SHAPING THE NATIONAL AIRSPACE SYSTEM FOR THE 21ST CENTURY

Gregory Burke

Federal Aviation Administration

Office of System Architecture

and Investment Analysis (ASD)

800 Independence Avenue, SW

Washington, DC 20591

ABSTRACT

Shaping the National Airspace System for the 21st century requires a clear understanding of the goal to be achieved as well as a firm grasp of the improvements which must be made to achieve that goal. This paper provides a description of the characteristics of a modernized NAS, the goal of current improvement efforts, as well as a description of the improvements that must be made in each functional area to provide the characteristics described.

INTRODUCTION

The Federal Aviation Administration's (FAA) mission is to promote a safe, orderly, and efficient flow of air traffic in the national air space. To accomplish its mission, the FAA provides services through its air traffic control towers, terminal area facilities, en route centers, and flight service stations. The FAA is also responsible for providing for safe separation of aircraft; acquisition, operation and maintenance of the National Airspace System (NAS); and certification of airmen, aircraft and engines, and airports.^[1]

NAS ARCHITECTURE

To compete in the global economy of the 21st Century, America needs a healthy, vibrant aviation

industry. In turn, the health and vibrancy of the aviation industry depend on improved levels of safety, security and modernization. For the last fifty years, the United States has led the field of aviation. But, that position is being challenged, by both competition from abroad and weakness in our own systems.^[2]

It is essential that the airspace system of the United States be modernized. Although the current system remains safe, it is showing signs of aging. System outages, brownouts, inefficiencies in air traffic control, and capacity limitations on the ground add cost to the FAA and to users of the airspace system.^[2]

The FAA is currently in the process of developing an architecture that addresses NAS modernization. This definition effort is currently underway and is expected to be essentially complete by the end of 1997.

The technology needed to modernize the airspace system by and large exists, and is available off-the-shelf. The challenge is completing the transition to the new system in a timely and cost-effective manner, and ensuring that all users participate in the upgrade.^[2]

Characteristics of a Modernized NAS

The modernized NAS takes a human-centered approach to maximize the efficient delivery of air traffic services to users. System processes and workstations are designed to expedite information exchange among NAS information systems, service providers, and users. Human factors analyses and human-in-the-loop simulations have determined the appropriate allocation of tasks among service providers, users, and automation systems. Moreover, issues such as situation awareness, workload, and computer-human interface design are being addressed by incorporating human factors and operational assessments into the NAS design and validation process.^[3]

When the new systems are in place, air traffic capacity can be significantly increased without a corresponding increase in the air traffic controller work force. Controller workload under peak traffic will remain equivalent to the workload controllers handled in the 1990s under lighter traffic demand. This increased air traffic control efficiency will be achieved by implementing decision support systems for traffic management and control, dynamic alteration of airspace boundaries, reduced vertical separation minima, improved air-to-ground communications and coordination, and enhanced ground-to-ground coordination aids. Air safety will be increased by implementing conflict detection and resolution tools and including the flight deck in some separation decisionmaking, and through greatly enhanced weather detection and reporting capabilities. Due to these improvements, the NAS will be marked by the following key characteristics:

- *Phased Technology Implementation.* The evolution of the operational environment is based on an incremental implementation of new technologies. This approach maintains safety as the first priority, while increasing capacity, efficiency, and flexibility in balance with environmental considerations. The Air Traffic Service organization considers community involvement to be an essential element in developing procedures and establishing facilities.
- *Redistributed Roles and Responsibilities.* Separation assurance remains the responsibility of the service provider. However, that responsibility is shifted to the flight deck for specific operations.
- *Human Factors Considerations.* The evolution of the NAS uses a clear transition strategy for each operational capability, and employs a human-centered approach for implementing new operational concepts and supporting technologies. This approach ensures that the human capabilities and limitations of users and service providers remain a primary consideration in systems development.
- *Information Distribution.* A NAS-wide information system distributes timely and consistent information across the NAS for both user and service provider planning. This information system is an avenue for a greater exchange of electronic data and information between users and service providers. The system provides the following information:
 - static data such as maps, charts, airport facility guides, and published notices to airmen (NOTAMs)
 - dynamic information such as current and forecast weather, radar summaries, hazardous weather condition warnings, information on updated airport and airspace capacity constraints, and special use airspace (SUA) schedules
 - flight information on each flight, including the filed flight profile and all amendments, first movement of the aircraft, wheels-up, position data in flight, touchdown time, gate or parking assignment, and engine shutdown

- schedule information that is updated throughout the day to reflect changes in carrier operations.
- *Airspace Boundary Adjustments.* With increased computational and communications capabilities, airspace design and underlying sector configurations are no longer constrained by current geographic boundaries, particularly in high altitude. Once the National Airspace Review is completed, tools and procedures will be developed for frequent evaluation (up to several times a day) of the airspace structure and anticipated traffic flows, with adjustments made accordingly. Due to this increased flexibility, the number and scope of air traffic facilities may be modified to support dynamic traffic factors, rather than institutional requirements.
- *Seamless Communications.* Automation systems will support the dynamic air-space structure with seamless inter- and intra-facility communication and coordination.
- *Airspace Flexibility.* Seamless communications and coordination, coupled with the NAS-wide information system, allows for the dynamic reassignment of airspace between facilities to meet contingencies such as equipment outages.
- *Collaborative Decisionmaking.* The system allows increased collaboration between users and service providers for resolving strategic problems. For situations such as demand-capacity imbalances or severe weather, this capability supports collaboration in determining when, where, and how to transition to temporary route structures to meet a short-term problem.
- *Fault-Tolerant Systems.* The NAS is a fault-tolerant system, designed through safety and risk analysis to identify areas requiring higher reliability and backup. Since it is recognized that systems will fail, the NAS design maintains a balance of reliability, redundancy, and procedural backups. Thus the design provides a system that not only is available, but that requires minimal time for restoring failed functionalities.
- *Automation Aids.* Automation aids enable the elimination of paper flight strips throughout the NAS. Aircraft progress is tracked electronically, with all critical functions provided for in backup systems. There is also increased use of decision support systems that provide both information and heuristics to support service providers in their tasks. These tools reduce the burden of routine tasks while increasing the provider's ability to evaluate traffic situations and plan appropriate responses. This increases productivity and the flexibility of user operations, which is especially important for reduced vertical separation minima and increased traffic density.
- *Infrastructure Management.* Improved methods for collecting and processing NAS infrastructure data make these data available as an integral part of the NAS-wide information system for prioritizing and scheduling NAS infrastructure activities. Users and service providers collaborate in this prioritization and scheduling, using decision support tools that provide information about the coverage and status of NAS infrastructure components.
- *Enhanced Weather Information.* Increasingly accurate weather data is distributed simultaneously to service providers, the flight deck, and user operations centers. These data include hazardous weather alerts for wind shear, microbursts, and gust fronts. As weather tools are improved and integrated into the decision support tools, the ability to provide separation from convective weather is improved.
- *NAS Performance Measurement.* Improved methods and tools measure NAS performance, identify user requirements, and provide daily

archiving of the NAS-wide information system. These improvements are designed to providing the information in a meaningful and readily accessible form.^[3]

FUNCTIONAL AREAS

The functional areas included in the proposed architecture are described in the following paragraphs.

Communications

To modernize communications systems, resolve deficiencies, and meet future needs, the ground-to-ground network will be fully digital and integrated to provide both voice and data capabilities, as well as information and control for the NAS Infrastructure Management System (NIMS). The network will carry both operational and administrative communications over the same physical network and will enable information sharing among all NAS users. Centers will be equipped with digital voice switches, and terminal and flight service station switches will be replaced with modularly expandable digital voice switches.

Air-ground communications requirements will be met by using next generation air-to-ground communications. The radio will be a multimode radio that includes 25 kHz VHF analog, and 25 kHz VHF digital modes. The system radios could also be designed so that other modulation techniques may be utilized. This would allow the FAA to retain maximum flexibility in responding to user needs.

Data Link

Data link capabilities will be expanded in the terminal/tower environment and data link services will be introduced to the en route environment. Two-way data link and broadcast-mode data link capabilities will be provided. The tower data link system will continue to operate at towers. Initial data link capability will be achieved using VDL-2

from a commercial service provider. Future data link applications may use satellite transmission.

New services that this system will support include: flight information service, terminal information service, and controller-to-pilot data link communications.

Navigation and Landing

To modernize navaid functional area capabilities, resolve current deficiencies, and meet future needs, the NAS will transition from ground-based navaids to satellite navigation using the global positioning system (GPS), augmented by the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS). GPS WAAS/LAAS will provide the precise navigation position source for an automatic dependent surveillance broadcast (ADS-B) system and replace all NDB, VOR/DME, TACAN, and ILS ground-based navaids.

The GPS/WAAS will provide sole-means navigation in the en route and terminal areas. It will support non-precision and Cat I precision approaches at the vast majority of runway-ends in the NAS.

The GPS/LAAS will support Cat I, Cat II, and Cat III precision approaches at every airport within coverage of the LAAS. In conjunction with ASD-B, GPS/LAAS will also be used for airport surface guidance and collision avoidance.

Surveillance

To modernize surveillance and meet future needs, new digital radars and surveillance distribution will be used to share terminal radar data with the air route traffic control centers (ARTCCs). This will allow the FAA to maintain airspace coverage with fewer radars. The ADS-B system relies on GPS satellites as a source of aircraft position and velocity data. New air traffic control beacon integrator radars will use ADS-B data to improve the accuracy of target positions and tracking. ADS-B also will be used to provide the basis for improv-

ing airborne collision avoidance systems and airport surface conflict detection and surveillance.

Avionics

To derive the full benefits of the modernized the NAS, users will need to equip with the necessary avionics to receive, process, and display data. New or upgraded avionics will be required for air-to-ground communications, data link communications with data processor and message display, satellite-based navigation, and satellite-based surveillance.

Decision Support System (Automation)

The modernized traffic flow management (TFM) system will allow seamless interaction between TFM and other NAS service providers. For TFM specialists, automation will facilitate information sharing, monitoring NAS performance, and better management of the impact of demand-capacity imbalances. Common information services will be provided by national and local applications, and integrated national TFM applications will be developed and merged with existing applications. The TFM infrastructure will be replaced with open system compliant hardware and software to reduce the cost of system development and future upgrades.

The new TFM capabilities will be provided via a phased upgrade of infrastructure and applications in the categories of information exchange, collaborative decisionmaking, and NAS analysis and prediction. The TFM infrastructure upgrades include network management and web technologies, a client-server architecture, and improved visual displays.

En Route

The display system replacement program replaces the aging en route controller consoles and display channel equipment with new, color, workstation consoles. New capabilities, e.g., sequencing and spacing (CTAS) and conflict probe, will be imple-

mented using peripheral processors connected to the HID/LAN before full replacement of the host computer system (HCS). Initially, the HCS hardware will be replaced while retaining the existing software (re-host). Then the HCS hardware and software will be replaced by a distributive combination of flight and surveillance data processors and a new decision support system (reengineered). A phased implementation of a local information system will provide the capability to exchange en-route-related information across the NAS.

Terminal

The Standard Terminal Automation Replacement System (STARS) (which is jointly sponsored by the FAA and Department of Defense will replace all terminal automation systems. STARS, an all-digital air traffic control automation system, is based on an open system architecture that supports new air traffic management functionalities. STARS radar data processing will be the basis for the development of new surveillance data processing capabilities for the en route and oceanic domains. Some pre-planned product improvements (P³Is), e.g., interfaces, surveillance processing enhancements, and improved weather displays, will be introduced on the STARS platform to support new air traffic management functionality. An LIS will provide the capability to exchange terminal-related information across the NAS.

Tower/Surface

The degree of modernization required at a tower is determined by the combination of traffic volume and complexity of airport operations.

The STARS tower display workstation is the basis for integrating applications in the tower. It will provide a combined display of surface and airborne traffic, runway incursion alerts, graphic weather overlays, and traffic flow management information. New information display systems will display status and control information, e.g., lighting, navigation, landing, non-graphic weather information,

and electronic flight data (including pre-departure clearance). Selected towers will have conflict alert processing for surface vehicle and aircraft incursions, and decision support tools.

Weather

Modernized aviation weather systems will make all weather information available to all NAS users, via tailored broadcast or request from a common network. The weather information will include graphical, textual, and voice data; gridded weather products; and current and forecast data. Aircraft and controllers will receive time-critical information simultaneously, and thus will have common situational awareness.

Windshear detection will be improved by using the airport surveillance windshear processor (ASR-WSP) and by replacing the Terminal Doppler Weather Radar situation display with the Integrated Terminal Weather System (ITWS). ITWS integrates windshear, microburst, and gust front alphanumeric and graphic products to provide improved automated weather information and predictions. The Weather and Radar Processor (WARP) will be deployed to convert weather data from NEXRAD and other sources for display to ARTCC controllers.

Flight Service

Currently, pilots interact with flight service specialists to acquire pre-flight briefings, file flight plans (VFR/IFR), obtain in-flight weather reports, and secure VFR flight following. Flight Services also coordinates search and rescue activities. In the future, these services will continue to be provided, while transitioning to increased pilot self-reliance through a computer network.

The Operational and Supportability Implementation System (OASIS) will be implemented in the near-term. OASIS will enable increased emphasis on pilot self-reliance for pre-flight services, but some level of human assistance will always be available to pilots. The national flight service

workload will be balanced and redistributed in accordance with daily weather conditions and seasonal demands (dynamic flight advisory areas).

Oceanic

Technological breakthroughs in automation and in satellite communications and navigation offer the opportunity for a modernized oceanic environment. Oceanic service providers will have a display of traffic in oceanic airspace, allowing them to ensure separation in the same manner as in domestic airspace, although the separation criteria may be different. The oceanic decision support tools (which will be similar to the domestic en route decision support tools) will be used to detect and resolve possible conflicts, and to prevent controlled aircraft from entering restricted airspace. However, oceanic and en route centers will be different in certain specifics based upon some unique oceanic requirements; for example, oceanic data link control, oceanic conflict alert, oceanic weather processing, and oceanic conflict probe decision support tools.

NAS-wide information sharing will facilitate collaboration between national and international service providers to determine the daily airspace structure (based on weather, demand, and user preferences), identify and explore alternatives to capacity problems, and manage traffic flow at gateway entries.

NAS Infrastructure Management System (NIMS)

NAS Information Management System (NIMS) will implement a three-tiered management system. Overall management and direction will be furnished by a National Operations Control Center (NOCC). Four Operational Control Centers (OCCs) will monitor, prioritize, and direct maintenance activities within their geographic areas, while multiple work centers in each geographic area, staffed by maintenance technicians, will perform onsite maintenance.

The ability to prioritize maintenance actions on the basis of impact on ATC service delivery is a key feature of the modernized maintenance system. Remote monitoring and control of NAS assets will allow the operational staff to take corrective action without dispatching field personnel, enabling more efficient use of maintenance personnel. Additionally, when field maintenance personnel are dispatched, they will be able to make more informed decisions regarding the tools, test equipment, and repair parts needed.

NIMS also will provide a common repository of maintenance data for monitoring and evaluating NAS performance, i.e., reliability, maintainability, and availability. This data will be shared with service providers and users for internal planning and collaborative maintenance decisions.

SUMMARY

Many of the ATC systems in use today are approaching the end of their service life and will become increasingly difficult and expensive to maintain. The NAS architecture will provide an integrated and coordinated plan for the modernization of the NAS. New technologies will be used to modernize the NAS. Advanced communications, navigation, and surveillance systems will revolutionize the air traffic management system. Data links, space-based navigation and landing systems, as well as digital communication systems will allow the safe and efficient movement of aircraft in the 21st century. A human-centered design approach will ensure the capabilities of the NAS required for continued safe management of the NAS are not compromised while the capabilities of each functional area are improved.

REFERENCES

[1] GAO, "Air Traffic Control, Status of FAA's Modernization Program," GAO/RECE-95-175FS, May, 1995.

[2] AL Gore, "White House Commission on Aviation Safety and Security, Final Report", February 12, 1997.

[3] FAA, A Concept of Operations for the National Airspace System in 2005, Revision 1.3, 27 June 1997.