prototype and test.**	**Implement interfaces in LIS; assign FAA responsibility for updating and maintaining standards .**
NAS/International Standards	**Strengthen ties with Eurocontrol and ICAO; adopt ICAO flight plan format; identify data standardization priorities.**	**Work in international forums to define and adopt high priority (e.g. flight data) international standards.**	**Maintain working relations with international standards developers and introduce applicable standards into NAS information services.**
Local and System	**Review and**	***FDM National***	***NAS Automation P3I***

Application Integration	**coordinate with local and system information service developer on cross-cutting issues and projects.**	***Development [536]*** **Coordinate Local and Domain information services.**	***[841]*** **Coordinate Local and Domain information services.**

Table 1-4. Local-level Services Transition Steps

Services	Step 1	Step 2	Step 3
Local Information Services	***Information Services LIS [697]***	***Information Services LIS [698]***	***Information Services LIS [699]***
Local Data Policy and Procedures	**Supplement NAS-wide data policies with local requirements.**	**Assign responsibility for local policy development, review, and enforcement.**	**Update policy and organizations as required to enhance information services delivery.**
Local Common Data Standards	**Analyze existing systems for data common to local environment not in NAS-wide structures.**	**Add information developed in the near-term time-frame; provide definitions for reuse by other facilities.**	**Use NAS-wide data standards augmented with local-only data standards.**
Local Common Data Structures	**Analyze existing systems for data common to local environments not in NAS-wide structures.**	**Begin to incorporate NAS-wide data structures.**	**Conform to NAS standards augmented with local-only information structures.**
Local Information Directory	**Document and maintain record of existing local data items.**	**Begin fielding a standards-based directory of local common data.**	**Expand directory to reference NAS-wide data.**
Local Data Archive, Backup and Recovery	**Provide local data bases and access for data shared between local systems; initiate deployment of structured local data archives.**	**Deploy local archive services with standard, structured data; introduce common backup and recovery service to local systems.**	**Where needed, add data warehouse services to local common data services.**
Local Information Security	**Initiate physical security of data systems and log-on procedures to protect**	**Add internal (authorized user) access via a secure intranet.**	**Incorporate multi-level access control and data partitioning.**

	local data.		
Local TRM and Standards Profile	**Add local infrastructure standards details to NAS TRM framework.**	**Add local general application services standards to NAS TRM framework.**	**Add local mission specific applications services standards to NAS TRM framework.**
Local Database Management	**Initial implementation of COTS database management technology.**	**Provide direct database-to-database exchange of information.**	**Maintain uniform database management services across the facility.**

Table 1-4 (concluded)

Services	Step 1	Step 2	Step 3
NAS Common Datamart	Identify requirements for datamart-like access to NAS and common local data.	Introduce datamarts at local facilities, loaded from NAS data warehouses to provide improved access to NAS-wide data.	Operate datamarts at local facilities, loaded from data warehouses (NAS and local) to improve access to selected NAS-wide data.
NAS/User Interface	Initiate NAS user access to local data via a central data repository; no direct local access.	Add internal (authorized user) access via a secure intranet.	Provide external (authorized users) and public access to some NAS-wide data via a public internet.
GUI standards	Apply human factors techniques to present consistent, quality information to service providers within a class of facilities.	Upgrade and apply GUI standards as new or upgraded services involving humans are introduced at a facility.	Continue to evaluate and standardize human-to-automation interfaces as information technology evolves.
Application Engineering Support	Determine multi-system requirements for common applications such as FDM.	*FDM National Development [536]* (see NAS-level)	*NAS Automation P3I [841]* (see NAS-level)

Table 1-5. System-level Services Transition Steps

Services	Step 1	Step 2	Step 3
System Data Policy and Procedures	Supplement NAS-wide data policies with system and system requirements.	Assign responsibility for system policy development, review, and enforcement.	Update policy and organizations as required to enhance information services delivery.
System Common Data Standards	Develop system-unique data element standards where local and NAS are not available.	Transition system applications to system, local and NAS standard elements.	Update system data standards and use system, local and NAS standards in new application development.

Table 1-5 (continued)

Services	Step 1	Step 2	Step 3
System Common Data Structures	**Develop system-unique data structures where local and NAS structures are not available.**	**Transition system applications to system, local and NAS standard structures.**	**Update system data structure standards and use system, local and NAS standard structures in new application development.**
System Information Directory	**Document and maintain record of existing system data items.**	**Begin fielding standards-based directory of system common data.**	**Expand directory to reference NAS and local common data.**
System Data Backup and Recovery	**Determine system and application requirements for common backup and recovery service.**	**Begin test and deployment of systems and applications using local common backup and recovery services.**	**Use common data backup and recovery services when needed for application upgrades and new applications.**
System Information Security	**Initiate physical security of data systems and log-on procedures to protect system data.**	**Add internal (authorized user) access via a secure intranet.**	**Incorporate multi-level access control and data partitioning**
System TRM and Standards Profile	**Identify information technology areas and levels of detail needed to apply TRM to system and application acquisition.**	**Augment NAS and Local TRM frameworks to build a system TRM that includes details and standards for system systems & applications; establish technology standards profile(s).**	**Update system TRM and standards profiles as technology evolves to support application upgrades and new application development.**
System Database Management	**Determine opportunities and requirements for use of standards-based database management technology.**	**Transition applications (upgrades and new) to use common database management services.**	**Use common database management services for application upgrades and new applications.**
NAS Common Data Access	**Determine opportunities and requirements for use**	**Transition applications (upgrades and new) to use NAS**	**Use common data access services for application upgrades**

	of proposed NAS and Local common data.	**and Local common data services.**	**and new applications.**

Table 1-5 (concluded)

Services	Step 1	Step 2	Step 3
NAS Information System Engineering Repository Update	**Populate an engineering repository with system and application-specific details.**	**Use an engineering repository to coordinate transition of system applications.**	**Use an engineering repository to develop and acquire new system applications.**
Application Engineering Support	**Determine system requirements for multi-domain applications such as FDM.**	***FDM National Development [536]***	***NAS Automation P3I [841]*** **(see NAS-level)**

Timing of the transition of services at each level and within each level may vary significantly, adding to the challenge of coordinating the transitions within and across level.

Evolutionary Transition. The transition steps identified in the three tables above in many cases assume that future information services will evolve incrementally from some of the information services embedded in existing and developing systems and applications. Future information services, especially at the system level will continue to be embedded and implemented in systems and applications, but there will be a transition to common services and data standards that are developed once and used many times.

Roles and Responsibilities. Future information service responsibilities cut across traditional FAA management structures. Roles and responsibilities for common information service definition, development, procurement, and operation will be re-examined. In some instances, new ways of doing business are needed (e.g., NAS-level services). Possibly, new organizations are required that specialize in managing NAS information. The NAS Information Architecture Committee (NIAC) is a newly formed cross-cutting organization that can play a key role in addressing roles and responsibilities for common information services. The Committee, working with FAA and NAS user organizations that specialize in information management, can also be a vehicle for documenting data standards, producing prototype information management capabilities, and examining promising information technologies.

Cost. Shared data services will improve interoperability and speed the fielding of systems and applications that take advantage of common data services. The incremental development of a systems engineering repository (database) will facilitate and enhance all NAS development efforts. As NAS information services are fielded, NAS domain capability developers will spend less time and resources developing the

information management components of a system and focus on development of needed functionality. It is clear that a systematic architecture approach will improve system operations. Whether there will be cost avoidance, cost savings, or both requires a detailed analysis of the costs of a particular implementation strategy.

Recommendations. The following recommendations are made for implementing a NAS-wide Information Service (NIS):

- **Establish NAS-wide oversight for a re-engineered information architecture with coordinated information management at the NAS level, local (facility) levels, and at the system level. Develop a distribution plan for allocating responsibilities and services among the three levels.**
- **Establish coordinated interfaces between the FAA and NAS user systems for the exchange of the three basic types of data: system engineering data (metadata), archival operational data, and real and near-real-time operational data**
- **Introduce common data standards and structures, along the lines described in NIST's and DOD's TRM and as supported by the OMB and GAO. Coordinate these with corresponding technical architecture standards.**
- **Coordinate the information architecture with other key architectural components, such as:**
  - **Information security (DBMS-based vs. other security technologies and practices)**
  - **Communications (peak loading; system capacity and distribution relative to data volumes)**
  - **Application development (use of structured data)**
  - **Hardware (functionality, sizing, and location)**
  - **Software (implementation of business rules, link to COTS, data management tradeoffs).**
- **Shift system development of customized information services by assisting legacy systems to convert their information inputs and outputs to a more common information view.**
- **Develop systems to track costs to be used to make improved investment decisions about a range of information-based costs, including the following costs:**
  - **Data acquisition**
  - **Database development, including COTS information technology, preprocessing, validation, and data modeling**
  - **Data pre-processing using parsing code and other software filters**
  - **Data access and distribution**

- **Data control and security**
- **Data exchange among FAA systems and with NAS users systems**
- **Data sizing and growth**

Bibliography

Bernstein, P., December 1996, "The Repository: A Modern Vision," Database Programming and Design, Volume 9, Number 12, pp.28-35.

Cherdak, S. J. B., et al., September 1996, *Traffic Flow Management Research and Development Activities,* MP96W200, The MITRE Corporation, McLean, VA.

"Digital Media Management: A White Paper," Sun Microsystems, 13 February 1997; found at http://www.sum.com/media/presentations/dmmwp/whitepaper.htm

"Engineering Information Systems and the IEEE Standard 1220-1994," National Council on Systems Engineering (NCOSE) Conference, July 1996, Boston, MA.

Federal Aviation Administration, November 1993, *The Future Traffic Flow Management System: Volume II, Operational Description,* U.S. Department of Transportation, Washington, DC.

Federal Aviation Administration, June 1996a, *A Concept of Operations for the National Airspace System in 2005, Revision 1.3,* U.S. Department of Transportation, Washington, DC.

Federal Aviation Administration, September 1996b, *TFM R&D Project Summaries,* U.S. Department of Transportation, Washington, DC.

Federal Aviation Administration, October 1996c, *National Airspace System Architecture, Version 2.0,* U.S. Department of Transportation, Washington, DC.

General Accounting Office, February 1997, *Air Traffic Control: Complete and Enforced Architecture Needed for FAA Systems Modernization*, Accounting and Information Management Division, GAO/AIMD-97-30.

Hermes, M. and Dunham, S., 28 May 1997, "Preliminary Draft: Initial Operational Concept for Traffic Flow Management Information Exchange," Letter F067-L-005, 1297013F, The MITRE Corporation, McLean, VA.

Joint Technical Architecture (JTA), 22 August 1996, Department of Defense (DOD), Version 1.0, p. 2-3.

Karangelen, Hoang, and Howell, July 1996, "Top Level Requirements for an Advanced Systems Engineering Information Repository," National Council on Systems Engineering (NCOSE) Conference, Boston, MA.

Kyungpook, K., *The Essential Distributed Objects Survival Guide*, (see http address to complete)

Masters, M., Dall, A., Monaco, M., August 1996, *Objectizing a Relational Database: An Extensible Approach to Many-to-Many Relationships*, The MITRE Corporation, Presented at the Department of Defense Database Colloquium '96, San Diego, CA.

Moriarity, T., March 1990, *Are You Ready for a Repository?*, Database Programming and Design, Volume 3, Number 3, p. 61-71.

Parker, B., June 1995, "On Repositories," Briefing, The MITRE Corporation, McLean, VA.

Renner, Dr. S., Scarano, J., August 1996, *Migrating Legacy Applications to a Shared Data Environment*, The MITRE Corporation, Presented at the Department of Defense Database Colloquium '96, San Diego, CA.

Rennhackkamp, M., "Building a DBA Repository System," January 1996, DBMS Magazine, Volume 9, Number 1, pp. 59-64.

Rosenthal, Dr. A., Ceruti, Dr. M., August 1996, *Toward Data Administration in the Large*, The MITRE Corporation and NCCOSC, respectively, Presented at the Department of Defense Database Colloquium '96, San Diego, CA.

RTCA, Inc, November 1996, *Minimum Aviation System Performance Standard for Air Traffic Management - Aeronautical Operational Control Ground-Ground Information Exchange*, Washington, DC.

Glossary

AOC	**Aeronautical Operational Control**
ANSI	**American National Standards Institute**
ARTCC	**Air Route Traffic Control Center**
ATCSCC	**Air Traffic Control System Command Center**
ASD	**(FAA) System Development & Program Evaluation (Organization)**
ATC	**Air Traffic Control**
CDM	**Collaborative Decision Making**
COTS	**Commercial-off-the-Shelf**
CTAS	**Center TRACON Automation System**
DBMS	**Database Management System**
DoC	**Department of Commerce**
DoD	**Department of Defense**
DoE	**Department of Energy**
DOTS	**Dynamic Ocean Tracking System**
DSS	**Decision Support System**
EATMS	**European Air Traffic Management System**
ETMS	**Enhanced Traffic Management System**
FIO	**Flight Information Object**
FMS	**Flight Management System**
GA	**General Aviation**
GAO	**General Accounting Office**
GIS	**Geographical Information System**
GUI	**Graphical User Interface**
HCI	**Human Computer Interface**
ICAO	**International Civil Aviation Organization**
IPT	**Integrated Product Team**
ITA	**Information Technology Architecture**
LAN	**Local Area Network**
LIS	**Local Information Service**
MAMS	**Military Airspace Management System**

NAS	**National Airspace System**
NAVAID	**Navigational Aid**
NCIS	**NAS-level Common Information Service**
NIAC	**NAS Information Architecture Committee**
NIMS	**NAS Infrastructure Management System**
NIS	**NAS-wide Information Service**
NIST	**National Institute of Standards and Technology**
NOTAM	**Notices to Airmen**
OMB	**Office of Management and Budget**
PIREP	**Pilot Report**
SAMS	**Special Use Airspace Management System**
SQL	**Structured Query Language**
STARS	**Standard Terminal Automation Replacement System**
SUA	**Special Use Airspace**
TFM	**Traffic Flow Management**
TRACON	**Terminal Radar Control**
TRM	**Technical Reference Model**
URET	**User Request Evaluation Tool**
WAN	**Wide Area Network**