EXECUTIVE SUMMARY

This architecture is an evolutionary plan for modernizing the National Airspace System (NAS) and moving toward Free Flight. It incorporates new technologies, procedures, and concepts intended to meet the needs of NAS users and service providers.

The publication of the *National Airspace System Architecture Version 4.0* marks a major milestone for the Federal Aviation Administration (FAA). The first published version of the NAS Architecture (Version 2.0, October 1996) focused on sustaining existing infrastructure while evolving toward a system that supports Free Flight. Version 2.0 generated over 2,200 comments and initiated discussion about the need for an Air Traffic Services (ATS) concept of operations for a modernized NAS, aviation community needs, stable funding requirements for the FAA, and the required pace of NAS modernization. These issues were debated, with assistance from RTCA and the Research, Engineering, and Development Advisory Committee (REDAC).

Published in December 1997, the draft *NAS Architecture*, commonly referred to as Version 3.0 (V3.0), incorporated feedback from the aviation community; the new ATS document, *A Concept of Operations for the National Airspace System in 2005;* and anticipated funding levels. The draft generated over 1,600 comments. In response, the Administrator formed the NAS Modernization Task Force to examine the remaining NAS modernization issues and risks.

This document, *National Airspace Architecture Version 4.0*, incorporates previous comments; input from the Administrator's Modernization Task Force; and more realistic funding profiles for research, engineering, and development (R,E&D), facilities and equipment (F&E), and operations (OPS). This architecture, which covers the period 1998 to 2015, is based on: (1) the *Government/Industry Concept of Operation*, developed jointly by RTCA and the FAA, (2) ATS's *A Concept of Operations for the National Airspace System in 2005*, and (3) a set of capabilities recommended by the RTCA Task Force 3 Report on Free Flight.

In accordance with the evolutionary development paradigm recommended by RTCA and industry, certain maturing technologies in the architecture are deployed on a limited basis and assessed by the FAA and users. Results of the assessment will be used to modify the technologies, if required, prior to national deployment.

NAS modernization is implemented in three phases.

Phase 1 (1998–2002). Current NAS systems and services are maintained while new systems such as the Standard Terminal Automation Replacement System (STARS), display system replacement (DSR), and Wide Area Augmentation System (WAAS) are introduced.

The NAS Modernization Task Force recommended that a Free Flight Phase 1 Core Capabilities Limited Deployment (FFP1 CCLD) program be implemented to mitigate risk and provide highly desired capabilities at selected locations before the end of 2002. The NAS Architecture Version 4.0 incorporated the FFP1 CCLD program as an initiative to provide early user benefits. FFP1 CCLD will deploy key automation capabilities to a limited number of sites within the NAS for formal evaluation by aviation stakeholders and FAA operators. Each capability will be evaluated for operational suitability and affordability prior to full-scale development or deployment.

To mitigate risk in the communications, navigation, surveillance (CNS) area, many of the ground systems, airborne avionics, decision support tools, supporting procedures, and training needed to provide an integrated set of capabilities will be tested in an operational environment during the Safe Flight 21 and Alaska Capstone programs. The results of Safe Flight 21 will drive national deployment strategies and timing for key CNS technologies.

Phase 2 (2003–2007). This phase concentrates on deploying new CNS and automation technologies to support the concept of operations.

Phase 3 (2008–2015). The required infrastructure for modernizing the NAS will be completed. Automation advancements integrated with new CNS technologies will result in less restrictions and more Free Flight capabilities throughout the NAS.

Capabilities

The NAS will be modernized incrementally. New systems will replace older ones, and new capabilities derived from advanced technologies and/or procedures will be added. The new capabilities will be a result of integrating new systems, airspace changes, procedures, training, avionics, and rulemaking. This architecture identifies and synchronizes the activities necessary for fielding a capability to provide benefits as early as is affordable under current and projected funding.

The following paragraphs describe the evolution of the NAS provided in the architecture by functional and domain areas.

Navigation, Landing, and Lighting Systems. In Phases 1 and 2, the ground-based navigation infrastructure will transition to a satellite-based system that uses the Global Positioning System (GPS) augmented by WAAS and the Local Area Augmentation System (LAAS). This satellite-based navigation and landing architecture will provide the basis for NAS-wide direct routing and guidance signals for precision approaches to most runway ends in the NAS, and it will reduce the variety of navigation avionics required aboard aircraft. Some ground-based navigational systems may be retained to back up satellite-based navigation operations along principal air routes and at high-activity airports.

Surveillance. The NAS architecture calls for evolution from the current primary and secondary radar systems to digital radar and automatic dependent surveillance (ADS). This change is designed to improve and extend surveillance coverage and provide the necessary flexibility for Free Flight. After data from weather radars become available on the new en route controller displays (i.e., DSR), primary radar will be phased out of en route airspace.

A new radar for approach control services (the ASR-11) will include weather-detection capability. The weather capability of the ASR-9 radar will be improved with the addition of the weather system processor (WSP). Primary radars will also be installed at more airports for airport surface surveillance. Secondary surveillance radars (SSR) with selective interrogation (SI) capability will be used in both en route and terminal airspace.

Based on successful Safe Flight 21 demonstrations and better definition of user benefits, users are expected to equip with automatic dependent surveillance broadcast (ADS-B) for air-air surveillance during Phase 1. If users do so, ADS, based on ADS-B, will be implemented during Phase 2 to enhance en route, terminal, and airport surface surveillance. ADS, based on automatic dependent surveillance addressable (ADS-A), is planned to provide surveillance in oceanic airspace in Phase 2.

Communications. The FAA will transition from analog voice and commercial service-provider data link communications to an integrated digital communications capability. Data link communications in Phase 1 will evolve as new applications are tested. Implementation of data link will reduce voice-channel congestion and increase the capacity of each very high frequency (VHF) frequency. During Phase 2, the FAA will begin replacing its analog air-ground radio infrastructure with digital radios (next-generation air-ground communication system (NEXCOM)). The capability of NEXCOM radios to provide digital voice and data communications will be implemented gradually during Phases 2 and 3. Ground-ground operational and administrative communications systems will be combined into an integrated, ground digital telecommunications system.

Avionics. Aircraft are expected to gradually transition to avionics that use satellite technology (GPS WAAS/LAAS) for navigation, landing, and reporting position information to other aircraft (ADS-B) and surveillance systems. The GPS WAAS/LAAS receivers will enable pilots to navigate via direct routes and to fly precision instrument approaches to virtually any runway. Aircraft radios will also be replaced for compatibility with the new, digital air-ground communications infrastructure. New, multifunctional cockpit displays will show the position of nearby ADS-B-equipped aircraft, provide moving map displays, and present data-linked information, such as graphical weather and notices to airmen (NOTAMs). Lengthy transition periods are designed into the architecture to accommodate the varying avionics transition schedules of all NAS users (i.e., airlines, general aviation (GA), and the Department of Defense (DOD)).

Information Services for Collaboration and Information Sharing. Integrated NAS information services will be the basis for operational planning improvements such as receiving and sharing common data and the ability to make joint planning decisions. A systemwide computer network with standardized data formats will allow NAS information services interoperability. The NAS-wide information services will evolve from today's current array of independent systems and varying standards to a shared environment that connects users and service providers for traffic flow management, flight service, and aviation weather information.

Traffic Flow Management. Air traffic management (ATM) encompasses traffic flow management (TFM) and air traffic control (ATC) capabilities and is designed to minimize air traffic delays and congestion while maximizing overall NAS throughput, flexibility, and predictability. TFM is the strategic planning and management of air traffic demand to ensure smooth and efficient traffic flow through FAA-controlled airspace.

TFM capabilities are managed primarily at the Air Traffic Control System Command Center (ATCSCC). Some functionality is distributed to traffic management units at air route traffic control centers (ARTCCs), high-activity terminal radar approach control (TRACON) facilities, and at the highest-activity airport traffic control towers (ATCTs). The Enhanced Traffic Management System (ETMS) will be updated with new tools. For example, the new control-by-time-of-arrival (CTA) tool will give users the capability to determine which flights and departure times are suitable for the capacity at the destination airport. The FAA will provide ground delay program (GDP) data to airline operations centers (AOCs). GDP data include operative airport acceptance rates, which will enable airlines to respond with revised, suitable flight schedules. A further enhancement, interactive flight plan filing, will enable FAA automation systems to provide feedback on system constraints and options to users' flight plans.

En Route. The current ARTCC computer hardware and software infrastructure will be replaced with new hardware, software, and operating systems. During Phase 1, new controller workstations (i.e., DSRs) will be installed and the current Host computer hardware will be replaced with a new computer (the Host/oceanic computer system replacement (HOCSR)) that uses the existing software applications. Controller tools such as conflict probe and the Center TRACON Automation System/Traffic Management Advisor (CTAS/TMA) will be implemented on outboard processors as part of the FFP1CCLD program. During Phase 2, the existing software applications will be recoded and new applications added to support air traffic control functions. During Phase 3, this modern computer infrastructure is expected to support advanced traffic management capabilities that support the movement toward Free Flight.

Oceanic and Offshore. During Phase 1, manual aircraft tracking that currently relies upon verbal pilot position reports will transition to satellite-based position reports received via data link. Communications between oceanic controllers and pilots will also be through satellite data link. During Phase 2, the oceanic infrastructure will be upgraded to use automatic data-linked position reports for automated aircraft tracking. In Phase 3, as the oceanic communications, surveillance, and automation capabilities for air traffic management improve, separation between properly equipped aircraft will continue to be reduced.

Terminal. A combination of ground automation and airborne systems will allow flexible departure and arrival routes and reduce or eliminate speed and altitude restrictions. During Phases 1 and 2, the existing terminal automation system will be replaced with the STARS. During Phase 2, the terminal automation infrastructure will evolve to incorporate new air traffic control functions such as ADS and weather information from the Integrated Terminal Weather System (ITWS). During Phase 3, the hardware and software will be improved to accommodate advanced controller tools such as conformance monitoring, conflict detection, and enhanced arrival/departure sequencing. These tools will enable controllers to maintain clear weather aircraft-acceptance rates at airports during inclement weather conditions.

Tower/Airport Surface. The tower/airport environment will evolve from having minimal automation support to having expanded use of data link, improved surface surveillance displays, and decision support tools. During Phase 1, the initial surface movement advisor (SMA), as part of the FFP1 CCLD initiative, will provide airline ramp control operators with arrival and departure information. New automation systems and increased information exchange among airport operators and users (i.e., airline operations centers, aircraft, and surface vehicles) will be implemented during Phases 2 and 3 to provide dynamic surface movement planning. This dynamic planning enables users and service providers to balance arrivals, departures, runway demand, gate changes, taxi routes, and deicing requirements.

Flight Services. Flight planning information distribution will evolve to provide easier access to information on weather, special use airspace (SUA) status, traffic management initiatives, and NOTAMs. During Phase 1, the current flight service automation systems will be replaced by the new Operational and Supportability Implementation System (OASIS). During Phases 2 and 3, OASIS will be integrated with the NAS-wide information network for improved information sharing.

Aviation Weather. The current NAS standalone weather systems will evolve and become integrated into a weather server so that information is single-source and shared by all systems. Weather information gathered and processed at the servers will be available to users and service providers in a more timely manner, promoting common situtational awareness and enhancing collaborative decisionmaking for controllers, traffic managers, aircrews, and dispatchers. In Phase 1, two key systems will be implemented, ITWS for terminal airspace and the weather and radar processor (WARP) for en route airspace.

Infrastructure Management. The current decentralized method of managing equipment maintenance will be replaced by a centralized method that will expand the FAA's reliance on remote monitoring and restoral of systems. New air traffic control equipment will include remote monitoring and restoral features to support this management strategy. This will enable the FAA to manage the infrastructure nationally rather than regionally and allow users to collaborate on service restoration priorities.

Conclusion

This architecture is a plan for an evolutionary approach to NAS modernization in which current NAS capabilities are sustained or improved while new technologies are introduced. In this architecture, the FAA and the NAS users have identified which technologies are likely to provide significant benefits, how to evaluate them, and when to implement them (contingent on affordability).

The risks associated with some of the new technologies will be mitigated by FFP1 CCLD and the Safe Flight 21 and Alaska Capstone programs, which provide for operational testing in a limited area prior to national deployment. Technology growth, funding levels, and other factors can and probably will affect the course of modernization. As new information arises, the FAA and the NAS users will collectively revise the architecture to refine the course of NAS modernization.