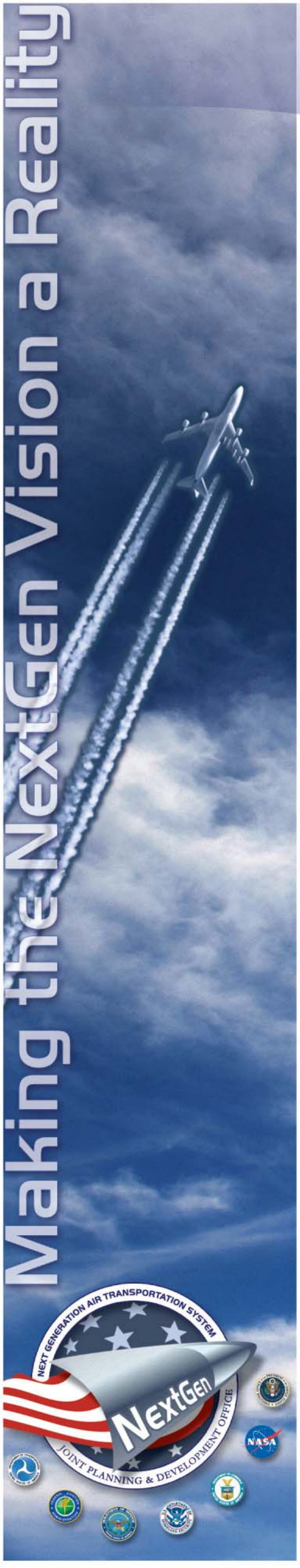


Joint Planning and Development Office

Concept of Operations for the Next Generation Air Transportation System

Version 2.0

13 June 2007

NEXTGEN

Next Generation Air Transportation System

Preface

The Joint Planning and Development Office (JPDO) is developing a Concept of Operations (ConOps) for the Next Generation Air Transportation System (NextGen). The final version of the ConOps will provide an overall, integrated view of NextGen operations in the 2025 timeframe, including key transformations from today's operations.

The development of the ConOps is an iterative and evolutionary process that will encompass the input and feedback of the aviation community. This is Version 2.0 of the document, which includes accepted comments resulting from an internal review and an expanded breadth of the NextGen concepts.

The purpose of this document is to provide all aviation stakeholders with an iterative version of the NextGen ConOps in order to gain further consensus from their comments for incremental improvement. Details of the JPDO comment and review process can be found at www.jpdo.gov.

This document identifies key research and policy issues that need resolution to achieve national goals for air transportation. In many cases, this document presents "aggressive" concepts that have not been validated, but are envisioned to maximize benefits and flexibility for NextGen users. Many potential futures are possible, and much will depend on the insights gained by the evolution of the ConOps.

The research and policy issues referenced throughout the text appear in detail in Appendices D and E, respectively. They are referenced within each chapter as [R-#] or [P-#]. Comments directed at refining these research and policy issues are requested.

The following page outlines the expected development chronology of the ConOps.

Document Revision Register

Version	Document Content Added	Reviewer	Release Date
0.1	Initial document that includes the major "day-of-flight" air navigation elements that support operational activities of a flight moving from "block to block"	JPDO Staff and Integrated Product Teams	May 9, 2006
0.2	Major comments from Version 0.1 review	Aviation Stakeholder Community	July 24, 2006
1.0	Major comments from Version 0.2 review	Submitted to JPDO Board for Approval	Unreleased
1.1	Initial addition of remaining key NextGen concepts that support operations from "curb to curb" as well as planning and strategic support functions	JPDO Staff and Integrated Product Teams	November 14, 2006
1.1a	Revised Version 1.1, including air navigation and flight operation concepts as well as revised Executive Summary	JPDO Staff and Integrated Product Teams	December 6, 2006
1.1b	Major comments from Version 1.1/1.1a review	Integrated Product Team Leads	January 29, 2007
1.2	Major comments from Version 1.1/1.1a/1.1b review	Aviation Stakeholder Community	February 28, 2007
2.0	Major comments from Version 1.2 review	Submitted to JPDO Board for Approval	June 13, 2007
2.1	Operational scenarios, additional definitions, and previous comments not included in prior versions	JPDO Staff and Integrated Product Teams	
2.2	Major comments from Version 2.1 review	Aviation Stakeholder Community	
3.0	Major comments from Version 2.2 review	Submitted to JPDO Board for Approval	
3.1 and above	Additional versions developed as needed	TBD	

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

The Concept of Operation (ConOps) provides a common vision of how the Next Generation Air Transportation System (NextGen) will operate in the 2025 timeframe and beyond. Transformation is needed to achieve the overall goals of NextGen. This includes management of air traffic and airports to achieve greater safety and efficiency. Security functions will protect our airspace, people, and infrastructure. Environmental impacts from aviation will be managed for sustainability and for an overall improvement in environmental quality. The ConOps forms a baseline that can be used to initiate a dialogue with the aviation stakeholder community to develop the policy agenda and encourage the research needed to achieve our national and global goals for air transportation.

The *NGATS Integrated Plan* (2004) clearly defines the problem: The U.S. air transportation system as we know it is under significant stress. With demand in aircraft operations expected to grow significantly through the 2025 timeframe, there are well-founded concerns that the current air transportation system will not be able to accommodate this growth. Antiquated systems are unable to process and provide flight information in real time, and current processes and procedures do not provide the flexibility needed to meet the growing demand. New security requirements are affecting the ability to efficiently move people and cargo. In addition, the growth in air transportation has provoked community concerns over aircraft noise, air quality, and congestion. In order to meet the need for increased capacity and efficiency while maintaining safety, new technologies and processes must be implemented.

The goals for NextGen focus on significantly increasing the safety, security, and capacity of air transportation operations and thereby improving the overall economic well-being of the country. These benefits are achieved through a combination of new procedures and advances in the technology deployed to manage passenger, air cargo, general aviation (GA), and air traffic operations. The *NGATS Vision Briefing* (2005) identifies eight key capabilities needed to achieve these goals:

- Network-Enabled Information Access
- Performance-Based Services (now Performance-Based Operations and Services)
- Weather Assimilated into Decision-Making
- Layered, Adaptive Security
- Broad-Area Precision Navigation (now Positioning, Navigation, and Timing [PNT] Services)
- Aircraft Trajectory-Based Operations (TBO)
- Equivalent Visual Operations (EVO) (the characteristics of which are described throughout this concept)
- Super-Density Arrival/Departure Operations.

These transformations fundamentally change the approach to air transportation operations in 2025. Capacity and efficiency are increased with the transformation from clearance-based operations to TBO, as required by demand and complexity. Advancements in aircraft capabilities allow for reduced separation and support the transition from rules-based operations to performance-based operations. Controller workload is no longer a limiting factor because of tools and automation, which provide expanded information and improved decisionmaking capabilities. In addition, the transition of separation responsibility from the controller to the flight crew in some areas allows controllers to focus on overall flow management instead of individual flight management. Increased levels of service and dynamic resource management will enable NextGen to meet demand rather than constrain demand to meet available resources.

Airports are the nexus of many of the NextGen transformation elements, including air traffic management (ATM), security, and environmental goals. Accordingly, the sustainability and advancement of the airport system is critical to the growth of the nation's air transportation system. Airports form a diverse system that serves many aviation operators and communities with different needs. Airport operators include a mix of private and local government/public entities that are responsible for aligning their activities with NextGen goals. New technology and procedures will improve access to airports, enabling better utilization of existing infrastructure and currently underutilized airports. The sustainability of existing airports will be enhanced with a preservation program to increase community support and protect against encroachment of incompatible land uses and impacts to airport protection surfaces. Finally, new airport infrastructure will be developed using a comprehensive planning architecture that integrates facility planning, finance, regional system planning, and environmental activities to enable a more efficient, flexible, and responsive system that is balanced with NextGen goals.

At the heart of the NextGen concept is the information-sharing component known as net-centric infrastructure services or net-centricity. Its features allow NextGen to adapt to growth in operations as well as shifts in demand, making NextGen a scalable system. Net-centricity also provides the foundation for robust, efficient, secure, and timely transport of information to and from a broad community of users and individual subscribers. This results in a system that minimizes duplication, achieves integration, and facilitates the concepts of distributed decisionmaking by ensuring that all decision elements have exactly the same information upon which to base a decision, independent of when or where the decision is made. The net-centricity component binds NextGen operational and enterprise services together, thereby creating a cohesive link. Enterprise services provide users with a common picture of operational information necessary to perform required functions. The suite of enterprise services includes shared situational awareness (SSA), security, environment, and safety.

SSA services offer a suite of tools and information designed to provide NextGen participants with real-time aeronautical and geospatial information that is communicated and interpreted between machines without the need for human intervention. A reliable, common weather picture provides data and automatic updates to a wide range of users, aiding optimal air transportation decisionmaking. PNT services reduce dependence on costly ground-based navigation aids (NAVAIDs) by providing users with current location and any corrections, such as course, orientation, and speed, necessary to achieve the desired destination. Real-time air situational awareness is provided by integrating cooperative and noncooperative surveillance data from all air vehicles.

Security services are provided by a risk-informed security system that depends on multiple technologies, policies, and procedures adaptively scaled and arranged to defeat a given threat.

New technologies and procedures aid in passenger screening and checkpoint responsibilities. Baggage screening improvements include integrated chemical, biological, radiological, nuclear, and high-yield explosives (CBRNE) detection and sensor fusion systems in a range of sizes for increased portability and remote screening.

Environmental interests are proactively addressed through the development and implementation of an integrated environmental management system (EMS). Technologies are incorporated before and during operations to enable optimized route selection, landing, and take-off procedures based on a range of data feeds including noise, air emission, fuel burn, cost, and route efficiency. At airports, a flexible, systematic approach is developed to identify and manage environmental resources that are critical to sustainable growth. Environmental considerations continue to be incorporated into aircraft design to proactively address issues including noise reduction and aircraft engine emissions.

Because of the profound impact adverse weather has on transportation, NextGen is focusing on a major new direction in aviation weather information capabilities to help stakeholders at all levels make better decisions during weather situations. For NextGen, weather information has a core function—identify where and when aircraft can or cannot safely fly. These safe and efficient NextGen operations will be dependent on enhanced aviation weather capabilities based on three major tenets:

- A common picture of the weather for all air transportation decisionmakers and aviation system users
- Weather directly integrated into sophisticated decision support capabilities to assist decisionmakers
- Utilization of Internet-like information dissemination capabilities to realize flexible and cost-efficient access to all necessary weather information.

NextGen sets forth a new way of looking at weather information's role in the system of the future. It is not about the weather products themselves; rather it is about enabling better air transportation decisionmaking. The common weather picture, enabled by the single authoritative source capability, facilitates SSA and reduces the need for stakeholders to decide between potentially competing or conflicting sources.

Aviation safety is steadily improved to accommodate the anticipated growth in air traffic while the number of accidents is decreased through an integrated safety management system (SMS). A national safety aviation policy is established that formalizes safety requirements for all NextGen participants. The safety improvement culture is encouraged by management and utilizes nonreprisal reporting systems. Safety assurance focuses on a holistic view of operators' processes and procedures rather than the individual pieces of the system. Modeling, simulation, data analysis, and data sharing are utilized in prognostic assessments to improve safety risk management.

Data from the above services is used to provide real-time system-level risk assessments and operational impact reviews to evaluate the performance, system safety, and security of NextGen via the performance management service. Real-time, onboard data is monitored and shared to evaluate and manage individual aircraft risk. Safety compliance is monitored through network-enabled data gathering, which collects interaircraft and pilot-to-pilot performance data. This enhanced monitoring of operational characteristics facilitates the integration of “instantaneous” system performance metrics into system management decisions.

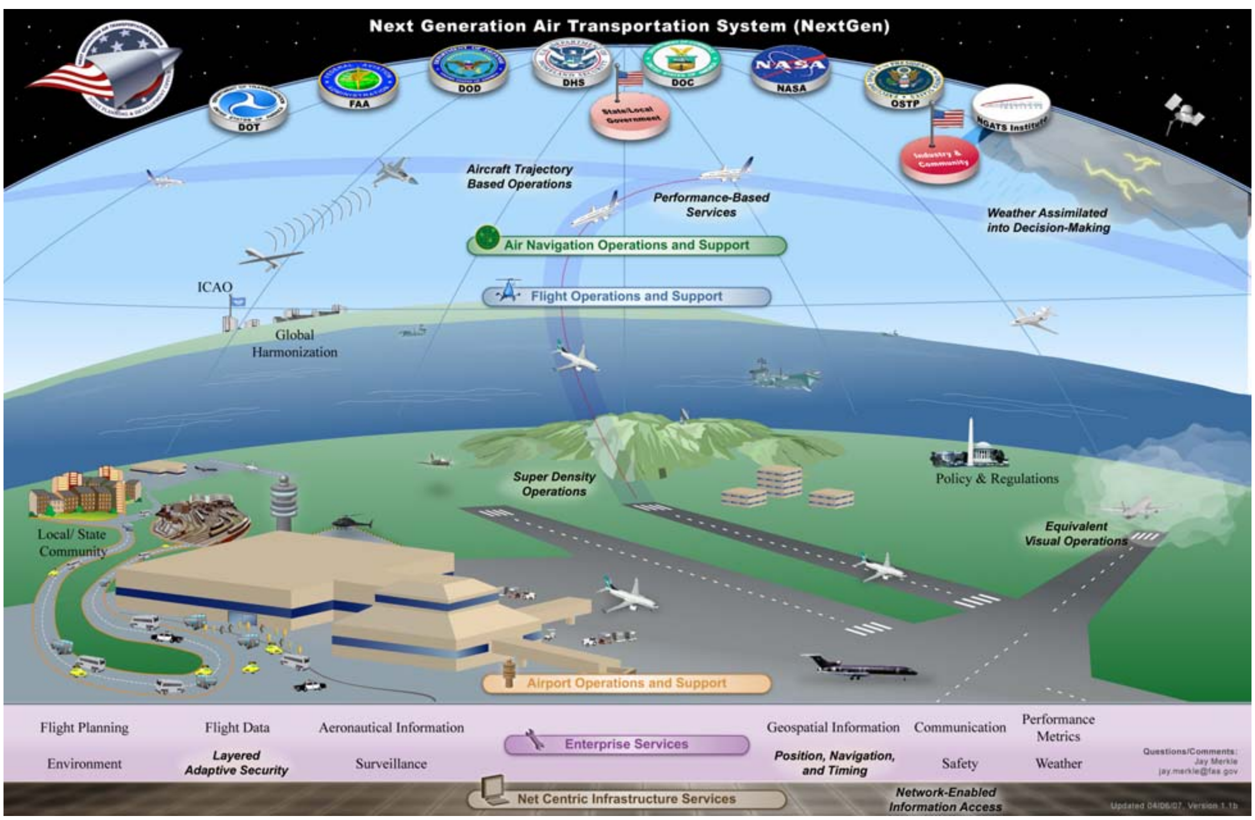
NextGen is a complex system with many public and private sector stakeholders that must smoothly, promptly, and capably integrate with the changes in the global air transportation system. National defense, homeland security, ATM, commercial and GA operators, and airports work together to support passenger, cargo, recreational, and military flights. Through a net-centric infrastructure, enterprise services provide users with a common picture of operational information necessary to perform required functions. These integrated capabilities of NextGen will provide the capacity required to meet the nation’s need for air travel in the most effective, efficient, safe, and secure manner possible.

1 Introduction

The concepts presented in this document provide an operational view of the Next Generation Air Transportation System (NextGen) in terms of how air traffic and airports are managed, how security is provided to protect our airspace and people, how goals for protecting and enhancing our environment are achieved, and how processes in government and civil organizations provide increased safety and efficiency.

The air transportation system is a complex global system with many public and private sector stakeholders. The system includes national defense, homeland security, air traffic management (ATM), commercial and general aviation (GA) operators, and commercial space transportation (CST) operators. It also includes airports that support passenger, cargo, recreational, and military flights, and spaceports (either dedicated or dual use) to support CST operations. NextGen integrates national defense and civilian capabilities to provide services to both civil and military users that are harmonized on a global scale. The integrated capabilities of NextGen provide the capacity needed to meet the nation's need for an air transportation system in the most effective, efficient, safe, and secure manner possible. Figure 1-1 provides an overall operational view of the environment supported by NextGen.

Figure 1-1. The NextGen Operational View



The Concept of Opertions (ConOps) provides a robust framework for the aviation stakeholder community to discuss and develop the policy agenda as well as encourage the research needed to achieve national and global goals for air transportation. As such, this document not only provides an operational view of air transportation in the future but also highlights key research and policy issues.

The concepts for the 2025 air transportation system will undoubtedly evolve over time as the aviation community stakeholders gain more insight from research, policy evolution and emerging technology; some concepts may be eliminated and other concepts may be incorporated, the ultimate objective is an air transportation system that meets the goals and objectives as stated in the NGATS Integrated Plan.

1.1 BACKGROUND

A mandate for the design and deployment of an air transportation system to meet the nation's needs in 2025 was established in the "Vision-100" legislation (Public Law 108-176) signed by President Bush in December 2003. The legislation also established the Joint Planning and Development Office (JPDO) to carry out this mission. This document is a product of the JPDO and describes the operational concept for NextGen as envisioned in 2025.

The JPDO is a joint initiative of the Department of Transportation (DOT), Department of Defense (DoD), Department of Commerce (DOC), Department of Homeland Security (DHS), National Aeronautics and Space Administration (NASA), and White House Office of Science and Technology Policy (OSTP). In addition to these government agencies, the JPDO includes the NGATS Institute, which provides access to the knowledge and skills of many in the private aviation stakeholder communities, enabling a two-way communication process between the Government and the private sector.

The U.S. aviation system must transform itself and be more responsive to the tremendous social, economic, political, and technological changes that are evolving worldwide. We are entering a critical era in air transportation, in which we must either find better, proactive ways to work together or suffer the consequences of … [losing] $30B annually due to people and products not reaching their destinations within the time periods we expect today.

-- NGATS Integrated Plan, 2004

The air transportation system transformation is motivated by the need for aviation to grow and continue to serve the national and international community while responding to tremendous social, economic, political, and technological changes worldwide. During the next two decades, demand will increase, creating a need for a system that (1) can provide two to three times the current air vehicle operations; (2) is agile enough to accommodate a changing fleet that includes very light jets (VLJs), unmanned aircraft systems (UASs), and space vehicles; (3) addresses security and national defense requirements; and (4) can ensure that aviation remains an economically viable industry.

The *NGATS Integrated Plan* (2004) recognizes these national needs and identifies 6 national and international goals and 19 objectives for NextGen (see Table 1-1). Separately, each goal represents an ambitious agenda. Meeting these goals and objectives requires a transformation that embraces new concepts, technologies, networks, policies, and business models.

Table 1-1. NextGen Goals and Objectives

Retain U.S. Leadership in Global Aviation	Expand Capacity
• Retain role as world leader in aviation • Reduce costs of aviation • Enable services tailored to traveler and shipper needs • Encourage performance-based, harmonized global standards for U.S. products and services	• Satisfy future growth in demand and operational diversity • Reduce transit time and increase predictability • Minimize impact of weather and other disruptions
Ensure Safety	**Protect the Environment**
• Maintain aviation's record as safest mode of transportation • Improve level of safety of U.S. air transportation system • Increase level of safety of worldwide air transportation system	• Reduce noise, emissions, and fuel consumption • Balance aviation's environmental impacts with other societal objectives
Ensure Our National Defense	**Secure the Nation**
• Provide for common defense while minimizing civilian constraints • Coordinate a national response to threats • Ensure global access to civilian airspace	• Mitigate new and varied threats • Ensure security efficiently serves demand • Tailor strategies to threats, balancing costs and privacy issues • Ensure traveler and shipper confidence in system security

In 2005, the JPDO developed a high-level vision to communicate the key operating principles and characteristics of NextGen. This vision emphasizes a shift in how information is accessed, allowing those who use the air transportation system to have more direct access to information affecting their operations. The intent of this ConOps is to describe a system that meets these national goals.

The role of the JPDO is to establish how to transform the air transportation system. Part of this transformation involves integrating and reshaping capabilities across all aspects of air transportation so that the entire system operates as an interconnected structure. In many cases, this operational concept builds on visionary material that captures the aviation community's goals for different aspects of transportation.

- For ATM, many of the concepts build on the *National Airspace System (NAS) Concept of Operations and Vision for the Future of Aviation* (RTCA 2002) and the International Civil Aviation Organization's (ICAO) *Global ATM Operational Concept*, which represents a globally harmonized set of concepts for the future.
- Additional foundational and related conceptual documents will be referenced in future versions of this document.

A point of departure for NextGen is its scope. NextGen encompasses all aerospace transportation, not just aviation, and not just ATM. In addition to technological innovation, NextGen emphasizes changes in organizational structure, processes, strategies, policies, and business practice, including shifts in government and private sector roles that are required to fully exploit new technology.

1.2 OVERVIEW OF NEXTGEN

The goal of NextGen is to significantly increase the safety, security, capacity, efficiency, and environmental compatibility of air transportation operations, and by doing so, to improve the overall economic well-being of the country. These benefits can be achieved through a combination of new procedures and advances in the technology deployed to manage passenger, air cargo, and air traffic operations. The *NGATS Vision Briefing* (2005) identifies eight key capabilities that will help achieve these goals:

- **Network-Enabled Information Access.** Through network-enabled information access, information is available, securable, and usable in real time for different communities of interest (COIs) and air transportation domains. This greater accessibility enables greater distribution of decisionmaking and improves the speed, efficiency, and quality of decisions and decisionmaking. Information can be automatically provided to users with a known need and be available to users not previously identified as new needs arise. Information access improves operational decisions, enabling system operators and users to make use of risk management practices to enhance safety. Cooperative surveillance for civil aircraft operations, where aircraft constantly transmit their position, is used with a separate sensor-based noncooperative surveillance system as part of an integrated federal surveillance approach.

- **Performance-Based Operations and Services.** Performance-based operations provide a foundational transformation of NextGen. Regulations and procedural requirements are described in performance terms rather than in terms of specific technology or equipment. The performance-based definition and delivery of services and levels of service will encourage private sector innovation and enable efficiencies throughout NextGen. Minimum performance levels are expected to be required to maximize capacity in congested airspace during specific periods of time. Service providers can use service tiers to create guarantees for different performance levels so that users can make the appropriate tradeoffs between investments and level of service desired to best meet their needs. A benefit of performance-based operations and services is that service providers can define capability improvements in terms of users' existing equipage, thus potentially maximizing the value of the service providers' and users' investments.

- **Weather Assimilated into Decisionmaking.** By assimilating weather into decisionmaking, weather information becomes an enabler for optimizing NextGen operations. Directly applying probabilistic weather information to ATM decision tools increases the effective use of weather information and minimizes the adverse effects of weather on operations.

- **Layered, Adaptive Security.** Through layered, adaptive security, the security system is constructed of "layers of defense" (including techniques, tools, sensors, processes, information, etc.) that help reduce the overall risk of a threat reaching its objective while minimally affecting efficient operations. Layered security is additive; failures in any one component should not have a catastrophic effect on other components. For that reason, the system can handle attacks and incidents with minimal overall disruption. Layered, adaptive security adjusts the deployment of security assets in response to the changing profile of risks; responses to anomalies and incidents are proportional to the assessed risk of involved individuals or cargo.

- **Positioning, Navigation, and Timing (PNT) Services.** PNT services are provided where and when needed, in accordance with demand and safety considerations, to enable reliable aircraft operations in nearly all conditions. Instead of being driven by the geographic location of a ground-based navigational aid (NAVAID), PNT services allow operators to define the desired flight path based on their own objectives.

- **Aircraft Trajectory-Based Operations (TBO).** The basis for TBO is each aircraft's expected flight profile and time information (such as departure and arrival times). The specificity of four-dimensional trajectories (4DTs) matches the mode of operations and the requirements of the airspace in which an aircraft operates. A major benefit of 4DT is that it enables service providers and operators to assess the effects of proposed trajectories and resource allocation plans, allowing both service providers and operators to understand the implications of demand and identify where constraints need further mitigation.

- **Equivalent Visual Operations (EVO).** Improved information availability allows aircraft to conduct operations without regard for visibility or direct visual observation. For aircraft, this capability, in combination with PNT, enables increased accessibility, both on the airport surface and during arrival and departure operations. This capability also enables those providing services at airports (such as ATM or other ramp services) to provide services in all visibility conditions, leading to more predictable and efficient operations.

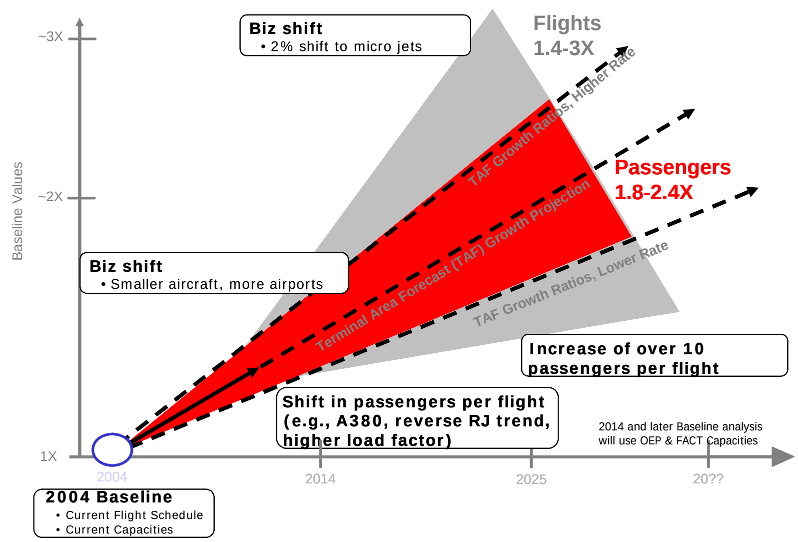
- **Super-Density Arrival/Departure Operations.** With increasing demand, an even greater need exists to achieve peak throughput performance at the busiest airports and in the busiest airspace. New procedures to improve airport surface movements, reduce spacing and separation requirements in place today, and better manage overall flows in and out of busy metropolitan airspace provide maximum use of the highest-demand airports. Airport terminals also maximize efficiency of egress and ingress, matching passenger and cargo flow to airside throughput while maintaining safety and security levels.

These eight capabilities support the NextGen ConOps. Although not detailed separately, they are incorporated in the concepts described in the following sections.

1.2.1 NextGen Environment

In the NextGen timeframe, demand for air transportation and other airspace services is expected to grow significantly from today's levels in terms of passenger volume, amount of cargo shipped, and overall number of flights. With respect to air traffic, changes will occur not only in the number of flights but also in the characteristics of those flights. Figure 1-2 illustrates some of the potential variations in demand characteristics. For example, a range in the potential increase of passengers exists. This range, combined with a potential range in the distribution of passengers to aircraft, may result in a wide range in the number of flights in NextGen. NextGen thus must be flexible enough to manage variations in number of passengers, types of aircraft flown, and overall number of flights.

Figure 1-2. Planning for a Range of Futures



In NextGen, aircraft are expected to have a wider range of capabilities than today and support varying levels of total system performance via onboard capabilities and associated crew training. Many aircraft will have the ability to perform airborne self-separation, spacing, and merging tasks and precisely navigate and execute 4DTs. Along with navigation accuracy, aircraft will have varying levels of cooperative surveillance performance via transmission and receipt of cooperative surveillance information, as well as the ability to observe and share weather information. In terms of flight operational performance, a wider range of capabilities regarding cruise speed, cruise altitudes, turn rates, climb and descent rates, stall speeds, noise, and emissions will exist. Aircraft without a resident pilot (e.g., UASs) will operate among traditional manned, piloted aircraft, and domestic supersonic cruise operations will also be more prevalent.

Aircraft operators are also expected to have a diverse range of capabilities and operating modes. Many operators will have sophisticated flight planning and fleet planning capabilities to manage their operations. Operating modes include all of today's modes, such as traditional hub/spoke operations, point-to-point flights, military/civil training, and recreational flying. Operational demand may vary among highly structured flights (e.g., today's air carrier, cargo, or operators), irregularly scheduled flights with frequent trips to regular destinations with variable dates and times (e.g., air taxi operators or business operators with regular customers), and unscheduled, itinerant flights driven by individual events (e.g., lifeguard flights, personal trips, or law enforcement missions). In addition, new types of operations are expected, including UASs that perform a wide variety of missions (e.g., sensor platforms and cargo delivery) and more frequent commercial space vehicle operations (e.g., suborbital flights to low-earth-orbit payload delivery and return missions). Commercial space transport operations are also expected to grow overall, increasing pressures to efficiently balance competing needs for airspace access and efficiency.

Overall, NextGen is expected to accommodate up to three times today's traffic levels with broader aircraft performance envelopes and more operators operating within the same airspace, increasing the complexity and coordination requirements when ATM is required. The key NextGen capabilities described in Section 1.2 will be critical in meeting the NextGen goals.

A key aspect of NextGen is providing environmental protection that allows sustained aviation growth. With NextGen, significant community noise and local air quality impacts are reduced in absolute terms compared to today, even with the increase in growth. Water quality, energy use, and climate effects of aviation are addressed and mitigated. This is accomplished with advanced technologies and operational capabilities, environmental improvements in airframe and engine technology resulting from a robust research and development (R&D) program, and appropriate policy approaches and financial support.

1.2.2 Key Characteristics of NextGen

To meet the goals and objectives described above, the NextGen vision involves a transformed air transportation system that allows all communities to participate in the global marketplace, provides services tailored to individual customer needs and capabilities, and seamlessly integrates civil and military operations. The following paragraphs describe some of the significant NextGen characteristics.

1.2.2.1 User Focus

A major theme of NextGen is an emphasis on providing more flexibility and information to users while reducing the need for government intervention and control of resources. NextGen enables operational and market freedom through greater situational awareness and data accessibility, and it aligns government structures, processes, strategies, and business practices with customer needs. The provision of multiple service levels permits a wider range of tailored services to better meet individual user needs and investment choices.

With a focus on users, NextGen is also more agile in responding to user needs. Capacity is expanded to meet demand by investing in new infrastructure, shifting NextGen resources (e.g., airspace structures and other assets) to meet demand, implementing more efficient procedures (e.g., reducing separation between aircraft to safely increase airport throughput), and minimizing the effects of constraints such as weather on overall system capacity. The system will be nimble enough to adjust cost effectively to varying levels of demand, allowing more creative sharing of airspace capacity for law enforcement, military, commercial, and GA users. Restrictions on access to NextGen resources are limited in both extent and time duration to those required to address a safety or security need.

1.2.2.2 Distributed Decisionmaking

To the maximum extent possible, decisions in NextGen are made at the local level with an awareness of system-wide implications. This includes, to a greater extent than ever before, an increased level of decisionmaking by the flight crew and Flight Operations Centers (FOCs). Stakeholder decisions are supported through access to a rich information exchange environment and a transformed collaborative decisionmaking (CDM) process that allows wide access to information by all parties (whether airborne or on the ground) while recognizing privacy and security constraints. Information is timely, relevant, accurate, quality assured, and within established security procedures. Decisionmakers have the ability to request information when they need it, publish information as appropriate, and use subscription services to automatically receive desired information. This information environment enables more timely access to information and increased situational awareness while providing consistency of information among decisionmakers. Because decisionmakers have more information about relevant issues, decisions can be made more quickly, required lead times for implementation can be reduced, responses can be more specific, and solutions can be more flexible to change. To ensure that locally developed solutions do not conflict, decisionmakers are guided by NAS-wide objectives and test solutions to identify interference and conflicts with other initiatives.

1.2.2.3 Integrated Safety Management System (SMS)

NextGen ensures safety through use of an integrated SMS approach for identifying and managing potential problems in a system, organization, or operation. Specifically, NextGen uses a formal, top-down, businesslike approach to manage safety risk, which includes systematic procedures, practices, and policies for safety management, including—

- **Safety Policy.** Defines how the organization will manage safety as an integral part of its operations, and establishes SMS requirements, responsibilities, and accountabilities
- **Safety Risk Management (SRM).** The formal process within the SMS that consists of describing the system, identifying the hazards, and assessing, analyzing, and controlling the risk. The SRM process is embedded in the processes used to provide the product or service—it is not a separate process.
- **Safety Assurance.** SMS process management functions that systematically ensure that organizational products or services meet or exceed safety requirements; includes the processes used to ensure safety, including audits, evaluations, and inspections, and data tracking and analysis
- **Safety Promotion.** Training, communication, and dissemination of safety information to strengthen the safety culture and support integration of the SMS into operations.

1.2.2.4 International Harmonization

The ATM system is globally harmonized through collaborative development and implementation of identified best practices in both standards and procedures. International harmonization also requires advocating for the highest operational standards for aircraft operators and air navigation service providers (ANSPs) to ensure the safest global air transportation system. ICAO Planning and Implementation Regional Groups (PIRGs) or multilateral agreements coordinate planning and implementation of NextGen transformations to harmonize the application of technology and procedures. This harmonization allows airspace users to realize the maximum benefits of the NextGen transformations.

1.2.2.5 Taking Advantage of Human and Automation Capabilities

NextGen capitalizes on human and automation capabilities to increase airspace capacity, improve aviation safety, and enhance operational efficiency. This capitalization is based on building processes and systems that help humans do what they do best—choose alternatives and make decisions—and help automation functions accomplish what they do best—acquire, compile, monitor, evaluate, and exchange information. Research and analysis will determine the appropriate functional allocation of tasks among ANSPs, flight operators, and automation. They will determine when decision support tools (DSTs) are necessary to support humans (e.g., identifying conflicts and recommending solutions for pilot approval) and when functions should be completely automated without human intervention.

1.2.2.6 Weather Operations

In the NextGen environment, weather information is no longer viewed as separate data viewed on a "stand-alone" display. Instead, weather information is integrated with and supports NextGen decision-oriented automation and human decisionmaking processes. A common weather picture is used by all stakeholders. This common picture facilitates improved communications and information sharing. NextGen weather data is translated into information directly relevant to NextGen users and service providers, such as the likelihood of flight deviation, airspace permeability, and capacity. Flight trajectory plans are developed with an increased understanding of the potential severity and probability of weather hazards. As a result, less airspace is constrained because of weather. Operators of aircraft equipped with capabilities to mitigate the effects of weather may choose to tactically fly through certain weather-impacted areas.

Decision support systems (DSSs) directly incorporate weather data and bypass the need for human interpretation, allowing decisionmakers to determine the best response to weather's potential operational effects (both tactical and strategic) and minimizing the level of traffic restrictions. This integration of weather information, combined with the use of probabilistic forecasts to address weather uncertainty and improved forecast accuracy, minimizes the effects of weather on NextGen operations.

1.2.2.7 Environmental Management Framework

Environmental management is performed in the context of the NextGen objectives. Capacity increases will be consistent with environmental protection goals. New technology, procedures, and policies in NextGen minimize impacts on community noise and local air quality and mitigate water quality impacts, energy use, and climate effects. NextGen environmental compatibility is achieved through a combination of improvements in aircraft design, aircraft performance and operational procedures, land use around airports, and policies and incentives to accelerate technology introduction into the fleet. Intelligent flight planning and improved flight management capabilities enable the optimization of route selection, landing, and approach procedures based on a range of data including noise, emissions, and fuel burn, thus enhancing the ability to reduce environmental effects on the ground and in the airspace. Reinvigorated R&D and refined technology implementation strategies—balancing near-term technology development and maturity needs with long-term cutting-edge research—help aircraft keep pace with changing environmental requirements.

1.2.2.8 Robustness and Resiliency

Overall, NextGen is more resilient in responding to failures and disruptions and includes contingency measures to provide maximum continuity of service, including business continuity, in the face of major outages, natural disasters, security threats, or other unusual circumstances. Moreover, the increased reliance on automation is coupled with "fail-safe" modes that do not require full reliance on human cognition as a backup for automation failures. Because individual systems and system components can fail, NextGen maintains a balance of reliability, redundancy, and procedural backups. It provides a system that not only has high availability but also requires minimal time to restore failed functionality.

1.2.2.9 Scalability

NextGen is adaptable to meet the changes in traffic load and demand that occur every day or over the decades to come. Its capabilities provide an overall system design that can handle a wide range of operations and modes of operation. Increased use of automation, reduced separation standards, super-density arrival/departure operations, and additional runways allow busy airports to move a large number of aircraft through the terminal airspace during peak traffic periods. Each of these features contributes to an environment that supports growth in operations. New capabilities, such as virtual towers, enable the cost-effective expansion of services to a significantly larger number of airports than is possible with traditional methods of service delivery. As a result of its scalability, NextGen is able to adapt both up and down to changes in short-term or long-term demand, even when the changes are not predicted.

1.3 AUDIENCE AND INTENDED USE

This document addresses aviation stakeholders and invites them to help develop the policy agenda, identify the research needed to achieve the NextGen operational concept and goals, and ensure global harmonization. Initially, this document will be updated annually as research, implementation, models, policy, budget realities, and other findings are assessed and as further dialogue helps refine common goals and priorities. This document also serves as the official record and repository for operational concept insights that emerge from the in-progress national debate on the scope, characteristics, and capabilities of NextGen.

This ConOps is part of the overall NextGen enterprise architecture, and it will help in the formulation of roadmaps and research recommendations to improve overall intergovernmental collaboration in achieving national goals for air transportation. This document, along with other engineering artifacts, also provides the basis for deriving top-level requirements.

The list of key stakeholders includes—

- **Airport Communities.** Cities and towns located in the vicinity of airports that have a vested interest in and are affected by the operation of the airport
- **Airport Operators.** Organizations and people responsible for enabling passenger, flight, and cargo operations conducted within an airport with consideration for safety, efficiency, resource limitations, and local environmental issues
- **Airport Tenants.** Organizations and people who offer services at an airport, such as fueling and maintenance services or catering services
- **ANSPs.** Organizations and people engaged in the provision of ATM and air traffic control (ATC) services for flight operators for the purpose of safe and efficient flight operations. ATM responsibilities include communications, navigation, and surveillance (CNS); ATM facility planning, investment and implementation; procedure development

and training; and ongoing system operation and maintenance of seamless CNS/ATM services. This category includes ANSP personnel and ANSP automation.

- **Customers.** Individuals and organizations, including Government and military, using NextGen for personal or business transportation or to transport cargo
- **Flight Operators.** Individuals and organizations responsible for planning and operating a flight within NextGen, including flight crews (on the aircraft or controlling it remotely) and FOC personnel. Includes personal, business, commercial aviation, and commercial organizations, as well as government and military organizations.
- **Manufacturers.** Organizations and people who manufacture equipment for flight operators, ANSPs, security and defense providers, and so forth. Includes the manufacture of airframes, aircraft engines, avionics, and other aircraft systems and parts, as well as DSSs and other systems used in NextGen.
- **Owners.** Organizations and people responsible for making investment decisions related to the development and implementation of NextGen and its associated capabilities
- **Regulatory Authorities.** Organizations and people responsible for certain aspects of the overall performance of the aviation industry, including aviation safety, environmental effects, and international trade. Includes aviation safety regulators, certification authorities, standardization organizations, environmental regulators, and accident/incident authorities.
- **Researchers.** Organizations and people engaged in conducting R&D activities that support the evolution of the air transportation system, including academia and government organizations
- **Security and Defense Providers.** Organizations and people responsible for national and homeland defense, homeland security, law enforcement, information security, and physical and operational security of NextGen
- **Weather Service Providers.** Organizations and people engaged in the provision of aviation weather information products.

1.4 DOCUMENT SCOPE AND ORGANIZATION

This document describes the operational concepts for NextGen in the 2025 timeframe. It is organized into the following chapters. Of note, the research and policy issues are referenced within each chapter as [R-#] and [P-#] and are detailed in Appendices C and D, respectively.

- **Chapter 2.** Provides a description of **Air Traffic Management Operations** within NextGen, including interactions among ANSPs and operators
- **Chapter 3.** Provides a detailed overview of the **Airport Operations and Infrastructure Services** that address the activities surrounding the airport
- **Chapter 4.** Addresses **Net-Centric Infrastructure Services** that enable the NextGen enterprise services

- **Chapter 5.** Provides an initial overview of specific **Shared Situational Awareness Services** that support the ATM-related NextGen concepts
- **Chapter 6.** Provides a detailed perspective of **Layered, Adaptive Security Services** within NextGen
- **Chapter 7.** Describes how environmental impacts will be addressed and reduced in an **Environmental Management Framework** for NextGen
- **Chapter 8.** Addresses the **Safety Management Services** woven into NextGen, including risk management efforts
- **Chapter 9.** Discusses the concept of **Performance Management Services**, a near-real-time system performance assessment for system performance management.

Included in the document are the following appendices, which contain supplemental information for the reader:

- **Appendix A.** Provides a list of acronyms used in this document
- **Appendix B.** Provides a glossary of terms
- **Appendix C.** Provides a list of the research issues
- **Appendix D.** Provides a list of the policy issues
- **Appendix E.** Provides a list of references used to create this document.

2 Air Traffic Management Operations

2.1 INTRODUCTION

Air traffic management is the dynamic, integrated management of air traffic and airspace—safely, economically, and efficiently—through the cost-effective provision of facilities and seamless services in collaboration with all parties. In the NextGen timeframe, ATM evolves into an agile, robust, and responsive set of operations that can keep pace with the growing needs of an increasingly complex and diverse set of air transportation system users.

2.1.1 ATM Goals and Overall Framework

The three major goals for ATM in NextGen are as follows:

- Meet the diverse operational objectives of all airspace users and accommodate a broader range of aircraft capabilities and performance characteristics
- Meet the needs of flight operators and other NextGen stakeholders for access, efficiency, and predictability in executing their operations and missions
- Be fundamentally safe, secure, of sufficient capacity, environmentally acceptable, and affordable for both flight operators and service providers.

Today's ATM system usually performs well, but it is susceptible to disturbances such as weather events and is reaching its capacity limits. The NextGen ATM system needs to be *scalable* so that it can respond quickly and efficiently to increases in demand and *flexible* so it can respond to changes in fleet mix, customer schedules, and operational constraints (e.g., weather).

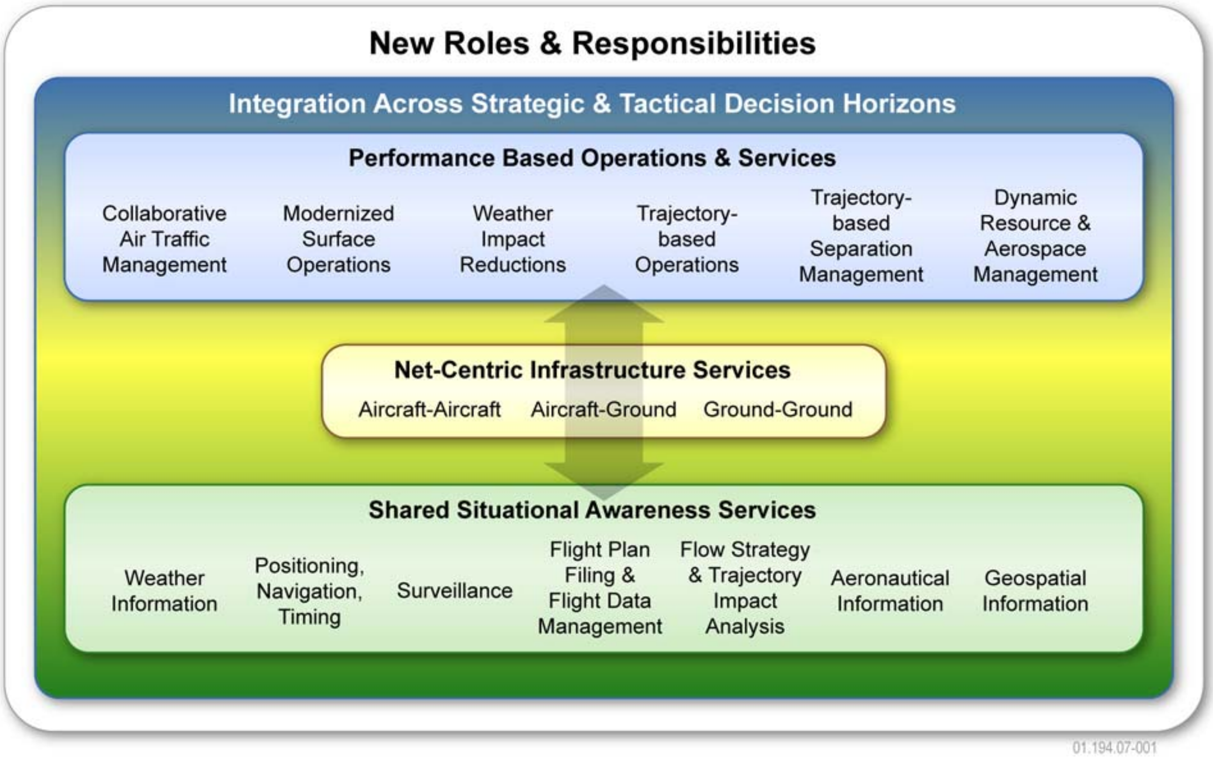
The overall philosophy driving the delivery of ATM services in NextGen is to accommodate flight operator preferences where possible and to minimize imposed restrictions by applying them only when user actions are not sufficient to balance demand and capacity. This philosophy also includes the need to meet capacity, safety, security, and environmental constraints. In other words, the ATM system, to the maximum extent possible, adjusts airspace and other assets to satisfy forecast demand, rather than constraining demand to match available assets.

Transformation of the ATM system in NextGen is necessary because of the inherent limitations of today's system, including limits driven by human cognitive processes and verbal communications. The NextGen ATM system designs in provisions to achieve safety, capacity, security, and environmental goals, enabling these objectives to complement rather than compete with one another. Safety, capacity, security, and environmental requirements are integrated into all aspects of the ATM system, including operations, decision support, automation, procedures, and airspace design.

2.1.1.1 The NextGen ATM Framework

To achieve these goals, a number of transformations are needed that fundamentally change how ATM is performed in the NextGen timeframe (see Figure 2-1). To respond to increases in demand and the overall complexity of operations, the roles and responsibilities of people evolve. Automation is used to a greater extent to manage complexity and expand the information that is available; individual roles migrate to more strategic management and decisionmaking. As part of this shift of roles, the flight crew is more integrated into ATM, leveraging onboard aircraft capabilities to achieve a scalable[1] system design.

Figure 2-1. Air Traffic Management Transformation



Collaborative Air Traffic Management. With the increase and diversification in the number of airspace users—each possessing a unique operating need—and the increased importance and impact of other airspace uses, collaborative air traffic management (C-ATM) mechanisms support a diverse set of participants, having common awareness of overall constraints and the impacts of individual and systemwide decisions. Decisionmaking among these participants significantly improves in this C-ATM environment, which builds on automation tools and systemwide information exchange capabilities, enabling participants to better understand the prevailing constraints, short- and long-term effect of decisions, and interdependence among national, regional, and local operations. Use of advanced automation to manage information across all phases of flight and contingency planning also results in a system that is more agile in responding to changes in environment or demand.

[1] In this instance, scalability refers to the ATM ability to respond quickly and efficiently to increases in demand.

TBO and Trajectory-Based Separation Management. Perhaps the most fundamental requirement of NextGen is to safely accommodate significantly increased traffic, and to do this in airspace that is already congested, such as between heavily traveled city pairs (such as Washington and Chicago) and near the busiest airports. This requirement leads to a transformation in high-density airspace to TBO, in which precise management of an aircraft's current and future position enables major increases in throughput. This trajectory prediction capability facilitates separation assurance in this airspace, as well as delegating separation to capable aircraft for some operations, further improving efficiency and throughput. Within TBO, peak demand at the busiest airports is accommodated with *super-density arrival/departure operations*, in which advanced aircraft and ANSP capabilities support optimized and efficient runway throughput.

Using TBO and probabilistic decisionmaking for weather events, entire flows of aircraft and individual trajectories can be dynamically adjusted to take advantage of opportunities and avoid constraints safely and efficiently while reducing the overall impact of said events. These operations replace the broad, static directives that are characteristic of today's operations. To accomplish these trajectory actions, digital data exchange of trajectories becomes the primary mode of communication between the ANSP and flight operators, replacing verbal delivery of clearances. TBO is applied to parts of en route, oceanic, and arrival/departure[2] airspace, as well as some surface operations.

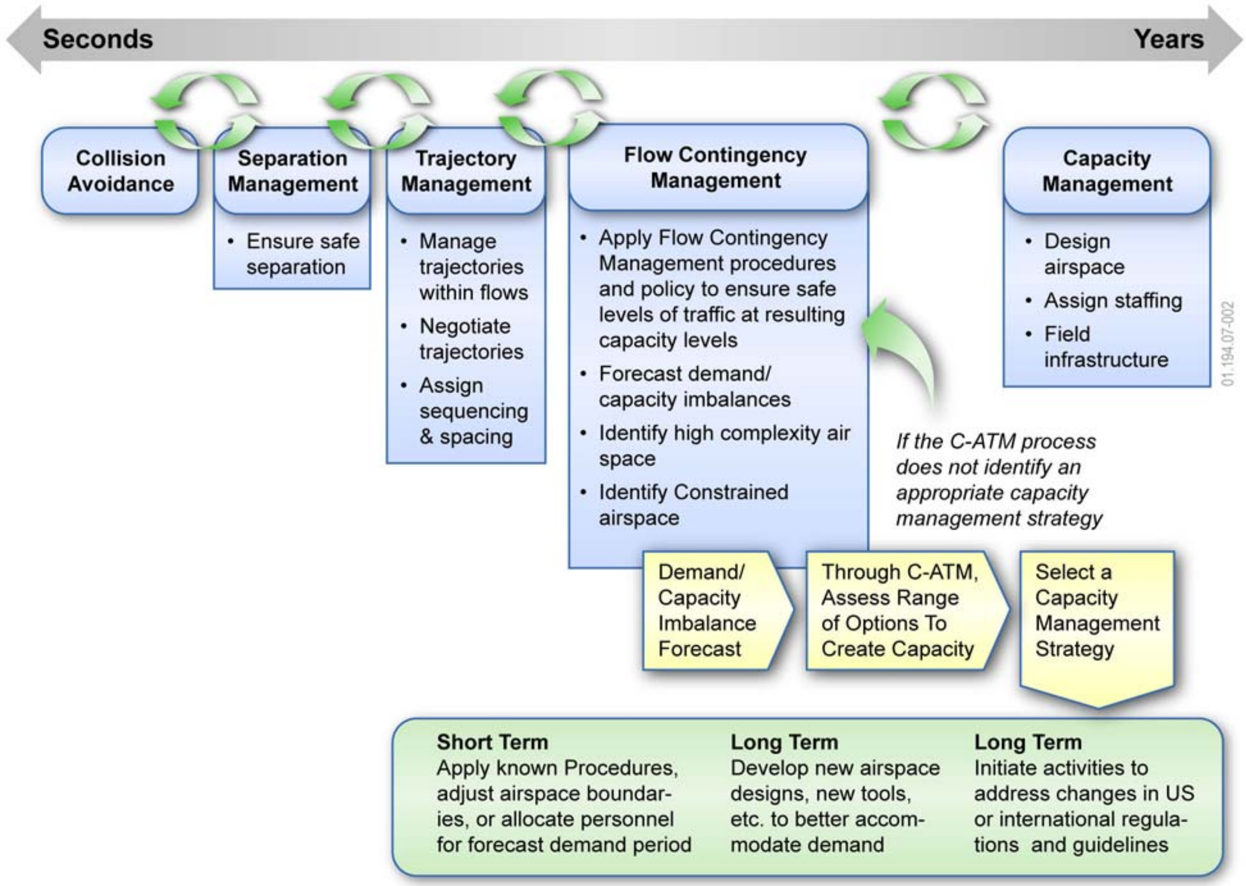
ATM Service Delivery. TBO transforms ATM service delivery with four main functions, as shown in Figure 2-2. An integral part of the transformation is that real-time performance measurement is used to assess the effectiveness, efficiency, and capacity of the system against established performance metrics. The results of the analysis are used in the collaboration among the ANSP and flight operators for integrated decision-making between the functions. The functions are—

- **Capacity Management (CM)** is the design and configuration of airspace and the allocation of other NAS resources. CM is the preferred means of responding to dynamic forecast demand—resources and performance-based services are matched with the expected demand (see Section 2.3.2.1).
- **Flow Contingency Management (FCM)** comprises strategic flow initiatives addressing large demand/capacity imbalances within CM plans resulting from severe weather or airspace restrictions. FCM ensures the efficient management of major flows of traffic while minimizing the impact on other operations (see Section 2.3.2.2).
- **Trajectory Management (TM)** is the adjustment of individual aircraft within a flow to provide efficient trajectories, manage complexity, and ensure that conflicts can be safely resolved (see Sections 2.4.4 and 2.5).

[2] Arrival/departure airspace is airspace including climbout to eventual en route altitude and from the start of descent to the airport surface. It includes only the arrival and departure corridors leading to the currently used runways.

- **Separation Management (SM)** is the provision of separation between aircraft. SM tactically resolves conflicts among aircraft and ensures avoidance of weather, airspace, terrain, or other hazards (see Sections 2.4.5 and 2.5).

Figure 2-2. ATM Decisions—Interactive and Integrated Across Time Horizons



In other parts of the NAS, where demand is such that TBO is not needed, airspace and operations are similar to the current system—*classic operations* based on clearances and predefined routes—but with significant improvements enabled by space-based navigation, cooperative surveillance, and advanced automation. *Classic airspace* includes some high-altitude (today's Class A) and significant low-altitude airspace, some oceanic airspace, and most of the airspace for arrival and departure to and from smaller airports. Increased levels of service (at lower cost) and capabilities that reduce the impact of weather provide safety, capacity, and efficiency benefits to airspace users operating from the smallest to the busiest airports. Visual flight rule (VFR) operations are conducted in classic airspace and have more access around major airports as a result of the reduced airspace "footprint" required for TBO. The ANSP designates whether classic operations are used or whether TBO is required. Figure 2-3 shows the NextGen airspace hierarchy.

Figure 2-3. NextGen Airspace Hierarchy

Dynamic Resource Management. The move toward dynamic resource management supports the need to provide improved services to all NextGen users. In NextGen, ATM system resources and services are delivered to meet demand, rather than constraining demand to match the available resources (including people, facilities, and airspace). Delivery of services is no longer tied directly to the geographic location of the aircraft; ANSP personnel acquire needed information and communicate with flight operators independent of their facility location. [P-92]

Weather Impact Reductions. Within NextGen, the impact of weather is reduced through the use of improved information sharing, new technology to sense and mitigate the impacts of weather, improved weather forecasts, and the integration of weather into automation to improve decisionmaking. The impacts of instrument meteorological conditions (IMC), for example, are limited via aircraft and ANSP capabilities that allow operations independent of visibility (e.g., the use of electronic flight rules for UASs). Using automation to better manage uncertainties associated with weather minimizes airspace capacity limitations and reduces the likelihood of overly conservative actions.

Modernized Surface Operations. Finally, another transformation in ATM is the advent of modernized surface operations. Surface operations move from a highly visual, tactical environment to a more strategic set of operations that are independent of visibility, better achieve operator and ANSP efficiency objectives, and better integrate surface, airspace, and traffic flow decisionmaking. Surface and tower services are delivered more affordably, enabling access to ANSP services at more airports than is practical today, resulting in greater value to flight operators and airport operators.

Table 2-1 compares the key transformations summarized in this section with operations in 2006.

Table 2-1. Significant ATM Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Roles and Responsibilities	• Primary roles for ATC services are air traffic controllers and ATM specialists. • Demand/capacity imbalances are managed through broad flow contingency initiatives.	• New ANSP roles focus on CM, FCM, and TM. • DSTs enable more strategic decisionmaking. • Air traffic controllers continue to serve classic airspace.
Collaborative Air Traffic Management	• Focus is on managing demand to meet available capacity. • ATM initiatives are conservative and broad. • Communications are usually verbal and written. • Conservative measures are used to manage uncertainty caused by weather and other capacity constraints.	• Focus is on allocating NAS assets to maximize capacity to meet user demand. • There is better decision support and integrated strategic and traffic flow management (TFM). • There is better use capacity in presence of uncertainty. • A broader set of flight operators participates in C-ATM process.
Integration Across Strategic and Tactical Decision Horizons	• Stakeholders have limited ability to exchange data supporting integrated decisionmaking. • Uncertainties in demand, weather, and flight trajectories are cognitively handled by ANSP personnel using operational judgment.	• SSA and integrated impact assessment tools provide stakeholders with common awareness of situations and impacts of decisions. • Automation incorporates probabilistic data to reduce likelihood of overly conservative decisions.
Trajectory-Based Operations	• Flights are managed via verbal delivery of clearances and vectors. • Time-based metering is used in some localities to improve predictability and throughput. • Required navigation performance (RNP) operations are used initially to manage complexity and increase capacity.	• Flights are managed through use of 4DTs that specify accurate current and future aircraft position. • Metering, controlled time of arrival (CTA) exchange, and more flight-specific adjustments increase overall throughput and operator efficiency. • Safety, security, and environmental considerations are integrated in TBO. • Flight crew–initiated, dynamic trajectory adjustment is possible with ATM and airport operations center (AOC) collaboration.

Table 2-2. Significant ATM Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Dynamic Resource and Airspace Management	• Airspace classification is largely fixed, with Earth-referenced boundaries. Sectors may be combined during low demand. Class B and C airspace volumes are defined to protect all possible runway configurations and to match charting capabilities. • Delivery of services is constrained by geographic location of physical facilities.	• Airspace allocation is flexible over different time horizons and geographic boundaries to meet demand. Airspace restrictions for aircraft capability are applied only when needed (e.g., for capacity, safety). • Changes to airspace configuration are provided dynamically to flight crews so that maximum flexibility is possible. • Delivery of services is flexible and not constrained by geographic location of personnel and infrastructure.
Reduced Impact of Weather	• Ability to deal with weather is often limited to Severe Weather Avoidance Program and similar initiatives. In-flight rerouting causes significant delays and flight inefficiencies. • Visibility limits surface, arrival, and departure operations.	• Weather information is integrated into automation, improving decisionmaking. • Forecast and current weather measurements are improved. • Operations are supported independent of visibility and make better use of forecast uncertainties.
Separation Management	• Tactical separation by individual controller visualizing aircraft trajectories on radar screen and issuing voice instructions limits throughput and flight efficiency. • DSTs provide controllers with strategic awareness of future conflicts and provide capability to evaluate alternative solutions. • Separation standards are relatively fixed.	• Separation provision, both airborne or by ANSP, relies heavily on automation support, allowing reduced and performance-based separation standards for different airspace categories. • 4DTs of many aircraft following similar routes may be aligned to nearly eliminate conflicts. • Trajectory changes required for separation assurance are communicated digitally.

2.1.2 ATM Key Principles and Assumptions

A number of key principles are associated with the delivery of ATM services in NextGen:

- NextGen resources are managed to maximize utility to flight operators. Restrictions are imposed only for projected congestion or to meet security, safety, or environmental constraints.
- NextGen supports a range of operator goals and business models and does not inherently favor one business model over another; however, public policy may provide incentives for one or more business models, if desired. [P-3]

- NextGen stakeholders maximize their ability to achieve their goals and business objectives by actively participating in the C-ATM process. This involves not only information exchange and negotiation with respect to flight trajectories but also involvement in the process of allocating ATM resources. Tools are in place in NextGen to allow virtually any operator to participate in the C-ATM process.

- When excess demand exists that cannot be addressed by using performance-based operations and applying C-ATM, known policies prioritize access to NextGen resources among all operators. [P-2]

- All national objectives for NextGen are considered in addressing access to NAS resources. For example, military, state, and civil aircraft that are involved in national security, homeland defense, response to national disasters, police actions, life-guarding actions, and movement of high-ranking government officials receive appropriate priority.

- Airspace is a national resource to be used for the “public good.” Government mandates are an acceptable means of meeting public good objectives when incentives are insufficient. [P-89]

- Key assumptions for the NextGen ATM system and services include the following:

- *Performance-based operations* are the basis for defining requirements. In particular, CNS performance becomes the basis for operational approval, rather than specific equipage or technologies (e.g., RNP routes). Performance-based operations simplify regulatory activities in the presence of technology proliferation and allow the opportunity to define “preapproved” operations based on performance levels.

- The ANSP provides performance-based services, giving operational benefits to aircraft that have advanced capabilities. For a given airspace volume, the minimum level of capability may vary depending on overall demand characteristics and the environment. Flight operators choose capability levels for their aircraft according to their needs and to make the economic tradeoff between level of service and aircraft investment.

- Network-enabled services in NextGen provide a broad ability to move, store, and access information. All stakeholders have a consistent view of factors that affect their decisionmaking, while data security and privacy mechanisms ensure that information is not misused or inappropriately disclosed.

- Advanced automation performs routine tasks and supports distributed decisionmaking between flight operators and the ANSP. Both aircraft and the ANSP have new automation procedures and systems in place, enabling TBO and other transformations critical to achieving NextGen objectives.

- There is a wider range of aircraft capabilities and performance levels than exists today.

- Environmental outcomes are increasingly important in designing and conducting ATM operations.

- International interoperability in performance-based operations is a requirement as capabilities and procedures are defined.

2.1.3 Overall Organization of Chapter 2

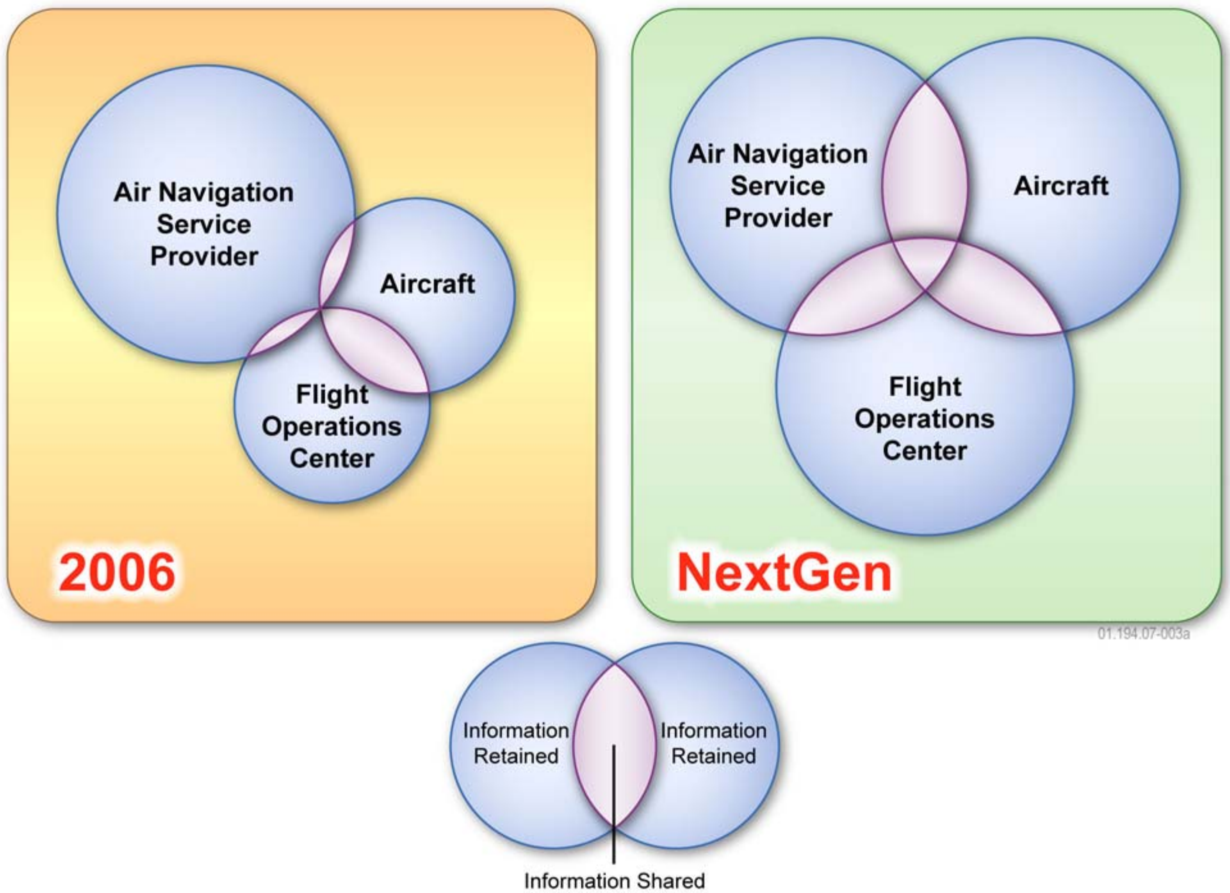
The rest of Chapter 2 provides greater depth of discussion on many of the transformations highlighted so far.

- **Section 2.2** addresses the change of roles and responsibilities between the ANSP and flight operators, addressing both human-human and human-automation interactions.
- **Section 2.3** examines the transformations in C-ATM, focusing on collaboration for CM, FCM, and TM.
- **Section 2.4** focuses on how TBO provides key capacity, safety, and productivity benefits in airspace with high-density operations.
- **Section 2.5** addresses classic operations, including VFR operations.
- **Section 2.6** addresses surface and tower operations for both TBO and classic operations.
- **Section 2.7** provides a different view of this content, addressing transformations from a flight operator perspective.
- **Section 2.8** addresses internal ANSP transformations not included in previous sections.

2.2 CHANGES IN ROLES AND RESPONSIBILITIES

With the significant increase in demand and the increasing complexity of operations, changes in roles for ANSP personnel and flight operators are needed for the NextGen environment. New tasks are performed by automation to support the decisionmaking process and the shift in focus from tactical separation between individual aircraft to the strategic management of traffic flows in high-density airspace. [R-1] Flight operator roles change accordingly. As illustrated in Figure 2-4, decisionmaking is more distributed among ANSP personnel, flight crews, and flight planners, with significant increases in information exchange. Flight planners have an increased role in collaborating with the ANSP on capacity and flow management strategies, and the flight crew has a greater role in many of the tactical flight management tasks. [R-2] For some aircraft, the flight crew also begins to take on a more strategic flight management role, building on aircraft automation.

Figure 2-4. Relative Influence of the ANSP and Aircraft/Pilot in ATM Decisions



2.2.1 Benefits and Rationale

Today's NAS, in which controllers provide safe aircraft separation by issuing tactical clearances to individual aircraft, is reaching its capacity as splitting sectors further produces diminishing benefits. A new paradigm is required to better manage human workload, increase productivity, and leverage advanced automation capabilities. This in turn defines transformations required to achieve NextGen scalability and affordability goals, including the following:

- Restructuring the roles of humans and automation and how they perform their respective functions to synergize human and automation performance [R-3]
- Better distributing tasks and decisionmaking between service providers, flight crews, and flight planners to achieve operational efficiencies and scalability
- Broadening the resource pool of service providers by eliminating the "hard–wired" connection between service providers and geographic regions (see Chapter 4).

These transformations are discussed in further detail in the following subsections.

2.2.2 Functional Task Allocation

The NextGen ATM system capitalizes on human and automation capabilities. It employs complementary air and ground technologies in a distributed manner. Both humans and automation play important and well-defined roles, which takes advantage of the types of functions each can best perform. Although new technology is critical to implementing the NextGen ATM system, equally critical is ensuring that both service providers and flight operators are given appropriate roles; these are described in Sections 2.8 and 2.7, respectively.

Automation supports the migration from tactical to strategic decisionmaking by assimilating data and supplying information, as well as by performing many routine tasks. Ultimately, the determination of when to fully automate and when to provide decision support is made to optimize overall system performance and ensure that service providers and flight operators perform well and can respond to off-nominal and emergency events when required. [R-4], [P-80]

Increased reliance on automation is coupled with “fail–safe” modes that do not require full reliance on humans as a backup for automation failures. In addition, backup functions are distributed throughout the system, and there are layers of protection to allow for graceful degradation of services in the event of automation failures. [R-5], [R-6], [P-1]

2.2.3 Human-System Interactions

Human-system interactions are designed to gain safety, productivity, efficiency, and scalability benefits. Human factors considerations are paramount to maximizing ANSP productivity and performance and are integrated into system acquisition management and planning. Human factors considerations that drive human-system design and impact human-system performance include human cognitive capabilities and limitations, human error, situational awareness, workload, function allocation, hardware and software design, procedural design, decision aids, visual aids, training, user manuals, warnings and alarms, environmental constraints, workspace design, and team versus individual performance. [R-7]

Within NextGen, human interactions with automation are more intuitive and user-friendly, allowing increased utility of tools while mitigating human error. [R-8] New tools, measures, and mechanisms are in place to preclude and mitigate the effects of human error, with error tolerance and error resistance achieved through human-centered design processes. Service providers and flight operators are presented with well-integrated user interfaces. Flight deck systems are easier to use and better integrate information for situational awareness and decisionmaking. Likewise, ground automation systems seamlessly integrate capabilities such as automated conflict detection and resolution, data communications, and other decision aids.

2.3 COLLABORATION FOR ATM, AIRPORT, AND AIRSPACE OPERATIONS

In NextGen, all airspace users are able to collaborate on ATM decisions. This capability ranges from today’s large-scale FOC with a complete set of C-ATM automation tools to hand-held and home personal computers for individual pilots with appropriately scaled C-ATM collaboration access. Those who participate in the collaboration process are better able to achieve their own objectives within the constraints imposed by overall traffic demand or short-term effects such as weather or airspace restrictions.

Collaboration involves the exchange of information to create mutual understanding among participants of overall objectives and to share decisionmaking among stakeholders. With the collaborative capabilities in NextGen, stakeholders are aware of constraints, system strategies, and the performance metrics that describe the past and predicted behavior of the ATM system. The service provider is aware of stakeholder route preferences, performance capabilities, and flight-specific performance limitations. Key stakeholders in ATM decisionmaking include the ANSP, flight operators (including both flight planners and flight crews), airport operators and regional authorities, security providers, and U.S. military and state organizations. These groups and others collaborate in developing and assessing strategies to expand NAS capacity, addressing short-term demand and capacity imbalances, balancing national and civil needs in the use of special use airspace (SUA), and coordinating appropriate responses to address security needs.

2.3.1 Benefits and Rationale

Key benefits from the collaborative environment in NextGen include the following:

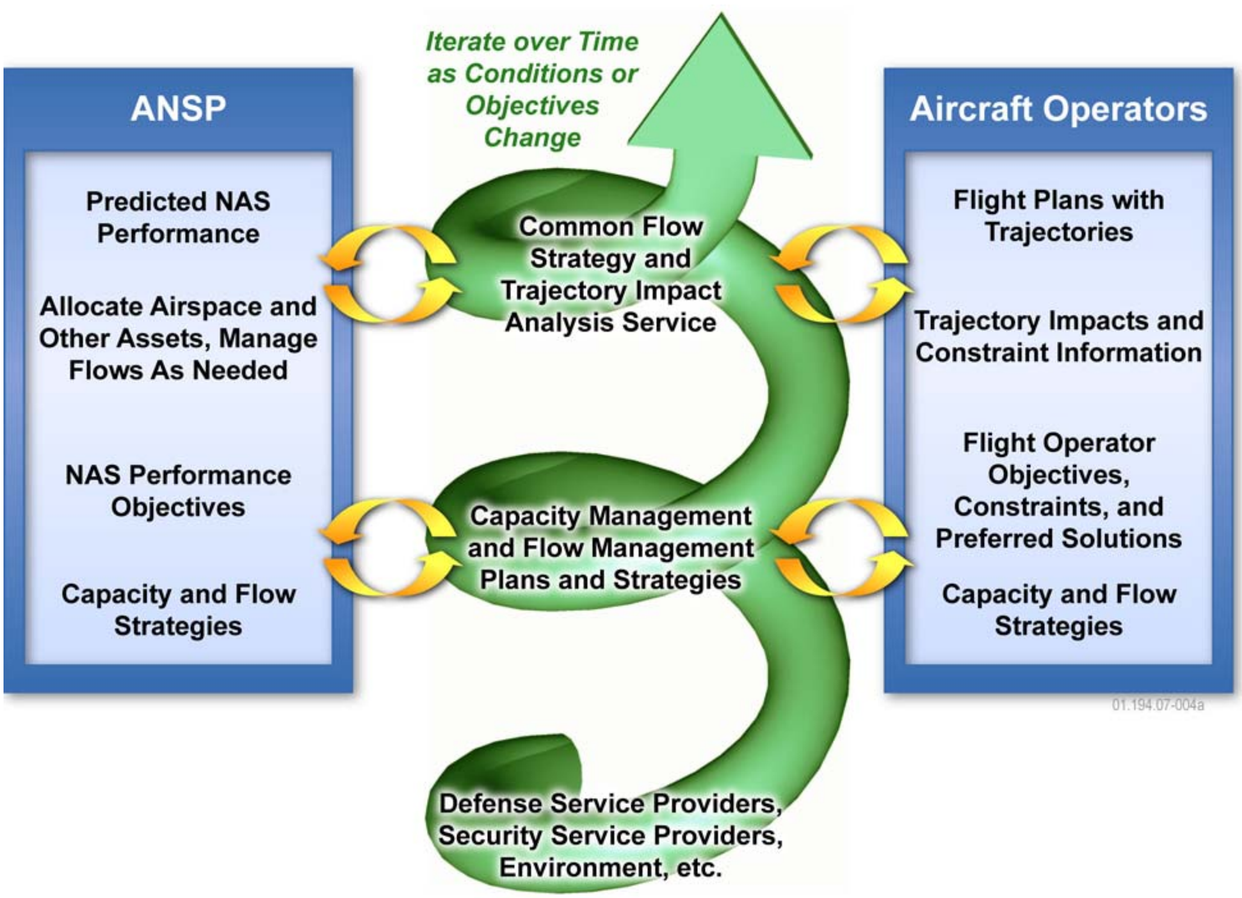
- Airspace users benefit from improved collaborative DSTs, which better assess the potential impacts of decisions, reducing the likelihood of unintended consequences. Better DSTs also increase the sytem’s ability to maintain capacity and increase predictability in the presence of continuous uncertainty. Less-conservative operational decisions are made because decision support capabilities can better integrate large amounts of data over multiple time horizons.
- A larger percentage of users participate in the collaboration process than do currently. Today’s process is characterized by poor information distribution capabilities and is limited by verbal negotiations. Flight operators gain benefits in efficiency, access, and overall performance, and other national needs are accommodated effectively.
- Information exchange is more clearly targeted to the appropriate decisionmakers, reducing workload and unnecessary actions by those not affected. Machine-to-machine negotiation replaces labor-intensive, voice, or text-based processes.
- Needs for managing airspace security are integrated into overall collaboration and decisionmaking.
- Participants are assured of data privacy and protection, so that sensitive or proprietary information can be shared in a way that helps to achieve their objectives.
- By participating in the collaborative process and providing user preferences, the airspace users benefit from flying their desired routes based on their business need.

2.3.2 Collaborative Air Traffic Management

C-ATM is the means by which flight operator objectives are balanced with overall NAS performance objectives and accomplishes many of the objectives for CM, FCM, and TM. [R-9], [R-10] Flight planners or an operator's flight planning automation interact with the ANSP via a set of services that provide all stakeholders with the opportunity to participate in the C-ATM process. Among these services is a common flow strategy and trajectory analysis service that enables SSA of current and projected NAS status and constraints. This service provides stakeholders with the capability to examine the individual or aggregate impacts of proposed strategies for CM or FCM.

With information sharing, flight operators and the ANSP have a common understanding of overall national goals and desired performance objectives for the NAS. A transparent set of strategies is in place to achieve overall performance objectives, including airspace management to maximize capacity when demand is high and, as required, flow management initiatives to ensure that safe levels of traffic are not exceeded when capacity limits are reached. [P-2], [P-3] ANSPs are better able to communicate and collaborate on the effects of procedures for flights transiting across airspaces managed by different ANSP entities (e.g., for different flight information regions [FIRs], for specially managed special activity airspace [SAA]). A pictorial view of C-ATM is provided in Figure 2-5.

Figure 2-5. Collaborative ATM Among the ANSP and Operators



The rest of this section provides greater depth on the C-ATM process. Section 2.3.2.1 describes the CM process. Section 2.3.2.2 describes the FCM process. FCM is used only when CM cannot fully adjust resources to match anticipated demand.

2.3.2.1 Capacity Management

CM has two main components. "Short-term" CM is the reallocation of assets and the use of procedures to maximize capacity to match anticipated demand. In contrast, "long-term" CM includes planning for major changes to airspace design, significant airport infrastructure improvements, and the establishment of new operational procedures.The CM process allocates NAS resources to meet overall system goals based on user plans, including the designation of trajectory-based airspace and the determination of procedures required for access to airspace. CM structures routings where required to manage complexity and reserves airspace as needed for special uses. [R-11] CM responds to an aggregation of airspace users' expected or desired trajectories, infrastructure, geographic, and environmental constraints, and it provides airspace assignments and dynamic routings to manage the resulting demand.

The CM process begins years before flights are in operation and continues up to and including the day of operation. It includes the long-term and short-term management and assignment of NAS airspace and trajectories to meet expected demand, as well as assignments of related NAS assets and coordination of long-term staffing plans for the airspace assignments. Significant structural changes to airspace or operations (e.g., building a new runway or introducing a new flight procedure) are planned years in advance. The best usable solutions are selected through iterative collaboration across decision horizons.

2.3.2.1.1 Short-Term Capacity Management

Short-term CM involves the allocation of existing assets (e.g., allocation of personnel, adjustment of airspace structures, or designation of performance-based services) to appropriately create the required capacity to meet anticipated demand. In NextGen, resource management is flexible and dynamic, which enables the ATM system to apply people where their services are most needed, to manage and configure facilities (including airports) appropriately, and to designate the use and design of airspace to complement operations. Delivery of services is no longer tied directly to the geographic location of the flight operator or the aircraft; instead ANSP personnel have the ability to acquire needed information and communicate with flight operators independent of their facility location.

As operators plan flights, they share information with the ANSP about the planned trajectory of the aircraft. These trajectories may have different levels of precision based on the expected operations to be performed. For TBOs, the operator's flight plan includes a 4DT. As more information becomes available about the conditions affecting a flight, operators are automatically informed and in turn, make adjustments to provide "best–known" information updating their flight plans. In general, operators use predefined routes less and have more flexibility in designating preferred routings. Some route structure remains where needed to manage complexity, especially at lower altitudes and in terminal airspace where ANSP personnel must be trained on the airspace, and where environmental restrictions exist. Airspace designated for high-capacity or high-complexity operations may hold such an operations designation for a certain set of hours in the day or over a set period of days. This dynamic use of airspace is complemented with the move toward performance-based services that identify performance criteria for an aircraft to meet the requirements for operating in a volume of airspace. Further, this dynamic nature is not capricious—flight operators have the ability to plan and execute their flights.

One of the important areas of short-term collaboration for CM is in addressing the use of SUA and assessing the impacts of proposed SUA. For example, if a military flight operator plans to reserve airspace for a set of operations, the military operator and the ANSP negotiate to balance the need to reserve the airspace with other civil needs for the airspace. The ANSP and the military operator may agree to adjust the airspace boundaries or the time of operations to accommodate civil needs. However, a military need may also outweigh a civil need and, for a given mission, preempt other planned uses. Criteria for this process are defined between service providers and the military.

Both defense and homeland security restrictions are dynamically managed to enhance airspace access. Restrictions for accessing airspace are managed flexibly to accommodate security and defense needs in a nondisruptive manner. When airspace restrictions are proposed to address security concerns, the impacts of a proposed restriction are weighed against the risks that have been identified, and where possible, mitigations are identified to reduce the impact on flight operator plans. The philosophy for airspace restrictions is to provide the maximum available airspace to all users at all times, meet national security needs via priority 4DT reservations, and facilitate immediate user notification of "just-in-time" national needs for restricted airspace. In addition to improved SSA and automated conformance monitoring, management of security and defense needs evolves wherever possible toward flight-specific access requirements and away from blanket restrictions for access.

CM and FCM functions are interactive, as are airspace and TM functions. The demand-capacity balancing process determines which airspace CM strategies to employ across the NAS. Part of the CM process also includes the use of metrics and analyses to determine which strategies were most effective under which conditions. [R-12] Examples of CM strategies include the following:

- Increasing the capacity of a given area of airspace to accommodate projected traffic growth through reassignment of resources (e.g., personnel, RNP routes)
- Instituting structured routes to reduce traffic complexity
- Establishing flow corridors to better accommodate high levels of traffic
- Adjusting the boundaries or activation times of SAA
- Balancing workload among ANSP personnel for a forecast demand "surge."

2.3.2.1.2 Long-Term Capacity Management

Long-term CM generally requires months to several years to implement, depending on the solution set (e.g., build a new runway, develop a new automation system). CM solutions requiring the development of new operational procedures, design of airspace, or implementation of a new technology require the ANSP to perform pre-implementation activities including R&D, environmental impact assessment and mitigation, and safety and security analysis. The solutions typically also involve external collaboration with manufacturers, flight operators, regulators, or other stakeholders. As proposed changes are defined, the ANSP addresses U.S. or international regulatory and policy bodies in a more effective and streamlined manner than is possible today. [P-93]

2.3.2.2 Flow Contingency Management

FCM is the process that identifies and resolves congestion or complexity resulting from blocked or constrained airspace or other off-nominal conditions. FCM deals with demand-capacity imbalances that cannot be addressed through the CM process. [R-13] FCM involves managing the conflicting objectives of multiple stakeholders regarding the operational use of over-subscribed airspace and airports while taking advantage of available capacity to address demand. The collaborative process among flow contingency managers, flight operators, and airport operators allows flight operators to find solutions that best meet their priorities and constraints while satisfying the conditions specified in a given FCM plan. [P-3]

Several guiding principles govern the concept of FCM:

- FCM ddresses multiple types of constraints, including airspace, airport, and metroplex constraints.
- FCM becomes more agile in dealing with uncertainties, developing adaptive traffic management plans that use capacity as it becomes available, and safely dealing with scenarios that become more constrained than expected.
- FCM provides equitable treatment of flight operators and, as much as possible, gives them the flexibility to meet their objectives.
- FCM becomes more focused, affecting only those flights that are necessary to deal with a constraint.

FCM strategies can include establishing multiple trajectories and/or flow corridors to reduce complexity (see Section 2.4.7), restructuring the airspace to provide more system capacity, or allocating time-of-arrival and –departure slots to runways or airspace. Operators with multiple aircraft involved in an initiative have the flexibility to adjust individual aircraft schedules and trajectories within those allocations to accommodate their own internal priorities. The ability for automation to monitor conditions and identify new trends facilitates dynamic refinement of traffic management initiatives (TMIs) and reduces the likelihood that TMIs are overly conservative in managing the NAS. Various FCM functions and activities may occur months or days in advance of a flight, or during a flight. As with all TMIs, probabilistic decisionmaking is used to assess the likely regional and local effects of anticipated flows, weather patterns, and other potential constraints and take incremental actions to reduce the probability of congestion to acceptable levels without overprotecting NAS resources.

2.3.3 Collaboration on Airport Operations and Planning

Significant collaboration occurs in NextGen among the ANSP, flight operators, and airport operators regarding ground operations and planned improvements for airports. [R-14] The ANSP plays a greater role in the NextGen timeframe in supporting regional system planning and addressing airspace interactions among air traffic flows to and from airports and the potential distribution of traffic among a regional system of airports, as described in Chapter 3.

2.3.4 Collaboration on Airspace Operations for Security and Defense Needs

Use of airspace involves collaboration among the ANSP, flight operators, defense services providers, and security services providers. The overall goal for airspace collaboration is to minimize disruption of air traffic while recognizing national defense needs to train pilots and protect the security of sensitive assets, significant activities, and critical infrastructure. Defense and homeland security airspace restrictions are dynamically managed to enhance airspace access. Restrictions for accessing airspace are based on risk and managed flexibly to accommodate security and defense needs in a nondisruptive manner. For security and defense uses of airspace, blanket restrictions as a default strategy are no longer used to address security needs. Instead, management of security and defense needs is based on flight-specific access requirements, where practical (also see Section 6.4.5 on secure airspace concepts). Flight operators receive this information so they can better plan flights and be aware of likely restrictions. [R-15]

2.4 TRAJECTORY-BASED AIRSPACE AND OPERATIONS

A major transformation in NextGen is the use of TBO as the main mechanism for managing traffic in high–density or high-complexity airspace. Within trajectory-based airspace, all TM functions across all time horizons are based on the aircraft's 4DT. Digital data communication and ground-based and airborne automation to create, exchange, and execute 4DTs are prerequisites for TBOs. [R-16], [P-4], [P-90] The use of precise 4DTs dramatically reduces the uncertainty of an aircraft's future flight path, in terms of predicted spatial position (latitude, longitude, and altitude) and times along points in its path. [R-17] This enables airspace to be used much more effectively than is possible today to safely accommodate high levels of demand and maximize the use of capacity-limited airspace and airport resources. TBO and super-density arrival/departure operations are likely to be used during peak periods at the busiest metropolitan areas. High-altitude en route and oceanic airspace, and areas where major flows occur, have airspace reserved for TBO. With TBO, less airspace is needed for these major flows, resulting in reduced impact and improved access for other flights.

In trajectory-based airspace, differing types of operations are conducted, distinguished by the manner in which procedures are selected and clearances are initiated, transmitted, negotiated, monitored, and revised. Performance-based services are applied based on the anticipated traffic characteristics; minimum requirements for operations and procedures to be used are selected to achieve the necessary level of capacity. Overall, preferences for all users are accommodated to the greatest extent possible, and trajectories are constrained only to the extent required to accommodate demand or other national concerns, such as security, safety, or environmental concerns. With TBO, the ANSP provides services to aircraft of differing capability in proximity to each other. Operators that equip their fleets to conduct TBO receive services from the ANSP that allow them to achieve operating benefits.

A major element of TBO is trajectory-based SM, which uses automation and shared trajectory information to better manage separation among aircraft, airspace, hazards such as weather, and terrain. Trajectory-based SM also includes delegation of separation tasks to the flight crew. The benefits envisioned depend upon reducing the impact of weather. Improved information sharing, improved sensors and forecasting, and better integration of weather into automated DSTs help reduce the impact of weather on the entire system. Finally, the ATM framework builds on surface operations that are modernized and better integrated into airspace operations to achieve efficiencies not possible today.

2.4.1 Benefits and Rationale

A number of capacity, efficiency, and general benefits have resulted from the increased predictability of operations, which is based on use of precise trajectories. These benefits include safety and increased ANSP productivity. [R-18], [R-19] Benefits from the use of 4DTs include the following:

- **Capacity/Better Airspace and Airport Utilization.** One of the primary uses of TBO is to increase the inherent capacity of airspace to better accommodate demand from flight operators. As a result, TBO and trajectory-based planning, together with improved weather information integrated into decisionmaking and integration of military, security, environmental, and other requirements, allow access to more airspace more of the time, with reduced impact to traffic flows. [R-20] The flexible management of aggregate trajectories enabled by TBO allows the ANSP to maximize access for all traffic, while adhering to the principle of giving advantage to those aircraft with advanced capabilities that support the ATM system. TBO minimizes excess separation resulting from today's control imprecision and lack of predictability and enables reduced separation among aircraft, allowing increased capacity. TBO is also a key element of super-density arrival/departure procedures. Runway capacity at the busiest airports is the primary limiting factor in NAS operations today, and even with the maximum possible efficiency gains, some airports may need additional runways to accommodate the expected NextGen traffic growth. Implementing super-density arrival/departure procedures enables new runways to be built much closer to existing runways and potentially reduces the cost of new runway construction.

- **Efficiency and Environment.** Operational management of 4DTs enables efficient control and spacing of individual flights, especially in congested arrival/departure airspace and busy runways. This enables use of noise-sensitive and/or reduced-emissions arrival/ departure flight paths. For long flights, particularly in oceanic airspace, the increased predictability afforded by TBO improves fuel efficiency and facilitates optimal fuel loading. Overall, flight operations are more consistent and operators are able to maintain schedule integrity without the excess built into today's published flight times.

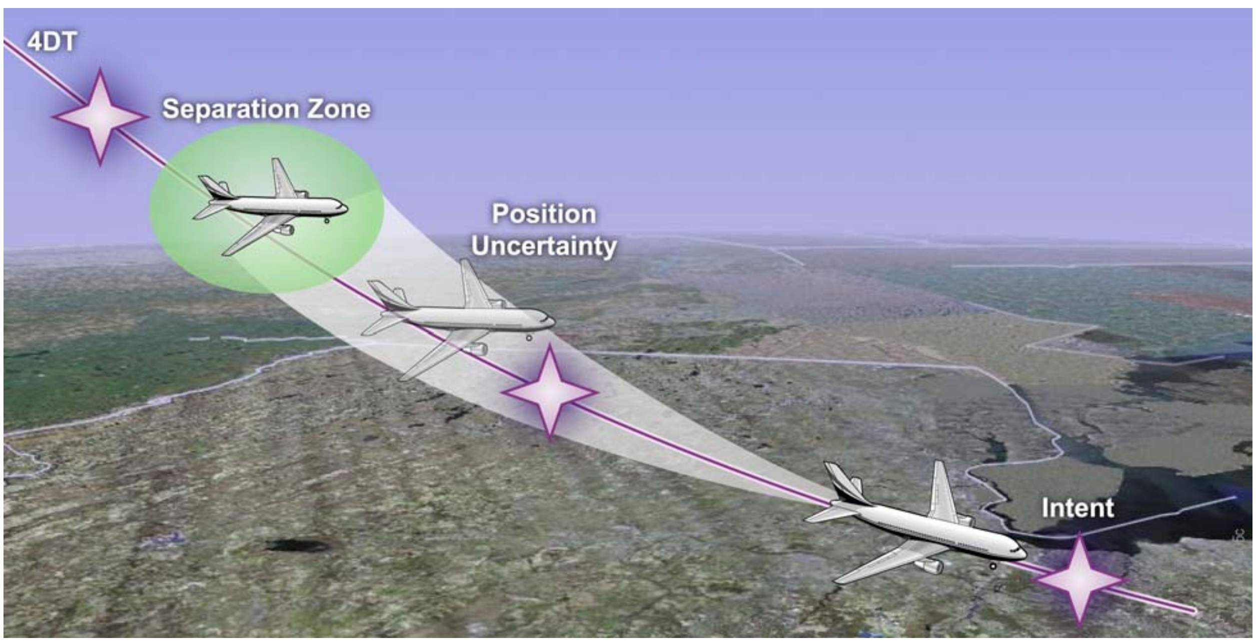
- **Other Benefits.** In addition to supporting increased flows, TBO enables collaboration between the ANSP and operators to maximize utility of airspace to meet ANSP productivity and operator goals. [R-21] Around major airports, TBO is flexibly managed, significantly reducing the "footprint" of today's Class B airspace to only the active arrival/departure corridors and allowing vastly improved access to other trajectory-based and nontrajectory-based flights in the vicinity. [R-22] TBO also allows for scalability of the entire system, as operators become more active in collaborations with the ANSP to manage their own trajectories. Finally, TBO is seen as a key enabler to increase ANSP productivity, so services can be provided at a much lower per–operation cost.

2.4.2 Definition and Attributes of 4DTs

A 4DT is a precise description of an aircraft path in space and time: the “centerline” of a path plus the position uncertainty, using waypoints to describe specific steps along the path (see Figure 2-6). This path is Earth-referenced (i.e., specifying latitude and longitude), containing altitude descriptions and the time(s) the trajectory will be executed.

Some of the waypoints in a 4DT path may be associated with CTAs. CTAs are time “windows” for the aircraft to cross specific waypoints within a prescribed conformance tolerance and are used when needed to regulate traffic flows entering congested en route or arrival/departure airspace. Both the flight crew and the ANSP may need to renegotiate CTAs during the flight for reasons such as winds encountered that are different than those forecast or a change in the destination airport acceptance rate. [R-23], [R-24] Much larger windows in time are allotted to cross all other waypoints not designated as CTAs, allowing operators more flexibility to optimize their flight operations.

Figure 2-6. Elements of a Four-Dimensional Trajectory



The required level of specificity of the 4DT depends on the flight operating environment. Information regarding the operator’s flight plan is managed as part of the flight object.[3] The

[3] The flight object is a software representation of the relevant information about a particular flight. The information in a flight object includes aircraft identity, CNS and related capabilities, flight performance parameters, flight crew capabilities including for separation procedures, and the flight plan (which may or may not be a 4DT), together with any alternatives being considered. [R-7] Once a flight is being executed, the flight plan in the flight object includes the “cleared” flight profile, plus any desired or proposed changes to the profile, and current aircraft position and near-term intent information (see Figure 2-6). For VFR aircraft, the level of detail on the flight profile varies (e.g., it may consist of only information needed for Search and Rescue (SAR) operations). Allocation of responsibility for separation management along flight segments is also likely to be stored. International collaboration on the development of standards for the definition of a flight object is ongoing.

flight object provides access to all relevant information about a particular flight (see Section 5.6 on flight plan filing and flight data services).

2.4.3 Use of 4DTs for Integrated TBO

One of the key concepts associated with TBO is the integration of trajectory planning and execution across the spectrum of time horizons from strategic planning to tactical decisionmaking. [R-25] Strategic aspects of TBO include the planning and scheduling of flight operations and the corresponding planning and allocation of NextGen resources to meet demand, as described in Section 2.3.2.1. [R-21] Tactical components of TBO include the evaluation and adjustment of individual trajectories to synchronize access to airspace system assets (or to restrict access, as required) and ensure separation, described below and in Section 2.4.4.

New ANSP personnel roles and supporting operations (described in Section 2.7) build on the use of TBO to provide ATM services. Air traffic services are provided through the generation, negotiation, communication, and management of both individual 4DTs and aggregate flows representing the trajectories of many aircraft. Flexible route definitions allow traffic flows to be shifted as necessary to enable more effective weather avoidance; meet environmental, defense, and security requirements; and manage demand into and out of the arrival/departure environment. [R-4] Capabilities for managing airspace structure include a common mechanism for implementing and disseminating information on the current airspace configuration to ensure that all aircraft meet the performance requirements for any airspace they enter. Similar information on airspace restricted for defense and homeland security ensures that these needs are met, maximizes access, and minimizes disruptions to commerce. Using automation to better manage uncertainties associated with weather minimizes airspace capacity limitations and reduces the likelihood of overly conservative actions. [R-8] Different aircraft and flight crews also have varying levels of ability and preferences to operate in specific weather conditions. Individual flight limitations and preferences are key inputs to flight planning and execution, and flight operators may dynamically update these features. With this knowledge, the ANSP can support 4DTs tailored to individual flight preferences. [R-26]

Within trajectory-based airspace, some aircraft support additional operations via onboard capabilities and associated crew training, including the ability to perform delegated separation, airborne self-separation, and low-visibility approach procedures. [R-27] Overall, these new kinds of flight operations dramatically improve en route productivity and capacity and are essential to achieving NextGen. [R-28] Delegation of ATM functions to capable aircraft means these services are provided only when and where the aircraft need them, promoting scalability of the overall ATM system.

In the highest-density arrival/departure areas, super-density arrival/departure operations are implemented to maximize airport throughput at times of peak demand while facilitating efficient arrival/departure profiles for equipped aircraft. Super-density arrival procedures are conducted, usually requiring airborne separation capability, and may be continued on the airport surface where required for throughput. [R-29], [R-30] Other arrival/departure areas with less demand, and high–demand arrival/departure areas during off-peak hours, provide access to a wider range of aircraft. Aircraft routinely conduct low–noise approaches, mitigating noise impacts.

2.4.4 Trajectory Management Process

TM is the process by which individual aircraft trajectories are managed just before and during the flight to ensure efficient individual trajectories within a flow. [R-18], [R-31] TM corrects imbalances within an established flow to ensure that congestion is manageable. Like FCM (see Section 2.3.2), TM is only imposed when resource contention requires. The TM process considers any active FCM initiatives and known airspace plans in establishing the best mitigation to resource contention. TM assigns trajectories for aircraft transitioning out of self-separation operations and for aircraft entering or leaving flow corridors. [R-32] For arrival/departure operations, including super-density operations, TM assigns each arriving aircraft to an appropriate runway, arrival stream, and place in sequence. TM supports the SM function through managing the frequency and complexity of aircraft conflicts and reduces, but does not eliminate, the need for tactical separation maneuvers. In high-density or high-complexity operations, and especially for climbing and descending aircraft around airports, some conflicts occur; otherwise, aircraft overconstrain the system and underuse available capacity.

2.4.5 Separation Management Process

The SM process ensures that aircraft maintain safe separation from other aircraft, from certain designated airspace, and from any hazards (e.g., terrain, weather, or obstructions). [R-33] Where TBO is used, SM relies significantly on automation for predicting conflicts and identifying solutions. [R-34] Use of automation also allows SM to move away from fixed human-based standards to ones that allow variable separations that factor in aircraft capabilities, encounter geometries, and environmental conditions. [R-35] Flight crews approve the recommended conflict resolution before it is implemented, whether it is generated on the ground or in the cockpit.

In managed airspace, the ANSP has overall responsibility for SM and may delegate this responsibility to separation-capable aircraft. [R-36] The ANSP SM function is fully automated, and separation responsibility is delegated to automation or, for specified operations, to the flight crew. [R-37] The operating norm is that the ANSP delegates tasks to aircraft to take advantage of aircraft capabilities; however, ANSP personnel (typically, the trajectory manager) may identify the need for the ANSP to maintain separation responsibility. For aircraft not delegated separation, whether this is because the aircraft are not capable or because the ANSP wishes to retain separation authority, ANSP automation manages separation and negotiates short-term, conflict-driven updates to the 4DT agreements with the aircraft. Delegated separation operations include both a single aircraft having separation authority for a specific maneuver (e.g., for crossing or passing another aircraft) or more general separation responsibility, such as for flow corridors (described in Section 2.4.7). ANSP and aircraft automation track the delegation of responsibility and its limits and ensure that the delegation is always unambiguous and clearly communicated.

Aircraft performing self-separation procedures separate themselves from one another and from aircraft whose separation is managed by the ANSP without intervention by the ANSP. In self-separation airspace, the ANSP provides neither separation nor TM services for that airspace, but the aircraft may still be subject to TM in downstream transition airspace. [R-38] Standardized algorithms detect and provide resolutions to conflicts at least several minutes ahead of the predicted loss of separation. The resolution maneuver is usually very small (because of the increased precision in TBO) and generally includes course, speed, or altitude changes. Rigorous right-of-way rules determine which aircraft should maneuver to maintain separation when a conflict is predicted. These rules specify the conflict resolution maneuver options for resolving the conflict with minimum disruption to the maneuvering aircraft and for preventing a conflict with a third aircraft in the short term. [R-170] Contingency procedures requiring the other aircraft to execute an avoidance maneuver are invoked in the event the "burdened" aircraft does not make the appropriate maneuver within a specified time.

Self-separating aircraft have 4DTs with sufficient flexibility defined to allow for separation maneuvers. [R-39] After such maneuvers, the aircraft is expected to return to its route toward its next waypoint defined in the 4DT or negotiate a new 4DT. Usually the aircraft is able to achieve and maintain its most efficient trajectory without renegotiating its 4DT. In oceanic or remote airspace, the aircraft may have sufficient flexibility to deviate around weather. An FCM function may be needed in self-separation airspace to impose sufficient structure to ensure that traffic density remains safe, especially around convective weather or other constraints. [R-40]

Transition airspace around self-separation airspace exists to allow for the safe transfer of separation responsibility between the aircraft and the ANSP. For aircraft entering self-separation airspace, separation responsibility is transferred so that the aircraft is safely able to assume it, implying that there are no very near-term conflicts with other aircraft or hazards. For aircraft exiting self-separation operations, the transition may include waypoints with CTAs to enable sequencing and scheduling by the ANSP. In this transition zone, the ANSP provides CTAs and possibly TM to maintain safe separation between the aircraft exiting the airspace. As with delegated separation, the ANSP and aircraft automation track the transfer of separation responsibility and communicate it to those affected. [R-41]

Today, most high-performance aircraft are equipped with an aircraft-based collision avoidance system that is independent of the ATC system. In the United States, this system is referred to as the Traffic Alert and Collision Avoidance System (TCAS) II; internationally, this system is referred to as the Airborne Collision Avoidance System (ACAS). TCAS II reduces the risk of collision between aircraft when the separation assurance process fails. Under NextGen, a collision avoidance system independent of the separation assurance system, and which acts only in the event the separation assurance process fails, will still likely be required (see ICAO AN-Conf/11, ASAS Circular). [R-42]

2.4.6 Trajectory-Based Aircraft Procedures

The procedures performed by 4DT-capable aircraft are described in this section. The procedures used most include—

- **4DT Procedures.** In addition to basic RNP capability (described in Section 2.5), aircraft must meet specified timing constraints at designated waypoints along their route. Aircraft comply with the resulting 4DT procedure in flight. Several levels of 4DT operations exist, defined by the level of navigational and timing constraints.

- **Delegated Separation Procedures.** The ANSP delegates responsibility to capable aircraft performing the basic 4DT procedures described above to perform specific separation operations using onboard displays and automation support. Examples include passing, crossing, climbing, descending, and turning behind another aircraft. In these operations, the ANSP is responsible for separation from all other traffic while the designated aircraft performs the specific maneuver.

- **Airborne Merging and Spacing Procedures.** 4DT aircraft are instructed to achieve and maintain a given spacing in time or distance from a designated lead aircraft as defined by an ANSP clearance. Cockpit displays and automation support the aircraft conducting the merging and spacing procedure to enable accurate adherence to the required spacing. Separation responsibility remains with the ANSP.

- **Airborne Self-Separation Procedures.** Aircraft are required to maintain separation from all other aircraft (and other obstacles or hazards) in the airspace. Aircraft follow the "rules of the road" and avoid any maneuvers that generate immediate conflicts with any other aircraft. Self-separation procedures are conducted only in self-separation airspace. The ANSP does not provide TM or SM, except as needed to safely sequence and schedule aircraft exiting self-separation airspace.

- **Low-Visibility Approach/Departure Procedures.** Aircraft with appropriate cockpit displays and automation support conduct landings and takeoffs safely in low-visibility conditions without relying on ground-based infrastructure by using onboard navigation, sensing, and display capabilities.

- **Super-Density Arrival/Departure Procedures.** Aircraft conduct delegated separation procedures, such as closely spaced parallel approaches, within very precise tolerances for position and timing to maximize runway throughput.

- **Surface Procedures.** Trajectory-based procedures may be used on the airport surface at high-density airports to expedite traffic and schedule active runway crossings. Equipped aircraft may perform delegated separation procedures, especially in low-visibility conditions.

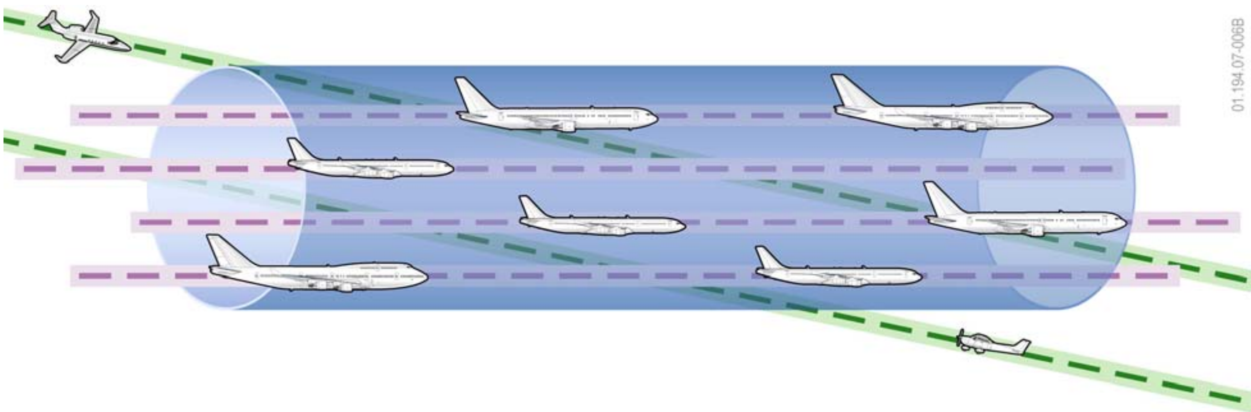
The procedures listed above are not mutually exclusive, and the flight object captures the abilities and authority of aircraft to perform these procedures.

2.4.7 En Route and Cruise TBO

Operational distinctions between oceanic and en route airspace fade as performance-based operations and necessary advanced CNS technologies become the norm. Some operational considerations remain for oceanic and remote airspace (e.g., when there are long distances between suitable landing locations). These operations accommodate aircraft equipped only for basic 4DT procedures, possibly along fairly structured routes when more capable aircraft are occupying the efficient routes and altitudes.

4DT procedures allow the ANSP to precisely schedule traffic through congested airspace, especially as aircraft start to converge approaching a major airport. When demand is very high, the ANSP may implement "flow corridors" for large numbers of separation-capable aircraft traveling in the same direction on very similar routes (see Figure 2-7). Flow corridors consist of long tubes or "bundles" of near-parallel 4DT assignments, which consequently achieve a very high traffic throughput, while allowing traffic to shift as necessary to enable more effective weather avoidance, reduce congestion, and meet defense and security requirements. [R-43] The airspace for aircraft operating in flow corridors is protected; aircraft not part of the flow do not penetrate the corridor.

Figure 2-7. Flow Corridors



The 4DT assignments in a flow corridor do not ensure that conflicts never occur, but do ensure that any conflicts are easily resolved with small speed or trajectory adjustments even with the high traffic density. The corridor is large enough for aircraft to use their separation capabilities for entering and leaving the corridors, as well as for overtaking, all of which are accomplished with well-defined procedures to ensure safety. Flow corridors are procedurally separated from other traffic not in the corridor. The high traffic density achieved increases the airspace available to other traffic, and often eliminates the need for a TMI; thus the flow corridor is implemented along the optimum routes and altitudes. The corridor may be dynamically shifted to avoid severe weather or take advantage of favorable winds. Procedures exist to allow aircraft to safely exit the corridor in the event of a declared emergency.

For scalability and affordability, the ANSP delegates separation tasks to capable aircraft whenever this benefits the aircraft involved, overall operations, or ANSP productivity. [R-44] Some airspace is designated as self-separation airspace, where self-separation operations are required. En route trajectory-based procedures are summarized in Table 2-3.

Table 2-3. Summary of En Route and Oceanic Trajectory-Based Operations

Operation	Benefit	ANSP Capability	Aircraft Capability	Provision of Separation
ANSP-Managed Operations	High traffic density; accommodate wide range of aircraft capabilities	4DT exchange, including updates for SM, TM	Exchange and execute 4DT, CTA, RNP; some aircraft have delegated separation capability	ANSP via automation; or ANSP delegates to aircraft

Table 2-4. Summary of En Route and Oceanic Trajectory-Based Operations (continued)

Operation	Benefit	ANSP Capability	Aircraft Capability	Provision of Separation
Flow Corridors	Very high traffic density; preferred routing; ANSP productivity	4DT exchange with reduced requirement for updates, TM	Exchange and execute 4DT, CTA, RNP; delegated separation capability	Procedural separation of corridor from other airspace; aircraft within corridor separate themselves
Self-Separation Operations	Preferred routing; ANSP productivity	FCM, manage entry to/exit from self-separation airspace	Exchange and execute 4DT, CTA, RNP; full self-separation	Aircraft

2.4.8 Arrival/Departure TBO

Airspace around airports serving trajectory-based traffic is ANSP-managed, with the TM and SM functions supported by advanced automation. Integrated arrival/departure area and airport surface management ensure that arrival flows match projected airport capacity for improved overall throughput and efficient flight trajectories that eliminate today's low–altitude path-stretching and holding. [R-45] Aircraft are typically assigned final 4DT arrival profiles at top of descent. The development of quieter aircraft coupled with widespread implementation of low-noise approaches eases restrictions currently imposed for noise abatement at many airports. Rotorcraft and other "runway-independent" aircraft needing access to trajectory-based arrival/ departure areas are coordinated with the major fixed-wing flows to avoid congestion and improve the overall flow of both types of aircraft. Table 2-5 presents arrival and departure procedures.

Table 2-5. Arrival and Departure Procedures

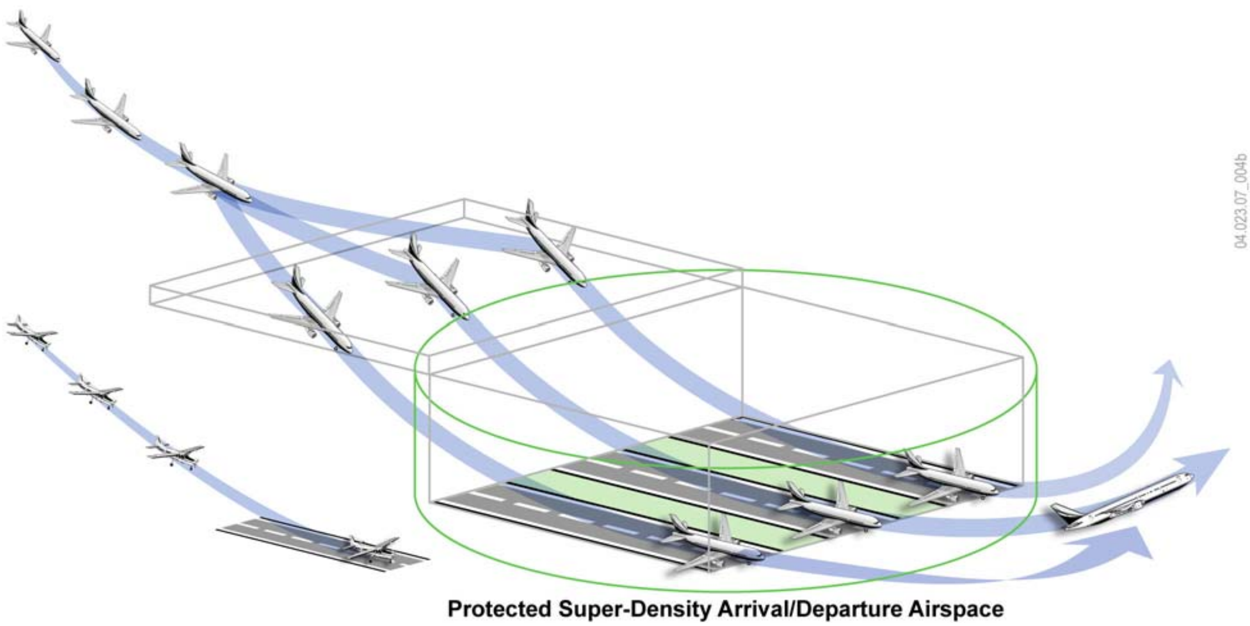
Operation	Benefit	ANSP Capability	Aircraft Capability	Provision of Separation
CDA, other RNP trajectories	Reduced environmental effects; high throughput	4DT exchange, TM, SM	Exchange and execute 4DT, CTA, RNP,CDA; airborne spacing	ANSP automation
Merging and spacing	Arrivals matched to runway capacity, ANSP productivity	TM, 4DT exchange, SM	Exchange and execute 4DT, RNP; airborne spacing	ANSP automation
Closely spaced parallel approach (CSPA), paired approaches	Closely spaced runways maintain visual meteorological conditions (VMC) capacity in all visibility conditions	TM, 4DT exchange to establish aircraft on approach; SM wake vortex monitoring and automation	Exchange and execute 4DT, RNP; delegated separation	ANSP automation, except between aircraft conducting approach

At times of peak demand, major airports conduct super-density arrival/departure operations in which capacity-enhancing arrival and surface procedures are implemented to maximize runway throughput. [R-46] Other airports with lower demand have fewer restrictive aircraft capability requirements, allowing access to all 4DT-capable aircraft. Some airports serving trajectory-based traffic accept both trajectory-based and non-trajectory-based traffic (usually on different runways), depending on the airport configuration and level of demand.

2.4.8.1 Super-Density Arrival/Departure Operations

Super-density arrival/departure operations may be required at more airports than today's Class B airports to handle the projected traffic increase; however, as super-density arrival/departure operations restrict access to high-capability aircraft, they are only designated when warranted by demand and revert to accepting all trajectory-based traffic at other times of the day. As illustrated in Figure 2-8, super-density arrival/departure corridors handle arriving and departing traffic, while much nearby airspace remains available to other traffic. [R-47]

Figure 2-8. Super-Density Arrival/Departure Terminal Operations



Capabilities used to achieve super-density arrival/departure operations are likely to include the procedures listed in Table 2.3 above and the following:

- Use of RNP operations
- Use of procedures that eliminate requirements for visual operations [R-48]
- Mitigation of wake vortex constraints through detection and real-time adaptation of applied separations
- Improved runway incursion prevention procedures and technologies
- Automatic distribution of runway braking action reports
- Distribution of taxi instructions before landing that can be automatically executed without waiting for a separate clearance

- Use of aircraft sensors to more quickly identify the need for de-icing operations, increasing efficiency of surface movements.

2.5 CLASSIC AIRSPACE AND OPERATIONS

Classic operations build on many of the advanced capabilities of aircraft and ANSP decision support but do not require 4DTs. Performance-based services are used in classic airspace. Capacity and ANSP productivity gains are achieved through improved CM and FCM capabilities (see Section 2.3.2), coupled with decision support automation and the leveraging of aircraft capabilities. Even in classic airspace, ANSP personnel have a more strategic view and rely more on automation to perform routine tasks, yielding ANSP productivity gains as controllers handle more traffic. Area navigation (RNAV) flight routes are flown except where congestion forces structured routes. The ANSP, supported by advanced automation, provide TM and SM services in managed classic airspace through the issuance of clearances and instructions, similar to today. Some aircraft support the use of data link for many communications, especially routine transmissions such as sector handoffs. Electronic format has largely replaced today's paper charts for all phases of flight.

Overall, a wide range of aircraft capabilities are accommodated, including many of today's approximately 200,000 commercial and noncommercial aircraft, and trajectory-based airspace is designed and implemented with consideration for providing classic flight operators with improved access to ATM resources. Much high- and low-altitude airspace outside of high-traffic areas remains similar to today's Class A, C, D, E, and G airspace, as well as some oceanic airspace. [R-49] Aircraft capable of TBO often transit classic airspace and often are able to use their advanced capabilities to their advantage, depending on the conditions. [R-50] The airspace around airports serving classic traffic operates similarly to today and accommodates aircraft with various equipage levels, with the improvements noted above for en route operations. CDAs are the norm, allowing for growth in operations and reduced noise impacts.

2.5.1 Nonmanaged Airspace Operations

Areas of uncontrolled Class G low-altitude airspace continue to exist in NextGen in some remote areas. Operations are unchanged from today, and no ANSP services are provided, except as required to coordinate entry to a different class of airspace. VFR procedures are used by most aircraft, as is done today. Cooperative surveillance may not be a requirement for nonmanaged operations.

2.6 SURFACE AND TOWER OPERATIONS

For both trajectory-based and classic traffic, surface operations in the NextGen timeframe at medium- and large-demand airports are integrated with other ATM functions, including departures, arrivals, and collaborative traffic management. [R-45] Improved surveillance, automation, and information sharing enhance surface and tower operations for all traffic, as described in Section 3.3.1. The busiest airports at peak times (most likely those implementing super-density arrival/departure operations) conduct super-density surface operations for trajectory-based traffic to maximize runway throughput and minimize taxi times while moving aircraft safely and with robust runway incursion prevention. Aircraft control towers provide enhanced services compared to today. Particularly in low-visibility conditions, the ANSP can safely make more efficient use of runways through real-time depiction in the tower of the location and intent of arriving and departing aircraft, as well as any aircraft intending to cross an active runway. For lower-demand airports, staffed or automated virtual towers may be implemented, enabling tower services equivalent to those provided by traditional towers to be provided at more airports than is affordable today and/or for extended hours of service. A summary of NextGen surface transformations is given in Table 2-6.

Table 2-6. NextGen Surface Operation Transformations

2006	NextGen
Ground surveillance available to ANSP limited. Mostly primary, some secondary surveillance capability installed. Limited effectiveness of runway incursion prevention automation	Cooperative ground surveillance at most airports, including state vector information (e.g., aircraft speed/direction), with more effective runway incursion prevention automation
Essentially no cockpit surveillance of other ground traffic/vehicles, other than visual (out the window)	Integrated surveillance of ground traffic, along with airport layout and taxi routes, with cockpit warning of runway incursions
Surface movement information (pushbacks, departures, taxi delays, etc.) mostly not integrated with TFM. Difficult to implement flight-specific TMIs	Updated pushback information provides improved surface and departure management. Surveillance of surface movement provides basis for more accurate departure time and taxi delay estimates. Availability of improved departure time estimates significantly improves capability of FCM and TM. Flight-specific traffic management initiatives are handled via automation and data communications.
Many non-towered airports	Automated virtual towers (AVTs) or better where economically feasible
Inefficient one-in-one-out operations at smaller airports without approach controls or towers	Elimination of one-in-one-out restrictions at most airports for equipped aircraft

2.7 TRANSFORMED FLIGHT OPERATIONS

There is a wide diversity of flight operations and flight operators in NextGen. Flight operators, the primary users of ATM services, have a range of objectives for operating flights, depending on their business models. Examples of flight operators and their objectives include the following:

- **Scheduled Operators.** The primary objectives associated with scheduled operations are maintaining schedule integrity and operating efficiency. For many operators, the ability of NextGen to accommodate growth in schedules is also important.
- **On-Demand Operators.** The objectives for on-demand operators include continual access to NextGen resources and operating efficiency.
- **Corporate Operators.** Corporations operating aircraft to support their core (and not necessarily aviation) business need access to airports and airspace for the conduct of commerce.

- **Personal Aircraft Operators.** The objective for personal aircraft operators is equitable access to NAS resources—both airports and airspace. Many of these operators require the ability to conduct flight training and VFR operations with minimal restrictions.

- **State and Military Aircraft Operators.** State and military operators require access to all areas of NextGen and may, at certain times, require NextGen to accommodate aircraft that do not meet all expected capability and performance requirements. These operators may also require priority access to complete a specific mission or objective. Military aircraft operators require the ability to operate in areas designated for their special use to conduct training and proficiency operations.

- **Space Vehicle Operators**. Routine access to space requires space vehicle operators to operate through the NAS on the way to and from space, according to schedules that are known well in advance.

The term "flight operator" is used broadly to cover all people or organizations that operate aircraft, including scheduled, on-demand, personal aircraft, and state and military aircraft operators and emerging flight operations such as unmanned aircraft and space vehicles. [R-51] The common theme for this diversity of ATM customers is their transformed ability with NextGen to achieve their business and operational objectives through access to reliable real-time information relevant to their proposed operation, to understand the impact of their decisions related to their operations, and to negotiate with the ANSP to achieve their objectives. Many operators have advanced capabilities that are complementary to the ANSP and can take advantage of the significant opportunities for access, efficiency, and predictability afforded by NextGen. These transformed operations provide benefit for any operator that invests in the needed capability, whether GA, commercial, civil, or military. The adoption of performance standards rather than equipment standards encourages innovation by avionics suppliers to produce affordable capabilities supporting trajectory-based procedures and real-time flight information (weather, airspace configuration, traffic, etc.) in the cockpit. [P-88]

Flight operator roles during flight planning and flight execution vary based on flight operator capabilities and are highlighted in Table 2-7. Other flight operator roles such as marketing and strategy development are outside the scope of this document.

Table 2-7. Flight Operator Roles

2006 Roles	Corresponding NextGen Roles
Dispatcher/FOC Personnel Responsible for originating and disseminating flight information, including flight plans. Responsible for operational control of day-to-day flight operations. Also responsible for understanding weather and other constraints, incorporating these into flight plans, and in some organizations, coordinating with ANSP personnel regarding overall flow issues.	**Flight Planner** Responsible for making tactical decisions about what flights to operate and when and where they operate. May be the same as flight crew. Is the interface with the ANSP C-ATM function to develop collaborative capacity and traffic flow management decisions and in trajectory negotiation.

Table 2-8. Flight Operator Roles (continued)

2006 Roles	Corresponding NextGen Roles
GA operators also may interact with third-party (fee-for-service) vendors who provide weather and other services (e.g., flight planning) through dedicated computer terminals, direct phone contact, or the web.	Operators with multiple aircraft involved in the initiative have the flexibility to adjust individual aircraft schedules and trajectories within those allocations to accommodate their own internal business concerns, both preflight and in flight.
Flight Crew Responsible for the control of an individual aircraft while it is moving on the surface or airborne.	**Flight Crew** Responsible for the control of an individual aircraft while it is moving on the surface or airborne. Under delegated operations, responsible for separation. May comprise a single pilot or multiple individuals (e.g., two pilots). For UAS systems, may operate the aircraft remotely; for “autonomous” UAS (programmed with an overall mission), may be an automata.

For flight execution, there is a transition from pilot to aircraft systems manager for all classes of pilots as aircraft capabilities evolve. The roles of the flight crew for advanced aircraft in NextGen include aircraft system manager, supervisory override, and participant in the C-ATM function. When separation is delegated, the flight crew assumes the role of separation manager as well. For other aircraft operating in classic airspace, the flight crew operates much as today, including those operating under VFR. In the supervisory override role, the flight crew is responsible for operating the aircraft and taking any actions deemed necessary to correct system malfunctions that occur during flight. During surface operations, the flight crew has full control of the aircraft and is responsible for maneuvering it and determining if it is fully functional before takeoff. For some aircraft, flight management automation may be used for surface operations as well.

2.7.1 Benefits and Rationale

Flight operators, the primary users of ATM services, have a range of objectives for operating flights. Benefits desired by flight operators include maintaining schedule integrity, operating efficiency, having access to airspace and airports in the presence of congestion, being able to operate with minimal disruption from weather or visibility, having increased safety and utility, suffering minimal disruptions from security and defense operations, and having reduced operating costs. State and defense providers also have unique needs for access to airspace and transit through airspace to complete missions or for training. In addition, a broad community of operators who fly under VFR continue to want access to airspace without the requirement to be in communication with the ANSP.

Flight operators have a wide range of capabilities and options to meet their mission needs. The minimum capability for operating in any managed airspace is cooperative surveillance, the ability to perform RNAV operations (if operating under instrument flight rules [IFR]), and communication with the ANSP via voice radio. In airspace where TBO is used (see Section 2.4), the minimum capability includes the ability to conduct RNP operations combined with the exchange (via a digital data link) and execution of precision 4DTs. [R-52] Digital data communications between flight operators and the ANSP are the norm in trajectory-based airspace [P-91]; voice radio is used on exception and as a backup. Some airspace requires the ability to perform delegated or self-separation operations in addition to the above. Many aircraft in NextGen are capable of digital data communications to communicate with the ANSP (for clearances, requests, and aeronautical information) to send and receive weather information and to receive surface movement instructions. Many operators also are able to communicate between aircraft and their FOC for exchanging flight planning and trajectory information, aircraft performance and maintenance data, flight following information, and passenger-related information. Flight planning systems also have a range of capabilities, including the ability to exchange and negotiate information supporting the C-ATM process.

Each operator makes choices, based on his or her own business model, about the desired operations and the tradeoffs between increased levels of service from the ANSP versus the needed investment in flight planning and aircraft capabilities and performance. As populations grow and operations rise in level and complexity, operators continue to make choices on whether to invest in needed capabilities and training, if additional procedures are required to operate.

2.7.2 Special Vehicle Operations

2.7.2.1 State and Military Operations

Many state aircraft—primarily those operated by the military—require transition between seamless operations among civil aircraft and exceptional flight requirements (e.g., needing special services from the ANSP or departing airspace managed by the ANSP) during a single flight. The initial phases of the mission operate in similar fashion to those of civil users until aerial refueling (AR) operations are initiated; at that point, the operation becomes unique and remains so until the AR mission is accomplished. After the AR mission is complete, the aircraft is re-integrated into normal NAS operations.

2.7.2.2 Unmanned Aircraft Systems

UAS operations are some of the most demanding operations in NextGen. UAS operations include scheduled and on-demand flights for a variety of civil, military, and state missions.

Because of the range of operational uses, UAS operators may require access to all NextGen airspace. UASs are expected to fly in trajectory-based airspace (see Section 2.4). The UAS operators are capable of conducting the procedures required for the airspace and must achieve the same target level of safety against collisions as manned aircraft. Because UASs may also operate in airspace in which cooperative surveillance may not be required, they have the responsibility for sensing and avoiding other aircraft. This may include responsibility for separating from aircraft that do not have cooperative surveillance in some airspace.

2.7.2.3 Vertical Flight

Rotorcraft, tiltrotor, vertical/short takeoff and landing (V/STOL), and similar aircraft have different flight capabilities and limitations from fixed-wing aircraft, and they often perform unique and demanding missions.

Transport category IFR-capable rotorcraft are being acquired in larger numbers. With growing ground congestion, these aircraft have increased utilization. In addition to civil uses, rotorcraft continue to have an increasing role in homeland security and other missions. They provide emergency medical services in all areas and cities of the United States and increasingly perform IMC operations. Rotorcraft are also used for UAS applications for commercial, police, and security operations. These operations add to the density and complexity of operations, particularly in and around urban areas.

2.7.2.4 Trans-Atmospheric and Space Operations

Some aircraft are destined for specific mission operations at flight level (FL)600 and above. These "near-space" and space operations continue and expand in diversity in the NextGen timeframe. Near-space and space aircraft exhibit a wide variance in capability and vehicle performance (e.g., aerostats, medium- and high-speed research/reconnaissance aircraft, suborbital spacecraft, launching and reentering orbital spacecraft). Some users of this airspace are expected to have unique needs that can be accommodated only with security restricted airspace (SRA) (today's temporary flight restrictions [TFRs]).

2.8 TRANSFORMATIONS IN ANSP PROCESSES

ANSP service delivery mechanisms are transformed to provide ATM services in a safer, more secure, scalable, and affordable manner. Processes are revolutionized, from the way ANSP personnel are trained and allocated to airspace to the way long-term capacity changes are managed. The changes in ANSP processes and personnel management are geared toward the following goals:

- Managing resources dynamically to enable the ATM system to apply people where their services are most needed
- Managing and configuring facilities (including airports) appropriately
- Designing airspace and designating its use to complement operations
- Ensuring that the ATM system is globally harmonized through collaborative development and implementation of identified best practices in both standards and procedures
- Ensuring that safety, security, and environmental considerations are fully integrated into ATM.

Within the ANSP workforce, the emphasis in NextGen is on strategic flow management and collaboration with airspace users. Flow contingency managers monitor and assess capacity requirements for flows of traffic. With DSTs, they determine optimum flow and airspace configurations in collaboration with capacity managers and through collaboration with flight operators and other stakeholders. Separation managers and trajectory managers interact to determine optimum system solutions and implement decisions strategically. A broad set of strategic ANSP functions include the following:

- Forecasting demand to support effective and timely capacity planning
- Managing capacity, including dynamic management of NAS resources

- Collaborating with airspace users on flow management strategies
- Managing trajectory and negotiating with flight operators, if needed
- Maintaining the flight object and providing flight planning support
- Providing flow strategy and trajectory impact analysis services
- Maintaining the net-centric infrastructure and providing other NAS infrastructure services (e.g., navigation and surveillance)
- Coordinating changes to U.S. and international procedures.

Some of these functions are new in NextGen; many are enhanced. Existing functions (e.g., forecasting demand, providing navigation and surveillance services) are also transformed. The transformations are discussed in subsequent chapters. In addition, although flight planning and weather services are automatically disseminated or provided by third-party service providers, ANSP personnel still provide safety-critical in-flight services. Table 2-9 defines the NextGen service provider roles in relation to those of 2006 service providers.

Table 2-9. Air Navigation Service Provider Personnel Roles

2006 Roles	Corresponding NextGen Roles
Area Supervisors, Airspace Designers (SUA/Space Launch Coordinator Are Partially Comparable) Design and strategically allocate airspace. Adjust the assignment of airspace to tactical separation providers (primarily by combining and decombining sectors). Structure routings (air and ground) where required.	**Capacity Managers in Collaboration with Airspace Users and Flight Operators** Design and strategically allocate airspace. Dynamically adjust the assignment of airspace to tactical separation providers. Structure routings (air and ground) where required, and flexibly allocate airspace for other purposes, including the operation of state (government) aircraft.
Traffic Management Specialists/ Coordinators Identify potential flow problems, such as large-demand capacity imbalances, congestion, high degrees of complexity, and blocked or constrained airspace (e.g., for special use, weather), and collaborate on traffic management initiatives.	**Flow Contingency Providers in Collaboration with Flight Operators** Identify potential flow problems, such as large-demand capacity imbalances, congestion, high degrees of complexity, and blocked or constrained airspace (e.g., for special use, weather), and collaborate to develop flow strategies (i.e., aggregate trajectory solutions).
Traffic Management Specialists/ Coordinators, Air Traffic Controllers (e.g., En Route D-Side) Ensure that traffic management initiatives are carried out. Perform planning for flights entering sector, identify future conflicts (i.e., strategic SM), and coordinate resolutions with adjacent sectors.	**Trajectory Managers in Collaboration with Flight Operators** Predict individual flight contention within a flow for resources, identify complex future conflicts (i.e., strategic SM), and coordinate individual trajectory resolutions. This is focused on near-tactical management of individual trajectories within a flow.

Table 2-10. Air Navigation Service Provider Personnel Roles (continued)

2006 Roles	Corresponding NextGen Roles
Air Traffic Controllers (e.g., En Route R-Side) Provide tactical separation to separate aircraft from other aircraft and SUA, and organize and expedite the flow of traffic.	**Separation Managers (May Be Flight Crew Depending on the Airspace and the Operation)** Eliminate residual conflicts left by the three strategic functions of TBO. Automation detects the conflicts and provides the resolution.
Flight Service, Third-Party Service Providers Provide flight planning and weather services (e.g., Direct User Access Terminal (DUAT)).	**Automated Dissemination to Operators and Flight Crews, FOCs, Third-Party Service Providers** Provide flight planning support and weather services. ANSP role is limited to safety-critical in-flight assistance. Operators may also interact with third-party weather providers or their own FOC.

2.8.1 International Harmonization

ICAO PIRG or multilateral agreements coordinate planning and implementation of NextGen ANSP transformations to harmonize the application of technology and procedures. [P-5] This harmonization allows airspace users to realize the maximum benefits of the NextGen transformations.

Encouraging performance-based, harmonized global standards and leveraging research and capabilities development helps reduce the cost of aviation. Global harmonization encourages performance-based, harmonized global standards and enables services tailored to traveler and shipper needs. Global environmental impacts are reduced, and security risks are assessed globally.

2.8.2 ANSP Personnel Management to Support NextGen

Because NextGen transformations significantly change the roles and responsibilities of ANSP personnel, substantive and organic changes in ANSP personnel management are necessary. NextGen transformations with the largest impact include—

- TBO and airspace
- Performance-based separation standards
- Greater role for the aircraft and flight crew in operations
- Reliance on intelligent automation, including for tactical SM
- Emphasis on strategic flow management to minimize the need for tactical separation maneuvers
- Dynamic assignment of airspace boundaries and associated NextGen operations.

These operational transformations require corresponding transformations in ANSP personnel selection, staffing, training policies, and practices to meet NextGen performance objectives (see Table 2-11). Considerations include—

- Personnel selection (e.g., minimum skill levels, special skills, experience levels, cultural issues)
- Staffing (e.g., staffing levels, team composition, job design, team communication, organizational structure)
- Training (e.g., training regimen, training effectiveness, skill retention and decay, retraining, emergency operations training, training devices and facilities, embedded training). [R-53]

Table 2-11. Personnel Management Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Personnel Skills and Selection	• Tactical (sector) controllers dominate ATC workforce. • Controllers must learn local characteristics of airspace. • Skill sets are matched to traffic characteristics within airspace (e.g., high-altitude cruise, transition, terminal).	• Separation managers are assigned only to classic airspace. • Common airspace/flow configurations, DSSs, and a network-centric information management system minimize the need for local airspace knowledge. • Skill sets are matched to traffic characteristics in airspace (i.e., classic, TBO).
Flexible Staffing	• Controllers are assigned to one area of specialty within a facility. • Sectors are combined/de-combined to manage workload. • Constant adjustments are made to facility staffing levels to match traffic levels; facility grade is assigned by traffic levels.	• ANSP personnel are assigned in and across facility boundaries to match staffing to traffic demand. • Airspace assignments change dynamically. • Different operational grade levels exist within a general service delivery point to support career progression.
Training	• Facility training is the longest part of training to learn local characteristics of airspace. • Training emphasizes tactical separation in a variety of conditions and traffic loads.	• Commonly configured airspace reduces facility training time from months to weeks or days. • Training emphasizes management of off-nominal operations.

Air traffic has different characteristics based on whether it is in classic or trajectory-based airspace; consequently, different sets of skills are needed for service providers in these two types of airspace—those of an air traffic controller and those of an air traffic manager. In trajectory-based airspace, the requirement for the service provider to retain local knowledge of the airspace (e.g., frequencies, airspace fixes, handoff procedures) is minimized; therefore, the airspace can be treated like commonly configured airspace. This is particularly true at high altitudes. Commonly configured airspace affords great flexibility in the airspace and corresponding traffic to which ANSP personnel can be assigned and in the frequency with which the assignments can dynamically change. It also enables the reclassification of ANSP personnel commensurate with the new types of operations. Direct-addressable communication reduces the requirement for frequency management and knowledge. In classic airspace where ANSP personnel provide tactical separation and all aircraft capabilities must be accommodated, the skill set of the ANSP personnel is similar to that of a radar controller.

New ways of staffing air traffic facilities take advantage of available resources and provide opportunities for career growth. Automated staffing tools help facility managers match staffing to traffic demand, so that management of NAS resources is dynamic and flexible to adjust for changes in the market as well as daily and seasonal traffic flow changes. Unconstrained by facility boundaries and with the necessary communication, data, and surveillance capabilities, ebbs and flows in traffic levels can be efficiently managed. By decoupling geographic airspace and infrastructure constraints from aircraft operations, capacity managers have the flexibility to leverage resources across facilities to match staffing to traffic demand. [R-54], [P-6]

Co-locating operational domains (e.g., tower control, classic airspace, TBO airspace) of differing complexity levels into general service delivery points allows service providers to advance to higher grade levels without having to relocate. This has the dual benefit of providing employees better opportunities for career progression while dramatically decreasing operating, maintenance, infrastructure, and permanent-change-of-station costs.

All air traffic facilities benefit from scheduling and workforce management improvements. Staffed virtual towers (SVTs) allow ANSP personnel to service multiple airfields from a single physical location. The ability to use SVTs enables airports to receive tower services that would not normally, given the criteria of today and the costs of building a tower. In addition, AVTs are an innovative way to provide new services in an affordable way where service delivery was not practical before. AVTs are beneficial for smaller towered airports or SVT airports to continue providing existing services during off-hours at reduced staffing costs. A voice interface ensures that minimally equipped aircraft receive service.

Commonly configured airspace significantly reduces from months to weeks or days the time required to achieve various levels of ANSP personnel certification. Reduced training time is in part enabled by the elimination of interfacility letters of agreement and the corresponding need to learn all local characteristics of the airspace. This in turn reduces training costs and fosters other benefits such as increased flexibility in scheduling, more rapid response to staffing needs, and reduced stress on training resources (e.g., on-the-job training instructors).

Various levels of fidelity in training simulators reduce training cost and time. The enhanced process and inherent simulation capabilities provide for more standardized instruction, unbiased assessment of performance, mitigation of weaknesses, and useful remedial and proficiency training. Performance measurement tools evaluate the efficiency and efficacy of training programs, processes, and paradigms on the development and enhancement of skills performance. They also measure job performance competencies and related knowledge, skills, and abilities that determine individual and work team safety, efficiency, and effectiveness.

Some members of the NextGen workforce are hired into the new roles of ANSP personnel (e.g., CM, FCM, TM), while others are retrained from the classic roles of air traffic controller and traffic flow manager. Given the reliance on automation, ANSP personnel are selected and trained to ensure that they can deliver the essential services when off-nominal or emergency conditions exist. This necessitates that a significant portion of the training focus on dealing with emergencies and exception situations in addition to all other necessary skills to support NextGen. This in turn necessitates not only that systems have a very high level of reliability but also that failures are controlled in a gradual degradation, providing ample time to reduce traffic to the reduced capacity levels.

Selection criteria tailored to the type of ATM services provided (e.g., classic air traffic controller, traffic flow manager), innovative and flexible staffing techniques, and a revamped training program ensure that the ANSP workforce is best prepared to meet the demands and challenges of NextGen.

2.8.3 Safety

New safety policies and processes, addressed in detail in Chapter 8, are sanctioned under the SMS to improve the safety culture, ensure a prognostic SRM capability, and enhance the safety assurance function. A positive safety culture ensures that safety-relevant events and data are shared without fear of disciplinary or legal action. The National Aviation Safety policy enacts performance-based rules and emphasizes quality goals. Proactive risk assessment and management quantifies safety risk levels of all system and procedural changes prior to implementation. [R-55] Advanced data analysis and risk modeling and simulations are used for greater understanding of system, procedural, and operational risk. The risk assessments are based on coordinated and interlinked data sources, and safety data is shared across cognizant organizations in a timely manner to improve safety performance. Risk mitigation strategies are coordinated and integrated where appropriate at a national level. Safety assurance is based on audits of processes and procedures with the regulatory authority focused on the comprehensive approval and periodic audits of the safety management programs. [R-56], [R-57]

2.8.4 Security

Given the limited resources of government and private industry, it is critical that mitigation measures be developed based on threat and vulnerability, as well as the potential consequences to individuals, transportation assets, and the economy. [R-58] To achieve the requisite adaptability while maintaining effective security standards, the NextGen security system has a sound method of prioritizing risks and assessing the proportional effectiveness of different ways of countering them. In NextGen, the security system is completely integrated with other NAS functions. Through advanced networking functionality, it is linked to external aviation industry stakeholders and non-federal government entities. Risk management continuously assesses threats, consequences, and vulnerabilities and is conducted from the strategic to the tactical levels.

The security relationship with the ANSP primarily falls under the processes for maintaining secure airspace and maintaining secure aircraft. The major objective for secure airspace is to prevent or counter external attacks on aircraft and other airborne vehicles anywhere in the NAS or using an aircraft as a weapon to attack assets and event venues on the ground.

To reduce the security risk in the air, NextGen secure airspace systems and procedures detect and mitigate anomalies in aircraft operation that indicate unauthorized use or pose a threat and prevent these aircraft from operating in the NAS. These risk management requirements include dynamically defining the boundaries of restricted airspace and implementing airspace access and flight procedures based on a verification process that dynamically adjusts for aircraft performance capabilities. The model combines credentialing data with performance data as part of developing the risk profile of the flight object, and ANSP observations may result in changes to the risk profile, including escalation of flight risk to security and defense. NextGen security advances improve the safety and security of the aircraft in flight through a variety of hardware, software, personnel, and procedural methods.

3 Airport Operations and Infrastructure Services

3.1 INTRODUCTION

Airports are the nexus for many of the transformational elements to be deployed as NextGen becomes reality; these include safety, security, environmental management, and ANSP initiatives. The successful transformation of airports is pivotal to achieving a threefold increase in system capacity.

In NextGen, new airports are built, including both major airports for scheduled air carrier service and nonmajor airport facilities that will serve the GA community. In busy metropolitan areas, some nonmajor airports grow into facilities to support significant scheduled air carrier service.

New runways will be proposed and built through 2025 and beyond, in order to expand upon the utility of existing facilities. Passenger terminals will also be built or expanded. While this chapter explores concepts that can streamline this process, the development cycle of major infrastructure will remain much longer than many aviation industry business cycles. Today, the planning, environmental review, design, and construction of a new runway is a 7- to 20-year process at a major airport. This means that many of the new runways that will be operational in 2025 are already being proposed today.

Accordingly, major capacity gains come from maximizing use of existing infrastructure, through both the increasing use of nonmajor airports and new procedures that increase runway throughput. For example, new point-to-point air service supports increases in traffic at regional airports. ATM procedures to enable independent operations on closely spaced parallel runways improve capacity of existing infrastructure. New technologies and ATM capabilities ensure safe aircraft separation, as well as assist in the forecasting and monitoring of wake vortices. For some classes of aircraft, synthetic vision (e.g., infrared goggles) and other new technologies mitigate the impact of low visibility and ceiling conditions on capacity. All of these advances increase the utilization of existing infrastructure.

Within the context of NextGen, the realm of airports is unique. Unlike other components of the NAS that are directly managed by the Federal Government (such as ATM, safety, certification, and security), airports are regulated but primary decisionmaking is done at the local level. Effectively, the development or transformation of an airport hinges on the efforts and decisions of the communities and users it serves. This chapter is not intended to identify specific locations for new airport development or specific infrastructure needs (e.g., runways, terminals, gates) at existing airports. Rather, it examines concepts that can advance the capabilities of existing infrastructure and enable new infrastructure to be developed as needed.

Concepts for nonmajor airports are also important to the success of NextGen. Many of the concepts in this chapter focus on initiatives to improve service at or expand major airports. This is a reflection of the volume of traffic that will continue to use these facilities in 2025. However, this is not meant to minimize the important needs of airports that primarily serve the GA community. The concepts in this chapter for airport preservation; airport mission, management, and finance; and airport and regional planning have applicability to both major and nonmajor airports. But future versions of this chapter will include concepts that focus on the needs of nonmajor airports as these concepts become available. [R-59]

3.1.1 Airports Are a Diversified System

The current U.S. airport system is composed of approximately 20,000 airfields, the majority of which are small, privately owned airfields that support a significant GA community. Of the 20,000 airfields, about 25 percent are open to the public. The Federal Aviation Administration (FAA) certifies airports that have air carrier service by aircraft with nine or more seats; only 575 airports are so certified under 14 CFR Part 139. The diversity of airports is an important consideration. Each airport is a unique operating environment to a far greater extent than the analogous airspace structures. Different airport layouts, constraints, and procedures pose unique challenges to achieving and maintaining efficient operations at peak capacity without sacrificing safety. Section 2.8.2 describes the NextGen concept of "commonly configured airspace," which should lead to further standardization of the airborne environment. Airports are much less amenable to standardization, as reflected in this ConOps.

Many of the factors that currently drive airport development are primarily market-driven, rather than falling under the control of the airport operator or Federal Government. Even as airports are responsive to their users, the users are in fact responding to market factors. Airport users include flight operators as well as the traveling public and neighboring communities that benefit from and are affected by the airport.

Many factors will drive airport development and operations through 2025 and beyond. These include the following:

- Some major airports that are at or near capacity today may not be able to reasonably expand to support up to a threefold increase in aircraft operations or a 1.8- to 2.4-fold increase in passenger movements. This will drive development of other airports in congested metropolitan regions.
- Nonmajor airports will expand by promoting higher levels of service to both aircraft operators and passengers, potentially pushing integration into the hub-and-spoke system and stimulating changes in the airline hub business models.
- Congestion and the "hassle factor" will drive some passenger choices as to whether to travel on scheduled carriers with connections through major airports or seek transportation via regional airports with (scheduled/nonscheduled) nonstop service or other modes of transportation.
- Sufficient intermodal transportation networks must be developed to link airports with population and business centers. People and cargo must be able to get to and from the airport in a predictable and efficient manner.

- Federal, state, and local agencies must evolve to support the effective governance of NextGen airport operations and regional considerations, given the many stakeholders who have vital interests in a successful airport system. [R-183]
- New aircraft technology will allow long-range flights with medium seating capacity aircraft at competitive yields, thus promoting point-to-point service to smaller airports.

Beyond traditional airline operations, new service offerings are expected from operators of V/STOL aircraft, VLJs, and space vehicles of various kinds (e.g., orbital and suborbital space vehicles, point-to-point suborbital spaceplanes).These new services are expected to continue to drive growth in GA and nonscheduled commercial operations as an alternative to scheduled air carrier travel.

Newly developed V/STOL aircraft (e.g., tiltrotors) could increase service within large metropolitan areas and thereby promote the development of small-footprint airports designed specifically to serve these operations. Insertion of increased V/STOL operations into major hub airports requires careful design to ensure that conventional aircraft operations are not negatively affected.

VLJs offer the potential to make business jet travel more efficient and cost effective. While the viability and sustainability of the VLJ air taxi business models have yet to be proven, VLJs could substantially increase air service options, especially in communities that currently have limited service. Ultimately, the airport infrastructure needed to accommodate VLJs already exists at most airports, because the aircraft have the capability to operate from shorter runways (i.e., 3,000 to 4,000 feet). With the expansion of satellite-based instrument approach procedures (IAPs) to most runway ends (and related infrastructure, such as approach/runway light systems and SVTs/AVTs), all-weather access by VLJs and other aircraft to nonmajor airports increases. Conversely, VLJ use at major airports and in congested airspace could exacerbate delay levels as a result of increased aircraft operations and the complexities of managing air traffic with dissimilar airspeeds and wake turbulence separation requirements.

Commercial space flight (suborbital, point-to-point, and orbital) offers considerable potential for the next 20 years. Some types of space vehicles could be interoperable with conventional fixed-wing aircraft in order to make the best use of existing infrastructure. This could help the integration of CST operations into congested airspace and airports. Alternatively, CST operations could be conducted at dedicated or dual-use spaceports remote from the busy facilities in metropolitan areas and utilize various kinds of airspace reservations for their transition through the NAS. Although suborbital flights may ultimately bring about a radical change in how people travel between continents and the time required to do so, the impact on airport infrastructure is unknown.At airports with significant scheduled air carrier service, the physical and functional layout of passenger terminals is likely to evolve in response to changes in passenger processing, aircraft size and geometry, remote data access and sensing, information sharing, and high-occupancy intermodal transportation connections. The trend for passenger check-in at locations outside the airport, such as at home, via mobile phone, and at hotels, will continue and expand as remote terminals support off-airport passenger and baggage processing. The infrastructure needed to support security screening and international arriving passenger processing (i.e., Customs and Border Protection [CBP]) should decrease as these processes are integrated and refined to support NextGen.

3.1.2 Catalysts for Airport Development Actions

While long-term development planning is an important tool for identifying potential infrastructure development projects, specific catalysts are needed to move projects from the planning stage to implementation. Historically, new gates and terminal layouts were built to accommodate widebody aircraft, regional jets, and hubbing operations. Airfield construction, including terminals, new runways, and runway extensions, has been done in response to specific localized needs.

More recently, new security procedures such as the need for in-line baggage screening have driven further changes. In an era when airport security has become a national priority, airports have been able to accommodate new and evolving infrastructure needs in order to guarantee aviation security. In coordination with SSPs, airports have been able to accommodate the screening of passengers and baggage with relative efficiency despite significant challenges associated with implementation. Rather than being driven by long-term planning, these efforts were undertaken in response to specific events. This illustrates the need for increased flexibility in airport planning, development, and operations.

At airports with substantial scheduled airline service, air carriers typically consent to pay for a substantial part of infrastructure development through lease agreements and user fees. Accordingly, development activities typically do not move forward until there is general consensus from the users on the need for the project. While new technologies are important drivers of airport transformation, the financial and political support from users is critical to project implementation, due in large part to the high capital and time investments required for infrastructure projects. A forecast of long-term demand alone is not sufficient given the cyclical nature of the aviation industry. There must be a definite, reasonably foreseeable need for the project. As a result, the development history of any particular airport is unique and is a reflection of that facility’s layout, aircraft operation types and activity levels, user demographics, and governing political systems.

Potential solutions to NextGen critical issues need to be evaluated using metrics relating to aircraft quantity, size, performance, capacity, landside access, and level of service. Interpreting the various metrics with an understanding of how changes might affect the entire network of airports is key. For example, solutions implemented at a number of major airports may cause significant and negative impacts at smaller airports, or vice versa. To achieve balance, NextGen must recognize the diversity of airports and work to integrate the national planning process with site-specific facility planning, financial planning, environmental sustainability, and regional system planning. This approach, combined with benchmarking, market analysis, effective policy, operational procedures, and technology, will help to identify the appropriate airport infrastructure necessary to develop an integrated airport system and thus meet the goals and objectives of NextGen.

3.2 KEY TRANSFORMATIONS

The fundamental mission of an airport is to be an interface between the ground transportation system and the air transportation system, transferring people and cargo to/from aircraft and then getting the airplane to/from the gate to the runway in a safe, efficient, and secure manner. As such, airports are a primary element in the total capacity of the air transportation system. This will continue to be true with NextGen.

The airport-specific concepts identified in this chapter are intended to provide the technology, policy, and regulatory mechanisms and other programs that will enable the airport system to meet the NextGen goal of accommodating up to three times the current number of aircraft operations at an acceptable level of service. Essentially, the concepts are a menu of available services that will be adopted by some airports but not others, depending on their needs and missions. For example, some airports that cannot expand their terminals may focus on off-airport passenger processing capabilities, while other airports will build expansive, flexible terminals. Following the tradition of airport development in the United States, the actual implementation of these concepts will be done on a case-by-case basis through local decisionmaking in cooperation with the airport operator, users, and neighboring communities.

Many of the opportunities to transform the standards, procedures, and processes by which airports are managed and developed will create corresponding policy and research questions that must be resolved in order to enable NextGen in 2025. While technology is important, many of the potential transformations related to airports (such as decisions to expand an airport) are ultimately policy choices that will be enacted at federal, state, and local levels.

As shown in Table 3-1, the key airport transformations are expected to be in the areas of operational enhancements, new enterprise services, and dynamic support and planning services that will be responsive to changes in the aviation industry.

Table 3-1. Significant Airport Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Integrated Surface and Ramp Traffic Management System	• Runway incursions and missed taxi clearances result from lack of situational awareness. • Ground support equipment (GSE) operates per prescribed procedures, although there is no active monitoring and awareness. • Constraints on information exchange between flight crews, ANSP, and ramp management result in inefficient traffic flows on the airport surface.	• There is proactive management of GSE, including schedule adjustments in response to demand, system integration, and advanced tracking capabilities. • SSA enables coordination between flight operators, ANSP, and ramp management. • There is automated coordination between ramp management and ANSP for transfers of aircraft management. • Coordinated pushback, deicing, and support functions for aircraft and GSE are supported. • Subterranean ground ramp support facilities are developed.
Airside Management Functions	Facility maintenance, emergency response, and environmental operations at airports are not fully integrated into decisionmaking by the aircraft operators, ANSP, and airport operator during day-to-day operations.	• Sensors, data management, and information exchange provide support for airport management functions to be aligned with NextGen goals. • Network-enabled operations (NEO) facilitate effective communication between airports, local emergency resources, and state and federal agencies during emergency situations. • Day-to-day operations at airports are conducted to achieve the NextGen goal of meeting demand while reducing overall environmental impact.
Terminal Operations	• Airport security procedures are conducted within the limitations and confines of existing terminal building designs and configurations to meet defined threat levels. Detection devices for checkpoints and for checked baggage screening are deployed as standalone units with limited systems synergy or automation. • Ground transportation system is based primarily on private automobiles, rental cars, and taxis. • There are limited opportunities for intermodal connections.	• Passenger screening is adaptive, cost-effective, unobtrusive, thorough, expeditious, and integrated into terminal operations. • Processing of international arriving passengers is more efficient and predictable. • Ground transportation system provides an efficient, effective transition across multiple modes of transportation while maintaining security, efficiency, and passenger convenience and choice.

Table 3-2. Significant Airport Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Off-Airport Passenger and Baggage Processing Enabled Through Integrated Trip Tracking	• There are multiple systems for tracking passengers and baggage, with limited opportunities for advanced integration and third-party access. • Centralized passenger processing/check-in can result in congestion and inefficiencies.	• Integrated trip tracking is available, with access by authorized third-party organizations that provide custom services such as remote check-in and baggage transport/processing. • Remote terminal security screening (RTSS) allows passengers to undergo full screenings at remote, off-airport locations and then be transported directly to the sterile portion of the airport terminal. • There is an enhanced baggage delivery system.
Passenger Flow Management	Nonsynchronous systems do not provide for coordinated efforts in enhanced passenger traffic through the terminal.	Efficient passenger flows in airport terminals support up to a threefold increase in operations, with technology for improved signage, status information broadcast, and predictive capabilities.
Airport System Planning Information	Substantial effort is expended to gather accurate and comprehensive information in standard formats (e.g., geospatial information systems [GIS]).	• Airport data and information are available in a centrally managed, comprehensive repository. • Integrated GIS is available for airport protection surface and flight hazard analyses.
Airport Preservation	Many airports are threatened by encroachment, new hazards to air navigation, conversion to nonaviation uses, and nonsustainable operating costs.	• States, localities, and metropolitan planning organizations work to preserve the viability of existing airports through incentives and linkages with federal programs. • Information on airport needs and growth is readily available to communities. • Decisions on land use, new structures that could impact airport protection surfaces, and future planning are made in the interest of long-term airport sustainability.

Table 3-3. Significant Airport Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Airport Mission, Management, and Finance	• Airports are typically publicly owned and operated by a city, county, or airport authority. • Airports in a region are often owned and operated by several different local governments that may have differing objectives. • Airports serve a utility function, providing service as a community gateway, economic engine, and transportation hub.	• Policy, financing, and regulatory mechanisms provide for both public and private ownership and management of airports. • As appropriate, increased use of joint-use military/civilian airports provides for improved civil access to the NAS. Also, capacity is expanded through the identification and conversion to civil aviation use of former military air bases that are part of the Base Realignment and Closure (BRAC) process. • Finance system has dedicated funding sources with government support for critical nonmajor airports. • Airports within a region are operated in an integrated and complementary manner.
Airport Planning Process Is Flexible, Efficient, and Responsive	Planning, environmental, and finance processes are often not well integrated, resulting in delays to implementation.	• Financial, ANSP, SSP, environmental reviews, and regional coordination is integrated into the planning process to reduce oversights, improve capabilities, and enhance efficiency. • Integrated, comprehensive, annual updates identify gaps and initiate solutions. • Post-implementation evaluation of new actions is carried out in coordination with environmental management systems (EMSs).
Regional System Planning	Regional considerations are not typically part of the master planning process, in part due to jurisdictional boundaries.	• Metropolitan planning organizations and an integrated planning process foster agency coordination in order to address jurisdictional constraints. • Incentives promote intermodal and ground transportation connections within regions as needed to facilitate expanded use of nonmajor airports.

Table 3-4. Significant Airport Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Optimized Airfield Design	Defined standards are used to guide airfield design, as appropriate for today's aircraft and operational procedures.	• Parallel runway separation standards, obstacle identification, airport protection surfaces, and sensor systems are optimized to take full advantage of NextGen-driven airspace and aircraft improvements. • Unique infrastructure needs for UASs, V/STOL aircraft, spaceplanes, and other new flight vehicles are incorporated into airport design standards. • Capacity constraints due to ground infrastructure, including ramp congestion, runway crossings, and overnight parking, are factored into airfield design.
Flexible Terminal Design	Terminal envelope is static, with considerable work and disruption required to accommodate changes and new developments.	Changes in processing technologies and security screening requirements can be accommodated in a terminal envelope that enables rapid reconfiguration of the building to meet ongoing needs.

3.3 AIRPORT ENTERPRISE OPERATIONS

At major airports, airfield and passenger terminal capacity continues to be a significant challenge for airport operators due to the complexities associated with runway/ramp operations, security, airline operational changes, and regulatory requirements. Addressing these elements is complex, as airport operators have limited control over many of the factors that affect day-to-day airport operations. For example, runway capacity is affected by FAA standards on airfield geometry, ATM procedures, and airspace structure. Passenger terminal capacity and level of service are affected by technology, airline business models, and security operations.

Airside, landside, and terminal airport infrastructure must be balanced in order to achieve optimal use of total airport capacity. Future growth in aircraft operations cannot be accommodated without application of innovative ATM technologies and procedures, construction of additional infrastructure at major airports, and/or better utilization of existing infrastructure at nonmajor airports. NextGen seeks to increase the overall capacity of the existing airport system through the implementation of transformational concepts that enable the optimum and balanced utilization of airside and landside (i.e., terminal and intermodal transportation) components at national, regional, and local levels. The growth of the airport system will incorporate factors for environmental, financial, and regional sustainability.

3.3.1 Airside Operations

The movement of aircraft and GSE on the airport surface requires new logistics, management, and technology in order to enable the efficiencies required with NextGen.

Many of the factors related to airport capacity, such as parallel runway separation standards and related procedures for independent operations, are a function of the ANSP and are therefore discussed in Chapter 2. This includes wake turbulence procedures, including the placement of active sensors on the airfield for wake turbulence. This chapter discusses the non-ANSP functions related to aircraft movements on the ground, such as ramp management and deicing operations, as well as GSE movements.

3.3.1.1 Integrated Surface and Ramp Traffic Management System

Surface movements of aircraft and GSE at airports are actively monitored and proactively managed, in real time, to ensure the smooth, efficient, and safe flow of traffic. With advanced technology, trained ANSP and ramp management staff are able to effectively manage high traffic volumes, including super-density operations, on the airport surface. Using SSA and NEO, information is shared among flight crews, ANSP, ramp management, airport operators, SSPs, and other stakeholders in near-real time.

In the interest of performance management, the Integrated Surface and Ramp Traffic Management System provides the capability to “replay” operational events, and analyze those events, with an eye for trend analysis and identification of opportunities to improve procedures. The system also provides data for SSA initiatives. This helps the NAS to routinely perform at optimum levels.

GSE, such as baggage carts, fuel trucks, catering vehicles, and other airport vehicles, is managed using real-time surveillance/tracking, integrated support systems, and enhanced communication capabilities. GSE has defined operating areas on the ramp specific to its function. [R-182] This aids in providing separation from aircraft and supporting security protocols. To the extent practical, subterranean conveyors and fuel hydrant systems are employed to reduce ramp congestion and improve safety.

In addition to management, the technology used in GSE advances in NextGen. GSE has sensors and logic to avoid hitting aircraft. As discussed in Chapter 7, GSE is powered by alternative and/or low-emissions fuels, including electricity and hybrid systems, in order to reduce airport-related emissions.

With proactive management of GSE, real-time schedule adjustments in response to demand are facilitated and made easier to implement. Through SSA, real-time surface surveillance of aircraft and GSE is available for all airport stakeholders, including the airport operator, aircraft operators, SSP, and ANSP.

Technology advances support aircraft safety and airport access. For example—

- Ground-based perimeter sensors ensure that aircraft can be maneuvered on the ramp without coming into contact with other aircraft, GSE, or obstructions.

- Systems and procedures are in place to support the interoperability of UASs, V/STOL, helicopters, spaceplanes, and conventional aircraft.

3.3.1.2 Airside Management Functions

With the aid of NEO, the airport operator monitors a variety of operationally critical data feeds in order to better manage facility maintenance, emergency response, and environmental operations.

3.3.1.2.1 Facility Maintenance

Airports will be expected to keep facilities open and available in all conditions. Sensors on the airfield collect data including weather and pavement conditions, and integrated systems are able to detect anomalies like chemical spills or debris. Forecasting systems use this data to provide predictions of surface conditions of the runways and taxiways and are linked with intelligent DSSs to provide pavement treatment crews with guidance on optimal strategies to keep runways and taxiways clear and serviceable. Using advanced technology, airport ground equipment and landing aircraft measure runway friction (e.g., braking reports). The runway friction measurements are automatically disseminated in an accurate and timely fashion using SSA. The ICAO Snowtam program could provide an effective template for reporting winter conditions. [R-60]

Systems in the terminal building and other airport facilities notify airport operators of security status and maintenance issues. These intelligent monitoring systems automatically feed into the AOC where the information is used to help manage the facilities.

3.3.1.2.2 Emergency Response

Airport operators support continuous monitoring and management of routine and emergency airport operations, with support from NEO. The emergency response mechanisms at airports are closely tied to security functions (see Chapter 6) and are heavily leveraged by NEO, which is able to instantly recognize an issue at the airport (e.g., fire, incursion, accident, other incidents) and dispatch the appropriate response. In addition, three-dimensional (3D) displays (virtual reality and live) provide a clear picture of the incident, enabling the AOC to accurately and efficiently manage and support the response. Communications links are quickly established and information automatically routed to the appropriate user groups. Adjacent jurisdictions and relevant regional and/or national entities are able to directly access NEO and provide the most efficient support possible. [R-61] Effective operational training is conducted under the National Incident Management System (NIMS).

The security of the airport perimeter and surface is improved, as discussed in Chapter 6. [P-7]

3.3.1.2.3 Integrated Environmental Operations

Day-to-day environmental operations at airports will be conducted to achieve the NextGen goal of meeting demand while minimizing overall, quantifiable environmental impacts, including the following: [R-62]

- Environmentally friendly aircraft have lower noise and air emissions and reduced fuel consumption.

- Environmental commitments are considered in concert with capacity needs and weather in the selection of runway configuration, maximizing net benefits and sustainability.
- Use of predictive weather capabilities and icing sensors and monitoring of icing holdover times (as defined by the flight operator) are included in the 4DT and flight object. Improved deicing/anti-icing technologies is used to expedite the process and reduce delay. These systems help to reduce the use of deicing and anti-icing fluids. [R-63]
- Water quality is improved via best management practices for storm water management (to reduce hydrocarbons, metals, and other monitored pollutants) and collection methods for spent deicing/anti-icing fluids. [R-64]
- Proactive monitoring of air quality and aircraft noise exposure support efforts aimed at minimizing impacts at local and regional levels.

Deicing is a significant operational, environmental, and safety issue that will continue to provide challenges in NextGen. The use of deicing and anti-icing with freeze-depressant point fluids involves subjective contamination inspections of critical aircraft surfaces, with inadequate or nonexistent tools to monitor conditions that affect estimated fluid holdover times. Current procedures are inefficient, provide a less-than-optimum margin of safety for winter operations, and are environmentally unfriendly. NextGen will need improved methods for both deicing and anti-icing.

Research is needed on alternative methods to both deice and anti-ice aircraft. Research is underway in the use of infrared energy to deice aircraft, but the effects of infrared energy on aircraft composite surfaces need further study. Also, depending on specific facility requirements, infrared solutions are not always cost effective. A more environmentally friendly Type 1 deicing fluid is also desirable.

Anti-icing must evolve beyond the current use of fluid protection with estimated holdover times. The issue of weight up until now has discouraged aircraft manufacturers from incorporating ground anti-icing systems on their airframes. However, aircraft manufacturers need to develop lightweight and energy-efficient deice/anti-ice systems for their next generation of aircraft. Short of that capability being developed, NextGen will have to continue to rely on the inefficient and less-than-desirable system of fluid deicing/anti-icing that is used today.

Airports will continue to have the challenge of monitoring noise, air quality, water quality, and wildlife. Through NEO, improved information access, availability, and exchange support enhanced airport environmental operations. For example—

- Sensors are place that automatically detect pollution thresholds in local waterways and alert operations personnel to actions, including diversion of used deicing/anti-icing fluids to storage for later treatment.
- Aircraft and surface deicing product usage are automatically monitored for reporting, mitigation, and compliance with environmental goals.
- UAS performing security functions and the airport perimeter security intrusion detection system may have the capability to assist with wildlife management programs.

3.3.2 Passenger Terminal Operations

Through improvements to technology and procedures, airport terminals support increasing passenger demand levels at acceptable levels of service.

3.3.2.1 Passenger Processing and Security

In NextGen, advances in common-use systems continue with existing trends toward automated issuance of boarding passes (whether paper or paperless) and faster processing of passengers. [P-8] As discussed in Chapter 6, the SSP is responsible for regulating, managing, and/or implementing new and transformational technologies and procedures to ensure system security using integrated risk management. Typically, a departing passenger is able to arrive at the airport curb, get his or her boarding pass and check baggage (as needed), clear security screening, and be at the gate within 30 minutes.

3.3.2.2 International Processing

With the increased passenger volumes that are projected with NextGen, processing of international arriving passengers needs to become more efficient and predictable. To the extent possible, CBP functions are integrated with security screening procedures and/or augmented by automation to ensure that the necessary procedures are incorporated throughout the network of airports without unnecessary duplication. [R-179]

As security systems move toward strategic actions, the need for international arrival processing facilities at point-of-entry airports, or even the classification as point-of-entry airports, may be unnecessary. For the airport infrastructure, this means that the requirements for dedicated international arrival boarding bridges, sterile corridors, transit hold rooms, and inspection facilities could be substantially reduced. At airports that currently have space allocated for those functions, this would provide additional space for passenger processing and improve passenger flows. Transit time for passengers on connecting flights would be reduced.

3.3.2.3 Intermodal Transportation Links

The ground transportation system provides for effective, efficient transitions across multiple modes of transportation while maintaining security, efficiency, passenger convenience, and choice. [R-65] Typically, this involves transfers from the air transport system to ground transportation with a higher density (i.e., mass transit) than that offered by passenger automobiles. The intent of this is to alleviate congestion and delay for passengers on the ground network when traveling to/from the airport.

Inclusion of intermodal links in this ConOps is not meant for funding or program implementation by NextGen, but rather to highlight the need for airports to work with their communities to integrate airport and landside access/transportation planning. With three times as many operations, people may not be able to get to the airport without landside transportation improvements. Moreover, intermodal transportation improvements are needed to support off-airport passenger and baggage processing, as described in Section 3.4.2.

As with many systems, the air transportation system is and will continue to be constrained by its weakest component. Most passengers and cargo get to the airport via the roadway system connecting the airport to the community it serves; thus, increasing activity at an airport puts added pressure on that system.

While other transportation agencies may be responsible for providing adequate infrastructure for access to airport property, each airport has to ensure that the terminal area and on-airport access roads meet user needs. Environmental sustainability and management must also be considered, as applicable to federal, state, and/or local regulations.

Tracking and analysis of curbside activity and subsequent optimization of curbside operations at existing airports is required. For new airports, designing landside access configurations in conjunction with terminals and while considering future development is a must. Establishing adequate rail or other mass transit service (e.g., shuttles and bus rapid transit systems) to airports to reduce the strain on roadways and parking facilities is also key. Implementing these planning tactics ensures that airports of the future can balance and meet landside as well as airside demand.

These strategies apply not only to major airports but also to any nonmajor airports that are used to augment regional capacity and alleviate congestion. In some cases, major investments must be made to develop required infrastructure to take full advantage of the benefit these airports offer, especially with the potential for increased usage by VLJs and V/STOL aircraft.

Traditionally, adding capacity to transportation systems leads to increases in demand. Demand and capacity must be balanced within airport systems. If there are multiple airports within a system, they need to be designed as one system and not as individual airports to avoid system imbalances, bottlenecks, and associated congestion and delay. Intermodal transportation links are an important component in making regional airport systems viable.

3.4 AIRPORT ENTERPRISE SERVICES AND CAPABILITIES

Enterprise services are specific programs (e.g., software, processes) that provide benefit to airport operations and mission support functions.

3.4.1 Passenger Flow Management

Efficient passenger flows in airport terminals are important so that congestion, queues, and baggage do not impede passenger movements. NexGen will define a minimum level of service to support this mission. Passenger (and other airport customer) flows are impacted by signage (e.g., Flight Informational Display Systems/Common Use Terminal Equipment [FIDS/CUTE]), public transportation, regional transportation, parking, conveyance systems, terminal space layouts (including gates, concessions, and restrooms), airline business models, and marketing. In addition, changes to security protocols can create bottlenecks, thus impacting the ability of a passenger terminal to meet the needs and goals of NextGen.

In order to meet the NextGen goals for smooth passenger flow management, coordinated information is broadcast to users, including current status and forecast for security wait, customs/ CBP processing, flight status, and so forth. Although these systems exist today, they are not sufficiently synchronized to facilitate passenger flows. NextGen provides open information standards for a centralized, wireless-enabled system to disseminate passenger flow information at key airports to include ground transportation connectivity, weather, delays, parking availability, check-in times, and so forth within a single network.

3.4.2 Off-Airport Passenger and Baggage Processing Enabled Through Integrated Trip Tracking

An enterprise service provides for integrated trip tracking of baggage and passengers, which adheres to industry-defined standards of service, reliability, maintainability, and universal access. The system supports tracking of passenger and baggage information (e.g., radio frequency identification [RFID]), synchronization, itinerary/handling information, remote check-in, and security assurance. The system does not conduct the transfer of passenger and baggage between venues, but supports the continuous tracking and availability of the plan, intent, and current locations of passengers and their baggage. Through an open information standard, transfer of passenger baggage is enabled (e.g., a passenger renting a car from a rental car company picks up the luggage at the rental car rather than at baggage claim).

The RTSS facility provides added value to conducting full-spectrum screening of both passengers and bags, as described in Chapter 6. Then, cleared passengers and bags are transferred in secure ground transport to the sterile portions of the airport terminal. Alternatively, self-tagged bags with RFID can be transported from off-airport terminals (that do not conduct security screening) to the airport by the passenger and then accepted by the air carrier for transport prior to the passenger security screening. Depending on their specific needs, airports are able to adapt off-airport terminals of varying capabilities into their operations.

The passenger and bag tracking system decentralizes passenger processing and allows bag processing to be conducted in an out-of-the-way area of the airport, if appropriate. This increases capacity, reduces check-in time, reduces personnel requirements, and enables tracking. Both bags and passengers are known information, allowing 4DT aircraft departures in a more reliable manner. Passengers and bags are treated as information monitored by the passenger remotely (e.g., via mobile phone or handheld device). Aircraft operator check-in personnel are reduced or no longer needed, as is space in the terminal for check-in. Arrivals baggage claim is not used by passengers but instead is an industrial sorting center at a remote part of the airport (similar to cargo operations). Information management and data exchange is integrated into NEO.

3.4.3 Airport System Planning Information Services

The airport operator has an important role in providing accurate and up-to-date GIS data to other elements of NextGen. Today, the lack of ready access to accurate and up-to-date airport surface GIS data is a significant issue with existing automation systems.

Systemwide airport planning for the NAS is difficult today because of the diverse standards and formats of information. Because each airport has responsibility for its own planning and development, the information quality, structure, and format is defined by each airport according to individual needs and budgets. Although the FAA has defined general guidelines for the development of airport documents, there is no central repository of available information. The noninteroperability of many of the formats, and the difficulty of conversion between formats, also inhibit simple exchange of airport planning information. [P-10]

In order to meet the goals of NextGen, high-quality airport data and information need to be available in a centrally managed, comprehensive repository. For example, the flight hazard/ obstacle review process can be automated through distributed GIS with information on Part 77/ Terminal Instrument Procedures (TERPs) surfaces and obstacles. This data can be used to support safety assessments and hazard mitigation tracking. Airport layout plan documents would be available in a central repository available through a managed access process (e.g., an airport map database). Other components, such as noise and emissions data, land use, historic aircraft trajectory data, and completed studies, would also be available in the central repository. As appropriate, these systems would be developed in GIS-based formats. Additional information on this topic is available in Sections 5.8 and 5.9.

3.5 AIRPORT MISSION SUPPORT

Many of the functions of airports that would be transformed with NextGen will occur in terms of mission planning; that is, the long-term planning that will enable the domestic airport network to accommodate up to a threefold increase in operations while maintaining a high level of service.

3.5.1 Airport Preservation

A diverse network of airports must be preserved throughout the nation in the best interest of an efficient national air transportation system. This includes all types of airports, inclusive of major air carrier airports and smaller, nonmajor airfields that act as relievers and regional airfields.

All are vital to the future success of NextGen. However, many airports are at risk from encroachment or closure, and preservation of these resources is vital to the success of NextGen. [P-82]

Today, airports provide a community with a fast and efficient gateway to the domestic and international air transportation system. Many companies consider proximity to an airport a key reason for locating their facilities, including proximity to smaller airports that have sufficient infrastructure to support business jet operations. This will become even more apparent as air taxi operators using VLJ business models come into operation during the next decade.

Smaller airports are also a vital resource during emergencies. Emergency response activities are often staged out of smaller airports, including responses to natural disasters such as hurricanes and wildfires. Without efficient airport access, emergency response services would be more constrained.

The sustainability of existing airports is critical to the future growth of communities and to the nation's air transportation system. Within NextGen, increased use of nonmajor airports is envisioned as a critical component to increasing total system capacity and thereby accommodate up to a threefold increase in operations. With the deployment of new precision approaches to most airfields, enabled by satellite navigation technologies and RNP, access to most nonmajor airports becomes safer and more reliable. Increasingly, aircraft operators make maximum use of the existing infrastructure at nonmajor airports in order to avoid congestion and higher costs at major airports. Increased use and expansion of the nonmajor airports is essential to achieving the goal of enabling an airport system that supports up to a threefold increase in operations.

A diverse network of airports is also needed to support new and emerging aircraft, including UASs, V/STOL, supersonic aircraft, and commercial space vehicles, as well as to support the ever-changing needs of the military. Where appropriate, increasing the utilization of existing and new joint-use facilities provides for improved civil access to the NAS.

The primary threats to airport preservation are land use encroachment of incompatible uses, conversion to nonairport uses, lack of sustainable capital and operating finance mechanisms, and lack of community support. [P-83] Land use encroachment and development has long been a concern to airport operators and users. Land use decisions are local and state concerns that reflect the political nexus of many interests: residential communities, developers, local governments, and airport users. Lack of support from communities that do not understand the importance of their airport is also a key factor. Accordingly, advocacy and sponsorship of the airport by local businesses, users, and the community is important for long-term preservation.

At the state level, several successful programs exist for airport protection, including those of the State of California (Airport Land Use Commission), the Washington State Department of Transportation, and the Maryland Aviation Administration. In addition to noise exposure and airport protection surfaces, some state programs evaluate areas adjacent to airports that can be affected by undesirable light, glare, fumes, vibrations, smell, and low-flying aircraft activity. These effects are most pronounced under the airport traffic pattern, which can extend several miles from the runway. According to some state programs, negative effects generated by airport operations in these areas can present health and safety problems and degrade quality of life for residents.

Within NextGen, a new Airport Preservation Program is needed to enhance the sustainability of at-risk airports. [P-81] In coordination with the National Plan of Integrated Airport Systems (NPIAS), at-risk airports would be identified via input from users, airports, and others with interests in airport preservation. States, airports, and metropolitan planning organizations (MPOs) would be partners in the implementation and success of the program. The FAA would participate in identifying and protecting critical airport infrastructure, without changing airport operator responsibilities and state and local determination of land use. In addition to airport advocacy and fostering community support for airports, the program would seek to align Federal airport programs toward the goal of long-term airport preservation. [R-66], [P-11]

Long-term maps (i.e., 20-year maps that coincide with comprehensive planning standards) of the airport protection surfaces, existing and future noise levels, and safety zones would be prepared for airports that participate in the program. Airport programs under 14 CFR Part 150 and EMS would be aligned with the Airport Preservation Program in the interests of protecting land use compatibility, preventing encroachment, and enhancing environmental sustainability. A robust obstruction evaluation process and comprehensive maps of airport protection surfaces (i.e., 14 CFR Part 77 and TERPS, as applicable to NextGen) would help to prevent new structures from exceeding height restrictions and thus constraining instrument approach access to airports during inclement weather. Depending on the state enabling legislation for land use decisions, the long-term mapping could be integrated into airport overlay zoning in order to curtail new development with the potential to affect airport preservation or future expansion plans.

Through intergovernmental agreements, information on proposed land use development actions within the long-term mapping (e.g., issuance of building permits, zoning amendments, comprehensive plan updates, etc.) would be shared with airports, local governments, MPOs, state aviation agencies, and the FAA. This information sharing could assist with problem identification and aid in building consensus on development actions. For example, participating organizations could have the opportunity to review and comment on the development actions for suitability with airport plans, federal grant assurances, community interests, and the long-term sustainability of the NAS. Potential recommendations on the proposed development actions could include consent/approval, disapproval, or a recommendation to amend the plan to include easements, noise mitigation, and disclosure requirements. The jurisdiction seeking to approve the development plans would respond to the comments and provide their reasons for acceptance, rejection, or amendment. Depending on the governing laws of the state and local jurisdictions, varying legal remedies could then be available.

At a regional level, the identification of former military bases (e.g., as part of the BRAC process) that have potential civilian aviation uses could continue to be an important component in enabling aviation growth. [P-84] In heavily developed regions, these former military bases may be the only realistic option for expanding regional airport access and capacity. Through NextGen, the conversion of suitable former military bases to civil aviation use is facilitated through integrated, long-term regional planning that identifies future applicable aviation uses for the facilities.

The obstruction evaluation process is more effective so that the airspace around airports is protected from encroachments that diminish aviation safety and reduce airport access and efficiency during inclement weather. As discussed in Section 3.4.3, a new GIS-based enterprise service will permit integrated obstruction analyses inclusive of the current 14 CFR Part 77 and TERPS obstruction criteria, as well as the protections needed for air carrier one engine inoperative takeoff performance criteria, dynamic RNP, and other advanced flight procedures. By making the obstruction analysis process more robust, builders and the FAA are able to evaluate proposals and alternatives thoroughly and efficiently. As a result, airports and aircraft operators are protected from obstructions that impact approaches and capacity, thus aiding in the preservation of airports as a component of NextGen.

3.5.2 Airport Mission, Management, and Finance

NextGen airports are operated by a mix of private and local government/public entities under safety, operational, and certification regulations similar to those used by the FAA today. As such, the airport operator is responsible for aligning its operating characteristics to support the NextGen goals and requirements.

The ownership, management, and mission of airports includes (1) publicly owned airports with a primary utility function, (2) private airports that operate in a business-focused environment, and (3) hybrid airports that include both public and private elements and partnerships. Policy, financing, and regulatory mechanisms provide for both public and private ownership and management of airports, including access to the NAS through level-of-service agreements with the ANSP. [P-12]

As a utility, airports provide at-cost access to the NAS for aircraft operators and the traveling public. Airports also serve as a gateway to the community. In the role of interstate commerce, airports can also function as a competitive business, especially in the case of the major airports. Airports serve as a catalyst in promoting the growth of both aviation- and nonaviation-related businesses.

3.5.2.1 Privatization Trends

While major airports today have sufficient access to capital for their infrastructure projects, publicly owned transportation systems in the United States are increasingly considering new sources of finance for both capacity investment and operating expenses. This can be seen in the privatization efforts of highways at the state level. This trend is likely to continue and may extend to airports, as public airport owners (states, cities, and municipalities) seek to divest themselves of the responsibilities of airport management and develop structures that would enable the private sector to assume these roles. This could come in the form of privatization or, more likely, long-term concession agreements between the airport operator and private enterprises to ensure that the needs of the public and stakeholders are met. [P-12]

The finance mechanisms available to airport operators will continue to evolve and will be a major determining factor in the management of airports. Major airport operators will continue the trend of seeking capital expense sources that are more flexible and independent from federal government sources. Airport operators may seek nontraditional sources of revenue in order to efficiently fund their development, given the requirements associated with federal funding. At the same time, private finance institutions are looking favorably on transportation facilities as secure and profitable investment opportunities. As a result, funding for capital projects is available through commercial markets (e.g., bonds, equity investors) for airports with substantial passenger volumes. This could help airports to more quickly grow to meet demand.

Current federal statutes include major impediments to private sector investment, ownership, or long-term leasing of large airports. The existing Airport Privatization Pilot Program has proven to be inadequate and ineffective in demonstrating the potential benefits of private sector ownership and operation of commercial airports. Major reformation of current federal statutes will be needed to encourage more investment, ownership, and operation of large airports in the United States by private investors, which may be crucial in meeting future air transportation demand. In certain situations, the disposition of aviation-related revenue and profits to nonaviation-related activities will need to be addressed. It is expected that this could be done while continuing to ensure that all airports are available for public use on reasonable terms and without unjust discrimination. [P-12]

3.5.2.2 Finance Needs of Nonmajor Airports

While funding is typically available for necessary projects at major airports, nonmajor airports often have difficulty in getting sufficient capital funding. Operating finances can also be a particular challenge for nonmajor airports. In the best interest of a sustainable NAS, the airport infrastructure finance system demands robust and dedicated funding sources with federal and state government support for critical nonmajor airports. As discussed in Section 3.5.1, the long-term preservation of the airport network is essential to the success of NextGen. Viable finance mechanisms are an important component in preservation.

As the business models of major airports become more competitive and commercial markets and user revenue sources (e.g., landing and leasing fees) are increasingly available to fund capital projects, the Federal Government could enhance funding support for critical nonmajor airports. Specifically, available federal funding for airport development could be primarily directed to critical nonmajor airports with a financing formula that is not enplanement based.

With policy mechanisms that support public, private, and hybrid models, airport operators will be able to more efficiently and effectively adapt to their operating environment and thus improve service to their users and communities. This would be true for airports with a broad range of missions, including major domestic and regional hubs, regional airports with commercial service, and GA and reliever airports. Most airports will probably continue to function in the public domain, with some services being run by private enterprises, as is done today. However, where feasible, privatized airports may enable improved market-based efficiencies and capitalization.

Regardless of the ownership, management, and mission model adopted by a specific airport, environmental standards and requirements will continue to apply. Airports will also continue to be responsive to the concerns and needs of the communities that they impact and serve.

3.5.2.3 NAVAID Support

The acquisition, operation, and maintenance costs of airport NAVAID infrastructure is a significant expenditure that needs a long-term strategy to guarantee its reliability and operation. This strategy needs to consider both existing and new NAVAID technologies and the benefits realized relative to the cost of development, installation, and maintenance of those technologies. This includes new sensor technologies for wake turbulence detection and advanced weather sensing.

3.5.2.4 Congestion Management

Congestion management is discussed in this ConOps in an effort to track the ongoing policy discussion regarding airports where infrastructure development and ATM capacity improvements are not likely to be sufficient to meet future demand (e.g., New York LaGuardia). Accordingly, congestion management is a policy issue rather than a specific concept. However, the policy choice made regarding congestion management will likely affect some airports in NextGen. Congestion management also differs from C-ATM concepts, which seek to meter traffic in and out of congested airports rather than manage airport access.

Congestion management programs at major airports may be used to manage short-term situations where demand exceeds the available capacity of the airport infrastructure. A combination of regulatory and market-based mechanisms could be used to balance the competing needs of aircraft operators seeking airport access, for airports to provide a reasonable level of service, and for the ANSP to accurately predict the impact of local congestion on the NAS and mitigate the ripple effects throughout the NAS. [P-85]

Concurrently, the congestion management program could incorporate mechanisms to facilitate aircraft operator competition (e.g., gate access for new entrant carriers) and ensure major airport access for flights from smaller communities. For example, congestion management could affect the viability of service from small communities to airports such as New York LaGuardia and thus convenient access to major economic centers such as New York City. If congestion management increases the cost of airport access, flights from certain small communities to major economic centers may not be economically sustainable. Alternatively, the market-based incentives could push flights to/from smaller cities to be scheduled at off-peak times that are not conducive to convenient access. Such adverse effects would be mitigated through specific measures within a congestion management program.

In addition to short-term situations, consideration may be given to allowing airports to impose long-term peak-period landing fees that will both help manage congestion at large airports and bring increased revenue to the airport for use in modernization investments and other improvements that will assist in meeting growing passenger and freight activity. Existing federal statutes require revenue neutrality, preventing the airport from increasing user fees if they produce revenues that exceed airport costs. Changes to federal law in this manner will also encourage greater interest by private investors to invest in airports.

Within the congestion management program, the roles and responsibilities of federal, state, and local government decisionmakers, as well as the airport operator, will need to be determined. [P-86] As discussed previously, the disposition of revenue over and above airport needs will need to be determined, including the potential use of this revenue to support the economic sustainability of airport infrastructure.

3.5.3 Efficient, Flexible, and Responsive Airport Planning Processes

Solutions to critical airport issues need to be balanced against other aviation metrics such as aircraft operational and passenger capacity, safety, level-of-service standards, landside access, and environmental goals. For each of these, the NAS will need to have a clear image of different airport types and the domino effect that could ensue as a result in major aviation policy changes. For example, solutions that are implemented at a number of large airports may cause significant and negative impact on smaller airports, or vice versa. To achieve the proper balance, the future airport system will require the ability to integrate multiple planning processes and analyses to determine the appropriate airport infrastructure necessary to develop the future integrated airport system plan. [P-79]

In NextGen, planning processes that encompass traditional master, financial, and environmental planning activities are integrated into a single, comprehensive planning architecture that enables more efficient, flexible, and responsive planning. NextGen goals are integrated into the planning process, as are ANSP coordination activities that are needed to ensure the successful implementation of airport improvements (e.g., so that airport planning actions take into account airspace constraints). [R-67] Regional considerations such as the specific roles of airports within a system, availability and need for intermodal transportation links, and the comprehensive plans (including land use) of local jurisdictions are key factors in successful airport planning efforts. By integrating these diverse activities into a complete process that is efficient, predictable, and transparent, oversights are reduced and capabilities are enhanced. Effective public involvement is also critical to ensuring that the community is aware of and can support airport infrastructure development. [R-68]

FAA-supported finance mechanisms are available to support integrated planning processes, as well as coordination actions for NextGen and ANSP. For major airports, planning is envisioned to occur on an ongoing, annual basis in connection with capital improvement programs (CIPs) and performance management activities, in order to identify long-term gaps and emerging trends and respond appropriately. A continuous, integrated planning process supports current environmental streamlining activities in that it speeds the identification and dissemination of airport data, as well as improving data comprehensiveness and quality. The continuous planning process also supports the EMS process discussed in Chapter 7.

The impact of aviation on the surrounding environment is a critical study element in the development of airport infrastructure. As air traffic grows, airports need to operate in a more environmentally sustainable and energy-efficient manner to prevent environmental degradation. Sustainability and environmental management measures will be incorporated into proposed facilities, programs, and procedures.

Environmental regulations for airports fall under the jurisdiction of many agencies representing federal, state, and local (city, county, municipality) governments. At many airports, community and stakeholder groups are also involved in environmental management. Although the process is essential to the preservation of an environmentally sustainable airport system, the cost (in terms of both time and money) associated with the environmental approval process can (today) constrain the expeditious implementation of airport capacity initiatives such as additional apron and gate expansion, landside access projects, and airfield improvements. With a planning process that integrates airport, financial, environmental, and regional planning activities, airports will be able to more quickly satisfy emerging infrastructure needs.

Post-implementation evaluation of actions will be an essential component of the planning process, so the actual benefits of new infrastructure can be quantified and compared to the planned estimates. This supports a lesson-learned function in planning activities, in order to identify successful project strategies and valuable lessons learned. EMS will be used to monitor and review and to provide information to adapt and improve.

3.5.4 Regional System Planning

Increased support at a national planning level will be needed to (1) promote intermodal and ground transportation initiatives directly related to using alternate airports, (2) manage demand among a system of airports, and (3) protect airports from noncompatible development while also recognizing the land use needs of communities in the vicinity of airports. In terms of long-term sustainability, airports and local governments must work together to improve compatibility and to protect airport and community resources, including consideration of off-airport environmental and community planning issues. Comprehensive, integrated regional system plans are critical to achieving these objectives.

Planning for airport systems, intermodal transportation, and land use are integral components of comprehensive regional system plans:

- Airport system planning includes activities to determine the role of each airport within a system, estimate aviation demand, determine infrastructure needs, and provide for environmental management.
- Intermodal transportation planning includes activities for highway, high-speed bus, and rail (including light, heavy, high-speed, and freight) connections between airports, RTSS facilities, central business districts, regional transportation arteries, and residential areas.
- Land use planning includes activities to integrate airport compatibility standards for aircraft noise and obstructions into the comprehensive plans implemented by local jurisdictions, while also considering the development, revenue, and demographic needs of the communities.

These components are interdependent; for example, the lack of appropriate intermodal connections can constrain use of an airport, regardless of available terminal and airside facilities. Without sufficient ground access in the form of intermodal infrastructure, super-density airports may be able to accommodate a higher number of aircraft operations but will not be able to deliver the passengers and cargo on the ground required to maintain an efficient transportation hub. Similarly, an airport that is used as an alternate facility will not be successful if efficient intermodal connections are not available to transport passengers and cargo to their ultimate destinations.

In addition, local land use decisions can constrain future airport growth:

- Decisions to permit development of noncompatible land uses can increase the number of people living within existing and future noise impact areas; this will ultimately increase the cost of airport expansion or curtail it altogether.
- Development of tall towers and structures can create new obstacles that impact IAPs, airport protection surfaces, and aircraft performance/flight profiles; this constrains airport access.
- Other development can affect runway protection zones and other safety zones.

Through regional system plans, airport operators can take a more active role in local land use planning by being involved in the development, review, and implementation of comprehensive plans that are used to manage local land use. Proactive use of multiple land use management tools, including disclosure requirements, conventional and overlay zoning, land banking, and development rights, will also be important. Efforts to prevent new obstructions to air navigation (e.g., radio towers) from constraining aircraft performance and instrument arrival/departure procedures at an airport will also be part of the regional system plan.

In order to manage interdependencies, multiple components will be integrated into the regional system planning process. Through consideration of the needs, constraints, and goals of aircraft operators, communities, and other stakeholders, the regional system plan will serve to integrate decisionmaking for airports, intermodal transportation, and land use. The regional system plan would provide guidance on the specific activities undertaken by local jurisdictions and airport operators for ground transportation and land use development. Potential environmental impacts and benefits will also be assessed, using appropriate metrics and impact criteria for noise, air quality, water quality, and other effects. Primarily, regional system planning would be most critical for major metropolitan regions with multiple airports and a diverse transportation network.

While regional system planning is not a new concept, it will become vital to the success of NextGen when faced with up to three times the level of operations in existence today. Specifically, airport planning processes will need to incorporate regional components, including regional policy decisions. Airports will provide local and regional transportation planning agencies (e.g., MPOs) with proposed development plans (including master plans) for review and comment. In addition, airports will collaborate with surface transportation agencies in their planning efforts so that airport ground access needs can be considered in the context of the overall regional transportation planning and programming process. Similarly, airport operators should be engaged in the review of proposed surface transportation plans and programs to ensure that the transportation access needs of the airport are properly taken into account. [R-69]

Federal, state, and local roles in regional coordination and decisionmaking will need to be defined in support of NextGen goals. Appropriate policy guidance and finance mechanisms will be identified and made available to support regional system planning and intermodal infrastructure development. For example, regional system planning could be transformed if federal funding for nonmajor and major airports is tied into the role of the metropolitan region within the NAS, rather than using the number of enplaned passengers as a primary measure.

An important element in regional planning is the recognition of the roles, responsibilities, and legal authority of the federal, state, and local jurisdictions that have interests in regional planning. Ultimately, the decisions to move forward on most airport and regional transportation projects are made by local governments, with guidance and financial support coming from the state and federal levels. For example, the Federal Government does not allocate demand to specific airports. Rather, market-based interactions in consideration of airport facilities, ground access, socioeconomics, and so forth determine how many and what types of flights operate at a specific airport (within a system of airports). For the purposes of NextGen, a better understanding of how market and nonmarket mechanisms affect the choices made by aircraft operators to serve specific airports is needed so that regional needs can be better forecasted and incorporated into decisionmaking. [R-70]

3.5.5 Optimized Airfield Design

Airfield design planning and engineering standards need to be optimized to take full advantage of NextGen-driven airspace improvements. Standards are needed to guide the design of new infrastructure, deployment of sensors and NAVAID equipment, and support operations at airports by new types of aircraft.

3.5.5.1 Parallel Runway Separation Criteria

Procedures that permit independent aircraft operations to/from closely spaced parallel runways (i.e., with smaller separation standards than those in use today) maximize the capacity of existing infrastructure. In terms of airfield design, reducing separation between parallel runways needed for independent aircraft operations reduces the land needed for runway development. One of the major limitations to new runway development is the lack of available land to develop new runways at high-traffic airports, especially in dense metropolitan areas. Specific parallel runway separation standards are a function of ANSP procedures; the development and implementation of new standards will have a substantial effect on airfield design and capacity. [R-71]

3.5.5.2 Obstacle Measurement and Data Distribution

Landing and takeoff minimums (i.e., required ceiling and visibility weather conditions) are lower at airports served by IAPs with the development of a robust and accurate national obstacle database. Today, there are many airports with higher-than-standard takeoff or landing minimums because of obstructions. In NextGen, mature airborne and satellite-based obstacle identification and measurement techniques supplement present-day ground survey practices. Accuracy tolerances and required clearance criteria currently added to obstacle locations and heights are reduced or eliminated, thereby allowing airspace designers to develop IAPs with the lower minimums. Obstacle data are readily available through a web-enabled distribution system using GIS technologies. This achieves substantial increases in capacity, as it increases access to the airport during low ceiling and visibility conditions.

3.5.5.3 Airport Protection Surfaces

Airport protection surfaces are zones around airports that define the maximum height of obstacles so as to not interfere with the safe operation of aircraft in the overhead airspace. Today, airport protection surfaces are defined in 14 CFR Part 77 and FAA Order 8260.3, Terminal Procedures (TERPS). In addition, 14 CFR Part 25 describes the engine out-climb gradients required for operation of air carrier aircraft. The climb gradients are a factor in the determination of takeoff weight. The takeoff weight of a planned flight can be reduced to ensure that climb gradients are clear of obstacles. Accordingly, obstacles can constrain aircraft payload.

Aircraft performance characteristics that increase present-day levels of safety, combined with advanced instrument procedure design criteria, allow for reductions in obstruction clearances and associated protection areas currently required for both ground and satellite-based aircraft flight procedures. [R-72] Reduced protection surfaces allow arriving aircraft to use lower ceiling and visibility minimums when using IAPs during inclement weather, thereby increasing access to the runway and increasing overall capacity because operations are not constrained due to inclement weather. Lower ceiling and visibility minimums also permit more aircraft to depart airports during adverse weather periods.

Consideration needs to be given to alleviating recent changes to precision obstacle-free zones (POFZs) and final approach “W” surfaces that have had dramatic impacts to airports with displaced landing thresholds.

3.5.5.4 Sensors

NextGen requires the deployment of new sensors on the airport. Sensors are needed in the runway environment for the active detection and dissipation measurement of wake vortices, which will enable reduced aircraft separation during conditions when wake turbulence is not a hazard. [P-13] Advanced weather sensors are also deployed to airports, including sensors that provide a detailed picture of the atmosphere along the airport approach and departure paths in order to detect the varying conditions that may affect flight operations and wake vortices.

Placement criteria, noninterference zones, maintenance requirements, and other necessary considerations for the sensors are incorporated into airport design standards.

3.5.5.5 NAVAIDs

The transition to satellite-based IAPs frees up airport surface movement areas previously constrained because of ground-based navigation systems (e.g., instrument landing system [ILS] critical areas). NextGen requires less ground-based radio navigation infrastructure to support IAPs than is used today with ILS and other systems. [R-171] Therefore, ILS critical areas and other zones designed to protect instrumentation from interference are less of a constraint. This facilitates the efficient movement of aircraft on the airfield.

3.5.5.6 Other Design Factors

In NextGen, airports have runway safety areas that meet applicable FAA airport design standards, in order to support potential aircraft overruns. Where sufficient land is not available or improved runway safety areas are not practical, alternative mechanisms to prevent overruns are implemented (e.g., Engineered Material Arresting System [EMAS]).

Unique infrastructure needs for UASs, V/STOL, spaceplanes, and other new flight vehicles are incorporated into airport design standards. A new collision risk model may permit use of larger aircraft in existing object-free zones. [R-73]

While efforts to increase runway capacity are vital to NextGen, the ground and gate capacity of the airfield is also critical. The ground interactions between GSE, people conveyance systems, and aircraft on the apron and taxiways, as well as aircraft crossing runways, is a significant constraint to capacity with up to three times as many operations. For example, super-density operations may require end-around taxiway systems and other changes to airfield layout in order to minimize the need for runway crossings by taxiing aircraft. At night, the apron space required for overnight parking of aircraft also increases substantially. The reduction of ground movement delays and congestion due to constrained airport infrastructure is an important component in enabling NextGen, as is providing sufficient gate capacity.

Ultimately, no single strategy will increase the capacity of the NAS and airports. Rather, a thorough analysis of the multiple components in the system and their interactions will provide the optimum combination.

3.5.6 Flexible Terminal Design

With flexible terminal designs, changes in processing technologies and security screening requirements can be accommodated in a terminal envelope that enables rapid reconfiguration of the building to meet ongoing needs. Available infrastructure would support common-use facilities such as gates, ticket counters, kiosks, and information systems. Note that the common-use infrastructure is not intended as a federal mandate; each airport and its users will determine gate allocation based upon its specific needs and factors related to efficiency, cost, and availability. [P-14]

Today, passenger terminals are experiencing an ongoing shift from traditional modes of operation. The airline industry has shifted to new operational efficiencies based on low cost and high volume. This shift is largely a result of carriers that have successfully driven changes in traditional operating models, including an increased reliance on automation of passenger check-in that results in reduced queue times at ticket counters. However, this does cause more pressure on security screening points due to peaking characteristics.

These changes are also having an effect on the rates and charges that airports can charge to the airlines for the use of terminal space. This shift is likely to result in a relative reduction in the space airlines will use for passenger processing in the future (in terms of square footage per enplanement), resulting in a different operational revenue structure for the airport. [R-74]

New terminal designs will increasingly incorporate provisions to support energy and resource conservation, including green design and technologies.

4 Net-Centric Infrastructure Services

4.1 INTRODUCTION

Integral to the NextGen concept is the establishment of an enterprise that facilitates air transportation system–relevant information to be shared widely among authorized users—both quickly and reliably.[4] At the same time, all information must be protected through trusted relationships and authentication of appropriate users. The structure that allows this to be accomplished is the ***Enterprise Services*** function.[5] Enterprise Services consists of two principal subsets—***Information Services*** and ***Infrastructure Services***. The first provides data and information to subscribers when and where needed in an accessible format. It maximizes compatible understanding for shared awareness by consistency of information (i.e., if two users ask the same question at the same time, they both get the same answer). The second provides communications connectivity to ensure that information flows reliably to support information communications before sharing functions.

4.1.1 Net-Centric Infrastructure Services for the Air Transportation System in 2025

Interagency development and provisioning[6] of Net-Centric Infrastructure Services supports the delivery of the operational improvements envisioned by this ConOps. The services described herein support the target air transportation system of 2025, which provides the interface between the NextGen Enterprise Services and the operational COIs.[7] These services provide the appropriate operational entities within the NextGen environment with the appropriate data at the opportune time to allow cooperative understanding and collaborative decisionmaking.

The concept of net-centricity ensures a robust, globally interconnected network environment in which information is shared in a timely and consistent way among users, applications, and platforms during all phases of aviation transportation efforts. By securely interconnecting distributed users and systems, net-centricity provides a robust, resilient, efficient, and effective information sharing environment enabling substantially improved situational awareness and shortened decision cycles.

This chapter proposes a structure that supports the information requirements from applicable COIs by outlining necessary policy, cultural, and political changes in order to leverage

[4] Sharing accurate information versus sharing information accurately; reliability takes care of the latter point.

[5] In the DoD, infrastructure comprises communications transport, enterprise services, information services (common to nodes and across nodes), and user interfaces. Historically, systems stopped producing redundant infrastructure and focused on information services and business logic, all decoupled from user interfaces. The concept of applications is split, more to providing information and functionality through services.

[6] Development is implementation—provisioning makes that implementation available and sustained.

[7] In NextGen, COIs are collaborative groups of users (public and private) who must exchange information in pursuit of their shared goals, interests, missions, and business processes.

interagency programs, research efforts, and ongoing agency and industry product development.[8] The result is an environment where information and data comprise an integrated, interoperable system to meet stakeholder objectives and are provided as a quality of service (QoS) shared in support of accurate decisionmaking. As greater understanding and awareness of COI capabilities, programs, and specific needs develops, the Net-Centric Infrastructure responds iteratively to provide infrastructure capabilities of increasing capacity. The following guiding principles are required to realize the Net-Centric Infrastructure Services in support of NextGen:[9]

- **Frequency Bandwidth/Spectrum Capacity Supporting Stakeholder/COI Information Sharing Needs.** There is more than sufficient bandwidth available across ground, airborne, space, and mobile networking to allow extremely fast transmission rates for all types of data (to include simultaneous transmission of graphics, video, and audio) with appropriate QoS. There is sufficient spectrum available to handle the transmission of critical information to appropriate COIs through a scalable infrastructure that evolves as technology advances. [R-75]

- **Voice by Exception and Improved Where Necessary.** A voice communications system carries voice transmissions over the established fixed and mobile ground, airborne, or space information networks. Data is the preferred method of communication to the flight deck as well as to the ground. Voice will be used in cases of emergency such as safety of flight (e.g., a situation where a conflict or midair collision is imminent and voice will preclude an incident). [R-76]

- **Protocol Resolution.** Communications transport provides sufficient and dynamic addressing with secure and assured end-to-end connectivity for all platform nodes, including cargo, passengers, and crew across the air transportation enterprise. [R-77]

- **Data Availability.** Data registries and discovery mechanisms between entities (government, commercial, private, and international organizations) allow for data sharing in a push/pull and publish/subscribe environment between authorized COIs. [R-78]

- **Content Understanding.** Metadata tagging and federated search allow the contents of data to be understood.

- **Technology for Timely Decisionmaking.** Wherever possible, the system includes the capability to automatically capture any and all relevant data about components of the ATC environment, including aircraft, baggage, expendable supplies, aircrew, controllers, ground-handling equipment, gates, and passengers, and provide this information to authorized COIs in order to make timely decisions. [R-79]

- **No Single Point of Failure.** A distributed information environment ensures information reliability, quality, and no single point of failure. The network operates as an enterprise with common transport mechanisms and services.

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8 This chapter does not propose the adoption of one agency to manage and administer the net-centric environment for aviation needs; that is a question to be answered by a future policy decision. In the interim, all agencies will have their own infrastructure with applicable standards enabling the sharing of data/information across platforms/domains.

9 Applicable areas are developed further in the policy and research issues associated with this chapter.

- **Data Interface Oriented.** Software-definable interfaces allow for scalable information sharing between authorized COIs. This is intended to minimize if not eliminate costly hardware swapouts when new COIs are developed; software interfaces would improve reliability as well as simplify upgrades.
- **Information Assurance.** Secure exchange of information includes access controls, trust relationships, and associated policies and mechanisms to provide appropriate access to information by authorized COI users. [P-15]
- **Cross-Domain (i.e., Multi-Level Security or Multiple Levels of Security) Exchange/ Gateway Capability.** Maintenance of information assurance across security levels and domains is a critical feature of data availability. [P-16]

4.2 KEY TRANSFORMATIONS

As shown in Table 4-1, the key infrastructure transformations are expected to be in the areas of network-enabled information sharing, aircraft data communications links, and infrastructure management services. This goal requires widespread access to secure, accurate, current, and timely information and the capability to share this information securely among the operational entities.

Table 4-1. Significant Net-Centric Infrastructure Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Network-Enabled Information Sharing	• Limited ATM (e.g., traffic) information on flight deck; often, non-common data shared among stakeholders • Limited data shared among stakeholders for CDM process • Information sharing concerning operational security done manually • Not all stakeholders able to access data they need • Stakeholders able to use custom data sources	• Standardized ATM information provided to the ANSP, flight deck, and aircraft operators • Information sharing among security stakeholders, facilitating collaboration, risk management, and decisionmaking • Flexible delivery of needed information and services independent of user physical location • Stakeholders able to access data they need

Table 4-2. Significant Net-Centric Infrastructure Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Aircraft Data Communications Link	• Limited data communications for ATM and operational control • Limited access to real-time weather and aeronautical data • Voice communications routine for ATM • Analog voice • Analog weather information display systems • Air-ground and ground-ground communications • Loss of communications due to Beyond Line-of-Site (BLOS) aircraft position (e.g., over the ocean) • Individual ground systems for each information type brought to the flight deck • Point-to-point aircraft communications based on ATC sectors	• 4DT, short-term intent, and other data routinely transmitted between aircraft and between aircraft and ANSP • Data communications routine for ATM; in airspace reserved for TBO, voice communications used only for extraordinary purposes • Capability to permit extensive negotiation between air and ground of 4DT • Weather information and applications on the network • Various alerts built or designed within a NEO environment to notify participants of predetermined activities (hazardous weather, security, trajectory nonconformance, etc.) that require immediate attention • Air-ground, ground-ground, and aircraft-aircraft network connectivity in real time • BLOS network connectivity relay via other airborne network participants, then to the ground • A single, common airborne network that allows multiple applications from as many sources as needed. • A network in the sky in which all aircraft are participants (nodes)
Infrastructure Management Services/QoS	• Limited ability to maintain operations when a major facility goes out of service • Limited ability to reconfigure resources to maintain operations when a major outage occurs	• Network-centric information sharing and ability to reconfigure resources, resulting in ability to maintain normal operations when a major outage occurs • Ad hoc capability to address unforeseen incident management • Cross-domain solution for holistic sharing without compromise

4.3 NETWORK-ENABLED INFORMATION SHARING SERVICES

Information sharing is achieved through a robust network among the NextGen stakeholders' infrastructure. This allows operational entities, COIs, services, and applications throughout the NAS to collaborate in a seamless information infrastructure, providing for the following:

- Air navigation service, airport, and flight operations
- SSA
- Compliance and regulation oversight
- Security, safety, environmental, and performance management services.

Integration of these operations and services requires an adherence to open standards that maximizes their interoperability across domains. It requires the Net-Centric Infrastructure to provide services that enable secure discovery of and collaborative use of this information for the purpose of effective and efficient operation of the NextGen air transportation system and business. It will move NextGen beyond traditional COIs (e.g., command and control, traffic flow, and flight services) to a net-centric, global information environment. Information flows freely from ground to aircraft, from ground to ground, and from aircraft to aircraft as needed. There is greater information connectivity to and from aircraft because the basic architecture of the airborne networking system, using air-air network connectivity, is designed to increase the probability of any single aircraft being connected to the network. Commercial network protocols and topology are employed with seamless integration between the aircraft, the ground, and the rest of the NextGen information network, making information available that was not previously available. The network is properly equipped and in position to handle information needs and unanticipated challenges of tomorrow. Aircraft are continuously part of and/or automatically joined to the network. Network connectivity is throughout the air domain and provided from the ground up to all flight altitudes, and includes oceanic and Gulf of Mexico regions. Mountainous regions such as Alaska see a significant increase in information connectivity for aviation as airborne networking is employed.

4.3.1 Ground Network Services

A key transformation enabled by the communications network and associated net-centric applications is the ability to provide surveillance, communications, and flight data management, including automation-assisted coordination, to any service provider regardless of its physical location. When coupled with a more flexible air-ground communications network, this transformation supports the optimal daily deployment of NextGen resources and assets. Airspace and air traffic can be assigned without regard to a fixed infrastructure constraint, allowing traffic load sharing across the ANSP workforce on a seasonal, daily, or hourly basis. The networking capability also provides a robust contingency/business continuity capability. Losses of ANSP personnel workstations due to equipment outages or catastrophic events can be mitigated by reassigning ATM and the supporting infrastructure to remaining workstations across the NAS.

Access to communication assets is as effortless across facility boundaries as within them. Virtual addressing allows any ANSP personnel workstation to use an air-ground or ground-ground resource. Moreover, the communications system is integrated into the larger operational automation support environment (e.g., flight data processing, surveillance data processing, systemwide information management [SWIM]) so that when control of airspace/traffic is dynamically moved to a new physical workstation, the associated flight data, surveillance, and communications messages are also moved. The option for human intervention to amend the associated configuration in real time is always available.

Some of the obvious drivers for dynamic reconfiguration include the need for efficient traffic flows, the effects of weather, personnel (staffing), SVTs, and facility or equipment outages, to mention a few. Regardless of the catalyst, the communications, navigation, and surveillance systems each respond when dynamic reconfiguration procedures are executed.

4.3.2 Air-Ground Network Services

With the transformed role of the flight crew and flight deck in NextGen, data communications are critical to ensuring that data is available for flight deck automation (i.e., avionics to support flight crew decisionmaking). [R-18] Data communications are also needed to provide real-time data to the ANSP on the operational aspects of flights. In certain defined airspace, data communications are the primary means of communicating clearances, routine communications, and 4DT agreements between the ANSP and flight deck. [R-80] Voice communications are used to supplement data communications for tactical situations and for emergencies to augment procedural responses or risk mitigations. Voice communications are used to communicate with lesser-equipped aircraft in appropriate airspace. [R-81]

One of the key transformations is that air-ground voice communications are no longer limited by the assigned frequency-to-airspace sector mapping. This allows greater flexibility for developing and using airspace/traffic assignments in all airspace. Communications paths, including both voice and data, are controlled by an intelligent network. Communications between the ANSP and the flight deck are established when the flight is activated and are maintained continuously and seamlessly. This capability is linked to the flight data management function so that the system automatically manages who has authority to interact with the flight deck based on the type of agreement being negotiated or information being exchanged. Labor-intensive transfers of control and communication are automated. Data and voice communications are automatically transferred in the flight deck as the aircraft moves between ANSPs.

Data communications are central to TBO, including the use of 4DTs (pushback and taxi inclusive) for planning and execution on the surface, automated trajectory analysis and separation assurance, and aircraft separation assurance applications that require flight crew situational awareness of the 4DTs and short-term intent of surrounding aircraft.

In addition, as indicated above, there is increased sharing of improved common data between the flight deck, operator, and ANSP. In classic airspace where data communications will be available but not required, information exchange can take place with data communications for participating aircraft to provide an operational advantage. Common data includes ATC clearances, current and forecast weather, hazardous weather warnings, notices to airmen (NOTAMs), updated charts, current charting, special aircraft data, and other required data. Data communications also include weather observations made by the aircraft that are automatically provided to ANSPs, weather service providers, and flight operators for inclusion in weather analysis and forecasts. Each of these data communications functions are managed by required communications performance (RCP) standards.

4.3.3 ANSP Facilities and Infrastructure Services

Since the flexible ground and air-ground communications networks negate the requirement for proximity of ANSP facilities to the air traffic being managed, facilities are sited and occupied to provide for infrastructure security, service continuity, and best deployment and management of the workforce. This includes co-locating several operational domains (e.g., en route transition, terminal) within a facility as well as staffing virtual towers. The virtual tower and any needed ANSP personnel do not have to be geographically located at the airport, and productivity gains may be achieved by allowing ANSP personnel to service multiple airports according to traffic ebbs and flows.

Information systems facilitate the monitoring of infrastructure health and remote maintenance to maintain service availability and automatically alert the community about the status of NextGen assets. One of the key transformations resulting from NextGen is the ability to operate NextGen with the loss of a limited number of key operational facilities. Network-enabled operations and infrastructure management services provide continuity of operations in the event of a major outage (e.g., major hurricane, terrorist event, power grid outage).

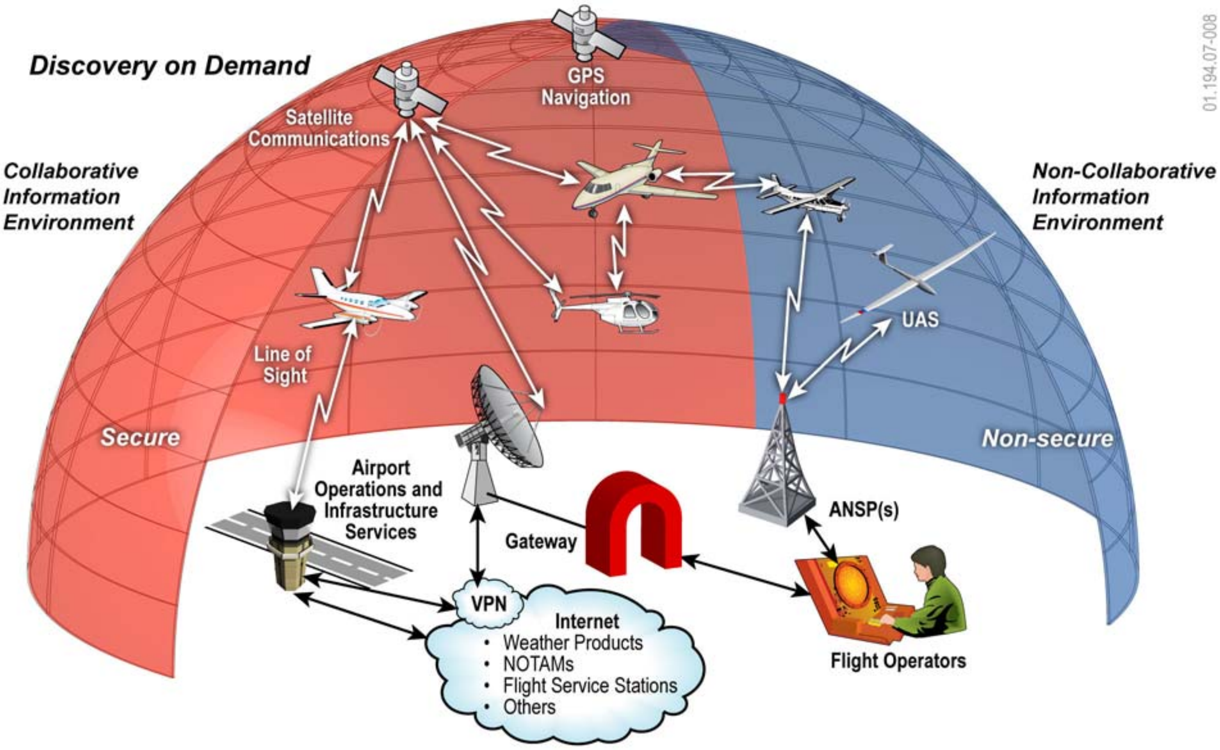
New facilities are as much about change management as they are about reducing the number of facilities and cost. In order to facilitate the significant transformations and changes in roles and responsibilities of ANSP personnel, new facilities were incorporated into the overall plan to achieve NextGen. Traffic is assigned to facilities on both a daily and long-term basis, with service continuity a foremost requirement. Moreover, the facilities are sited and sized to provide for a stable workforce environment with opportunities for career progression.

The transformations in the delivery of ground, air-ground, and ANSP facility services are fundamental enablers of the flexibility necessary to respond to demand in an affordable and timely manner. Flexible infrastructure supports changing user needs as well as providing cost-effective services that are scaled up and down as needs change. This ensures that the service providers and the information (e.g., flight data, surveillance, weather) are readily available when and where needed.

4.3.4 Aircraft Data Communications Link

Key to enabling an agile, scalable airspace environment and its management is the deployment of a fully capable aircraft data communications link. This data communications transformation enables the aircraft to collaborate with the Enterprise Services. This collaboration includes sharing real-time spatial information, identification, weather, security, and operational status for all aircraft. The operational information sharing includes PNT and airport status. Furthermore, the data communications link enables the real-time negotiation of 4DT collaboration between ANSP and aircraft (see Figure 4-1). This robust aircraft data communications link also enables a voice link to the aircraft. This link enables the flight deck to communicate with all necessary collaborative decisionmakers and operational entities. With the transformed role of the flight crew and flight deck and flight management skills in the NextGen, data communications are critical for ensuring that data is available for flight deck automation and that avionics can support flight crew decisionmaking and provide real-time data to the ANSP about operational aspects of flights. Data communications are the primary means of communication between the flight deck and the ANSP for airspaces that require data communications capability for clearances and 4DT amendments; for these aircraft, voice communications between the flight deck and ANSP are used only for extraordinary purposes.

Figure 4-1. Aircraft Data Communications



Additionally, aircraft communicate via airborne networking capability,[10] based on the level of required performance in airspace they are transiting (equipage policy). Every aircraft is a node on the network, providing information connectivity and relaying information when needed. Voice is only used in cases of exception or if strictly limited by equipage policy. *This network is based on commercial network technologies to the maximum extent possible* and as such provides connectivity for all types of aircraft, from large commercial jetliners to business jets, helicopters, and GA. When new information needs or capabilities are identified by the aviation community, the network conveys that information to the COI. [P-17]

4.3.5 Infrastructure Management Services/QoS

Infrastructure Management Services are necessary for operating and maintaining the NextGen enterprise. Infrastructure Management Services include the network management functional areas of fault, configuration, accounting, performance, and security (FCAPS) management, as well as higher-level functions such as services management.

Management of the Enterprise Services builds on the network and systems management capabilities of the underlying net-centric infrastructure. The network management capabilities include managing service quality, security, and resources. The emphasis is on an integrated and holistic approach to management that leverages the capabilities of tools at several levels.

10 The idea should be the optimization of the most effective combination of assets for communication. It may be aggregated data channels from airborne nodes, space, or ground, but key is the combination, not the primacy of one approach.

Ensuring the security and QoS of the NextGen enterprise requires close interaction between the management elements. Systems management within the Enterprise Services addresses the end-to-end business process of NextGen, with tools and technologies capable of delivering centralized management, configurable alerts for exception processing, and integration of Net-Centric Infrastructure Services with other information services.

To facilitate information sharing, NextGen engineering must include a cyber-protection approach that safeguards the information within an acceptable trusting relationship between the information suppliers and consumers. Agreement on a trust relationship is critical to making the information available to authorized members within the large NextGen stakeholder community —which includes federal government organizations, state and local governments, the aviation and avionics industry, the international aviation organizations and nations, and the flying public. NextGen information sharing is flexible and adaptable to circumstances and stress experienced by NextGen over time. Information access channels are opened and closed to changing COIs depending on the circumstances or events at the time.

The success of NextGen information sharing depends on constituent trust that information is properly protected, that it is not misused or mishandled, and that recipients have a valid need for the data. In turn, this trust depends on applying information assurance policies, designs, rules, and information systems hardware and software that can be tested and certified and on the perceived ability and willingness of the participants to effectively implement and manage their security responsibilities.

4.4 MISSION SUPPORT SERVICES

Mission Support Services addresses access, connectivity, collection, processing, and distribution of information. These are foundational functions of the services that provide information assurance, protocols, and standards applicable for Net-Centric Infrastructure Services.[11] These

[11] ***Access*** is a function of COIs, which are collaborative groups of users (public and private) who must exchange information in pursuit of their shared goals, interests, missions, and business processes. As a result, these COIs require shared and controlled vocabularies and exchange structure and services. COIs are formed based on user needs and common mission objectives. As needs and mission objectives are collaboratively agreed upon, the information and application access requirements to support the needs and objectives can be determined. ***Connectivity*** addresses standardized interfaces, security, and compression algorithms inherent to the addressable Net-Centric Infrastructure. Logical data exchange between COIs is accomplished via internationally standardized and enterprise standardized next-generation communication protocols that are independent of the underlying communications infrastructure. COIs determine the performance requirements of data/information sharing during operations, and the addressable Net-Centric Infrastructure determines the best path to meet the message requirements. ***Processing*** is the collection of information within the Net-Centric Infrastructure that relies on the "smart pull" of information from multiple sources throughout the network. Users subscribe to streams of information that they require to perform their jobs by referencing their geographic location, flight path, time, types of information they need, and other custom parameters designed for their particular needs. The Enterprise Services will then authorize the user to use the system, determine the level of access, and make available certain information feeds specific to that particular user. Information will be collected from multiple sources in a seamless manner, obviating the need of the user to be familiar with where the actual information resides and know that it is authoritative. ***Posting*** is the process of users making raw information available to all of the users in the network by advertising all of their information and posting it so that other users can discover it and make better-informed decisions, neither constrained in stovepipes nor available late to need. It is not their responsibility to determine what is important and what is not important to users. ***Pulling*** involves net-centric

functions are crucial to the successful evolution of a Net-Centric Infrastructure. However, without defined processes for people using the capabilities, the Enterprise Service is not likely to be effective. Therefore, formalization of an institutionalized sharing process is necessary to provide the policies, processes, measures, and accountability required to ensure that COIs integrate access, connectivity, and information distribution into their planning and daily operations. These key issues are described in the research and policy issues in Appendices C and D, respectively.

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information flows that permit user-identified streams of data. This customized flow will focus on the communication of the right information versus all information.

5 Shared Situational Awareness Services

5.1 INTRODUCTION

Chapter 4 discussed NextGen Infrastructure Services such as connectivity and networking. This chapter introduces the concept of SSA Information Services. The NextGen vision of information sharing depends on SSA Information Services being available. In turn, Information Services are dependent on Infrastructure Services being in place and available. In short, information sharing is accomplished by the processes and applications that constitute the Information Services function. Another way to envision Information Services is to consider where authorized subscribers can access the information desired. This access can be accomplished in an automated and virtual fashion where subscribers produce a standing request for information using established protocols and standards. This access concept is what facilitates the NextGen vision of the future—distributed data for distributed decisionmaking. The transformation of the air transportation system is dependent upon accessible and shared information—SSA.

The following elements of SSA Information Services are introduced in this chapter:

- Weather Information Services
- Robust PNT Services
- Surveillance Services
- Flight Plan Filing and Flight Data Management Services
- Flow Strategy and Trajectory Impact Analysis Services
- Aeronautical Information Services (AIS)
- GIS.
-

5.2 KEY TRANSFORMATIONS OF SSA SERVICES

Key SSA Information Services enable the fundamental operations of NextGen and transform the national airspace operation. Table 5-1 highlights these key services and their transformations.

Table 5-1. Significant SSA Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Weather Information Services	• Weather information requires skilled meteorological interpretation. • Weather information is drawn from numerous forecast sources. The resulting air transportation decisionmaking suffers when different and inconsistent weather forecast sources are used, resulting in different decisions and conflicting courses of action. • Limited use in decision support systems; not available to all users (primarily pilots)	• Net-centric weather information is made available and understandable to all approved users. • A reliable virtual, common weather picture is foundational for optimal air transportation decisionmaking. • Presentation of weather data is tailored to user operational needs. • Widespread use of integrated probabilistic weather-related decision support systems • Automatic updates to users based on operational need • An adaptive observing system, integrating ground-, airborne, and space-based sensors
Robust PNT Services	• Air routes are mostly defined by fixed ground-based navigational aids. • Expanding use of RNAV and RNP procedures • Costly ground-based infrastructure in parallel with space-based infrastructure	• Air routes are independent of the location of ground-based navigation aids. • RNAV is used everywhere; RNP is used where required to achieve system objectives, which reduces controller workload and increases efficient use of NAS resources (airspace and runways). • System performance meets operational needs to service the demand. • Increased availability of instrument approach procedures with lower weather minimums at smaller airports • Reduced costs to ANSP to provide better navigation services
Surveillance Services	• Air surveillance radars • Surface movement radars • Secondary radar (cooperative) • Primary radar (non-cooperative)	• Passive radar, cooperative (data-link-based) surveillance systems • Fused surveillance data services • Deployable area-specific surveillance systems
Flight Planning Services	• Limited interactive flight planning capability • Limited ability to receive projections on anticipated conditions that affect aircraft flight plans	• Flight planning information services provide all operators with extensive and interactive flight planning capability. • Operators receive feedback on anticipated conditions associated with a filed 4DT.

Table 5-2. Significant SSA Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Flight Object Services	• There are multiple similar calculations of flight trajectory, airspace penetrations, time of arrival, etc., leading to inconsistent information about a flight. • Information about a flight is specific to an application or location and is inconsistent across applications and locations. • Information about a flight is dispersed through many owners.	• Flight information is shared in a way that leads to consistent trajectory information that can be provided to all authorized flight data users as a service. • Flight information is consistent across applications and locations, including across international boundaries, and available to authorized flight data users. • Information about a flight is contained in one logical unit. • Proprietary and security-sensitive information is not shared with unauthorized agencies/individuals.
Flow Strategy and Trajectory Impact Analysis Services	• High reliance on oral and textual communication of strategies and concerns • Limited access to both data and tools • Limited decision support capabilities leading to conservative planning	• High reliance on data communications and graphical presentations • Significantly increased access to data, models, and tools • Better decision support to increase capacity • Common trajectories and analysis capability to improve the quality and consistency of decisionmaking • Automation and information services to increase awareness of constraints and strategies under consideration • Broader range of participants • Impact is estimated and presented with explicit consideration of uncertainties in the underlying data and predictions, allowing operators to appropriately manage risks.
Aeronautical Information Services	• Much of the AIS provided by hard copy or voice • Limited ability to receive and process information regarding airspace	• Aeronautical information is uploaded, received, and exchanged with more accuracy and in a timely manner. • Aeronautical information is globally harmonized in definition and distribution so that aeronautical information users can have access whenever and wherever they require. • System provides updates and accepts information from both ground and airborne users. • Most of the AIS data are text or graphic driven; data are ready to be processed using automation. • Users are supported by automation capabilities to exchange real-time information regarding airspace.

Table 5-3. Significant SSA Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Geospatial Information Services	• Limited use in current structure	• Dynamic airspace boundary adjustments, trajectory-based operations, and interactive flight planning • Ability to access and update information about the physical locations of fixed and mobile assets • System manages current information, maintains historical information, and allows desired/planned future capabilities.

5.3 WEATHER INFORMATION SERVICES

5.3.1 Introduction

Under this ConOps, the primary role of weather information is to enable the identification of optimal trajectories that meet the safety, comfort, schedule, efficiency, and environmental impact requirements of the user and the system. Weather information is not just an end product to be viewed in a stand-alone display. Rather, weather information is designed to integrate with and support NextGen decision-oriented automation capabilities and human decisionmaking processes.

Weather information in the form of meteorological variables that are observed or forecasted (e.g., storm intensity, echo tops) must be translated into information that is directly relevant to NextGen users and service providers, such as the likelihood of a flight deviation, airspace permeability, and capacity. [P-18], [P-87] This information is supported by a set of consistent, reliable, probabilistic forecasts, covering location (3D space), timing, intensity, and the probability of all possible outcomes, each with an associated likelihood of occurrence.

Today, weather information is drawn from numerous sources. In NextGen, consistency and continuity in the common weather picture are ensured by centrally managed weather information that is distributed by the Government through the NextGen Network Enabled Weather (NNEW) "virtual database" capability. [P-19] The reliable, virtual common weather picture concept means, for example, that information on convection for a geographic area, developed by different forecast models and in different databases, is arbitrated or merged into a single forecast that all requesting users receive. NNEW weather observations and forecasts are the primary source of weather used in joint government/user NextGen decisionmaking processes. NNEW represents the NEO vision of a "weather channel" in keeping with NextGen information sharing policy. Today's complex and costly architecture of point-to-point connections to weather sources is replaced by a single-access approach for all users.

At the core of the NNEW capability are 4D weather sources referenced to position and time, formed by automated processes through the merging of observations, models, climatology, and human forecaster input. The information is available to generate displays and for direct integration into automated decision support systems. The 4D weather capability provides the basis of the common picture and consists of weather attributes organized by horizontal, vertical, altitude, time, and probability components (x, y, z, t, plus probability). Observations from surface sources, aircraft, and satellites are incorporated into the common weather picture.

The update frequency of this weather information is commensurate with the need to react to unanticipated, rapidly changing circumstances. For instance, airspace structural changes are better customized in response to changing weather conditions (e.g., realigning sectors to conform to a line of thunderstorms). Also, the NextGen weather capabilities allow rapid notification (automation-to-automation) of changing weather situations to strategic and tactical NextGen decisionmakers.

As with enhanced communication of weather information to ground-based automation systems and human users, weather data communications to the flight deck involve both “subscribe” and “publish” dissemination of critical information. Aircraft may request (“subscribe to”) specific weather information impacting their flight route, while broad area weather advisories and warnings are issued (“pushed”) to all affected aircraft when safety-critical changes occur.

Under NextGen, network-enabled aircraft also become active participants in collection and transmission of weather information; observations are transmitted to ground-based systems for integration with other weather sources and to other aircraft. Aircraft operating in performance airspace act as fully enabled operational nodes on the NEO information grid. Aircraft contribute observations for, and receive via data link, localized nowcasts; they also provide critical in situ observations for use by nearby aircraft. UASs are used for making in situ observations, performing weather reconnaissance missions such as scouting for favorable routes and collecting critical observations where and when needed, and collecting ionospheric data and radiation activity originating from space weather. [P-18], [P-19]

5.3.2 Weather Information Operations

Under the direction of decision support systems, NextGen weather services provide information to stakeholders. Procedural ANSP processes, user-automated processes, and NextGen decision support systems use the common weather picture, including probabilities, to facilitate collaborative decisionmaking. NextGen decision support systems use a risk management approach in planning capacity management and FCM options. The use of the common weather picture is a primary basis for collaborative NextGen decisionmaking purposes (e.g., flow planning), but other commercially available, value-added weather sources may be used by stakeholders in making their own flight-planning decisions (e.g., determining what preferred flight paths they will request). In developing the NextGen common weather picture, the Government may choose to acquire commercially developed weather products and capabilities for inclusion in that common picture.

Weather information is tailored to the operational needs of those interested parties, maintaining a consistent view of weather information. For example, if multiple stakeholders are looking at levels of convection for a geographic area, the locations and intensity of the convection are the same. This tailoring of weather information is enabled by maintenance of a common weather picture at different resolutions, time scales, and geographic areas (e.g., the information for an airport is at a higher resolution and more rapidly updated than that for adjacent oceanic locations). Pre-flight and in-flight decisions are aided by weather services that assist the user in making tailored inquiries into the common weather picture. Other weather information such as alerts, advisories, and warnings regarding significant weather changes are proactively published to stakeholders via digital communications. For example, the flight deck receives key weather updates along the route of flight, thereby enhancing dynamic decisionmaking and flight safety. Weather Information Services transformed functions are highlighted and discussed below:

- **Transformed Function 1:** Aircraft Are Capable Of Receiving, Collecting, and Transmitting Weather Information as a Digital Data Stream.

  Fully capable aircraft have the appropriate automation (communication and computing) systems to receive weather data (including hazard information) and to transmit sensor data, which will be provided to the NNEW. Fully capable aircraft also possess the capability to collect and integrate weather information into onboard displays and weather-mitigating operational flight programs. [R-168]

- **Transformed Function 2:** Hazardous Weather Is Identified in Real Time.

  NNEW uses ground-based, space-based, and airborne sensors and systems to provide timely, relevant, accurate, and consistent hazardous weather information to aircraft and users in near-real-time. Automating traditional observations (e.g., pilot reports [PIREP]) facilitates improved hazardous weather identification. [R-82]

- **Transformed Function 3:** Observation and Forecast Are Provided for Non-Towered and Virtually Towered Airports.

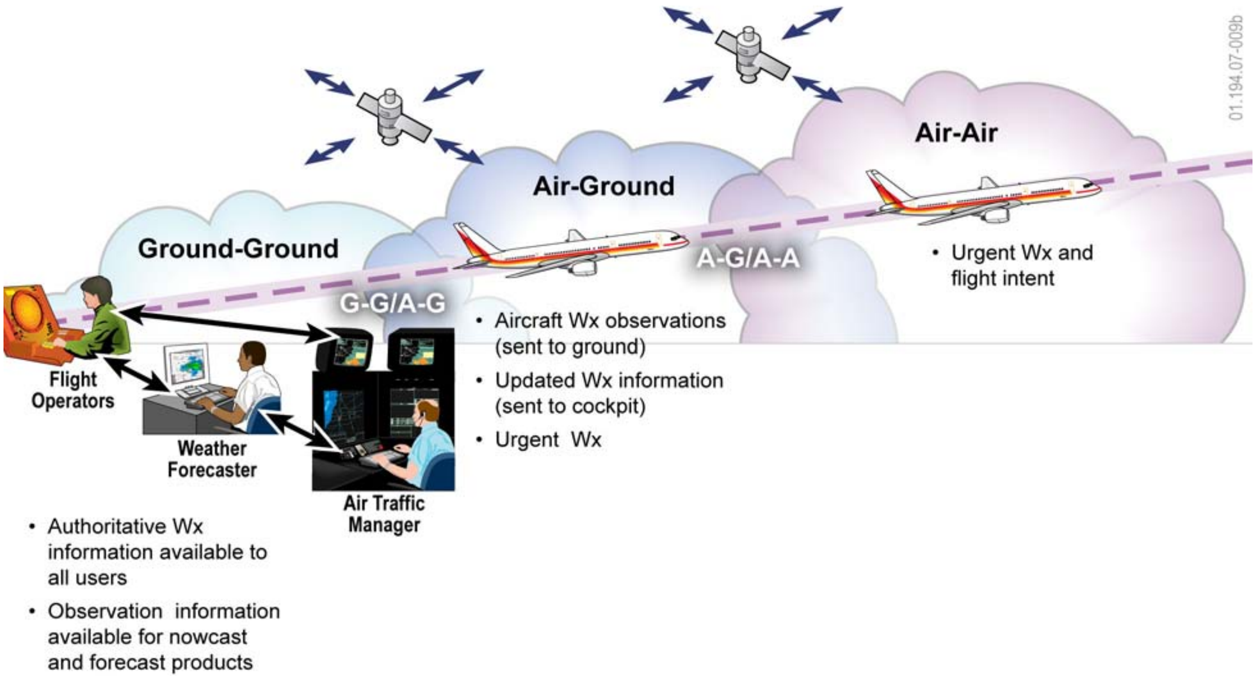
  NNEW provides current and forecast weather information from the common weather picture to non-towered and virtual towered airports at the required spatial and temporal resolution. Hazardous weather in the terminal area that impacts departures and arrivals is forecasted and also detected in real-time.

- **Transformed Function 4:** NNEW Provides the NextGen Decision-Oriented Tools (NDOT) with Trajectory-Based Weather.

- NNEW provides the NDOTs with trajectory-based weather information that is aligned with flight planning and ATM. Trajectory-based weather information (observations, forecasts, model/algorithm data, and climatology, including surface observations and weather aloft) allows full integration of weather into traffic flow decisionmaking. NNEW allows the NDOTs to identify weather-impacted airspace (both real-time and forecasted) as reduced-capacity and as no-fly airspace. NNEW provides the NDOTs with climatology (to permit up to at least a 3-month pre-flight planning window) and provides probabilistic forecasts to allow for multiple preplanned trajectories and airspace configuration scenarios.

- An example of weather information operations is shown Figure 5-1.

Figure 5-1. NextGen Weather Dissemination Foundation for Net-Enabled Weather Operations



5.3.3 Weather Information Enterprise Services

Decisionmaking by the diverse set of NextGen stakeholders is facilitated by an integrated, common picture of the weather situation. In general, stakeholders do not need meteorological expertise to interpret weather information. In addition, net-centric weather services tailored to the user's needs reduce or eliminate the requirement for stakeholders to manually gather, interpret, and integrate diverse and sometimes conflicting weather data to realize a coherent picture of the weather situation; instead this is achieved with automation assistance prior to dissemination. Decisions are predictable when stakeholders use an understandable common weather picture as a source and apply the same business processes.

A central enabler for this weather capability is access to a reliable, virtual common weather picture. This common picture for current and forecast weather information includes weather attributes organized by horizontal, vertical, altitude, time, and probability components (x, y, z, t, plus probability). Optimal air transportation decisionmaking mitigates the risk of conflicting courses of action by requiring a single reliable NextGen common weather picture. NextGen weather data is collected, processed, forecast-fused, and distributed through a service-oriented architecture (SOA)-enabled government weather information capability. The underlying premise is that the various weather data are consistent. Therefore, everyone looking into the weather information portal from the same aspect (point of view in terms of weather attributes) sees a common weather picture. However, the picture may vary on how the information is rendered (e.g., text, audio, graphics, imagery, polygons); thus a reliable, virtual common weather picture is provided. Furthermore, the weather source is not a single database but rather a network of information sources accessed via net-centric weather services, reinforcing the "virtual" concept. Moreover, net-centric enterprise weather services reduce stakeholder operational costs by eliminating expensive, customized, point-to-point interfaces from user systems to multiple sensors and sources. The services comprise—

- **Enterprise Service 1:** Multiple Weather Observations and Forecasts Are Fused into a 4D Common Weather Picture That Is Distributed Through NNEW.

  Weather data (observations, forecasts, model/algorithm data, and climatology) are integrated into a common weather picture (Earth's surface to low Earth orbit is used in all weather-oriented decision processes). Weather observations are contained in NNEW and used by forecasting tool sets to produce forecasts (both routine and aviation impacting) for all users. Users retrieve weather information needed for decisionmaking in real time from NNEW. Vendors may use information from NNEW to produce tailored, value-added products for use in and out of the cockpit. Some weather information, such as turbulence and icing, is also tailored to the airframe as well as the route. This capability depends on NNEW to disseminate a common weather picture in support of NextGen. Weather information is also used to help evaluate environmental impacts from increased aircraft operations, such as increased noise and exhaust emissions at and near airports and in volumes of airspace that may be particularly sensitive to aircraft exhausts.

- **Enterprise Service 2:** Weather Sensors Are Included in Performance-Based Services.

  Fully capable aircraft have a standardized set of weather sensors/algorithms to provide weather data to other users directly and via NNEW. Weather data from aircraft are valuable inputs to the common weather picture for providing advice and warning to nearby aircraft and for providing input and verification for weather forecast products. At a minimum, in addition to accurately providing their 4D geospatial position, aircraft provide in situ wind, temperature, water vapor, turbulence, and icing information. Aircraft may also measure nonweather parameters (e.g., volcanic ash), use forward- or downward-looking remote weather sensors, and carry dosimeters to measure the radiation environment that is affected by space weather activity.

- **Enterprise Service 3:** UASs Are Used for Weather Reconnaissance. [R-169]

  En route weather reconnaissance UASs are equipped to collect and report in-flight weather data. Specialized weather reconnaissance UASs are used to scout potential flight routes and trajectories to identify available "weather-favorable" airspace. UASs may also carry instrumentation to measure the radiation environment that is affected by space weather activity.

5.4 ROBUST PNT SERVICES

[Note: Formerly Broad-Area Precision Navigation Services]

5.4.1 Introduction

PNT Services provide the ability to accurately and precisely determine one's current location and orientation and one's desired path and position; apply corrections to course, orientation, and speed to attain the desired position; and obtain accurate and precise time anywhere on the globe, within user-defined parameters. NextGen relies on PNT Services for the implementation and conduct of many of its basic operations, as well as trajectory-based operations.

5.4.2 Positioning Services

Robust PNT Services provide NextGen users with a highly accurate and reliable positioning source that improves surveillance capabilities and reduces separation standards. Positioning is also needed for other activities in NextGen, such as surveying stationary assets (for representation in the GIS—see Section 5.9 for details). This service also provides the fundamentals for navigation (see below).

5.4.3 Navigation Services

Aircraft navigation has long been constrained by the capabilities of ground-based NAVAIDs and routes that are tied to the locations of these NAVAIDs. Reliance on ground-based NAVAID locations has also constrained airspace design. Navigation Services rely on area navigation (RNAV) as the standard method of navigation in NAS. Further, Navigation Services provide the foundation for performance-based navigation operations including those that have specified RNP. Note that performance-based RNP operations will vary based on airspace class to safely achieve operational objectives.

5.4.4 Timing Services

PNT Services provide a common, accurate, and precise timing source for all users from a standard universal coordinated time, as maintained by the U.S. Naval Observatory (USNO) and the denoted Universal Time Constant (UTC). These timing services enable the precise synchronization of operations and the reduction of uncertainties associated with disparate timing sources.

5.4.5 PNT Components

The primary system providing PNT Services is expected to be some form of global navigation satellite system (GNSS), perhaps with a satellite-based augmentation system (SBAS), providing increased accuracy, availability, and integrity to users of the service. Backup systems are critical to the PNT system and are required. Systems are currently under review, but a selection is yet to be determined. [R-83]

5.4.6 PNT Summary

With PNT Services, a user (or COI)-determined integrated air picture provides SSA to all users of NextGen.

5.5 SURVEILLANCE SERVICES

5.5.1 Introduction

C-ATM relies on cooperative surveillance information from all air vehicles in the national airspace, providing one of the key elements for trajectory-based operations in NextGen, as well as supporting the needs of defense and security providers. A non-cooperative surveillance capability is also required within NextGen for air sovereignty and security purposes. NextGen surveillance coverage includes a broad range of operational environments, ranging from remote areas (like Alaska and oceanic regions) all the way to airport surface areas at our busiest airports. Surveillance Information Services derived from integrated cooperative and non-cooperative surveillance systems permit the creation of real-time situational awareness (the capability to detect, identify, and monitor air vehicles) on the surface of an airport and in the air. This surveillance information is networked within a net-enabled system, providing approved COIs with access to appropriate and secure data. This in turn allows distributed decisionmaking on a real-time basis during normal operations, abnormal events, and system-wide crises. The Surveillance Information Services envisioned within NextGen will improve the speed, efficiency, quality, and timeliness of decisions.

NextGen Surveillance Information Services, including improved surveillance accuracy, latency, integrity, and availability, enable—

- Reduced separation standards
- Comprehensive tracking of aircraft and vehicles operating on the airport surface and within ANSP-responsible and sovereign airspace to improve safety, security, and operational effectiveness
- Increased C-ATM services within underused airspace and to underused airports
- Improved 4DT information(e.g., intent) that allows for flight path conformance monitoring
- Flexible assignment of multiple NextGen surveillance sources to any operational position at any time to support distributed decisionmaking
- Adaptive flexible spacing and sequencing of aircraft on the ground and in the air.

There are many new NextGen functions enabled by improved Surveillance Information Services; these range from air situational awareness to dynamic airspace, and from en route deconfliction to full self-separation. Different levels of Required Surveillance Performance (RSP) are associated with each new surveillance-derived capability and specified airspace. To achieve the high level of requirements for surveillance, it is envisioned that both a primary and backup system for surveillance will be required in these airspaces.

5.5.2 Core Surveillance Services

NextGen delivers cooperative and non-cooperative surveillance information on aerial vehicles to achieve the maximum levels of safety and security required for future air and ground operations.

5.5.2.1 Cooperative Surveillance Services

Cooperative surveillance services require aircraft to be equipped with functioning avionics, allowing surveillance systems to reliably, consistently, and unambiguously detect the aircraft while in the air and on the ground. This type of surveillance information is considered the primary method of aerial vehicle detection because of the additional flight information it can provide.

5.5.2.2 Non-Cooperative Surveillance Services

Non-cooperative surveillance allows an airborne object to be detected by ground-based, airborne, or space-based surveillance systems even if it does not have functional avionics equipment. Non-cooperative surveillance can be used when airborne or ground cooperative surveillance systems malfunction. NextGen non-cooperative and cooperative surveillance systems are designed and integrated to provide mutually supporting surveillance services information.

5.5.3 Surveillance Services Components

NextGen Surveillance Services consists of three components: surveillance sensors, an interconnected network structure (a part of the Infrastructure Services function), and components for distribution, processing, correlation, and display. The sum of these individual components creates a comprehensive capability that allows surveillance of NextGen airspace and the surface movement areas of an airport. Developing this capability will—

- Enable NextGen stakeholders to better conduct their individual missions
- Minimize the cost to establish and use the surveillance services by operating them as a common capability
- Allow each agency to satisfy its public responsibility while facilitating collaborative, cooperative, and integrated operations, and reducing duplicative and redundant investments.

5.5.3.1 Surveillance Sensors

The NextGen surveillance sensor components are a combination of cooperative and non-cooperative sensor capabilities. To enable the operational improvements envisioned in NextGen, Surveillance Services must be able to detect, monitor, track, and identify all airborne objects—anything that could present a safety risk to the community of airspace users or could be a risk to national security. Aircraft within and approaching U.S. airspace must be detected and monitored, whether cooperating and following correct procedures or behaving suspiciously and evading procedures. The NextGen must also provide enhanced air surveillance capabilities for low-altitude coverage in areas of national interest. It is envisioned that various federal departments will develop directives that will prioritize specified surveillance coverage capabilities and requirements in these national interest areas. [P-20] At airports, NextGen sensors must track all movements from ramps to runways to minimize risk of ground collisions and mishaps. [R-84]

Some capabilities of the future NextGen surveillance sensors include—

- Providing a unique reference identity for each flight object
- Providing 4D position, velocity, and directional information and identification of all airborne objects of relevance

- Predicting airborne object intent based on proximity to critical infrastructure; changes from assigned heading, altitude, and speed; and status of cooperative avionics

- Providing position, velocity, and directional information and identification of all surface vehicles and their movements, and contributing this information to the airport SSP systems.

5.5.3.2 Distribution, Processing, Correlation, and Display Components of Surveillance Data Information

NextGen integrates cooperative and non-cooperative surveillance data and information along with aircraft intent information to create the most accurate view possible of the actual situation. NextGen causes this integrated data to be distributed among stakeholders in accordance with approved policies and authorities. All participants in the system have access to the essential surveillance information needed for the decisions or negotiations concerning their particular activities, with the understanding that not all surveillance data may be available in the interests of national defense. The data protocols and processing parameters are designed to meet the requirements of the various subscribers using a common family of services. Subscribers can request that processing be done by the information service provider, or they can retain the responsibility for processing within their own applications by receiving unprocessed data. Automation advances enable coordination and communication between various agencies to occur in a fashion responsive to specific needs with greater fidelity than is possible today.

5.5.3.3 Surveillance Concept Summary

The sharing of surveillance data allows each user to create a tailored view, yet ensures that all users have a consistent “picture” of what is going on in their area of interest. This consistent view is essential to supporting multiple agency missions and providing stakeholders and users with key information necessary to their operations. Numerous entities, government and private alike, benefit from the shared surveillance data intrinsic to NextGen. Examples of how this shared surveillance information supports some of these missions include—

- ANSPs use surveillance information to provide separation assurance, navigational services, traffic management, and support emergency operations.

- Defense service providers (DSP) and SSPs use surveillance information to monitor, detect, and track suspect aircraft believed to be engaged in illegal or potentially hazardous activities and to identify, assess, and engage, if necessary, threats to our homeland.

- DSPs and SSPs use surveillance information to monitor and control airspace in permanent, semi-permanent, and roving exclusion security protective zones.

- Historical (recorded) surveillance information is used to support search and rescue efforts and aircraft incident and accident investigations.

- Surveillance data is collected, merged, and analyzed by various intelligence agencies before being integrated with other intelligence to contribute to a civil air intelligence database that can be shared as required in support of assigned activities.

5.6 FLIGHT PLAN FILING AND FLIGHT DATA MANAGEMENT SERVICES

Flight Plan Filing and Flight Data Management Services provide support to flight operators for flight planning activities. These services also manage data related to a flight, from the initial filing of a proposed flight to the closing of the flight plan and the archiving of the data to support performance management analyses. [R-85], [P-21]

Flight plan filing provides an interactive flight planning capability for all users (with or without the aid of an FOC) to file a user-preferred departure-to-destination flight profile. Plans, which are required for IFR flights, can be submitted in advance (pre-flight) or in response to changing conditions while the flight is active. The submission can be a formal filing (i.e., the negotiation of an agreement), or it can represent a tentative flight plan for evaluation. In either case, flight operators receive automated feedback on the flight plan provided, including the identification of any system constraints that would affect the flight as filed (such as the presence of congestion or reserved airspace), significant weather, and performance-based airspace capability requirements for the planned route.[12]

Flight operators are encouraged to file flight plans (containing the 4DT) well in advance of the flight. Common flight data is available for updates as the operator refines flight plans. For some airspace (such as locations with routinely high levels of congestion), there are incentives to encourage operators to file flight plans early.

The flight plan (including the planned trajectory) is managed as part of the flight object. The flight object provides access to all relevant information about a particular flight. Different stakeholders have varying access to elements of the flight object (e.g., for privacy or security concerns). The flight object is created for each proposed flight (either through user submission, published schedules, or historic data) and is updated from initial creation until the flight is closed, at which time the flight object is archived for post-analysis. Throughout the course of the flight, changes and updates to data associated with the flight object are automatically shared with everyone who has access to the flight object. Some data elements of the flight object are automatically updated; the flight object has methods to maintain updated historic and projected trajectories, including registration in the GIS.

Flight Data Management Services (FDMS) manage the flight object and its related data throughout the flight. These services ensure that ownership and integrity of the flight object and data are maintained throughout the flight. FDMSs also manage the distribution of flight information (stored in the flight object) based on a variety of requests, such as specific flights or temporal and spatial boundaries using GIS. For example, FDMS may generate alerts to the ANSP, the flight operator, or other stakeholders regarding flights for which updates of trajectories are missing or flights that are overdue. An alert may prompt security, law enforcement, and/or emergency responders to contact the operator and seek out the aircraft using the last known position in the trajectory and related flight information.

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12 Note that flight operators can also use the flow strategy and trajectory impact analysis service to analyze the individual and system performance impacts related to a proposed flight or set of flights. See Section 5.7.

5.7 FLOW STRATEGY AND TRAJECTORY IMPACT ANALYSIS SERVICES

A primary service supporting C-ATM interactions among the ANSP, flight operators, and other stakeholders is the Flow Strategy and Trajectory Impact Analysis Service. This NextGen capability assesses the impact of or capacity for potential changes in planned flights, the allocation and configuration of assets, and other conditions (e.g., weather, security initiatives) that may affect flight operations. The changes in capacity conditions are due to planned or current status of infrastructure, or as a result of "what-if" analyses based on forecasts. The service generates anticipated changes in target NAS performance metrics as well as estimates the impacts on individual trajectories. Impacts are assessed over multiple time and geographic horizons, so that both short-term and long-term implications of the conditions and mitigation plans can be understood. For example, the service can assess how a local change will impact other regions as well as the entire NAS. Planned trajectory information is acquired via the flight object, which is maintained by FDMS. The Flow Strategy and Trajectory Impact Analysis Service also employs appropriate privacy and data protection mechanisms to ensure that data is not accessed by unauthorized parties.

Flight operators have a range of flight-planning capabilities that optimize flights based on individual mission objectives, aircraft performance and capabilities, known constraints (e.g., airspace or security restrictions), and forecast weather. The operator's flight-planning capability interacts with the Flow Strategy and Trajectory Impact Analysis Service to understand the likely impact of overall conditions on a flight or set of flights and may make adjustments to plans based on the information provided. "What if" impacts can be identified for proposed, planned, and active flights. As flight operators participate in the C-ATM process, they may update their flight plans in accordance with known flow strategy plans, new performance restrictions, changing mission needs, or in response to forecast changes (e.g., to better optimize the planned flight based on forecasted winds aloft).

The service provides stakeholders with information on the likely impact of changes to NAS assets and flow strategies. Further, it evaluates the impacts of potential weather conditions or other changes to the NAS. A number of predefined flow strategies and asset configurations are available for decisionmakers; these can be used as-is or can be refined for "what if" analysis. For example, the ANSP capacity manager may evaluate the impact of changing the configuration of airspace or the use of additional procedures to verify that a seasonal variation in the demand forecast can be accommodated. During the C-ATM process, flight operators and ANSP personnel may use the Flow Strategy and Trajectory Impact Analysis Service to assess the impacts of adjusting aircraft to accommodate a forecast weather pattern. The service employs probabilistic algorithms to provide a range of impacts that encompass the breadth of demand, weather, or other uncertain factors.

When a new flow strategy or asset configuration is implemented by the ANSP, likely impacts to known trajectories are calculated and affected operators are notified via automatic updates to the flight object.

Long-range "strategic" planning by stakeholders is also supported with this service. For example, the impacts of new airport infrastructure and potential changes to airspace can be evaluated using long-term demand forecasts.

Overall, the Flow Strategy and Trajectory Impact Analysis Service provides an essential means of coordination among ANSP personnel, flight operators, and other stakeholders as key decisions are made regarding flight plans and the use of airspace and facilities.

5.8 SHARED SITUATIONAL AWARENESS AERONAUTICAL INFORMATION SERVICES

In NextGen, aeronautical information is uploaded, received, aggregated, and exchanged with accuracy and in a timely manner. Subscribers to the system include flight operators, airport operators, ANSPs, and other stakeholders. Aeronautical Information Services includes updates and aggregated information on—

- Current performance requirements for airspace access and operation
- Special-use airspace status and activity
- Airspace affected by temporary flight restrictions
- Route information and performance metrics
- System outages affecting global positioning systems (GPS), wide area augmentation systems (WAAS), local area augmentation systems (LAAS), and other NAVAIDs, including lighting
- Weather status, such as convective activity, winds aloft, icing, etc.
- Airport status information, including runway availability and planned long- and short-term activities affecting the airport, such as construction and snow removal
- Definitional data for airspace boundaries, fixes, terminal procedures, runways, and other supporting information.

The system accepts information from both ground and airborne users, aggregates the information, and makes it available to subscribers. Updates to aeronautical information are performed in real time and provided in a manner that allows users to readily understand the changes. The information is user-friendly and available in digital form (graphically or via digital text). The data is also machine readable and supports automated processing of information for TBO.

5.9 GEOSPATIAL INFORMATION SERVICES

GIS provides users with the ability to access and update information about the physical locations of both fixed and mobile assets within NextGen. This service provides information on such assets as physical facilities, airspace boundaries, airport survey information, and the locations of CNS infrastructure elements. To achieve this level of information exchange, all assets in the NAS are described in a common reference set (that is, an earth-based coordinate system) to ensure comparability and interoperability across all applications. Further, to increase the efficiency of these comparisons, GIS users can employ a common indexing structure to support the asset information development and exchange of information, as well as to query about overall asset inventories. The GIS manages current information, maintains historical information, and allows access to planned/desirable future capabilities. Under this structure, static elements (e.g., sectors, fixes, NAVAIDS, radars) and dynamic elements (e.g., aircraft, weather, TFRs) are referenced to latitude and longitude, then indexed to a single hierarchical grid to speed comparisons. The design of the index supports high-resolution data and includes the temporal (time) component necessary for projections and strategic planning. This capability supports the reconfiguration of airspace and airport assets to provide maximum use of the available capacity to meet traffic volume, while adjusting for weather or other constraints as they arise.

The GIS supports dynamic airspace boundary adjustments, trajectory-based operations, interactive flight planning, and future decision support tools operating in a collaborative environment of shared data. This service depends on the ability to describe, communicate, and manage the characteristics of airspace and other asset information (and their constituent elements) at increasingly finer levels of resolution. This increased precision and resolution supports decisionmaking by the ANSP as well as providing a basis for SSA for collaboration (such as C-ATM) among the ANSP, flight operators, and other stakeholders in NextGen.

6 Layered, Adaptive Security Services (Enterprise Operations)

6.1 INTRODUCTION

This ConOps for NextGen describes an effective security system that does not unduly limit mobility or make unwarranted intrusions on the civil liberties of users and employees by embedding layered, adaptive security measures throughout the air transportation system, from reservation to destination. The NextGen Security Services concept addresses—

- Integrated risk management (IRM)
- Secure people
- Secure airports
- Secure checked baggage
- Secure cargo/mail
- Secure airspace
- Secure aircraft.

The security system has particularly strong interrelations with NextGen SSA, airports, and global harmonization capabilities along with some aspects of ATM. This chapter provides an overview of the NextGen Layered, Adaptive Security Services; for a detailed look at specific aspects of this system, see the NextGen Layered, Adaptive Security Services Annex.

Layered, adaptive security is defined as a risk-managed security system that depends on multiple technologies, policies, or procedures that are adaptively scaled and arranged to defeat a given threat or threat category. This adaptability further permits the use of increased variability in security system operations that creates more uncertainty for the terrorist. Adversaries cannot defeat one particular security measure and thereby achieve a “break-through” to operate freely with no further barriers to their activities. Furthermore, the security system has the adaptability to scale its systems and procedures to the risk level of a threat in a given situation, rather than being bound to an inflexible “one size fits all” approach.

Given the limited resources of both the Government and private industry, it is critical that mitigation measures are developed based on threat and vulnerability, as well as the potential consequences to individuals, transportation assets, and the economy. The NextGen approach matches system costs with the risk assessment and the capacity demands at various airport and screening locations.

To achieve the requisite adaptability while maintaining effective security standards, the NextGen security system must have a sound method of prioritizing risks and assessing the proportional effectiveness of different ways of countering them. The Secure IRM process performs this essential function that then directs the deployment of equipment, personnel, and procedures/ policies to defeat the evolving threat. The remaining capabilities described at a high level in this chapter are the result of IRM assessments.

6.1.1 NextGen Security Management and Collaborative Framework

In NextGen, the security system is optimally integrated with other NAS functions and, through advanced networking functionality, linked to external aviation industry stakeholders and non-- federal government entities. To maintain effective security management across major stakeholders, a collaborative framework is composed of the following key functions and processes—

- **National Aviation Security Policy.** NextGen Security Policy embraces a broad view of threats including direct attack, exploitation, and transfer; recognizes interdependencies and uncertainty; nurtures virtual or extended enterprises supported by connectivity of diverse, informed stakeholder partnerships; employs layered security using physical, process, and institutional layers; accounts for systemic vulnerabilities that are created by the networked nature of the aviation system; and creates an environment that facilitates a rapid, seamless return to normal business operations subsequent to an incident. NextGen has achieved integration with the overarching Homeland Security Presidential Directives and their subsidiary documents.

- **Aviation Security Stakeholder Involvement.** NextGen Stakeholder Involvement fosters industry, federal, and local partnerships with clearly defined roles and responsibilities for prevention, protection, response and mitigation, and recovery operations at strategic, operational, and tactical levels. Collaborative decisionmaking contributes to a positive security culture. Timely, effective, and informed decisionmaking based on SSA is achieved through advanced communications and information-sharing systems.

- **Aviation Security IRM.** NextGen IRM includes prognostic tools, models, and simulations at the strategic, operational, and tactical levels, including nominal and off-nominal situations, to support all stakeholder decisionmakers and managers with incorporating cost-effective best practices into the design, acquisition, deployment, and operation of aviation security system assets and infrastructures. Knowledge bases concerning threats, vulnerabilities, and practices are tailored to user profiles that proactively determine need/authorization to know.

- **Aviation Security Implementation.** NextGen Implementation capabilities encompass a robust set of strategic, tactical, and operational capabilities and services focused on prevention, protection, response and mitigation, and recovery initiatives that are undertaken by a variety of stakeholder organizations.

- **Aviation Security Assurance.** NextGen Assurance capabilities include a variety of certification programs administered by federal, industry, and local stakeholders, surveillance and evaluation activities administered and performed by various stakeholders, enforcement inspections performed by federal and local stakeholders, and incident investigations performed and administered by various stakeholders.

6.2 KEY TRANSFORMATIONS

The key transformations inherent in the NextGen Security concept, described both in this section and in the supplemental Security Annex, provide new, significant security capabilities. As shown in Table 6-1, the key security transformations are expected to occur in the areas of checkpoint operations responsibilities, credentialing/authentication, baggage screening technology, passenger screening, CBRNE detection, and security system deployability.

Table 6-1. Significant Security Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Integrated Risk Management	Static facility or passenger risk assessments	Dynamic risk assessment management process producing real-time risk profiles for aviation facilities and flight objects
Checkpoint Operations Responsibilities	U.S. Government/TSA responsible for policy development and execution	Government, airport operator, or third-party decentralized while observing common standards developed by U.S. Government
Credentialing/Authentication	Badges and background checks (mainly manual)	Biometric credentials with 1-second authentication at access or screening checkpoints
Baggage Screening Technology	Large-footprint baggage screening devices—most not integrated with baggage system—only detect explosives. There are separate boxes for CBRNE sensors.	• CBRNE detection systems incorporating sensor fusion, with a range of sizes and throughput capacity from high-throughput in-line systems to smaller units for remote screening and local airports. Some are small, lightweight, portable devices that can screen bags from standoff distances. • Greater use of off-airport screening
Passenger Pre-Screening	Name-based checks against watch lists, performed by carriers	Leverage credentialing databases • DoD clearances • Trusted traveler program

Table 6-2. Significant Security Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Passenger Screening	Metal detector-based, relatively large explosive trade detection (ETD) air sampling equipment/portals	Sensor arrays deployable throughout terminal, enabling rapid movement of passengers through virtually invisible screening points—fast and efficient. Centralized monitoring center reducing security footprint at checkpoint. Advanced behavior profile recognition procedures. Biological threat/ disease detection and assessment
CBRNE Detection	Only deployed at a few high-threat locations (typically not airports)	Deployable for all airport screening operations, linked by Network-Enabled Information (NEI) to airport operations, law enforcement, and national network
Security System Deployability	Expensive, slow installation	Rapid-deployable units for low-capacity, temporary, and intermittent screening locations integrated with other airport customer service functions
Screening Checkpoint Location	In airport terminals between public area and "sterile" area	RTSS enabling all or a portion of security screening to be done off-airport
Airspace Security	• Frequent use of TFRs with blanket restrictions • Limited SSA among DHS/DoD/FAA operations centers • Non-integrated aircraft security-relevant databases	• SRA use is infrequent and based on integrated risk analysis. • SRA access depends on flight risk profiles to allow for flexibility and to increase access.
Man-Portable Air Defense Systems (MANPADS) (e.g., shoulder-fired missiles, lasers, electromagnetic pulse [EMP]) Detection and Defeat	Perimeter and adjacent jurisdiction observation (LEO)	Onboard aircraft-leveraged safety modifications, supplemented by ground-based and procedural systems
Commercial Spaceport	Licensing with no commercial passenger service	Passenger screening and bilateral agreements for international reentry of hypersonic vehicles

Table 6-3. Significant Security Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Security Risk Management	• Aviation risk management process is beginning. • Risk management tools and capabilities are under development.	• Mature and institutionalized risk management environment to inform investment and decisions • System-wide deployment of NEI applications with artificial intelligence capabilities to support risk management • Unified command, control, and communication with integrated risk-informed decisionmaking
Security-Relevant Information	Disparate, stand-alone systems; no easy transfer of data	Net-centric information access with “smart” applications proficient in data-mining and pre-analysis of large amounts of data. Decision-support applications assist Security Operations Center (SOC) and other security analysts.
Cargo Screening Technology	• Small percentage of cargo is screened for explosive threats. • Most cargo undergoes paper-based documentation (Known Shipper).	All air cargo items not packed in sterile area and securely conveyed to aircraft are screened for CBRNE.

6.3 IRM ENTERPRISE OPERATIONS

Risk management is the ongoing process of understanding the threats, consequences, and vulnerabilities that can be exploited by an adversary to determine which actions can provide the greatest total risk reduction for the least impact on limited resources. Risk management is inherent to every element of Layered, Adaptive Security Services; it is conducted from the strategic to the tactical levels. [R-86], [P-22], [R-172] In this section, the strategic aspects of the IRM process are described. The following sections briefly mention the relevant tactical aspects of IRM for that particular threat vector. The NextGen Layered, Adaptive Security Services’ IRM capability is an overall federated risk assessment and risk mitigation framework that guides multiple security service enterprises to assist in making decisions, allocating resources, and taking actions under conditions of uncertainty. This framework is a planning methodology that outlines the process for satisfying or exceeding security goals through prevention, protection, response and mitigation, and recovery. It satisfies the following needs—

- To understand the spectrum of threats that could be mounted against NextGen
- To identify the vulnerabilities that can be exploited by an adversary

- To evaluate and prioritize assets/activities to be protected from attack
- To determine which protective actions can provide the greatest total risk reduction for the least impact on limited resources
- To provide the most focused and adaptive security measures to reduce the impact of security systems and procedures on air transportation. [R-87]

IRM is characterized by a specific and consistent terminology to describe its various aspects. Threats are the likelihood of an attack on a particular asset. Vulnerabilities are weaknesses in the design, implementation, or operation of an asset or system that can be exploited by an adversary or disrupted by a natural disaster. Consequences are the result of an attack on infrastructure assets reflecting level, duration, and nature. Risks are measures of potential harm that encompass threat, vulnerability, and consequence. [R-88], [R-89], [R-90], [R-91], [R-92], [P-24], [P-25], [R-173]

The assessment of risks provides a prioritized list of vulnerabilities and potential mitigation strategies. [R-93] Since the terrorist has the freedom to choose targets and modes of attack, the NextGen Security system must develop (but not necessarily universally deploy) operationally feasible mitigations to as many potential threats as possible. [R-94], [P-27] Because of limited resources, mitigation requiring substantial investment (e.g., system cost or infrastructure intensive) is applied (deployed) in the order of risk level. For example, external attacks on aircraft may be an issue at some airports requiring mitigation. This doesn't mean that GA airports will have or need such systems.

Another way to effectively apply resources is through technical advances in sensor design and fusion as well as cost efficiencies typical of information processing system upgrades. With the development of low-cost CBRNE sensors for low-volume operations, it will be possible to conduct screening in 2025 at sites that would have been economically infeasible in 2006 for a given risk profile (thus permitting many more airports to provide commercial service). This does not mean that all non-commercial operations have to screen passengers or cargo for flights posing below-threshold risk levels. [R-95], [P-28], [P-29] Many flights occur far from major metropolitan areas or national security restricted areas. However, flights to sensitive areas have to make adjustments to mitigate their risk profile. [R-96]

In summary, it is essential to remember that the security system responses and procedures throughout NextGen are applied based on the risk profile of each flight and airport facility. [R-97] Facilities or flight objects that do not adopt particular security processes may still operate in NextGen but may have to observe some restrictions depending on the given risk profile created. Yet their overall access and performance in NextGen, even with some (self-imposed) security restrictions, is considerably greater than their access in 2006.

6.4 Security Enterprise Services and Capabilities

6.4.1 Service: Secure People

The perception of a secure aviation system environment via publicly visible or implicit checkpoint and carry-on baggage screening operations is an extremely important tenent of the NextGen Security Architecture. Other less-visible security procedures may work toward similar ends and achieve them as effectively. [R-98] However, the visible aspect of checkpoints and baggage screening is still the most tangible element to the general public and hence the most relied upon procedure in establishing the public's level of confidence and thereby their use of the system. The checkpoint displays an operating profile of consistency and routine, while behind the scenes it has several new screening techniques and tools [R-99] that are brought to bear upon the assessed risk and, in some cases, performed randomly as an added measure. [R-100]

In NextGen, the Secure People capability of the security architecture puts greater reliance on an integrated approach to correlate credentialing and identification processes with screening. [R-101], [R-102] Aviation security risks are mitigated by identifying people who, whether travelers or aviation workers, are a potential threat and preventing them from gaining access to the air transportation system through pre-screening/credentialing, screening, and intervention. [P-30], [P-31] For travelers, aviation security is provided continuously from the time the reservation is made until the safe arrival of the flight at the destination airport and the uneventful retrieval of baggage by the passenger. For persons with disabilities (PWD), the NextGen Secure People capability ensures accommodation and privacy by including special training and procedures for screeners, separate screening areas, and appropriate equipment to address PWD needs. For aviation workers, a standardized credentialing process; standardized, periodic updating and re-credentialing of secure access personnel; and identification technologies deny unauthorized individuals access to restricted areas of airports. The NextGen NEO permits more valid and faster credential verification. [P-32] A balance between security and customer service is maintained, permitting the consistent, efficient, and seamless movement of passengers at the airport.

6.4.2 Service: Secure Airports

The NextGen airport (as summarized in Chapter 3) has an integrated facility security system scalable to differing capacity, access, and risk environments. The Secure Airport ConOps includes both technological and procedural measures to protect against the dynamically evolving threat. This flexible security system leverages advanced net-centric capabilities inherent in NextGen to minimize redundant credentialing and access controls while providing SSA when security incidents occur or credentialing concerns surface.

The NextGen Airport NEO seamlessly links sensors and data sources from access and screening checkpoints for passengers, visitors, employees and vehicles, perimeters, and critical facility infrastructure. The airport security technologies and adjustable procedures are nominally transparent to passengers [R-103], [P-33], [R-174] and cargo, but hard to exactly predict by those who intend harm. Additionally, the NextGen airport has resident response and recovery programs enabled through local and regional memoranda of agreement (MOA) and supported by the U.S. Government. In this connection, the net-centric operations of NextGen maintain real-time connectivity to other regional airport operators, law enforcement, and government intelligence and SSP operational entities. These Secure Airports Services, used with IRM tools, enable quick ramp-up response operations to incidents of national significance, including CBRNE attacks on the airport or within the region. The emergency response has been appropriately rehearsed to ensure that the responders are fully prepared and informed for any contingency. [R-104], [R-105], [R-175], [P-36], [R-180], [P-38], [P-39]

The layered and overlapping security systems are in place at the following types of airport facilities—

- Commercial (passenger/cargo) airports [R-106], [R-107]
- RTSS facilities [R-108], [R-109]
- Public GA airports [P-41]
- Commercial spaceports. [P-40]

The systems are also located at the following areas within the above listed facilities, as appropriate—x

- **Airside.** Security identification display area (SIDA)/airport operations area (AOA), [R-110] terminal perimeter, terminal airspace (security)
- **Landside.** Terminal public and commercial roadways and parking lots, [R-111], [P-42] terminal entry and departure, airline ticketing kiosk/counter, sterile area, international arrivals/customs, security control center, response and recovery operations.

6.4.3 Service: Secure Checked Baggage

This section includes printing bag tags at remote locations for airport check-in. This section also includes provisions for RTSS to allow passengers to undergo full screenings at off-airport locations and then be transported directly to the sterile area of the airport terminal while their screened, checked bags are taken directly to the aircraft. [R-112], [P-43] The screened baggage is available for direct transfer to other modes of transportation (e.g., rail, ship or bus) without further screening. [R-113], [R-114], [R-115], [P-44], [P-46], [P-47] Additionally, integrated trip tracking, with access by authorized third-party organizations, provides custom services such as remote check-in and baggage transport and processing capabilities. [P-48], [P-49], [R-176]

6.4.4 Service: Secure Cargo/Mail

Cargo represents a critical vulnerability that was historically addressed with background investigations, inspections, and paper trails required of shippers, both known and unknown. The NextGen vision for cargo security moves beyond that to also include freight vulnerability assessments (through the IRM process), identifying the risk level of cargo, use of sterile cargo packing areas, cargo transit safety and integrity, and CBRNE screening for air cargo. [P-51]

Secure Cargo/Mail is intended to prevent checked cargo/mail from endangering aircraft, aviation facilities, or people and to prevent the air cargo system from being used as a threat vector. These objectives are met through a combination of policy, procedures, information, and technology to accurately differentiate normal commerce from threats. Cargo/mail screening equipment and container sensors, with multi-sensor capabilities, are linked through secured NEO to the SSP SOC and other analysis centers.

The security of cargo and mail begins at the point of initial packing (or when initial screening occurs prior to entry into the NextGen Security system) with the manufacturer, freight consolidator, air carrier, or licensed U.S. Customs broker. The SSP integrates all information related to the flight, cargo, and aircrew to provide additional information and ensure security during transit, enabled through NEO. [R-116] The SSP includes the following concepts—

- Vetting for Secure Supply Chain Entity (SSCE)
- Vetting for Certified Supply Chain Entity (CSCE)
- Security screening
- Loading and storage security
- Surface transportation security/tracking
- Cradle-to-grave tracking/integrity. [R-117], [R-177], [P-53], [P-54], [R-178]

The air cargo supply chain potentially has many organizations and personnel involved in the transport of any given piece of cargo: a source or shipper, freight forwarders, indirect air carriers, and other commercial and government personnel. Because of the many prospective transfer points, cargo/mail security has to take into account the entire custody chain. A continuous risk and threat assessment must be conducted to identify risks to the supply chain, assess those risks, and apply measures, procedures, and policy to reduce those risks to an acceptable level. A secure supply chain encompasses the concept that cargo must be initially packed in a sterile area and conveyed through a secure chain of custody to the aircraft. If any deviance from this process occurs, all cargo intended for air transport, whether on passenger flights or all-cargo operations, must undergo CBRNE screening from either the SSP or a CSCE. [P-56] After CBRNE screening, the integrity of the goods shipped must be maintained until the cargo exits the air transportation system. SSCE and CSCE are regularly inspected for compliance. All personnel with access to shipped goods must be properly credentialed, authenticated, and trained to ensure a secure shipping environment. In addition, all cargo items are subject to random inspection and CBRNE screening to maintain necessary variability and verification of the supply chain.

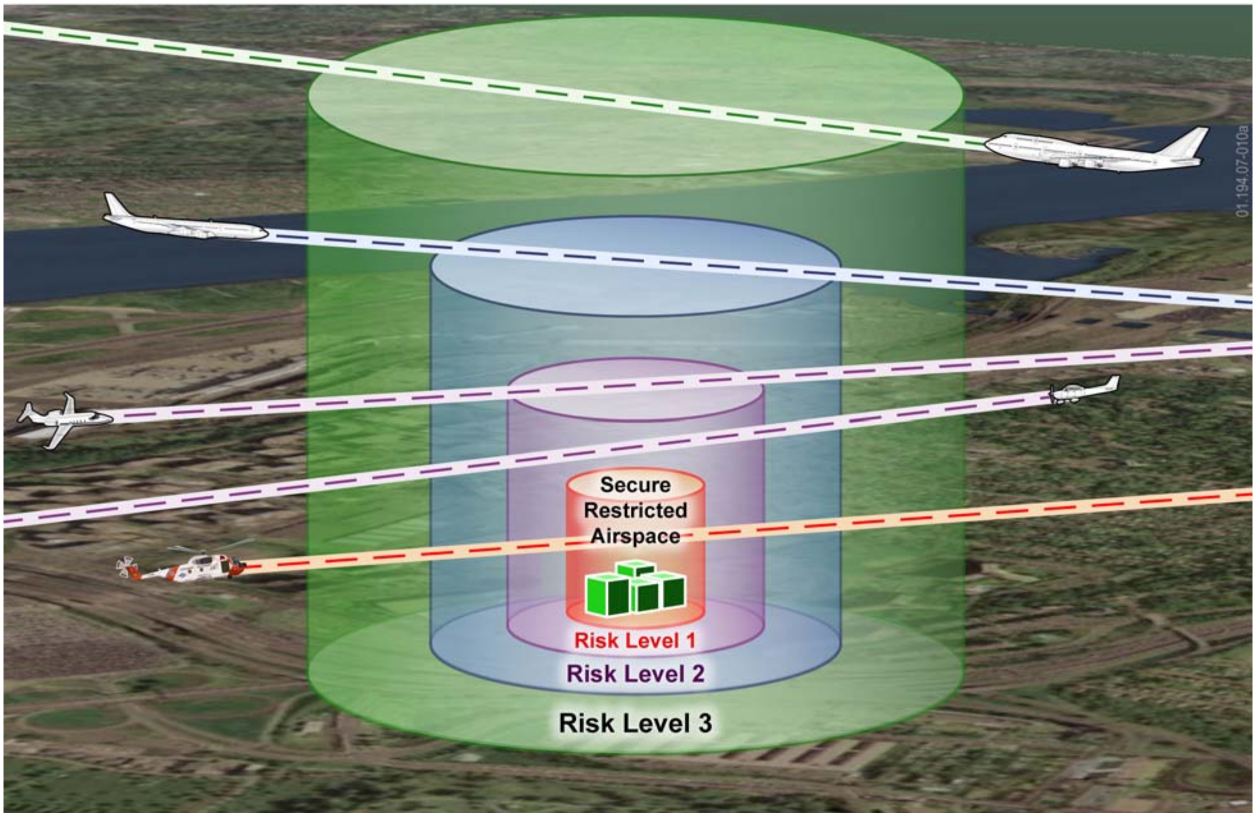
6.4.5 Service: Secure Airspace

The major objective of Secure Airspace is to prevent or counter external attacks on aircraft and other airborne vehicles anywhere in the NAS and to prevent or counter use of an aircraft as a weapon to attack assets and people on the ground. To reduce the security risk within the air domain, NextGen Secure Airspace systems and procedures detect and prevent or mitigate:

- Anomalies in aircraft operation that indicate unauthorized use or attempted unauthorized use
- Aircraft not providing the appropriate cooperative data concerning identity and intentions
- External attacks on aircraft
- Aircraft that can pose a threat from operating in the NAS.

These risk management requirements include defining (almost always dynamically) the boundaries of SUA and TFR; the cooperative division of responsibilities between the DSP, SSP, and ANSP in the event of security incidents in flight or by airborne threat aircraft; and the security personnel on flights and modifications/equipage to the aircraft. [R-118], [R-119], [R-120], [R-121], [R-122], [P-57], [P-58], [P-59] In addition, Secure Airspace implements airspace access and flight procedures based on a verification process that dynamically adjusts for aircraft performance capabilities. [P-60] The model combines credentialing data with performance data to develop the risk profile of the aircraft. [R-123], [P-61] One objective is to permit increased NAS access by low-performance aircraft through most restricted zones since the reaction time to intercept is correspondingly greater than with high-performance aircraft. Refer to Chapter 2 for additional information. A depiction of secure airpace is provided in Figure 6-1.

Figure 6-1. Secure Airspace—SRA



6.4.6 Service: Secure Aircraft

The Secure Aircraft Service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods. [R-124], [R-125], [R-126], [R-127], [P-62], [P-63] The threats that require mitigation include, but may not be limited to, hijacking/unauthorized diversion; internal explosive destruction; external attack; onboard CBRNE or other attack of crew, passengers, or aircraft systems; aircraft use as a transport for CBRNE; or aircraft use as a weapon of mass destruction (WMD). [R-128], [P-64] The Secure Aircraft Service applies to both civilian passenger aircraft and civilian cargo aircraft. [R-129] UAS aircraft (surveillance or cargo) are included as well for threats related to unauthorized diversion, internal explosive destruction, and use as a transport for CBRNE.

7 Environmental Management Framework

7.1 INTRODUCTION

Anticipated increases in air transportation demand will place significant environmental pressures on various segments of the NAS. Current operational trends show that environmental impacts such as noise, air emissions, water pollution, land use, climate change, and fuel consumption will be the primary constraints on the capacity and flexibility of NextGen unless these impacts are managed and mitigated. It should be noted that discussion of fuel consumption is not an environmental impact but is discussed as a surrogate for emissions impacts, such as carbon dioxide (CO2).

Environmental issues have resulted in the delay and/or downscaling of certain airport capacity projects over the past decade. Airports will need to escalate their efforts to address the environmental concerns of neighboring communities. Noise has been and will continue to be a primary area of concern. However, air quality, water quality, and other environmental demands are a growing challenge to significant capacity expansion without a detrimental impact to the environment. These challenges are not only of concern to commercial aviation; military readiness is also constrained by training and operations restrictions due to environmental issues. Therefore, the NextGen environmental challenge is to manage aviation's environmental impacts in a manner that limits or reduces their "footprint" and enables the U.S. air transportation system to meet the nation's future transportation needs.

NextGen manages mission-critical environmental resources/impacts through an Environmental Management Framework that is fully integrated into all NextGen operations. This framework ensures *environmental protection that allows sustained aviation growth*. The framework's success is dependent on the prevention or reduction of significant environmental impacts, especially as aircraft noise and local air quality emission concerns remain strong constraints on system capacity, while proactively addressing other important environmental issues (e.g., water quality, energy use, global climate change, and noise sensitive areas). The NextGen Environmental Management Framework must account for interdependencies among many environmental issues so that in addressing some, others are not exacerbated. To achieve this, the NextGen Environmental Management Framework consists of a self-correcting feedback cycle that systematically identifies, manages, monitors, and adapts to the environmental demands associated with the high-volume and dynamic nature of the NextGen air transportation system.

Objectives of the NextGen Environmental Framework: Environmental Protection that Allows Sustained Aviation Growth (*NGATS Integrated Plan, 2004*) include—

- Reduce significant community noise and local air quality emissions in absolute terms
- Proactively address emerging environmental issues (e.g., water quality, energy intensity, global climate change).

This chapter describes the operational concept of the NextGen Environmental Management Framework, including the key transformed environmental operations (Section 7.3) that will be enabled in the NextGen, and services and capabilities (Section7.4) that need to be implemented to enable these transformations. As some enabling services are not yet clearly understood, policy and research areas are identified in each applicable section.

7.2 KEY TRANSFORMATIONS

As shown in Table 7-1, the key environmental transformations are expected in the areas of aviation environmental management systems (EMS), airspace operations, airport planning and operations, and transformed aircraft design and technology. These transformations enable the fundamental operations of NextGen and transform the national airspace operation.

Table 7-1. Significant Environmental Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Transformed Aviation System EMSs	• Some airports, air carriers, and agencies have EMSs. • Organizations focus on individual objectives that are not necessarily dealt with on an integrated basis or focused on future capacity concerns. • Limited infrastructure exists for tracking performance of airports/agencies/aircraft operators in managing environmental impacts. • Limited infrastructure exists for collecting and sharing environmental information across airports, air carriers, and agencies. • Challenges exist for evaluating cumulative effects of multiple airports and nearby projects.	• All airports, air carriers, and agencies have integrated EMS principles to support NextGen continual environmental improvements. • Incentive programs exist for the establishment and integration of EMS requirements/objectives that focus on improvements to remove/reduce environmental constraints on capacity. • Metrics are established for key components of the air transportation system that support decisionmaking and policy development to sustain capacity while limiting the system's environmental effects. • Information management systems are established to enable real-time reporting of environmental conditions and performance metrics at airports, carriers, and other key components of the air transportation system. These systems transfer best practices, communicate incentives, gauge progress toward NextGen goals, and transfer other information.
Airspace Environmental Operations	• Fuel-efficient routes are sought but limited by dependence on ground-based NAVAIDS. • Environmental impacts are primarily evaluated by FAA for major airspace decisions.	• An agile air traffic system has flexibility to achieve improved fuel efficiency and emissions reductions during flight through the use of environmentally friendly procedures, such as CDA.

Table 7-2. Significant Environmental Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
	• Noise abatement arrival and departure procedures consider efficiency to some extent, but generally not emissions or fuel burn. • There are open questions about the contribution of the en route system to regional emissions, climate change, and noise over special quiet locations, e.g., national parks. • Management of en route congestion and delay in terminal airspace is not traditionally perceived as an environmental problem. However, many large commuter airports are in air quality non-attainment areas and there is growing concern regarding green house gas (GHG) emissions.	• In a dynamic airspace not limited to ground-based NAVAIDs, environmental impact management is embedded into en route flight planning on an ongoing and real-time basis. • Integrated noise/emissions/fuel burn/ costs/efficiency information feeds into and is optimized in selection of routes and procedures. • Better scientific information guides appropriate actions/procedures to responsively address noise, air quality, climate change, and fuel burn.
Airport Planning and Operations	• Generally, environmental planning and mitigation focuses on regulatory compliance or the next development project. • Procedures to minimize environmental impacts of operations focus on individual impacts, e.g., noise or emissions. • Almost 500,000 people continue to be exposed to significant levels of aircraft noise around airports, and local air quality issues are increasingly pressing. • Airport and community planning are often done in isolation from each other and are adversarial, especially with respect to land-use planning to manage noise. • Some airports are moving to low-emissions ground equipment in response to local air quality concerns. • Water quality impacts occur due to stormwater runoff and deicing operations. [R-130] • Management of congestion and delay at airports and terminal airspace is not traditionally perceived as an environmental problem, although there is growing awareness and concern.	• Environmental issues are fully integrated into a smart planning and management cycle. This focuses on enabling the long-term viability/sustainability of the airport. • A wide range of environmental procedures exist for managing operations, which are assessed and implemented in an integrated fashion that optimizes the environmental benefits. • Significant aircraft noise is contained within the airport boundary and/or neighboring compatible land uses. • Significant health and welfare impacts of local air quality emissions will be reduced in absolute terms. • Airport facilities, vehicles, and Ground Support Equipment (GSE) produce low or no emissions. • Airport and community planning processes acknowledge and complement each other. Communities value airports as regional economic engines and gateways to the national and international air transportation system. • More effective airplane and runway de/anti-icing agents reduce impact to water quality.

Table 7-3. Significant Environmental Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
		• Improvements that optimize performance and reduce congestion and delay promote energy conservation and lower emissions through reduced fuel burn. Airport terminals will incorporate energy-efficient green design technologies.
Transformed Aircraft Design and Technology	• Considerable research has been incorporated into aircraft and engines to improve environmental performance. • Significantly lower funding is going into federal research and development to improve aviation noise and emissions technology. • Environmental performance is an increasingly important component of aircraft design. • National and international regulatory frameworks are based mostly on multiple, uncoordinated approaches to noise and emissions. • Improvements in avionics provide significant opportunities for improvement in environmental operational performance.	• There is a well-established R&D and implementation process for technology that improves aviation's environmental performance. • Technological breakthroughs enabled by robust R&D programs allow dramatic reductions of noise and emissions impacts from airframes and engines. • Integrated models allow selection of the optimum environmental performance characteristics, including informed decisions on any necessary tradeoffs. • Alternative fuels are available and in service. • A significant portion of U.S. aircraft fleets contain environmental technology matured between 2007 and 2012. • Advanced aircraft avionics support the conduct of operations that reduce environmental impacts. • The optimization of environmental performance continues to be a critical factor in aircraft design.

7.3 TRANSFORMED ENVIRONMENTAL OPERATIONS

The NextGen Environmental Management Framework consists of enterprise-level operational transformations and describes the overarching environmental architecture (including systems, business processes, and infrastructure) to support NextGen. These transformations are driven by increased traffic volume and compounded by greater stakeholder and community awareness of environmental issues and increasing community expectations for environmental impact reductions. Transformations are facilitated by activating the services and capabilities described in Section 7.4. The major transformed environmental operations are described in sections 7.3.1 through 7.3.4.

7.3.1 Transformed Aviation System EMSs

The NextGen Environmental Management Framework does not treat the aviation system as a single unit, but as a community of organizations with a diverse range of requirements and drivers. The program establishes systematic but flexible approaches that enable individual EMS programs to respond to the aviation system's dynamic capacity demands by working within the

Environmental Management Framework. These approaches are supported by enhanced information flow and better connections between individual component organizations.

What are Environmental Management Systems?

EMS is an organizational business process that consists of four phases. In the "planning" phase of the NextGen EMS, the organization identifies environmental issues with the potential to constrain future capacity. These are the focus of tactical, measurable objectives for which improvement initiatives can be undertaken during the "implementation" phase. During the "assessment" phase, the effectiveness of these initiatives is monitored and key performance metrics are tracked. Monitoring data is then used to support planning at the organization itself in the "review and adaptation" phase. In the NextGen EMS, monitoring data is also reported at an enterprise level to support NextGen-wide planning.

The NextGen Environmental Management Framework aims to provide individual air transportation component organizations (e.g., airports, agencies, air carriers, manufacturers) with greater flexibility to identify and manage the environmental resources that are necessary to meet their individual long-term capacity demands. This includes integrating sound EMS principles into all aviation system component organizations (e.g., airports, air carriers, ANSPs, FAA) and ensuring that these EMS approaches, or models, focus specifically on capacity-related environmental issues. NextGen EMS models establish standardized, systematic approaches for managing the environmental aspects of operations in support of the organization's overarching mission. The use of NextGen-focused EMS models ensures that all aviation system component organizations contain processes that help them align with critical NextGen goals.

Implementing NextGen-focused EMS models will provide mechanisms for identifying and managing issues critical to sustainable growth, transferring information, standardizing operations based on best practices, and encouraging environmental stewardship. The implementation also provides a vehicle for NextGen-level objectives to be incorporated by individual organizations as part of their EMSs, thereby aligning them with NextGen goals. Individual organizations (e.g., airports, air carriers, FAA) connect through an information management system. As discussed in Section 7.4, this system enables environmental information management enterprise-wide, including tracking environmental metrics, storing best practices (e.g., on construction, maintenance, and operational procedures), and communicating NextGen environmental objectives, policies, incentives, and regulations.

7.3.2 Transformed Airspace Environmental Operations

The NextGen plan seeks to create a dynamic and flexible airspace capable of supporting a tripling in demand by 2025 in an environmentally sustainable manner. An agile air traffic system based on advanced cockpit avionics, satellite navigation, and dynamic airspace has enhanced ability and flexibility to maximize routings for fuel efficiency and emissions. NextGen has the ability to address relevant environmental impacts dynamically on a continuing real-time basis, augmenting the current, more rigid structure of federal review linked to federal actions with respect to the airspace. Environmental performance is embedded in the overall performance of the air traffic system and supported by EMS goals, including the availability of up-to-date critical system information.

Consistent with EMS principles, a holistic but flexible approach is used to manage key environmental issues as they pertain to specific geographic regions and to the system as a whole. This approach accounts for variations at an individual component level (e.g., airports or air carriers); adaptive EMS models implemented by individual components account for specific needs while also contributing to system-level requirements.

Environmental impacts and potential constraints of terminal airspace are currently better understood than those associated with en route airspace, but there is significant uncertainty associated with 2025 projections for both. Therefore, the primary capability of the Environmental Management Framework is its ability to adapt to the complex nature of the air traffic system. This framework is facilitated by a dynamic airspace structure and includes environmental management embedded into en route flight planning on an ongoing and real-time basis. For example, new technology, in concert with airspace redesign, enables optimized route selection during landing and takeoff procedures that are based on minimizing the impact of noise and air emissions, minimizing costs and fuel burn, and maximizing route efficiency and safety. The establishment of environmentally friendly operational procedures (e.g., CDA) for all traffic conditions is one example. [R-131]

In terminal airspace, single-purpose noise abatement procedures are replaced by more sophisticated environmental procedures that maximize benefits based on integrated assessment and management of multiple factors, including noise, emissions, fuel burn, land use, operational efficiency, and cost. Procedures are dynamic and adapt to changing needs rather than remaining static and institutionalized. There are additional procedures available using advanced technologies from which to select the best operational and environmental benefits.

In the case of the en route environmental impacts, ongoing discussions and analyses have resolved major questions, and outcomes are integrated into the Environmental Management Framework. Specific focus is placed on understanding and identifying the direct attributable role of aircraft emissions in climate change through targeted research with national and international partners. [R-132]

7.3.3 Transformed Airport Planning and Operations

The greatest interaction between the national aviation system, communities, and environmental resources occurs at airports. By 2025, significant aircraft noise will be confined within the airport boundary and over small areas of adjacent compatible land. Airports are emissions-friendly with ongoing transition to low- or no-emissions stationary facilities and GSE. Airport and community planning complement and support each other, and airports are valued community assets as air transportation gateways and economic engines. Through the integration of EMS, environmental planning and mitigation is continuous and includes activities to meet long-term goals for sustainable growth in airport capacity. These activities are supported by improved information management that, for example, transfers and stores information on environmentally preferable airport practices. In addition, an advanced capability to integrate and balance noise, emissions, fuel burn, land use, efficiency, and the costs and effects of alternative measures allows the selection of optimum operational modes, mitigation strategies, and surface planning procedures. [R-133], [R-134], [R-135]

The implementation of a NextGen-focused EMS model provides a flexible systematic approach to identify and manage environmental aspects of operations so as to meet capacity needs and environmental goals. The EMS approach is adaptable to the airport's characteristics, such as its size (large or small), its ownership (public or private), and its geography. Such a model allows airports to assess and improve environmental performance on an ongoing basis, rather than on a cyclic basis, linked to airport development, and it facilitates both capacity growth and environmental protection. The noise, air quality, and water quality concerns identified by airports and communities as critical to sustainable growth are fully integrated into "smart growth" management plans that have the ability for mid-course adjustment based on feedback and forecasts. Therefore, airports are able to assess their specific environmental requirements for sustainable growth and develop or select approaches (based on industry best practices) to address specific operational, geographic, and local community impacts that fit within that national framework. [R-136]

Local environmental monitoring allows the effects of management strategies to be assessed and best practices or lessons learned to be available system-wide. Monitoring enables regional and national trend analysis and supports decisionmaking and planning. Improved environmental information availability and subsequent information sharing ensures that proven practices are widely used and successes quickly proliferated.

7.3.4 Transformed Aircraft Design and Technology

Environmental considerations are a critical component of aircraft design and operations. These design and operational improvements also aim to reduce costs to aircraft operators, airports, and the ANSP. As regulation and environmental impact increasingly constrain capacity, public/private sector partnerships deliver more robust R&D that enables technological breakthroughs to dramatically reduce significant impacts. Scalable models and analytical capabilities that integrate noise, emissions, fuel burn, costs, and other factors enable development of the optimized aircraft performance characteristics, based on informed decisions of any necessary tradeoffs (e.g., between noise and emissions). [R-137]

The development of alternative fuels for aircraft is driven by costs, energy supply, security concerns, and environmental factors. Alternative fuels will be available and in service by 2025.

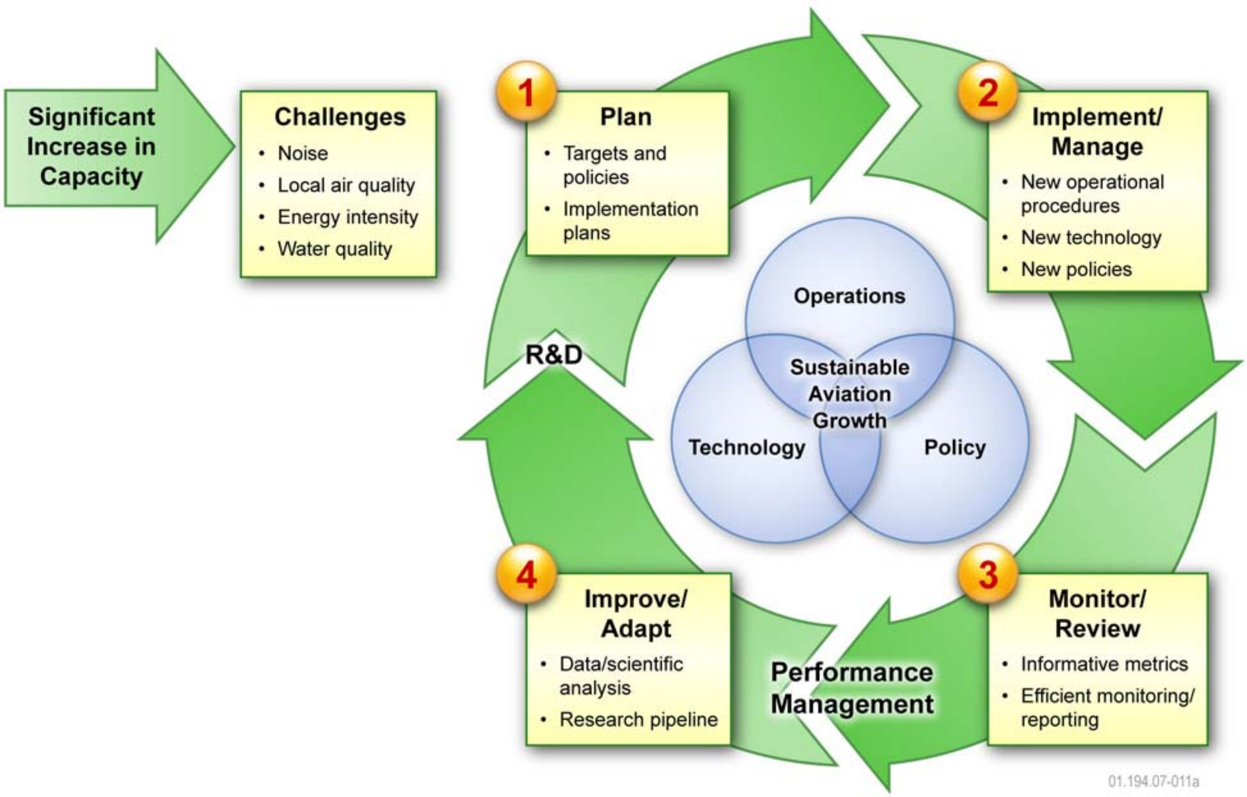
Use of environmentally sensitive technology is facilitated by a prompt and efficient development process where innovation, such as environmentally friendly airframe and engine design, is encouraged. [R-138] Design, product development, testing, and certification steps are well established, with changes in policy enabling a more direct flow from concept through implementation. This, combined with increased demand from aircraft operators, provides for a strong market for environmentally sensitive aviation technology. [R-139]

7.4 ENVIRONMENTAL MANAGEMENT FRAMEWORK POLICIES AND CAPABILITIES

The NextGen Environmental Management Framework is a single, fully integrated, cohesive system. NextGen uses this framework to manage and mitigate environmental constraints to capacity and impacts due to aircraft operations. An integrated NextGen Environmental Management Framework, consistent with this ConOps, is based on researching, designing, and implementing a broad set of enabling services and capabilities (i.e., systems and infrastructure). These services and capabilities are described in subsections 7.4.1 through 7.4.5. Each plays an important role in supporting the transformed operations of NextGen. [R-140], [P-65]

Figure 7-1 depicts the Environmental Management Framework Process.

Figure 7-1. Environmental Management Framework



7.4.1 Policy

NextGen Environmental Policy. Although many air transportation system component organizations have robust environmental programs, the focus of these multiple programs varies. Development of a unified NextGen environmental policy supported by a wide array of air transportation system stakeholders (e.g., airports, aircraft operators, agencies, communities) will assist component organizations with aligning their environmental systems with NextGen goals and objectives. The establishment of long-term measurable targets that address environmental issues critical to NextGen (e.g., noise, air emissions, fuel, climate effects, and water quality) is central to this policy. While this policy provides an overarching framework for NextGen, it also allows sufficient flexibility to ensure that organizations can design their programs to meet their unique challenges. Performance metrics provide a yardstick for monitoring and assessing progress towards meeting environmental targets. Metrics will be appropriate for use by the various air transportation system component organizations. These are reported via a net-centric environmental information management system for the purposes of analysis, continuous improvement, and public dissemination. [R-141]

Standardized EMS Model. There are a wide variety of approaches and methodologies for the application of EMSs. This flexibility is critical for EMSs to be applied to a diverse range of organization types. However, to meet future capacity challenges, NextGen EMSs will contain some necessary standard elements. Examples of these elements are mechanisms for incorporating enterprise-wide environmental objectives (e.g., reduction of significant community noise), reporting with standardized metrics, and linking to a NextGen environmental information management system. Therefore, a NextGen EMS model will be developed based on existing best practices. This model may be based on the globally recognized International Organization for Standardization (ISO) 14001 standard and will be sufficiently flexible to support the diverse needs of aviation system component organizations. It will also include those standard elements necessary to support an enterprise-wide approach to environmental management.

Incentives System. Although the NextGen Environmental Management Framework is expected to deliver net monetary savings to the system as a whole, incentives will likely be necessary to increase implementation and encourage environmental improvements at a more rapid pace than the market would normally provide. The consideration of incentives would be tied to specific NextGen environmental program initiatives or goals. [R-142]

Information Management System. A robust information management system is critical for transfering environmental information throughout NextGen. This system, for example, couples shared available information to provide real-time information to aircraft operators and the ANSP on dynamically forecasted areas of noise sensitivity, areas susceptible to dispersion of pollution, and volumes of airspace that are sensitive to emissions, so that these factors can be included in planning routes, approaches, and departures. This enables communication between different NextGen organizations; airports can share best practices or receive updates on new policy, regulation, or other initiatives with the NextGen system. Organizations are also able to directly input environmental metrics data, such as air emissions and noise monitoring data, from monitoring equipment into the system. Subsequent data analyses enable better decisionmaking and policy development, allowing for the adjustment of environmental objectives. They also facilitate the development of effective incentives and communication of all of these actions seamlessly across the NextGen in an efficient manner. Therefore, this single enterprise-wide system supports all the environmental information management needs of the NextGen. [R-143]

7.4.2 Operations Initiative

Integrated Environmental Planning. More flexible “smart plans” enable airports to make midcourse corrections to planned initiatives, thus shortening the planning horizon. Planning includes greater involvement of stakeholder groups and local communities. As part of the EMS, airports conduct standardized environmental evaluations to identify environmental resources that are adversely impacted and/or have the potential to constrain future airport capacity. This information supports long-term planning efforts and helps direct airport improvement initiatives to mitigate potential future resource constraints. Standardized environmental evaluations are reported via the enterprise-wide information management system so that it is possible to identify the specific, local environmental issues that must be addressed for NextGen to be enabled. This allows organizations to review regional and national trends and support planning and decisionmaking within NextGen.

Airport Approaches. A range of environmentally sensitive operational procedures are developed to assist airports and aircraft operators with minimizing environmental impacts. Currently, most aircraft use the standard approach route at an airport, though large numbers of noise abatement procedures are used. However, aircraft that use quiet technology will no longer produce significant noise impacts and therefore will be able to use a wide range of approaches. These procedures, developed based on improved tools and information (e.g., real-time weather information), increase airport efficiency and ensure the maximum number of aircraft operations can be accommodated within environmental limits (e.g., state implementation plan air quality requirements, land use compatibility guidance with aircraft noise exposure, or water quality regulations), without impacting capacity. [R-144], [R-145], [R-146], [R-147]

Environmental Routes Consideration. This initiative introduces environmental considerations into the route planning decisionmaking process, including identifying and considering cumulative effects in routing decisions and providing preference to quieter and less-polluting aircraft. In addition, advanced navigation systems enable greater routing flexibility without impacting capacity, while also enabling en route adjustments according to on-the-ground conditions (e.g., designated quiet times or air quality emergency days). For example, aircraft that have low noise and emissions have access to a wider selection of routes than those that do not have comparable technology. Enhanced real-time weather information allows better prediction of noise and emissions impacts. [R-148], [R-149]

Ground Procedures. The implementation of EMSs encourages the use of a range of environmentally sensitive and cost-effective standardized procedures for ground activities. These include converting airport GSE to alternative and low-emission fuels (e.g., use of fixed underground services), reducing the time spent on the ground by aircraft, reducing the use of auxiliary power units (APU), using environmentally sensitive deicing chemicals, and employing a wide range of other procedures. These standardized airport ground procedures are focused on enhancing surface operations, reducing delays, and minimizing environmental impacts. In particular, through the implementation of EMS, organizations use these activities in a focused manner specifically targeting pre-identified environmental impacts. An action taken to reduce emissions may increase aircraft noise, and vice versa.

7.4.3 Analytical Tools

Understanding the relationship and interdependencies between various environmental impacts is critical to minimizing environmental degradation. For example, if an action is taken to reduce air emissions, will this affect another impact category, such as noise? A suite of transparent, integrated aviation noise and emissions models is developed to help planners understand the environmental impacts of their actions holistically. The suite of models includes—

- The Environmental Design Space (EDS), a capability to provide integrated analysis of noise and emissions at the aircraft level
- The Aviation Environmental Design Tool (AEDT), which provides integrated capability to generate interrelationships between noise and emissions and among emissions at the local and global levels

- The Aviation Environmental Portfolio Management Tool (APMT), which provides the common, transparent cost/benefit methodology needed to optimize choice among standards, market-based options, policies, and operational procedures to gain the largest environmental benefit while understanding cost.

This suite of models allows government agencies and airport operators to understand how proposed actions and policy decisions affect noise and emissions. The models help industry understand how operational decisions influence proposed projects related to aviation noise and emissions. They also help the public understand how actions by Government and industry impact aviation noise and emissions. [P-66]

The tools allow optimized environmental benefits of proposed actions and investments, improved data and analyses on airport/airspace capacity projects, and increased capability to address noise and emissions interdependencies in the resolution of community concerns, health and welfare impacts, and better targeting of solutions to problems. Ultimately they will facilitate more effective portfolio management and support the EMS process. [P-66]

7.4.4 Technology

Clean and Quiet Technologies. In the near-term, new technologies to improve ATM enable new, quieter, and cleaner operations. In the mid-term, technologies from NASA's Quiet Aircraft Technology (QAT) and Ultra-Efficient Engine Technology (UEET) programs will be matured for private-sector implementation. In addition, the Research Consortium for Lower Energy, Emissions, and Noise Technology (CLEEN) is a partnership developed to make the aviation technology advances needed for quieter, cleaner, and more energy efficient NextGen. In the long-term, new engines and aircraft will feature enhanced engine cycles, components to enable quieter operations, more efficient aircraft aerodynamics, and reduced weight. These technology advancements enable significant reductions in noise and emissions.

Technology Development Processes. Aircraft design, navigational capabilities, and technology play a central role in NextGen's ability to increase capacity sustainably. The development of environmentally sensitive technology is encouraged by an efficient, expeditious R&D pipeline. A critical aspect will be the development of an innovative and sustainable source of funding and the formation of public/private partnerships to facilitate the movement of technology from the conceptual phase through to its operational use in NextGen. CLEEN is an example of the type of partnership needed to advance technology.

7.4.5 Science/Metrics

Enterprise Environmental Metrics. Environmental performance indicators (e.g., noise, emissions at the airport, emissions in the airspace), combined with other system information (e.g., forecasted traffic flows, market data, fleet size, technology implementation, operational procedures), provide the needed information to quantify the individual environmental impacts (noise impacts, local air quality, and global climate change). Based on information from the results of such scientific assessments, environmental metrics are defined to put all environmental impacts on a common scale and assign relative priority to reach a quantified goal. The metrics are used to derive analytical tools to study interdependencies and perform cost/benefit analyses.

These tools in turn drive policy, regulations, incentive programs, national objectives, operational procedures, and technology design goals. The development of new metrics to assess the impact of aviation activities on environmental and health welfare enables a robust NextGen EMS framework. Next generation metrics, based on improved scientific knowledge and computations of interdependent relationships and related benefit/costs, provide an enhanced platform for environmental decisions and mitigation. Metrics include new operating paradigms, such as very light jets and supersonic aircraft. [R-150]

7.5 ENVIRONMENTAL MANAGEMENT FRAMEWORK SUPPORT

The environmental framework focuses on improving linkages between various components of the air transportation system (e.g., airports, aircraft operators, federal agencies, manufacturers) and establishing a systematic but flexible framework to meet NextGen environmental protection needs for sustainable growth. Where possible, this aims to enable decisionmaking and planning at the implementation level with support from several mission support functions. These functions (e.g., environmental, market, social trends, best practices, lessons learned, feedback, incentives, monitoring) are accessible to provide more robust information to all components of NextGen through an information management and communication system. In addition, cross-functional groups that include representatives from all stakeholder entities are assembled to review trends, policy, monitoring, and goals at a national level. These groups provide a forum for discussing research, funding, policy, regulation, tools, and other issues linking the aviation system as a whole.

8 Safety Management Services

8.1 INTRODUCTION

The U.S. air transportation system is the safest in the world and has been for a long time. Achieving the NextGen safety objectives of *improving* the level of safety of the U.S. air transportation system and *increasing* the safety of worldwide air transportation requires designing the future air transportation system and safety management systems to control relatively benign events and how they combine in unexpected ways to create hazardous conditions.

The potential for significant growth and increased complexity in the air transportation system requires commensurate improvement in safety performance. To achieve this improvement there must be a fundamental change in the way the safety of the system is managed. NextGen's Safety Management Services will evolve from today's post-accident data analysis to integrated historical and prognostic evaluation and management of hazards and their potential safety risk to prevent future accidents. The key to success is the implementation of safety management systems integrated at the national level. The integrated safety management approach being developed includes—

- ***A national aviation safety strategy***
- ***A safety improvement culture***
- ***A prognostic SRM capability***
- ***A robust and protected safety information sharing and analysis procedure***

An enhanced safety assurance function.
This safety management approach is commonly referred to within the FAA as SMS and is in accordance with international standards.

The following three goals from the National Aviation Strategic Plan convey the system, practice, and worldwide impact of NextGen success:

- **Safer Systems.** Aviation system technologies are aimed at managing hazards, eliminating recurring accidents, and mitigating accident and incident consequences.
- **Safer Practices.** Safety is assured through standards, regulations, and procedures, including comprehensive monitoring, sharing, and analysis of safety information for proactive solutions.
- **Safer Worldwide.** System technologies, standards, regulations, and procedures are harmonized domestically and internationally to create an equivalent and improved level of safety across air transportation system boundaries.

This chapter focuses on the processes of safety management and the expectations for safety management practices for the 2025 timeframe. The safety goals for NextGen are intended to permit increases in capacity and efficiency while ensuring that the system's safety is maintained. Table 8-1 identifies present-day safety concerns and some of the proposed NextGen concepts that might mitigate each. As these concepts are designed and developed, they will be subjected to safer practices and risk management processes to ensure that they are indeed safe. Concept implementation must mitigate known risks and must not introduce significant sources of new risk. Transforming the air transportation system includes not only technological changes but human and institutional adjustments as well, which may be more challenging to implement.

Table 8-1. NextGen Mitigation Strategies to Reduce Risk

Current Safety Concern	NextGen Concept Elements That Mitigate Concern
On-Airport Collisions	• Optimized airfield design • Basic airport information supplied • Improved airport ability to operate in low visibility • Integrated Surface and Ramp Traffic Management System • Moving maps in the flight deck • 4DTs during super-density surface operations • Improved runway incursion prevention algorithms • SSA
Midair Collisions	• Interactive and iterative flight planning • Flow strategy and trajectory impact analysis • 4DTs, gate to gate • Dynamic resource and airspace management • Automated alerts within NEO environment • Improved avionics to support operations, including airborne separation • Delegated (airborne) separation • SSA
Landing Accidents	• Improved aircraft ability to operate in low visibility • Pre-landing distribution of taxi instructions • Improved airport ability to operate in low visibility • Automatic distribution of runway braking action reports • Detection of bird activity adjacent to airfield via UAS • Detection of entry of wildlife
Takeoff Accidents	• Aircraft sensors to improve deicing operations • 4DTs during super-density surface operations • Detection of entry of wildlife • Detection of bird activity adjacent to airfield via UAS
Terrain Encounters	• Improved aircraft ability to operate in low visibility • 4DTs, gate to gate • Extensive negotiation of 4D trajectories between air and ground • Automated alerts within NEO environment • Moving maps in the flight deck • SSA
Turbulence Encounters	• Weather assimilated into decisionmaking • Trajectory-based weather • Hazardous weather identified in real time • Improved avionics to receive and transmit weather information • Common integrated weather picture and virtual database • Real-time adaptation of applied separation for vortex mitigation • SSA

Table 8-2. NextGen Mitigation Strategies to Reduce Risk (continued)

Current Safety Concern	NextGen Concept Elements That Mitigate Concern
Mechanical Failures	• Integrated SMS • Improved safety management and oversight with focused audits • Improved safety analysis and prediction tools • Shared safety information • Integrated risk mitigation strategies
Maintenance Failures	• Integrated SMS • Improved safety management and oversight with focused audits • Shared safety information
Aircraft Fire	• Shared safety information • SSA

8.2 KEY TRANSFORMATIONS

Improved safety management is a principal enabler of a safe and efficient higher capacity air transportation system. Key transformations in safety management practices and processes facilitating improved operational safety are highlighted in Table 8-3. The transformations support the safety management functions addressed in Section 8.3.

Table 8-3. Significant Safety Management Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
National Aviation Safety Strategic Plan	• Safety management is inconsistent and fragmented. • Regulatory language is not consistently focused on safety priorities. • Safety rules and regulations are “prescriptive” in nature, restricting innovation in safety performance. • There is limited regulatory relief from enforcement actions afforded to voluntary disclosure programs. • Current safety programs are inefficient and nonuniform in administration. They are gradually giving way to improved global safety systems.	• A clear and cohesive National Aviation Safety Strategic Plan for the air transportation system formalizes safety requirements and compliance guidelines for all participants in the system. • Overall responsibility for safety management is assigned at the highest levels of the organization. Day-to-day safety management may be delegated. • A forum is established for continuous safety process improvements and the sharing of research, safety, and audit information. • Performance-based rules are enacted, emphasizing quality goals and allowing for greater certificate compliance delegation authority.

Table 8-4. Significant Safety Management Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Positive Safety Culture	• Not all government and industry stakeholders have a culture that embraces positive safety characteristics (e.g., punitive policies do not foster reporting and sharing of data).	• A positive influential safety culture is firmly established throughout all levels of stakeholder organizations. • A top-down management process is accountable for supporting a positive safety culture. • Mitigation strategy effectiveness can be improved through a non-reprisal reporting program where everyone reports errors and incidents.
Proactive Risk Assessment and Management	• Risk analysis is mostly forensic and diagnostic in nature. • Risk analysis is frequently performed after the system or operation is designed or implemented. • Risk analyses lack continuity, are slow, and are not always shared. • Monitoring, data sharing, and analysis are not integrated. • Precursors are not always known or proactively managed.	• Prognostic assessments are used to quantify safety risk levels of all system and procedural changes prior to implementation. • Advanced data analysis and risk modeling and simulations are used for greater understanding of unforeseen system risk introduced by unanticipated codependencies. • Risk assessments are based on coordinated and interlinked data sources. • Risk mitigation strategies are coordinated and integrated where appropriate at a national level. • Monitored data and assessments are shared and available in a timely manner. • A methodology is in place for determining the potential for combining contributing factors in unexpected ways that create a hazardous situation.
Safety Information Sharing	• System-wide sharing of voluntarily disclosed safety data is in the early stages of analysis and dissemination. • Information sharing is local and limited to specific challenges. • Legal and business concerns inhibit timely and widespread sharing of safety data. • Standards and infrastructure for sharing diverse safety and related data sources are not in place.	• A robust collection and analysis system for safety-related information and dissemination of lessons learned is in place. • Safety data is shared and employed across cognizant organizations to improve safety performance and drive action. • Timely sharing of sensitive safety-relevant data and information enables prompt action to prevent incidents and accidents. • A mechanism (network-enabled infrastructure) and standards are in place for sharing data among diverse stakeholders.

Table 8-5. Significant Safety Management Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Safety Assurance	• Safety assurance is based on prescriptive rule compliance, with the regulatory authority focused on extensive testing, inspecting, and certifying individual system and operational elements.	• The regulatory authority continuously measures and assesses the effectiveness of stakeholder safety management systems through joint audits and trend analysis. Performance-based standards are continuously reviewed and revised as experience dictates.

8.3 SAFETY MANAGEMENT ENTERPRISE OPERATIONS

The JPDO, along with its member agencies and industry partners, ensures the safety of NextGen by establishing and maintaining a *National Aviation Safety Strategic Plan* for air transportation; facilitating and stimulating the continuous improvement of the *safety culture* among NextGen stakeholders; consistently, systematically, and proactively applying and improving *safety risk management practices,* including increasing the *sharing of safety-critical data*; and enhancing *safety assurance*. The JPDO and its stakeholders will jointly define an optimal SMS that leverages government and industry experience to quickly identify and address non-normal, tactical, and strategic increased risk operations. [P-68]

8.3.1 National Aviation Safety Strategic Plan

A clear and cohesive National Aviation Safety Strategic Plan is developed to promote continuous improvement of safety and safety management practices and the sharing of research and safety-relevant information. This plan serves as the guiding principle to all government and industry participants in NextGen. It facilitates and encourages the proliferation and maintenance of a safety culture. This plan promotes SRM and safety assurance processes and practices. It assigns responsibility for safety to the highest levels of the organization, allowing delegation of day-to-day safety management but not of overall responsibility for safety. It establishes safety management standards and ensures that safety management processes and practices are "…consistent with the ICAO [International Civil Aviation Organization] standards."[13] [R-151], [R-152], [R-153], [P-69], [P-70], [P-71]

8.3.2 Safety Improvement Culture

A positive safety culture will focus Government and industry on "doing the right thing" by empowering individuals across functional lines to act upon reliable data according to clear expectations of measurement and behavior. The safety culture of an organization is the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety

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13 "Next Generation Air Transportation System Integrated Plan," Joint Planning and Development Office, referring to ICAO Annexes 6 (Operation of Aircraft), 11 (Air Traffic Services), and 14 (Airports Which Now Require Safety Management Systems).

programs. A positive safety culture is pervasive throughout all government and industry aviation stakeholders, thus facilitating a more proactive use of SRM principles and practices. These characteristics include but are not limited to management accountability, non-reprisal reporting, consistent use of SRM best practices, and sharing safety data and lessons learned. [R-154], [P-72]

8.3.3 Safety Risk Management

SRM is a construct that takes into account the frequency of an undesired outcome along with the possible consequences, permitting a rationale for appropriate prioritization of remedial action. It is a structured approach for identifying potential breakdowns in the system's operation, understanding the impact they may have on safety, identifying mitigation strategies, and evaluating and monitoring the strategies effectiveness. NextGen uses advanced data analysis, risk modeling, and simulations techniques, where applicable, for a systematic and comprehensive understanding of system and operational risk. These techniques are used to identify and understand the roles of precursors in past and potential accidents, and to evaluate the effectiveness of risk mitigation strategies, thus allowing accident precursors to be identified and proactively managed. Understanding the accident precursors and the effectiveness of risk mitigation strategies helps "…ensure safety requirements are established at the front end of every aviation process to prevent accidents before they happen" (*NGATS Integrated Plan*, 2004). Prognostic risk assessments based on data analysis and risk modeling techniques are used where feasible to quantify safety risk levels of system changes prior to implementation. Appreciating the interdependent and hierarchical risks of various NextGen operational improvements ensures optimal resource allocation for safety research and implementation. [R-155], [R-156], [R-157]

8.3.4 Safety Information Integration

The integration and sharing of high-quality, relevant, and timely aviation safety information is critical to the operational success of the Safety Management Enterprise. The Aviation Safety Information Analysis and Sharing (ASIAS) environment is a combination of processes, governance, technologies, information protection policies and standards, and architectures used to connect Safety Management Enterprise resources including information, organizations, services, and personnel.

In 2025, the ASIAS environment will support multiple levels of stakeholders within the Safety Management Enterprise, including government and private-sector decisionmakers with the responsibility of maintaining the aviation record as the safest mode of transportation. To do this, ASIAS provides easy access to a suite of tools used to extract relevant knowledge from large amounts of disparate safety information.

To facilitate the trusted exchange of aviation safety information, ASIAS leverages net-centric features by implementing need-to-know, role-based access capabilities. ASIAS plays a critical role in establishing and maintaining information protections. Further, ASIAS implements and continuously improves an Electronic Directory Service, a one-stop resource for stakeholders to discover relevant aviation safety information assets across multiple domains. Lastly, ASIAS establishes and continuously refines interoperability techniques by joining disparate data sources to uncover system-level hazards that were once undiscoverable.

8.3.5 Enhanced Safety Assurance

Safety Assurance is the independent oversight function that tests, evaluates, and certifies, as necessary, products and processes to ensure safety for the public and the stakeholders. The regulatory authority continuously measures and assesses the effectiveness of stakeholder SMSs through joint audits and trend analysis. Performance-based standards are continuously reviewed and revised as experience dictates. The responsibility for safety assurance is distributed among and between the regulators and the providers. As a result of this delegation, the regulatory authority is better equipped to focus resources on the most safety-critical systems and operations.

To support national-level proactive hazard identification, risk assessments, and the Safety Assurance function, the "incompatible databases scattered throughout Government and industry" (*NGATS Integrated Plan*, 2004) are transformed into a coordinated and interlinked data source using the network-enabled infrastructure. The safety-critical events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information. [R-158], [R-159], [R-160], [R-161], [P-73], [P-74]

8.4 SAFETY MANAGEMENT ENTERPRISE SERVICES AND CAPABILITIES

National-level Safety Management Services are provided to facilitate safety management and cooperation across aviation stakeholder organizations. These services providecoordination of safety activities such as research and risk mitigation strategies, injection of critical and timely safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation. [R-162], [R-163], [R-164], [R-165], [P-75], [P-76], [P-77] The safety services may be provided to varying degrees by local or federal government agencies, or by industry associations, technical societies, or other nongovernmental organizations. They may be either permanent or temporary bodies. These services have been grouped into categories further described in subsections 8.4.1 through 8.4.5 below. This does not diminish the responsibility for improving and managing safety that is the foundation for each stakeholder organization's safety culture.

8.4.1 Aviation Safety Strategic Plan Service

The Safety Strategic Plan Service provides—

- ***A coordinated and maintained national safety plan***
- ***Coordinated cooperation in aviation safety management research***
- ***Steps to promote and enhance an effective safety culture, including recommending appropriate training and addressing legal and liability issues***
- ***Direction that an organization's top management is responsible for safety performance much in the way that they are currently responsible for financial performance. Coordination with foreign and international organizations and air transportation stakeholders.***

8.4.2 Safety Promotion Service

The Safety Promotion Service provides—

- A Safety Culture Improvement Plan, which includes examples of strategies and tools that can be used by the stakeholders
- Implementation guidelines for safety culture improvement
- Capabilities for additional research into the relationship between safety climate scores and mishap rates
- Development and distribution of material that facilitates awareness of the importance of organizational culture in fostering safety.

8.4.3 Safety Risk Management Service

The Safety Risk Management Service provides—

- ***Safety data management capability, including data sharing and protection, and formatting requirements to facilitate data analysis and reporting***
- ***Integrated NextGen-wide risk assessment capability via data analysis, models, and simulations development, maintenance, and applications designed as an aid to understanding the relative risks across NextGen and also the effectiveness of mitigation strategies***
- ***Continued understanding of safety culture impacts on NextGen safety***
- Assessments of the impact on safety (including on safety culture) of proposed new regulations.

8.4.4 Safety Information Integration Service

The ASIAS environment provides—

- ***A one-stop-shop for aviation safety information required to support Safety Management Services***
- ***Large amounts of safety information from multiple domains under one virtual roof***
- ***Processes for acquiring access to data from multiple, disparate information sources***
- ***Authorized end users with easy and timely access to relevant aviation safety information***
- ***Role-based, need-to-know authorization features***
- ***Coordination and maintenance of aviation safety information protection policies and procedures***
- Adaptation to meet the ever-changing safety information requirements of the Safety Management Enterprise operations.

8.4.5 Safety Assurance Service

The Safety Assurance Service provides—

- Certification

- ***—SMS certification***
- ***—System and operation certification***
- ***Training***
- ***Independent evaluations (using SRM services) of systems, operations, and safety culture***
- ***Accident investigation services***
- ***Other regulatory and oversight services***
- ***Integration of safety management into infrastructure planning and management, and into intermodal operations***
- Regulatory and policy enforcement service.

8.5 INTEGRATION OF SMS INTO NEXTGEN SERVICES

All modifications to existing systems, procedures, equipment, and policies, and all transformations undertaken by the services to achieve NextGen, undergo the safety risk analysis and management process. Each of the services identifies the requirements to meet target levels of safety through integrated safety assessments and implements SMS to accomplish the goals. The NextGen-integrated SMS specifies a collaborative and integrated safety hazard/ mitigation strategy. Results from safety assessments are factored into the operational data requirements for each of the services. SMS data required for identification and tracking of hazards and trend analysis is centrally managed and accessible to users. SMS best practices and lessons learned are coordinated across the services.

9 Performance Management Services

9.1 INTRODUCTION

Among the major determinants of acceptable system performance is the acceptable level of risk. Historically, system risk has been managed at the component level by inspection, oversight, procedural compliance, verification, and trend monitoring. In the dynamic system of the future, risk management is a requirement for a real-time process, especially as dynamic changes in authority delegation and airspace definitions occur. The Performance Management Service is designed to facilitate decisionmaking with respect to the safety of these dynamic changes as well as establish a method for monitoring system component performance in real time.

The significant transformation this service will engender is the evolution from retrospective evaluation of risk and utility of system configuration to near-real-time system performance assessment for system performance management. The intent is to switch to real-time (operational impact) reviews of system safety and performance in lieu of historical-based analysis.

This capability fosters new integrated monitoring and management services through the use of new system design (including new roles and responsibilities). Further, real-time system performance allows—

- ***Use of onboard data monitoring to manage individual aircraft safety among the COIs***
- ***Use of inter-aircraft data to provide inter-element compliance and performance data to systems***
- Enhanced use of aircraft-ground monitoring of operational characteristics in the decisionmaking process.

As a result, the performance management system is a better integrated and more accurate tool for information.

9.2 KEY TRANSFORMATIONS

As shown in Table 9-1, the key performance management transformations are in the areas of providing real-time information and communication.

Table 9-1. Significant Performance Management Transformations

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Real-Time Performance Management System	Real-time NAS-level performance monitoring of many operational parameters	Real-time NAS-level performance monitoring for all key system metrics

Table 9-2. Significant Performance Management Transformations (continued)

Significant Transformation	2006 Current Capability	2025 NextGen Capability
Real-Time Aircraft Data Communication	Use of self-reports (via PIREPs, radio, etc.) or ADS-B to track aircraft performance; TCAS alerts in high-risk situations	Real-time inter-aircraft operational data sharing and system performance management decision framework
Real-Time On-Aircraft Operational Data Management	No real-time aircraft performance data collected; certification of compliance with navigation performance is done as an independent process.	Real-time on-aircraft operational data management and evaluation of aircraft performance for compliance with performance levels
Real-Time Inter-Aircraft Operational Data Management	Limited real-time aircraft-to-pilot health monitoring	Real-time inter-aircraft operational data management and evaluation of inter-aircraft performance for compliance with performance levels

Real-time measures of system risk and safety performance are developed based on the internal capability of system performance evaluation and integrated decisionmaking. This operational metric-based management completes the holistic model of Performance Management Services. Consequently, this transformation fosters real-time data communication, real-time operational data management, real-time measures of system risk and safety performance, and the metric results of operational system performance.

9.3 PERFORMANCE MANAGEMENT ENTERPRISE SERVICES

System risk management is an integrated function within the overall NAS architecture, using both the components of the architecture as nodes for data gathering and reporting and computing systems, both distributed and centralized, to identify anomalous situations and circumstances that are accident precursors as well as other potential hazards. [R-166] Since the current risk management system is based on historical data analysis and forensic situational decomposition, it is difficult to use it in a proactive manner to manage system safety. The new concept uses this historical data to develop a model of the relationship between risk (even probabilities and consequences) and observable operational data (including flight operational quality data on board aircraft, aircraft-to-aircraft transmissions, ground-based system observations, and NAS-level system performance information). This relationship is dynamically updated to provide risk indicators for various operational conditions, including environment (e.g., weather), aircraft density, airspace complexity, aircraft performance, and the performance of other system component characteristics that may affect risk. [R-167]

9.3.1 Service 1: Operational Metric Monitoring

The development of the system risk management process is based on a relationship between operational metrics and system risk. This model is based on historical incident/accident data and provides nominal conditions for normality (acceptable risk) associated with operational performance data. Metrics are suggested and verified for their ability to reflect risk and to provide operators with executable data.

9.3.2 Service 2: Aircraft OnBoard Data Collection and Management

In an operational environment that involves significant aircraft self-management, onboard collection of data on aircraft performance is required to provide two key types of decision-quality data: (1) the quality of the aircraft's performance vis-à-vis the operator's intended actions, and (2) the behavior of the aircraft vis-à-vis its neighbors and compliance with a given navigation performance requirement. Onboard integrated data management must be developed that provides information to operators, other aircraft, and the relevant actors in the NAS based on the statistical performance data collected by onboard instrumentation.

9.3.3 Service 3: Aircraft-to-Aircraft Data Standards and Exchange; Operational Metric (e.g., Risk) Model

The data and information collected in Service 2 must be broadcast in such a way as to give other aircraft that are operating in self-management information on intent and aircraft performance (e.g., navigation and height-keeping performance) to minimize the risk of collision due to aircraft failure or pilot error. The standard messages required for information exchange and SSA support information sharing developed in Service 2.

9.3.4 Service 4: Aircraft-to-Ground Data Standards and Exchange

Similarly, a standard message set related to operational metrics and based on aircraft performance data is developed to broadcast aircraft performance information to the distributed or centralized control facility. These data are part of the required inputs for aggregate airspace risk management.

9.3.5 Service 5: ANSP Management Software—Integrated System Performance Models

As discussed above, an integrated risk performance model is developed based on the historical association between incidents and accidents and the operational performance of the system associated with those incidents. This model provides a risk probability to control functions (such as the ANSP) for given time intervals based on the data collected on individual aircraft performance, aircraft-to-aircraft operational performance data, and environmental conditions (e.g., weather, visibility). The management software provides standard risk-level estimates to operators (such as controllers) or directly to aircraft (under self-separation and management) with respect to allowable separations, closing speed, access to airspace, and the like.

9.4 PERFORMANCE MANAGEMENT MISSION SUPPORT

The dynamic assignment of airspace to varying levels of capability and the reassignment of separation assurance functions within the system require a system evaluation function that provides real-time operational performance monitoring to assess risk and efficiency management.

Within each element of the system (e.g., aircraft, pilot, controller, airspace), levels of monitoring and comparison of current operational performance against the required performance metics must be maintained to facilitate allocation and management system decisions.

While the operator makes allocation decisions based on the performance of system optimization schemes, the system is not necessarily able to diagnose variance from performance requirements that may increase risk (to aircraft operation, among aircraft, for ground system control, or among system elements). This function provides a system-level model (aggregated from component-level models of risk and operational performance) that allows system elements to evaluate their current operational performance as compared to the ideal requirements for safe operation. Accordingly, this system-level model is compared to the elements of the system for decision quality data and recommended actions.

Appendix A: Acronyms

Term	Definition
3D	Three-Dimensional
4DT	Four-Dimensional Trajectory
ACAS	Airborne Collision Avoidance System
AEDT	Aviation Environmental Design Tool
AIS	Aeronautical Information Services
ANSP	Air Navigation Service Provider
AOC	Airport Operations Center
APMT	Aviation Portfolio Management Tool (Environmental)
APU	Auxiliary Power Unit
AR	Aerial Refueling
ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air Traffic Control
ATM	Air Traffic Management
AVT	Automated Virtual Tower
BLOS	Beyond Line-of-Sight
BRAC	Base Realignment and Closure
C-ATM	Collaborative Air Traffic Management
CBP	Customs and Border Protection
CBRNE	Chemical, Biological, Radiological, Nuclear, and High-Yield Explosive
CDM	Collaborative Decision-Making
CFR	Code of Federal Regulations

Term	Definition
CIP	Capital Improvement Program
CLEEN	Consortium for Lower Energy, Emissions, and Noise Technology
CM	Capacity Management
CNS	Communications, Navigation, and Surveillance
COI	Communities of Interest
ConOps	Concept of Operations
CSCE	Certified Supply Chain Entity
CSPA	Closely Spaced Parallel Approach
CST	Commercial Space Transportation
CTA	Controlled Time of Arrival
CUTE	Common-Use Terminal Equipment
DHS	Department of Homeland Security
DOC	Department of Commerce
DoD	Department of Defense
DOJ	Department of Justice
DOT	Department of Transportation
DSP	Defense Service Provider
DSS	Decision Support System
DST	Decision Support Tool
DUAT	Direct User Access Terminal
EDS	Environmental Design Space
EMAS	Engineered Material Arresting System

Term	Definition
EMP	Electromagnetic Pulse
EMS	Environmental Management System
EVFR	Electronic Visual Flight Rules
EVO	Equivalent Visual Operations
FAA	Federal Aviation Administration
FCAPS	Fault, Configuration, Accounting, Performance, Security
FCM	Flow Contingency Management
FDMS	Flight Data Management Services
FIDS	Flight Informational Display Systems
FIR	Flight Information Region
FL	Flight Level
FOC	Flight Operations Center
GA	General Aviation
GIS	Geospatial Information Services
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSE	Ground Support Equipment
IAP	Instrument Approach Procedure
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions

Term	Definition
IRM	Integrated Risk Management
ISO	International Standards Organization
JPDO	Joint Planning and Development Office
LAAS	Local Area Augmentation System
MANPADS	Man-Portable Air Defense System
MOA	Memoranda of Agreement
MPO	Metropolitan Planning Organization
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NAVAID	Navigational Aid
NDOT	NGATS Decision Oriented Tool
NEI	Network Enabled Infrastructure
NEO	Network Enabled Operations
NextGen	Next Generation
NGATS	Next Generation Air Transportation System
NIMS	National Incident Management System
NNEW	NGATS Network Enabled Weather
NOTAM	Notice to Airmen
NPIAS	National Plan of Integrated Airport Systems
OSTP	Office of Science and Technology Policy
PIREP	Pilot Report (Weather)
PIRG	Planning and Implementation Regional Group

Term	Definition
POFZ	Precision Obstacle–Free Zone
PNT	Positioning, Navigation, and Timing
PWD	Person with Disability
QAT	Quiet Aircraft Technology
QoS	Quality of Service
R&D	Research and Development
RCP	Required Communications Performance
RFID	Radio Frequency Identification
RNAV	Area Navigation
RNP	Required Navigation Performance
RSP	Required Surveillance Performance
RTSS	Remote Terminal Security Screening
SAA	Special Activity Airspace
SIDA	Security Identification Display Area
SM	Separation Management
SMS	Safety Management System
SOA	Services Oriented Architecture
SRA	Security Restricted Airspace
SRM	Safety Risk Management
SSA	Shared Situational Awareness
SSCE	Secure Supply Chain Entity
SSP	Security Service Provider

Term	Definition
SUA	Special Use Airspace
SVT	Staffed Virtual Tower
SWIM	System-wide Information Management
TBO	Trajectory-Based Operations
TCAS	Traffic Alert and Collision Avoidance System
TERP	Terminal Instrument Procedure
TFM	Traffic Flow Management
TFR	Temporary Flight Restriction
TM	Trajectory Management
TMI	Traffic Management Initiative
UAS	Unmanned Aircraft System
UEET	Ultra-Efficient Engine Technology
UTC	Universal Time Constant
V/STOL	Vertical/Short Takeoff and Landing
VFR	Visual Flight Rule
VLJ	Very Light Jet
VMC	Visual Meteorological Condition
WAAS	Wide Area Augmentation System
WMD	Weapon of Mass Destruction
Wx	Weather

Appendix B: Glossary

Term	Definition
Aeronautical Information Service (AIS)	The near-real-time transmission of accurate aeronautical information, including updates on airspace restrictions; performance requirements for airspace access and operations; system outages; airport status information; static information, such as approach plates; and certain fixed airspace definitional data, such as fixed special activity airspace and airport information.
Air Carrier	The Air Carrier operational node represents the operational users of NGATS. An air carrier includes commercial passenger or cargo airlines, military air commands, business aviation, and private air vehicle operators.
Air Domain	The global airspace, including domestic, international, and foreign airspace, as well as all manned and unmanned aircraft operating in and people and cargo present in that airspace, and all aviation-related infrastructures.
Air Navigation Service Provider (ANSP)	Used generically, ANSP refers to the organization, personnel, and automation that provide separation assurance, traffic management, infrastructure management, aviation information, navigation, landing, airspace management, or aviation assistance services for airspace users.
Air Traffic Management (ATM)	The dynamic, integrated management of air traffic and airspace—safely, economically, and efficiently—through the provision of facilities and seamless services in collaboration with all parties.
Airborne Self-Separation	Refers to all aircraft within the airspace or airport movement area maintaining separation from all other aircraft within the airspace or airport movement area according to defined rules and separation criteria. The ANSP is not responsible for separation between aircraft. When authorized by the ANSP, equipped aircraft in this airspace maintain separation from all other aircraft, including those managed by the ANSP.
Airborne Separation	Refers to separation delegated to an individual aircraft to maintain separation from a designated aircraft, either in flight or on the airport movement area, such as for a crossing or passing maneuver. Separation of this aircraft from all other aircraft, including all aircraft to which separation has not been delegated, remains the responsibility of the ANSP. Pairwise separation and closely spaced parallel approaches are also in this category.
Airborne Separation Assurance	Refers to a capability of the aircraft to maintain awareness of and separation from other aircraft, airspace, terrain, or obstacles. There are four different levels of airborne separation assurance (based on the RTCA definition)—airborne traffic situational awareness, airborne spacing, airborne separation, and airborne self-separation.
Airborne Spacing	Refers to the capability of one aircraft to achieve and maintain a defined distance in space or time from another aircraft. Separation responsibility remains with the ANSP.
Airborne Traffic Situational Awareness	Refers to flight crew knowledge of nearby traffic depicted on a cockpit traffic display without any change of separation tasks or responsibility.

Term	Definition
Aircraft	Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface. An aircraft can include a fixed-wing structure, rotorcraft, lighter-than-air vehicle, or a vehicle capable of leaving the atmosphere for space flight.
Airport	A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft.
Airspace Classification	Airspace with a common air traffic management interest and use, based on similar characteristics of traffic density, complexity, air navigation system infrastructure requirements, aircraft capabilities, or other specified considerations wherein a common detailed plan will foster the implementation of interoperable CNS/ATM systems.
Airspace Design	The process of transforming routes, fixes, sectors, and other structural/operational elements of the NAS to ensure a safe, secure, and efficient aviation system.
Air Navigation Service Provider (ANSP)	An organization responsible for and authorized to provide air traffic management (ATM) services; communications, navigation, and surveillance (CNS) services; meteorological services for air navigation; and aeronautical information services.
Air Navigation Service Provider (ANSP) Flow Airspace	High-density, moderate complexity airspace where the flight operator executes a 4DT agreement. Trajectory Management (TM) ensures the overall flows are well behaved so that potential conflicts are kept to a minimum. Separation Management (SM) is performed automatically by ground automation. If conflicts are detected, the ground automation issues revised 4DTs to the flight operator.
Area Navigation (RNAV)	A method of navigation that permits aircraft operation on any desired flight path within the coverage of station-referenced navigation aids, the limits of the capability of self-contained aids, or a combination of these.
Area Navigation (RNAV) Operations	Aircraft operations using an RNAV system. RNAV Operations remove the requirement for a direct link between aircraft navigation and a NAVAID, thereby allowing aircraft better NAS access and permitting flexibility of point-to-point operations. RNAV Operations include RNAV and RNP applications.
Area Navigation (RNAV) Route	An ATS route established for the use of aircraft capable of employing area navigation.
Arrival/Departure Airspace	Airspace from the top of climb or descent to the airport surface. It includes only the arrival and departure corridors in current use, but extends to en-route altitudes.
Automated Virtual Tower (AVT)	A facility where sequencing services and basic airport information are provided without the use of ANSP personnel, at a service level that is enhanced compared with typical nontowered airports in 2006.
Auto-Negotiation	The interaction among two or more systems to identify a specific operational response acceptable to the parties (e.g., flight operator and ANSP) served by the automated system. The automated systems would use the known operating constraints or user preferences to identify the preferred response.
Capacity	The maximum number of aircraft that can be accommodated in a given time period by the system or one of its components (throughput).

Term	Definition
Capacity Management	The long-term and short-term management and assignment of NAS airspace and routes to meet expected demand. This includes assigning related NAS assets as well as coordinating longer term staffing plans for airspace assignments. It includes the allocation of airspace to airspace classifications based on demand, as well as the allocation of airspace and routes to ANSP personnel to manage workload.
Classic Airspace	Low-altitude airspace away from the busiest terminal areas (those not engaged in super-density operations) that accommodates mixed capability aircraft, including those under visual flight rules.
Collaborative Air Traffic Management	The collaborative process among the ANSP, flight operators, airport operators, and other stakeholders, to manage objectives for capacity management, flow contingency management, and trajectory management. Collaborative air traffic management (C-ATM) is the means by which flight operator objectives and constraints are balanced with overall NAS performance objectives.
Complexity	A description of how nonhomogeneous the traffic demand is. Factors that cause complexity to be higher are large numbers of vertically transitioning aircraft, large numbers of crossing paths, large variation in speeds, etc.
Conflict	Any situation involving an aircraft and a hazard in which the applicable separation minima may be compromised.
Constraint	Any limitation on the implementation of an operational improvement, or a limitation on reaching the desired level of service.
Controlled Time of Arrival	The assignment and acceptance of an entry/use time for a specific NAS resource. Examples include point-in-space metering, time to be at a runway, or taxi waypoints.
Cooperative Surveillance	The determination of an aircraft's 3D position utilizing equipment on the airframe. In comparison, noncooperative surveillance would be the determination of an aircraft's 3D position without the aircraft participating.
Demand	The number of aircraft requesting to use the ATM system in a given time period.
Enablers	Initiatives, such as (new) technologies, systems, operational procedures, and operational or socioeconomic developments, that facilitate the implementation of operational improvements or of other enablers.
Enterprise Services	Any or all of the key services that are provided to all COIs throughout NGATS, and can be characterized by the net-centric infrastructure services that provide connectivity and universal access to information; and by services that provide the collection, processing, and distribution of information. This includes Shared Situational Awareness, Security Management, Safety Management, Environmental Management, and Performance Management Services.

Term	Definition
Environmental Management System	An organizational business process that consists of four phases. In the first “planning” phase of the NGATS EMS, the organization will identify environmental issues with the potential to constrain future capacity. These will be the focus of tactical, measurable objectives for which improvement initiatives can be undertaken during the second “implementation” phase. During the third “assessment” phase, the effectiveness of these initiatives is monitored and key performance metrics tracked. Monitoring data are then used to support planning at the organization itself in the fourth “review and adaptation” phase. In the NGATS EMS, monitoring data will also be reported at an enterprise level to support NGATS-wide planning.
Equivalent Visual Operations	The capability to provide aircraft with the critical information needed to maintain safe distances from other aircraft during nonvisual conditions, including a capability to operate at levels associated with VFR operations on the airport surface during low-visibility conditions. The ANSP personnel delegate separation responsibility to the flight operators. This capability builds on net-enabled information access, certain aspects of performance-based services, and some elements of PNT services and layered adaptive security.
Flight Crew	The individual or group of individuals responsible for the control of an individual aircraft while it is moving on the surface or while airborne.
Flight Object	The representation of the relevant information about a particular instance of a flight. The information in a flight object includes (1) aircraft capabilities, including the level of navigation, communications, and surveillance performance (e.g., FMS capabilities); (2) aircraft flight performance parameters; (3) flight crew capabilities, including level of training received to enable special procedures; (4) 4DT profile and intent, containing the “cleared” 4DT profile plus any desired or proposed 4DTs; and (5) aircraft position information and near-term intent. Standards for the definition of a flight object are in development.
Flight Operator	The organization or person responsible for scheduling, planning, and directly operating the aircraft. Roles within the flight operator include the flight scheduler, flight planner, and flight crew and may reside with one individual or be delegated to separate individuals.
Flight Plan	Specified information relating to the intended flight of an aircraft that is filed electronically, orally, or in writing with an ANSP facility.
Flight Planning	A series of activities preformed before a flight that includes, but is not limited to, reviewing airspace and navigation restrictions, developing the route, obtaining a weather briefing, completing a navigation log, filing a flight plan, and inspecting the aircraft.
Flight Plan Filing and Flight Data Management Services	The management of data related to a flight, from the initial filing of a proposed flight to the closing of the flight plan and the archiving of the data to support performance management analyses.

Term	Definition
Flow Contingency Management	The process that identifies potential flow problems, such as large demand capacity imbalances, congestion, a high degrees of complexity, blocked or constrained airspace, or other off-nominal conditions. It is a collaborative process between ANSP personnel and airspace users to develop flow strategies to resolve the flow problems. Examples of flow strategies include establishing routing to reduce complexity, restructuring airspace, and allocating access to airspace or runways.
Flow Corridor	A corridor is a long "tube" of airspace that encloses groups of flights flying along the same path in *one* direction. It is airspace procedurally separated from surrounding traffic and special use airspace, and it is reserved for aircraft in that group. There is a minimum distance that traffic within the corridor must maintain from the edge of the corridor (i.e., "the corridor walls have some thickness").
Flow Strategy and Trajectory Impact Analysis Services	This capability in the NGATS provides a common "what if" function to assess potential changes in planned flights, the allocation and configuration of assets, as well as other conditions (e.g., weather, security initiatives, etc.) that may affect flight operations.
Four-Dimensional Trajectory (4DT)	A 4DT represents the "centerline" of a path plus the positioning uncertainty, including waypoint. Positioning uncertainty includes lateral, longitudinal, and vertical positioning uncertainty. Some waypoints within a 4DT may be defined with controlled times of arrival (CTAs), which constrains the uncertainty for planning purposes. The required level of specificity of the 4DT will depend on the operating environment in which the flight will be flown. Associated with a 4DT is the separation zone around an aircraft and the aircraft intent information, which provides near-term information on the expected flight path.
General Aviation	The term used to describe any flight other than a military or scheduled airline flight, ranging from gliders and powered parachutes to large, nonscheduled cargo jet flights.
Hazards	The objects or elements from which an aircraft can be separated. These include other aircraft, terrain, weather, wake turbulence, incompatible airspace activity, and, when the aircraft is on the ground, surface vehicles and other obstructions on the apron and maneuvering area.
Human-Centric	The ATM system is designed around the capabilities and limitations of humans. It assigns functions to humans that are best performed by them, and it provides automation assistance when it can improve decision-making or make the humans' tasks easier. It does not imply that humans are always in direct control.
Human Factors	The discipline concerned with the understanding of interactions among humans and other elements of a system. It applies theory, principles, data, and other scientific methods to system design to optimize human well-being and overall system performance.
Information Services	A service that provides data and information to subscribers when and where needed in a common format. Ensures questions raised by data consumers are answered correctly and consistently.
Infrastructure Services	A service that provides communications connectivity to ensure information flows work reliably to support information communications and sharing functions.

Term	Definition
Integrated Risk Management (IRM)	A process that includes prognostic tools, models, and simulations at the strategic, operational, and tactical level to support all stakeholder decision makers and managers in the grafting of cost-effective "best practices" into the design, acquisition, deployment, and operation of aviation security system assets and infrastructures. Knowledge bases concerning threats, vulnerabilities, and practices are tailored to user profiles that proactively determine need/authorization to know.
Intelligent Agents	Within the context of this operational concept, refers to a computational system that includes the following characteristics: is aware of constraints, has goals, and operates autonomously within its construct to identify information or opportunities for human action. It is customized for an area or task, is adaptive, knows the user's preferences/interests, and can operate on their behalf (e.g., by narrowing the choices available through auto-negotiation). As such, this concept's definition is consistent with commonly accepted industry standards.
Intent	Information on planned future aircraft behavior, which can be obtained from the aircraft systems (avionics). It is associated with the commanded trajectory and takes into account aircraft performance, weather, terrain, and ATM service constraints. The aircraft intent data correspond either to aircraft trajectory data that directly relate to the future aircraft trajectory as programmed inside the avionics or the aircraft control parameters as managed by the automatic flight control system. These aircraft control parameters could either be entered by the flight operator or automatically derived by the flight management system.
Layered Adaptive Security	The security system will be constructed in "layers of defense" to detect threats early and prevent them from meeting their objective while minimally affecting efficient operations. Airports and aircraft will be designed to be more resilient to attacks or incidents. Building on the "net-enabled information access" and "performance-based services" capabilities, risk assessments will begin well before each flight so that people and goods will be appropriately screened as they move from the "airport" curb to the aircraft, or as they support aerodrome/aircraft operations. As technology matures, screening will be unobtrusive and more transparent to the individual. All people and cargo that "touch" or are carried by an aircraft will be positively identified. Responses to anomalies and incidents will be proportional to the assessed risk of the involved individuals or cargo.
Managed Airspace	An Air Navigation Service Provider provides Air Traffic Management Services; separation is delegated as appropriate to equipped aircraft.
Metroplex	A group of two or more adjacent airports whose arrival and departure operations are highly interdependent.
Near-Space Airspace	Low-density, low-complexity airspace at very high altitudes that accommodates a wide range of special operations (e.g., high-speed reconnaissance aircraft, aerostats, long-endurance orbiting unmanned aircraft systems).
Net-Centricity	For aviation transportation efforts, defines a robust, globally interconnected network environment in which information is shared in a timely and consistent manner among users, applications, and platforms.

Term	Definition
Net-Enabled Information (NEI)	An information network that makes information available, securable, and usable in real time to distribute decision making. Information may be pushed to known users and is available to be pulled by other users, including users perhaps not previously identified as having a need for the information.
Network Enabled Operations (NEO)	The decision support and other applications using NEI for information transfer and retrieval.
NGATS Decision Oriented Tool (NDOT)	A tool that incorporates observations, forecasts, model/algorithm data, and climatology, including surface observations and weather aloft to allow full integration of weather into traffic flow decision making.
NGATS Network Enabled Weather (NNEW)	The 4D net-centric weather information network that publishes discoverable past, current, and future weather data and information for decision makers; enabling weather situational awareness when planning and executing operations across the full spectrum of the Air Transportation System.
Non-Managed Airspace	Uncontrolled, low-altitude airspace where no ANSP services are provided, except as required to coordinate entry to a different class of airspace.
Oceanic Airspace	That airspace over the oceans of the world, considered international airspace, where oceanic separation and procedures per ICAO are applied. Responsibility for the provisions of ATC service in this airspace is delegated to various countries, based generally upon geographic proximity and the availability of the required resources.
Performance-Based Navigation	Performance-based navigation specifies RNAV system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure, or in an airspace. Performance requirements are defined in terms of accuracy, integrity, continuity, availability, and functionality needed for the proposed operation in the context of a particular airspace concept. Performance requirements are identified in navigation specifications that also identify the navigation sensors and equipment that may be used to meet the performance requirement.
Performance-Based Operations	Use of performance capability definition versus an “equipment” basis to define the regulatory/procedural requirements to perform a given operation in a given airspace.
Performance-Based Services	There are multiple service levels aligned with specified user performance thresholds to provide choices to users depending on needs, required communication, navigation and surveillance performance, environmental performance criteria, security parameters, and so forth. Services will be flexible according to the situation and consolidated needs of the users. Services vary from area to area in terms of airspace and “airport” surfaces, and they vary with time as needs dictate. Preferences are established based on user capability, equipage, training, security, and other considerations. The performance-based approach is used to analyze risks (e.g., safety, security, environment) instead of “equipment-based” approaches. The performance-based services capability will enable a definition of service tiers and allow the government to move from equipment-based regulations to performance-based regulations.

Term	Definition
Position, Navigation, Timing (PNT) Services	A service that enables the ability to accurately and precisely determine one's current location and orientation in relation to one's desired path and position; apply corrections to course, orientation, and speed to attain the desired position; and to obtain accurate and precise time anywhere on the globe, within user-defined timeliness parameters.
Required Navigation Performance	A statement of the navigation performance accuracy necessary for operation within a defined airspace. RNP Operations introduce the requirement for on-board navigational performance monitoring and alerting.
Required Navigation Performance Level or Type (RNP-X)	A value, in nautical miles (NM), from the intended horizontal position within which an aircraft would be at least 95 percent of the total flying time.
Route	A 3D path through space with no time component. Unlike corridors, aircraft can cross routes as operational need requires, with proper separation provided to all aircraft.
Safety Assurance	The independent oversight function that tests, evaluates, and certifies, as necessary, products and processes to ensure that they are safe for the public and stakeholders.
Safety Culture	The product of individual and group values, attitudes, competencies, and patterns of behaviors that determine the commitment to, and the style and proficiency of, an organization's health and safety programs.
Safety Management System (SMS)	The process that provides a systematic method for managing safety. The four components of an SMS are policy, architecture, assurance, and safety promotion.
Safety Risk Management (SRM)	The set of processes and practices by which a concept and its operation are designed and made to be safe.
Self Separation Airspace	That airspace where aircraft self-separation enables maximum user flexibility in exchange for high-capability equipage of the aircraft.
Separation Management	The function of ensuring aircraft or vehicles maintain safe separation minima from other aircraft or vehicles, protected airspace, terrain, weather, or other hazards. The function may be performed by ANSP personnel, the flight operator, and/or automation.
Separation Minima	The minimum displacements between an aircraft and a hazard that maintain the risk of collision at an acceptable level of safety.
Service Oriented Architecture (SOA)	A design for linking computational resources (principally, applications and data) on demand to achieve the desired results for service consumers (which can be end users or other services). The Organization for the Advancement of Structured Information Standards (OASIS) defines SOA as the following: *A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with, and use capabilities to produce desired effects consistent with measurable preconditions and expectations.*
Shared Situational Awareness (SSA)	The sharing of information among the processes and applications that constitute the information services function to the stakeholders in the system.

Term	Definition
Situational Awareness	Refers to a service provider or operator's ability to identify, process, and comprehend important information about what is happening with regard to the operation. Airborne traffic situational awareness is an aspect of overall situational awareness for the flight crew of an aircraft operating in proximity to other aircraft.
Special Activity Airspace (SAA)	A volume of airspace where certain aircraft must be restricted from transiting that airspace. SAAs may be defined for Alert Areas, Controlled Firing Areas, Military Operations Areas (MOAs), Prohibited Areas, Restricted Areas, or Warning Areas. SAAs may be available from national sources of published Special Use Airspaces (SUAs) or may be locally defined. Information associated with SAAs includes designators, the controlling agency, vertical and horizontal boundaries, separation distance, and activation schedule.
Staffed Virtual Tower	A facility where surface and tower services are provided by ANSP personnel, providing other-than-direct visual observation, who may or may not be located at the facility.
Stakeholders	All entities that are have a vested interest in ensuring the safest and most efficient operation of the NGATS. Through performance metrics analysis and research, these entities see that the proper training is coordinated and provided to the appropriate COIs, and that other enterprise needs are met.
Super-Density Flexible Airspace	The specific airspace configurations or routes chosen in near-real time to provide flexibility and maximize arrival and departure throughput. It is smaller than or lies within super-density protected airspace.
Super-Density Protected Airspace	The charted airspace protecting super-density terminals that is somewhat larger than the actual airspace used operationally. Statically defined for low-capability aircraft that do not have access to real-time updates of airspace definition.
Surveillance Services	This service integrates cooperative and noncooperative airport surface and airspace surveillance systems, fostering real-time air and airport situational awareness and enhancing safety and security.
Trajectory Management	The function of fine-tuning trajectories as required by the airspace plan or an active flow contingency management initiative to minimize pairwise contention and ensure efficient individual trajectories within a flow.
Trajectory-Based Operations	The use of 4D trajectories as the basis for planning and executing all flight operations supported by the air navigation service provider.
Transition Airspace	Airspace that allows aircraft to transition from one classification of airspace to another while maintaining separation from other airspace and aircraft entering and exiting adjacent airspace.
Unmanned Aircraft System	A pilotless aircraft is flown without a pilot-in-command onboard and is either remotely or fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous. The UAS includes the pilotless vehicle, control system, and operator.
Virtual Tower	A facility that provides surface and tower services without the requirement for ANSP personnel providing direct visual observation. Virtual towers may be automated or staffed.
Weather Information Services	NGATS Weather Information Service is a common service providing the following generic capabilities: sensor configuration, observation, forecast, and history.

Appendix C: Research Issues

Note: The following research issues are listed by chapter content; they are not listed in any priority order.

Reference	Type	Section	Line Reference	Issue
R-1	Research	2.2	New tasks are performed by automation to support the decision-making process and the shift in focus from tactical separation between individual aircraft to the strategic management of traffic flows in high-density airspace.	How can super-density operations be conducted safely to ensure no increase in current accident rates?
R-2	Research	2.2	Flight planners have an increased role in collaborating with the ANSP on capacity and flow management strategies, and the flight crew has a greater role in many of the tactical flight management tasks.	Determine the extent to which national policies on access to airspace can be transparent and implemented within automation.
R-3	Research	2.2.1	Restructuring the roles of humans and automation in NextGen and how they perform their respective functions to synergize human and automation performance.	Develop new traffic flow management and flight procedures enabling flight efficiency and ANSP productivity in both en-route and arrival/departure airspace, including how procedures will be integrated for consistency, appropriate workload, and training for flight crews, dispatchers, and ANSP personnel.
R-4	Research	2.2.2	Ultimately, the determination of when to fully automate and when to provide decision support is made to optimize overall system performance and ensure that service providers and flight operators perform well and can respond to off-nominal and emergency events when required.	Develop transparent policies and methodologies for the allocation of airspace and ANSP resources to implement the NextGen philosophies of providing enhanced services and access to better-equipped users while accommodating all users to the maximum extent possible.
R-5	Research	2.2.2	In addition, backup functions are distributed throughout the system, and there are layers of protection to allow for graceful degradation of services in the event of automation failures.	Develop policies, tools, and procedures for integrating and managing the different operations in trajectory-based airspace to achieve NextGen objectives.
R-6	Research	2.2.2	In addition, backup functions are distributed throughout the system, and there are layers of protection to allow for graceful degradation of services in the event of automation failures.	Develop guidance that specifies what flexibility is allowed in the implementation of airborne separation management algorithms to ensure operationally consistent results; understand the effects variations in algorithms can have with regard to major impacts on overall operations.

Reference	Type	Section	Line Reference	Issue
R-7	Research	2.2.3	Human factors considerations that drive human-system design and impact human-system performance include human cognitive capabilities and limitations, human error, situational awareness, workload, function allocation, hardware and software design, procedural design, decision aids, visual aids, training, user manuals, warnings and alarms, environmental constraints, workspace design, and team versus individual performance.	Determine the level of performance and trajectory specificity necessary for the different uses of the 4DT from initial planning to separation management.
R-8	Research	2.2.3	Within NextGen, human interactions with automation are more intuitive and user-friendly, allowing increased utility of tools while mitigating human errors.	Determine how to use probabilistic information (including and especially weather) to more effectively manage uncertainty in a management-by-trajectory framework over varying time horizons.
R-9	Research	2.3.2	C-ATM is the means by which flight operator objectives are balanced with overall NAS performance objectives and accomplishes many of the objectives for CM, FCM, and TM.	Super-density operations will result in many aircraft in close proximity. Consequently, an aircraft deviating from its assigned trajectory is much more likely to cause an immediate conflict with another aircraft, and safe avoidance maneuvers may be limited or unavailable. How can super-density operations be conducted safely, especially in the presence of severe weather?
R-10	Research	2.3.2	C-ATM is the means by which flight operator objectives are balanced with overall NAS performance objectives and accomplishes many of the objectives for CM, FCM, and TM.	Should requirements be developed for a collision avoidance system that is compatible with NextGen tactical separation? Unless mandated otherwise, some aircraft will likely be equipped with legacy TCAS/ACAS systems which may generate unwanted alerts during normal operations. What should be done to take such a situation into account?
R-11	Research	2.3.2.1	CM structures routings—where required to manage complexity—and reserves airspace as needed for special uses.	How is the safety and effectiveness of this adaptive automation ensured?

Reference	Type	Section	Line Reference	Issue
R-12	Research	2.3.2.1.1	Part of the CM process also includes the use of metrics and analyses to determine which strategies were most effective under which conditions.	Determine how to negotiate and ensure trajectory stability during 4DT updates, especially to the CTA, and the impact on system functions that rely on the CTAs. What tolerances in the time dimension are needed to make the 4DT useable?
R-13	Research	2.3.2.2	FCM deals with demand-capacity imbalances that cannot be addressed through the CM process.	Develop tools and procedures to allow ANSP-managed and delegated separation operations to be safely and efficiently integrated in the same airspace, while retaining adequate ANSP productivity.
R-14	Research	2.3.3	Significant collaboration occurs in the NextGen among the ANSP, flight operators, and airport operators regarding ground operations and planned improvements for airports.	Determine the range of demand and complexity that SVTs and AVTs can each provide, operationally and economically.
R-15	Research	2.3.4	Flight operators receive this information so they can better plan flights and be aware of likely restrictions.	Develop explicit approaches to integrate technical and organizational, cultural, and policy innovation.
R-16	Research	2.4	Digital data communication and ground-based and airborne automation to create, exchange, and execute 4DTs are prerequisites for TBOs.	Assess appropriate roles for humans and automation in NextGen, and develop an overall philosophy to enable human operators to safely and effectively manage the proposed advanced automation systems.
R-17	Research	2.4	The use of precise 4DTs dramatically reduces the uncertainty of an aircraft's future flight path, in terms of predicted spatial position (latitude, longitude, and altitude) and times along points in its path.	Develop metrics and analysis methodologies to quantify and assess the impact of new capabilities on the air transportation system.
R-18	Research	2.4.1	These benefits include safety and increased ANSP productivity.	What capabilities and technologies are required to enable a mobile aircraft-ground system communications service that is affordable, available globally, and fully interoperable?
R-19	Research	2.4.1	These benefits include safety and increased ANSP productivity.	Define RTSP.
R-20	Research	2.4.1	As a result, trajectory-based planning and operations—together with improved weather forecast accuracy and integration of military, security, environmental, and other requirements— allow access to more airspace more of	Develop the concept of Electronic Visual Flight Rules (EVFR), including applicability, equipage, procedures, training, and certification requirements.

Reference	Type	Section	Line Reference	Issue
			the time, with reduced impact to traffic flows.	
R-21	Research	2.4.1	In addition to supporting increased flows, TBO enables collaboration between the ANSP and operators to maximize utility of airspace to meet ANSP productivity and operator goals.	What are the cost benefits and safety assessments of ground-based versus airborne conflict detection/resolution automation? What alerts and information displays does a pilot need to safely oversee conflict detection and resolution when no one on the ground is responsible for tactical separation? Under what conditions are different modes more beneficial?
R-22	Research	2.4.1	Around major airports, TBO is flexibly managed, significantly reducing the “footprint” of today’s Class B airspace to only the active arrival and departure corridors, and allowing vastly improved access to other trajectory-based and non-trajectory-based flights in the vicinity.	How will decision-making across various time horizons be integrated?
R-23	Research	2.4.2	Both the flight crew and the ANSP may need to renegotiate CTAs during the flight for reasons such as winds encountered that are different from those forecast or a change in the destination airport acceptance rate.	Develop methods and tools to guide design decisions associated with allocation of responsibilities and functions among automation, aircraft operators, remote operators (e.g. UAS pilots), and the ANSP.
R-24	Research	2.4.2	Both the flight crew and the ANSP may need to renegotiate CTAs during the flight for reasons such as winds encountered that are different from those forecast or a change in the destination airport acceptance rate.	Determine the onboard controls and displays required for flight crews to safely perform self-separation operations within acceptable workload levels in en route airspace.
R-25	Research	2.4.3	One of the key concepts associated with TBO is the integration of trajectory planning and execution across the spectrum of time horizons from strategic planning to tactical decision-making.	Develop methods for assessing risk and safety for different service levels, including transitions across service levels, mission criticality, and backup requirements.
R-26	Research	2.4.3	With this knowledge, the ANSP can support 4DTs tailored to individual flight preferences.	Which NextGen systems should be fully automated without relying on human intervention for off-nominal situations?
R-27	Research	2.4.3	Within trajectory-based airspace, some aircraft support additional operations via onboard capabilities and associated crew training, including the ability to perform delegated separation, airborne	Define concepts/functionalities to enable provision of “tower-like” ANSP services without a physical tower.

Reference	Type	Section	Line Reference	Issue
			self-separation, and low-visibility approach procedures.	
R-28	Research	2.4.3	Overall, these new kinds of flight operations dramatically improve en route productivity and capacity and are essential to achieving NextGen.	If the automation fails, what is the backup plan in terms of people/procedures/automation?
R-29	Research	2.4.3	Super-density arrival procedures are conducted—usually requiring airborne separation capability—and may be continued on the airport surface where required for throughput.	Investigate aircraft energy management during rollout for high-speed runway turnoff.
R-30	Research	2.4.3	Super-density arrival procedures are conducted—usually requiring airborne separation capability—and may be continued on the airport surface where required for throughput.	Identify how to utilize probabilistic forecasts of weather to make optimal NextGen decisions, including direct integration of weather information into government/user decision support tools.
R-31	Research	2.4.4	TM is the process by which individual aircraft trajectories are managed just before and during the flight to ensure efficient individual trajectories within a flow.	How is flight crew situational awareness maintained in an environment that does not include “party-line” communications?
R-32	Research	2.4.4	TM assigns trajectories for aircraft transitioning out of self-separation operations, and for aircraft entering or leaving flow corridors.	Determine the responsibilities and boundaries between capacity management, flow contingency management, trajectory management, and separation management and whether some of these functions can be combined in some cases for ANSP productivity.
R-33	Research	2.4.5	The SM process ensures that aircraft maintain safe separation from other aircraft, from certain designated airspace, and from any hazards (e.g., terrain, weather, or obstructions).	Develop a methodology to address how weather hazards are incorporated into separation management capabilities within the ANSP and aircraft automation.
R-34	Research	2.4.5	Where TBO is used, SM relies significantly on automation for predicting conflicts and identifying solutions.	Determine the levels of flexibility and persistence in structure needed to achieve operational goals in en-route and arrival/departure airspace. Address how environmental and noise reduction goals are integrated with other operational goals.
R-35	Research	2.4.5	Use of automation also allows SM to move away from fixed human-based standards to ones that allow variable separations that factor in aircraft capabilities, encounter geometries, and environmental	Develop forecast systems that provide 4-D weather data that includes probability levels.

Reference	Type	Section	Line Reference	Issue
			conditions.	
R-36	Research	2.4.5	In managed airspace, the ANSP has overall responsibility for SM and may delegate this responsibility to separation-capable aircraft.	Develop airport taxiway and runway configuration requirements to enable high-capacity traffic operations on the airport surface.
R-37	Research	2.4.5	The ANSP SM function is fully automated, and separation responsibility is delegated to automation or, for specified operations, to the flight crew.	Determine the appropriate contents of the flight object for the full spectrum of NextGen operations.
R-38	Research	2.4.5	In self-separation airspace, the ANSP provides neither separation nor TM services for that airspace, but the aircraft may still be subject to TM in downstream transition airspace.	Address the international harmonization of capabilities and associated aircraft equipage requirements.
R-39	Research	2.4.5	Self-separating aircraft have 4DTs with sufficient flexibility defined to allow for separation maneuvers.	Conduct research to understand how increased automation and new technologies affect flight crew and ANSP workload. Such research should include the following: ● Do cockpit workload limitations exist that inhibit the proposed technologies? ● What effect do the changing roles and responsibilities (flight deck versus ANSP, automation versus human) have on safety? ● What effect do the changing workload and changing workforce have on safety?
R-40	Research	2.4.5	An FCM function may be needed in self-separation airspace to impose sufficient structure to ensure that traffic density remains safe, especially around convective weather or in the presence of other constraints.	What is the aircraft/flight crew provided regarding the security restricted airspace (SRA) perimeter (based on the risk profile) prior to and during flight?
R-41	Research	2.4.5	As with delegated separation, ANSP and aircraft automation track the transfer of separation responsibility and communicate that transfer to those affected.	What is the relationship between airport capacity and separation management at airports? Will airports be the constraint on capacity? Who will assume the responsibility for separation on the ground (ANSP or shared responsibility)?
R-42	Research	2.4.5	Under NextGen, a collision avoidance system independent of the separation assurance system, and which acts only in the event the separation assurance process fails, will still likely be required (see	Develop concepts to effectively balance operator flexibility against system predictability and flow management objectives.

Reference	Type	Section	Line Reference	Issue
			ICAO AN-Conf/11, ASAS Circular).	
R-43	Research	2.4.7	Flow corridors consist of long tubes or "bundles" of near-parallel 4DT assignments, which consequently achieve a very high traffic throughput while allowing traffic to shift as necessary to enable more effective weather avoidance, reduce congestion, and meet defense and security requirements.	How will the ANSP and trajectory-based flight operators develop and manage trajectories to enable safe and efficient flight profiles that meet capacity and productivity objectives?
R-44	Research	2.4.7	For scalability and affordability, the ANSP delegates separation tasks to capable aircraft whenever this benefits the aircraft involved, overall operations, or ANSP productivity.	For systems that are not fully automated and for which human involvement is required to ensure effective performance and resilience, how should the automation (in terms of roles and responsibilities, underlying functionality, and associated controls and displays) be designed?
R-45	Research	2.4.8	Integrated arrival and departure area and airport surface management ensure arrival flows match projected airport capacity for improved overall throughput and efficient flight trajectories that eliminate today's low altitude path-stretching and holding.	Develop tools for airport design and operations to match surface throughput with arrival/departure flows.
R-46	Research	2.4.8	At times of peak demand, major airports conduct super-density arrival/departure operations in which capacity-enhancing arrival and surface procedures are implemented to maximize runway throughput.	How will we design and implement systems to be resilient to failures and robust to operator error?
R-47	Research	2.4.8.1	As illustrated in Figure 2 - 8, super-density arrival/departure corridors handle arriving and departing traffic, while much nearby airspace remains available to other traffic.	We do not "prove" today's ATC system is safe, but rely on historical data. NextGen will be required to both be safe and to demonstrate it is safe. How will safety be designed into all aspects of NextGen and then proven?
R-48	Research	2.4.8.1	Use of procedures that eliminate requirements for visual operations.	Develop wake vortex prediction capabilities and resulting safe aircraft arrival spacing.
R-49	Research	2.5	Much high- and low-altitude airspace outside of high traffic areas remains similar to today's Class A, C, D, E, and G airspace, as well as some oceanic airspace.	Develop and refine metrics associated with overall ATM system performance and the effectiveness of C-ATM processes. What processes, tools, and data sources are needed for effective and equitable management of system resources?
R-50	Research	2.5	Aircraft capable of TBO often	How is broadcast intent information

Reference	Type	Section	Line Reference	Issue
			transit classic airspace, and often are able to use their advanced capabilities to their advantage, depending on the conditions.	handled in the event of a trajectory change?
R-51	Research	2.7	The term “flight operator” is used very broadly to cover all people or organizations that operate aircraft, including scheduled, on-demand, personal aircraft, and state and military aircraft operators. The term is also used to refer to emerging flight operations such as unmanned aircraft and space vehicles.	Develop standards for communicating flight limitations and flight operator preferences.
R-52	Research	2.7.1	In airspace where TBO is used (see Section 2.4), the minimum capability includes the ability to conduct RNP operations combined with the exchange (via a digital data link) and execution of precision 4DTs.	Develop a broad-area navigation capability accurate enough to enable takeoff, landing. and taxi operations with no visual references.
R-53	Research	2.8.2	Training (e.g., training regimen, training effectiveness, skill retention and decay, retraining, emergency operations training, training devices and facilities, and embedded training).	As part of the development of procedures for surface operations in low visibility conditions, identify and address potential safety risks.
R-54	Research	2.8.2	By decoupling geographic airspace and infrastructure constraints from aircraft operations, capacity managers have the flexibility to leverage resources across facilities to match staffing to traffic demand.	Conduct research to determine how super-density procedures will be managed, conducted, and integrated with arrival/departure operations, including ground-based automation support.
R-55	Research	2.8.3	Aviation safety policy enacts performance-based rules and emphasizes quality goals. Proactive risk assessment and management quantifies safety risk levels of all system and procedural changes prior to implementation.	Develop the concept of EVFR, including applicability, equipage, procedures, training, and certification requirements.
R-56	Research	2.8.3	Safety assurance is based on audits of processes and procedures with the regulatory authority focused on the comprehensive approval and periodic audits of the safety management programs.	Determine training requirements for flight crews and ANSP personnel associated with delegated separation management.
R-57	Research	2.8.3	Safety assurance is based on audits of processes and procedures with the regulatory authority focused on the comprehensive approval and periodic audits of the safety management programs.	What is the most effective way to allocate traffic to ANSP personnel (e.g., portions of airspace versus flows of traffic) to increase productivity, manage workload, and ensure situation awareness?

Reference	Type	Section	Line Reference	Issue
R-58	Research	2.8.4	Given the limited resources of the government and private industry, it is critical that mitigation measures be developed based on threat and vulnerability, as well as the potential consequences to individuals, transportation assets, and the economy.	What are the responsibilities and liabilities of different stakeholders in the event of automation failure?
R-59	Research	3.1	But future versions of this chapter will include concepts that will focus on the needs of nonmajor airports as these concepts become available.	What are the infrastructure and development needs for general aviation airports as part of NextGen? What is the role of the FBO in NextGen?
R-60	Research	3.3.1	Airports report winter airport conditions using advanced friction testing equipment and automatically disseminate the condition information in an accurate and timely fashion using SSA. The ICAO Snowtam program could provide an effective template for reporting winter conditions.	Define the role of airport operator in disseminating support information during winter operations, including runway friction and the ICAO Snowtam program.
R-61	Research	3.3.1	Adjacent jurisdictions and relevant regional and/or national entities will be able to directly access the NEO and provide the most efficient support possible.	How is business continuity maintained following a catastrophic event regarding multi-modal transportation connections and regional systems?
R-62	Research	3.3.1	Day-to-day environmental operations at airports will be conducted to achieve the NextGen goal of meeting demand while reducing the overall environmental impact, including . . .	What is the potential for advanced technologies to improve environmental operations and efficiencies, such as heated runway systems?
R-63	Research	3.3.1	Use of predictive weather capabilities, icing sensors, and monitoring of icing holdover times (as defined by the Flight Operator) for inclusion in the 4DT and Flight Object. Improved deicing/anti-icing technologies will be used to epedite the process and reduce delay. These systems will help to reduce the use of deicing and anti-icing fluids.	Define technologies and procedures to enable efficient deicing and anti-icing activities, including linkages to 4DT and the Flight Object as well as environmental goals.
R-64	Research	3.3.1	Water quality is improved via best management practices for stormwater management (to reduce hydrocarbons, metals, and other monitored pollutants) and collection methods for spent deicing/anti-icing fluids.	Synthesize available information on best practices related to stormwater management and collection of spent deicing/anti-icing fluids.
R-65	Research	3.3.3	The ground transportation system provides for effective, efficient transitions across multiple modes	How can landside design be optimized to facilitate passenger movement to/from gates to multi-

Reference	Type	Section	Line Reference	Issue
			of transportation while maintaining security, efficiency, passenger convenience, and choice.	modal connections, including ground transportation?
R-66	Research	3.5.1	In addition to airport advocacy and fostering community support for airports, the program would seek to align federal airport programs with the goal of long-term airport preservation.	Define the NextGen Airport Preservation Program. Define the federal role in protecting critical infrastructure, including linkages to NPIAS and airport advocacy. Analyze liability concerns with safety zones. Define the applicability of airport traffic patterns in the overall program. Incorporate recommendations of existing TRB/ACRP research, when available.
R-67	Research	3.5.3	NextGen goals will be integrated into the planning process, as will ANSP coordination activities that are needed to ensure the successful implementation of airport improvements (e.g., so that airport planning actions take into account airspace constraints).	Need to determine process and performance standards for coordinating airspace actions. Performance standards would permit third-party participation in the airspace design to speed up the process.
R-68	Research	3.5.3	Effective public involvement is also critical to ensuring that the community is aware of and can support airport infrastructure development.	Identify best practices in public and community involvement to support airport infrastructure development.
R-69	Research	3.5.4	Airport operators should be engaged in reviewing proposed surface transportation plans and programs to ensure that the transportation access needs of the airport are properly taken into account.	How can regional planning agencies coordinate with regional transportation authorities to prioritize regional allocation of air traffic, multi-modal linkages, land use?
R-70	Research	3.5.4	For the purposes of NextGen, a better understanding of how market and non-market mechanisms affect the choices made by aircraft operators to serve specific airports is needed so that regional needs can be better forecasted and incorporated into decision-making.	For the purpose of regional system planning and demand models, need to better understand economic theory of airports as a monopoly versus a competitive industry. At 3X operations, what are the economics of congested mega hubs versus smaller hubs with less O/D traffic but less delay?
R-71	Research	3.5.5	Specific parallel runway separation standards are discussed in Chapters 2 and 3; the development and implementation of new standards will have a substantial effect on airfield design and capacity.	With the reduced separation standards available for arrival/arrival and departure/departure operations (as opposed to mixed operations), could modifying design to favor arrival only and departure only runways improve capacity? What would be the changes to runway design and layout (e.g., Denver

Reference	Type	Section	Line Reference	Issue
				International Airport (DEN)?
R-72	Research	3.5.5	Aircraft performance characteristics that increase present-day levels of safety, combined with advanced instrument procedure design criteria, allow reductions in obstruction clearances and associated protection areas currently required for both ground- and satellite-based aircraft flight procedures.	How will Part 77/TERPS process change with dynamic airspace, dynamic RNP approaches, synthetic vision, etc.? What airspace design and protection area criteria would change as a result of the review and revision of the FAA Order Series 7000, FAA Order Series 8000, 14 CFR Part 77, and AC150/5300-13? Also, the research needs to determine if aircraft flight paths could be less constrained in regard to airport protection surfaces while maintaining adequate levels of safety.
R-73	Research	3.5.5	A new collision risk model may permit use of larger aircraft in existing object free zones.	Research new collision risk model for permiting use of larger aircraft in existing object free zones.
R-74	Research	3.5.6	This shift is likely to result in a relative reduction in the space that airlines will use for passenger processing in the future (in terms of square footage per enplanement), resulting in changing the operational revenue structure for the airport.	What are some potential outcomes of changes to the finance structure as the terminal design evolves to support NextGen?
R-75	Research	4.1	There is sufficient spectrum available to handle the transmission of critical information to appropriate COIs through a scalable infrastructure that evolves as technology advances.	Frequency Bandwidth/Spectrum Capacity: Sufficient bandwidth in ground, airborne, and mobile networking to allow extremely fast transmission rates for all types of data (to include simultaneous transmission of graphics, video, and audio) with appropriate quality of service (defined later) must be addressed. Bandwidth for ground communications does not appear to be a future problem. Airborne networking to the aircraft cockpit will be limited by the spectrum currently protected by the FAA. Voice over Internet Protocol (VoIP) to the cockpit is a significant challenge. Spectrum for airborne networking for passenger services may be more readily available, but will still be limited and remains a concern. There will be sufficient spectrum available to handle the transmission of critical information to appropriate COIs through a scalable enterprise that evolves as

Reference	Type	Section	Line Reference	Issue
				technology advances.
R-76	Research	4.1	Data is the preferred method of communications to the flight deck as well as to the ground. Voice will be used in cases of emergency such as safety of flight (e.g., a situation where conflict or midair is imminent and voice will preclude an incident).	Voice By Exception: Voice communications have transitioned from analog to digital technology and employ some form of VoIP to allow voice transmissions to be carried over the established ground, airborne, or mobile information networks. In addition, as indicated above, the NextGen involves increased sharing of improved common data among the flight deck, operator, and ANSP. This data includes ATC clearances, 4DT, current and forecasted weather, notices to airmen, hazardous weather warnings, updated charts, current and special aircraft data, and other required data (RTCA, 2002). Information exchange also includes weather observations made by the aircraft that are automatically provided to the ground (for inclusion in weather analysis and forecasts) and other aircraft. The NextGen will have a level of required communications performance (RCP) for each of these data communications functions.

Reference	Type	Section	Line Reference	Issue
R-77	Research	4.1	Communications transport providing sufficient and dynamic addressing with secure and assured end-to-end connectivity for all platform nodes including cargo, passengers, and crew across the air transportation enterprise.	Content Definition Standards Resolution: Shared data must have a controlled vocabulary and exchange structure. A uniform basis for categorizing and protecting sensitive information needs to be developed because the lack of uniform definitions and policy can only lead to breaches. Procedures need to be developed for dealing with asynchronous changes to higher-authority laws and policies in national and policy domains, recognizing that regulations and guidance may not always be consistent. There are an unmanageably large number of different types of Sensitive but Unclassified information (SBU) used among United States Government agencies. Many types of SBU are defined in statutes and regulations created at different times. The Federal Government will need to identify and remove inconsistencies, contradictions, and complications embedded in law, executive order, departmental policies, and customary usage. Necessary capabilities needed for transformation include the following: ● Parallel development of information assurance security for NextGen to comply with DoD, DHS, DOC, DOJ, NASA, FAA, and other applicable agency requirements ● Interagency collaboration through information management: – Interoperability among various agency net-enabled information sharing capabilities (examples include FAA's System Wide Information Management [SWIM], DoD's Global Information Grid [GiG], Air Force Technical Implementation Architecture, DHS's OneNet, and DOJ/DHS's Network Information Exchange Model

Reference	Type	Section	Line Reference	Issue
				[NIEM]) as they evolve/mature/transform – Multilevel and multilayered security ● Exploitation of technologies designed to maximize: – Traffic flow management – Safety and security parameters – Dynamic or flexible routing capabilities – Static and dynamic airspace management (to include special use airspace), coordination, and collaboration ● Integration of expanded information sources/assets: – Shared all-source weather decision making – ADS-B–like and datalink-equipped aircraft ● Establishment of contingency operations and continuity of operations for the air traffic system to include such characteristics as: – Recognized integrated user-definable operational air picture – Standardized emergency and all hazard responses (re-deployable capability, etc.) – Incorporating the use of commercial technologies, standards, and government initiatives, the Net-Centric Infrastructure Services will consist of a tiered transport layer and a net-centric enterprise services layer that fully support the information needs of our ANSP and the NextGen enterprise. Information assurance will be integral to the infrastructure, and data management strategy initiatives will ensure that data is appropriately tagged, posted, and made available to others with access to the services. – Information redundancy, storage, and backup to enhance reliability in the event a node in the system is lost

Reference	Type	Section	Line Reference	Issue
				(definition of lost is not limited to power interruption, failure, or attack of some type such as cyber, physical, or other asynchronous means).
R-78	Research	4.1	Data registries and discovery mechanisms between entities (government, commercial, private and international organizations) allow for data sharing in a push/pull and publish/subscribe environment between authorized COIs.	Information Assurance: NextGen needs a common understanding and foundation for establishing policies and procedures so that all stakeholders can share information yet remain committed to protecting organizational and individual rights in information and information systems. This trust relationship must ensure that: ● Systems devised to facilitate the storage and sharing of the information cannot be corrupted, degraded, penetrated, or denied to authorized subscribers by agents both inside and outside the community of recognized and authorized users ● Information received is accurate, timely, and authoritative. NextGen information sharing must

Reference	Type	Section	Line Reference	Issue
				be flexible and adaptable to circumstances and stress experienced by the NextGen over time. Information access channels must be opened and closed to changing communities of interest/subscribers depending upon the circumstances or events at the time. The potentially conflicting goals of safety, security, and operational efficiency must be addressed head-on. The cyber security protections must accomplish simultaneous and competing demands by: ● Openly sharing as much information as possible ● Providing appropriate controls preventing unauthorized use or access ● Protecting the security interests of the nation and the NextGen ● Protecting Privacy Act information ● Protecting proprietary information and other intellectual property.
R-79	Research	4.1	Wherever possible, the system includes the capability to automatically capture any and all relevant data about components of the ATC environment, including aircraft, baggage, expendable supplies, aircrew, controllers, ground-handling equipment, gates, and passengers, and provide this information to authorized COIs for making timely decisions.	Commitment to airborne networking: Early technological solutions must be evaluated and demonstrated for the aviation community. Minimum Acceptable System Performance Standards (MASPS) and Minimum Operational Performance Standards (MOPS) must be defined. Commercial ground and avionics systems must be certified by the FAA as acceptable for use for air traffic and safety of flight information. This whole process currently takes a minimum of 15 to 20 years to accomplish.
R-80	Research	4.3.2	Voice communications are used to communicate with lesser-equipped aircraft in appropriate airspace	Because voice communication is now the exception and not the rule, how is situation awareness maintained without party-line communications?
R-81	Research	4.3.2	In certain defined airspace, data communications are the primary means of providing clearances, routine communications, and 4DT agreements between the ANSP and flight deck.	How will accurate data transmission in air-ground communications be ensured? What happens when instruction is sent to the wrong aircraft, or the data sent to the aircraft is misread or

Reference	Type	Section	Line Reference	Issue
				misinterpreted by the flight operators, or only a partial transmission (data or voice) is received?
R-82	Research	5.3.2	Improved information from ground sensors (e.g., next-generation radar [NEXRAD] dual polarization), new sensors on satellites, as well as increased weather observations by ground and aircraft sensors (e.g., commercial, general aviation, UAS, pilot report) identify weather hazards, which are disseminated to aircraft and users in real time.	Assess the cost/benefit of aircraft modifications that could mitigate the impact of airborne weather hazards.
R-83	Research	5.4.5	Backup systems are under review, but a selection is yet to be determined.	What systems and capabilities are used to supplement or back up the space-based satellite infrastructure? How are navigation and surveillance backup strategies related?
R-84	Research	5.5.3.1	At airports, NextGen sensors must track all movements from ramps to runways to minimize risk of ground collisions and mishaps.	Determine surveillance (cooperative and non-cooperative) backup needs/requirements including the completion of the necessary safety risk analysis research to support NextGen.
R-85	Research	5.6	This service also manages data related to a flight from the initial filing of a proposed flight to the closing of the flight plan and the archiving of the data to support performance management analyses.	Can this more automated process provide flexibility in flight data service that eliminates the flight data constraint for CM and FCM? What are the functional requirement on the flight object and the flight data services to support both security and search and rescue?
R-86	Research	6.3/C.2.1	Risk management is continuous; it is conducted from the strategic to the tactical levels.	Can valid and time-sensitive risk probability models be developed for different threat scenarios?
R-87	Research	6.3/C.2.2.3	Provide the most focused and adaptive security measures to reduce the impact of security systems and procedures on air transportation	For airports of similar capacity requirements, what is the most cost-effective mix of baggage screening equipment consistent with throughput requirements and security standards?
R-88	Research	6.3/C.2.2.6	Risks are measures of potential harm that encompass threat, vulnerability, and consequence.	Can lightweight aircraft hardening material be developed?
R-89	Research	6.3/C.2.2.6	Risks are measures of potential harm that encompass threat, vulnerability, and consequence.	Are there cost-effective MANPADS attack detection and countermeasure technologies?
R-90	Research	6.3/C.2.2.6	Risks are measures of potential harm that encompass threat, vulnerability, and consequence.	How can biometric access be integrated safely with aircraft cockpit systems?
R-91	Research	6.3/C.2.	Risks are measures of potential	Can the adaptive flight control

Reference	Type	Section	Line Reference	Issue
		2.6	harm that encompass threat, vulnerability, and consequence.	technologies TOC/PCAR be implemented in a way that mitigates risk while the cost/benefit remains viable? [Rationale: Adaptive flight controls may provide the last chance to control/land safely after an attack that damages flight-critical systems/surfaces.]
R-92	Research	6.3/C.2.3	Risks are measures of potential harm that encompass threat, vulnerability, and consequence.	(a) What information should we share among the IRM stakeholders? (b) What decisions will be made based on the IRM risk management analysis?
R-93	Research	6.3/C.2.2.4	The assessment of risks provides a prioritized list of vulnerabilities and potential mitigation strategies.	What are the kinds of air cargo that can be adequately screened by operationally feasible NextGen detection technologies for CBRNE in cargo/mail?
R-94	Research	6.3/C.2.2.1	Because the terrorist has the freedom to choose targets and modes of attack, the NextGen security system must develop (but not necessarily universally deploy) operationally feasible mitigations to as many potential threats as possible.	How can watch lists be validated so the NextGen IRM – Secure People capability minimizes false positives as well as failures to detect a threat?
R-95	Research	6.3/C.2.2.6	This does not mean that all non-commercial operations have to screen passengers or cargo for flights posing below-threshold risk levels.	What factors should be considered for the security envelope of an aircraft?
R-96	Research	6.3/C.2.4	Many flights occur far from major metropolitan areas or national security restricted areas. However, flights to sensitive areas have to make adjustments to reduce their risk profile.	What data are needed to develop the metrics to examine the adequacy of IRM? What are the metrics?
R-97	Research	6.4.1/C.3.4	In summary, it is essential to remember that the security system responses and procedures throughout the NGATS are applied based on the risk profile of each flight and airport facility.	How can certified checkpoint CBRNE and weapons detectors be designed for maximum deployability and reconfigurability to facilitate deployment at the full range of NextGen airports?
R-98	Research	6.4.1/C.3.4	Other less visible security procedures may work toward similar ends and do so as effectively.	What checkpoint detection devices/systems can be smaller, lighter, less costly as well as have high detection accuracy?
R-99	Research	6.4.1/C.3.5	The checkpoint displays an operating profile of consistency and routine, while behind the scenes it has several new screening techniques and tools	How can the accuracy rate of Behavior Pattern Recognition techniques be improved? What aspects can be performed through automated systems?
R-100	Research	6.4.1/C.	that are brought to bear upon the	How can personal data used for

Reference	Type	Section	Line Reference	Issue
		3.2.1	assessed risk, and in some cases performed randomly as an added measure	credentialing be safeguarded against misuse or exposure given collecting, storing, and sharing personal information across many government and commercial (e.g., airport, airline) systems?
R-101	Research	6.4.1/C. 3.4	In the NGATS, the Secure People capability of the security architecture puts greater reliance upon a more integrated approach correlating credentialing and identification processes with screening.	How can detection of weapons become more automated?
R-102	Research	6.4.2/C. 3.4	In the NGATS, the Secure People capability of the security architecture puts greater reliance upon a more integrated approach correlating credentialing and identification processes with screening.	(1) What are the optimal sensor fusion strategies? (2) Are there safety issues that emerge in such systems that are not present with the individual sensors?
R-103	Research	6.4.2/C. 4.3.3	The airport security technologies and adjustable procedures are nominally transparent to passengers.	What are the costs and benefits of using UAS in terminal airspace surveillance?
R-104	Research	6.4.2/C. 4.5	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and informed for any contingency.	(1) System integration of the full array of surveillance input on disparate systems and data inputs. (2) What is the most effective and suitable way to display data to foster shared situational awareness and increase decision quality and decrease response time?
R-105	Research	6.4.2/C. 4.3.3	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and informed for any contingency.	What defense technologies can be developed to interdict a fourth generation MANPAD (i.e., radio frequency weapons or electromagnetic pulse weapons)?
R-106	Research	6.4.2/C. 4.3.3	Commercial (passenger/cargo) airports	What safety-related modifications to the aircraft can be leveraged as mitigation to a MANPADS hit (e.g., non-explosive fuels and damage-adaptive flight control systems)?
R-107	Research	6.4.2/C. 4.2.2	Commercial (passenger/cargo) airports	What cost-effective technologies and operating techniques can make the transportable RTSS a viable option?
R-108	Research	6.4.2/C. 5.3.3	RTSS facility	How can CBRNE detector systems be made part of an easily deployable screening checkpoint for remote, intermittent, or temporary demand locations?
R-109	Research	6.4.2/C. 4.3.1	RTSS facility	What cost-effective technologies and operating techniques provide

Reference	Type	Section	Line Reference	Issue
				for effective vehicle screening that does not impede airside operations?
R-110	Research	6.4.2/C.4.4.1	Airside: Security Identification Display Area (SIDA)/AOA	R&D needed to develop and refine operationally effective and suitable technologies to detect vehicle anomalies and sense CBRNE at a distance. R&D needed to improve blast mitigation and neutralize CBRN containment.
R-111	Research	6.4.3/C.5.3	Landside: Terminal Public and Commercial Roadways and Parking Lots	Systems designs for differing CBRNE equipment combinations for different types will need to be developed.
R-112	Research	6.4.3/C.5.2.1	This section includes printing bag tags at remote locations for airport check-in, as well as provisions for RTSS to allow passengers to undergo full screenings at remote off-airport locations and then be transported directly to the sterile area of the airport terminal and their screened checked bags directly to the aircraft.	What is the optimum way to achieve sensor fusion for higher accuracy of threat detection?
R-113	Research	6.4.3/C.5.2.1	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	What is the optimum way to integrate human and automated decision making for the screening system?
R-114	Research	6.4.3/C.5.2.2	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	What alarm resolution systems are appropriate for systems with sensor fusion?
R-115	Research	6.4..4/C.6.9	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	What technologies provide effective and operationally suitable procedures to screen air cargo for CBRNE?
R-116	Research	6.4.4/C.6.9	The SSP integrates all information related to the flight, cargo, and aircrew to provide additional information and ensure security during transit, enabled through NEO.	Identify best locations within the air cargo supply chain to conduct 100% screening of cargo if required by the risk profile for given flight object or facility. This screening should occur as early as possible within the supply chain.
R-117	Research	6.4.4/C.7.3	Cradle to grave tracking/integrity	What are the airspace security performance requirements for different types of flight operators for the NextGen timeframe?
R-118	Research	6.4.5/C.7.3	These risk management requirements include defining (almost always dynamically) the boundaries of SRA and temporary flight restrictions (TFR); the cooperative division of responsibilities among the DSP,	How large should the SRAs be? How do we balance the need for security airspace versus user demand? To what extent should the use of SRAs be accommodated while serving the needs of air traffic?

Reference	Type	Section	Line Reference	Issue
			SSP, and ANSP in the event of security events in flight or by airborne threat aircraft; the security personnel on flights; and modifications/equipage to the aircraft.	
R-119	Research	6.4.5/C. 7.3	These risk management requirements include defining (almost always dynamically) the boundaries of SRA and TFR; the cooperative division of responsibilities among the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft; the security personnel on flights; and modifications/equipage to the aircraft.	What are the specific operational requirements for the various types of SRAs? What is the relationship between high-density terminal airspace and SRAs? What are the exemption criteria?
R-120	Research	6.4.5/C. 7.5.2	These risk management requirements include defining (almost always dynamically) the boundaries of SRA and TFR; the cooperative division of responsibilities among the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft; the security personnel on flights; and modifications/equipage to the aircraft.	What are the information-sharing requirements? Who should have what information in different operational situations?
R-121	Research	6.4.5/C. 7.5.2	These risk management requirements include defining (almost always dynamically) the boundaries of SRA and TFR; the cooperative division of responsibilities among the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft; the security personnel on flights; and modifications/equipage to the aircraft.	What is the overall NEO Operational Concept for the Security Command/Operational Centers?
R-122	Research	6.4.5/C. 7.4	These risk management requirements include defining (almost always dynamically) the boundaries of SRA and TFR; the cooperative division of responsibilities among the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft; the security personnel on flights; and modifications/equipage to the aircraft.	How many alert severity status levels should NextGen have? What are the alert escalation criteria?

Reference	Type	Section	Line Reference	Issue
R-123	Research	6.4.6/C.8.5	The model combines credentialing data with performance data as part of developing the risk profile of the flight object.	If certain aircraft are at risk for MANPADS, what kinds of countermeasures are feasible? Does the threat justify the expense of mitigation efforts? If no, no action required. If yes, are defensive systems aircraft based or land based? Are there other, non-hardware methods for reducing the threat posed by MANPADS?
R-124	Research	6.4.6/C.8.5	The secure aircraft service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods.	The primary objectives of aircraft hardening research are to determine the vulnerabilities of commercial passenger aircraft to terrorist threats and to investigate and develop methods to protect or mitigate the damage from an in-flight explosion or other criminal action. This includes assessment of threats such as explosives, directed energy, electromagnetic and MANPAD systems. (1) Identify methods of modeling internal blast loading in a typical passenger aircraft environment and the respective structural damage including blast and damage characteristics and failure mechanisms. Identify model adaptability to various aircraft designs and model capability to clearly determine specific vulnerabilities.(2) Demonstrate methods/means to protect commercial passenger aircraft from catastrophic structural or critical system failures due to in-flight explosions including solutions applicable to the cargo hold and/or passenger cabin.
R-125	Research	6.4.6/C.8.5	The secure aircraft service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods.	Identify, assess, and test as appropriate potential countermeasures to aircraft threats from laser, directed energy or electromagnetic pulse, and other emerging threats. Include efforts that complement existing Department of Defense (or other public or private) programs that can be leveraged.
R-126	Research	6.4.6/C.8.5	The secure aircraft service increases the safety and security of aircraft in flight through a variety of	Will video download to ground stations interfere with other aircraft functions? Is there enough

Reference	Type	Section	Line Reference	Issue
			hardware, software, personnel, and procedural methods.	spectrum to project/download real-time cockpit, cabin, and cargo hold information?
R-127	Research	6.4.6/C.8.4	The secure aircraft service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods.	Determine the type of aircraft hardening required to effectively and efficiently enhance safety and security.
R-128	Research	6.4.6/C.8.3.2	The threats that require mitigation include, but may not be limited, to hijacking/unauthorized diversion; internal explosive destruction; external attack; onboard CBRNE or other attack of crew, passengers, or aircraft systems; aircraft use as a transport for CBRNE; or aircraft use as a weapon of mass destruction.	Can operationally effective and suitable onboard chemical and biological sensors and treatment systems be developed to mitigate risk to passengers?
R-129	Research	6.4.6/C.5.2.3	Secure aircraft applies both to civilian passenger aircraft and civilian cargo aircraft.	What kinds of threat defeat systems are operationally effective and suitable for particular CBRNE threats?
R-130	Research	7.2 (Table 71)	Water quality impacts occur due to stormwater runoff and deicing operations.	Research methodologies to reduce water runoff from airports and minimize impacts on local water quality.
R-131	Research	7.3.2	An example consists of the establishment of environmentally friendly operational procedures (e.g., continuous descent approach [CDA]) for all traffic conditions.	Identify airports at which various operational procedures, such as CDAs and RNP can be implemented and used in a variety of traffic-level conditions that reduce aircraft noise and emissions.
R-132	Research	7.3.2	Specific focus is placed on understanding and identifying the direct attributable role of aircraft emissions in climate change through targeted research with national and international partners.	Work internationally to identify directly attributable impacts and take appropriate actions to manage significant climate change impacts associated with aircraft operations.
R-133	Research	7.3.3	Advanced capability to integrate and balance noise, emissions, fuel burn, land use, efficiency, and costs effects of alternative measures and alternatives allow selection of optimum operational modes, mitigation strategies, and surface planning procedures.	Develop methodologies to streamline environmental reviews to support capacity growth at the key airports.
R-134	Research	7.3.3	Advanced capability to integrate and balance noise, emissions, fuel burn, land use, efficiency, and costs effects of alternative measures and alternatives allow selection of optimum operational modes, mitigation strategies, and	Develop a repository of environmentally preferable operations proven in practice.

Reference	Type	Section	Line Reference	Issue
			surface planning procedures.	
R-135	Research	7.3.3	Advanced capability to integrate and balance noise, emissions, fuel burn, land use, efficiency, and costs effects of alternative measures and alternatives allow selection of optimum operational modes, mitigation strategies, and surface planning procedures.	Identify improvements to surface planning procedures to reduce emissions.
R-136	Research	7.3.3	Therefore, airports are able to assess their specific environmental requirements for sustainable growth and develop or select approaches (based on industry best practices) to address specific operational, geographic, and local community impacts that fit within that national framework.	Identify incentive programs for the adoption of environmentally friendly technology, operations, and planning at airports.
R-137	Research	7.3.4	Uncertainties regarding the contribution of aircraft to climate change, emissions-induced health effects, and noise annoyance over special noise-sensitive areas (e.g., national parks) are sufficiently resolved to either put them to rest or to affect approaches to aircraft technology.	Research the environmental and health impacts of particulate and hazardous air pollutants from aviation.
R-138	Research	7.3.4	Use of environmentally sensitive technology is facilitated by a prompt and efficient development process whereby innovation, such as environmentally friendly airframe and engine design, is encouraged.	Increase budgets and focus research on development and maturing of environmentally friendly airframe and engine design.
R-139	Research	7.3.4	This, combined with increased demand from aircraft operators, provides for a strong market for environmentally sensitive aviation technology.	Identify incentives for the adoption of environmentally friendly design and technology by carriers.
R-140	Research	7.4	These services and capabilities are described in the following subsections. Each plays an important role in supporting the transformed operations of the NextGen.	Develop an EMS framework to support NextGen leveraging existing practices at leading airports.
R-141	Research	7.4.1	These are reported via a net-centric environmental information management system for the purposes of analysis, continuous improvement, and public dissemination.	Research effective methodologies to expand FAA EMSs to external programs governing the NAS.
R-142	Research	7.4.1	Although the NextGen environmental management framework is expected to deliver	Investigate incentive options for encouraging EMS implementation and operation.

Reference	Type	Section	Line Reference	Issue
			net monetary savings to the system as a whole, incentives are likely to be needed to increase implementation momentum and encourage environmental improvements at a more rapid pace than the market would normally provide. The consideration of incentives would be tied to specific NextGen environmental program initiatives or goals.	
R-143	Research	7.4.1	Therefore, this single enterprise-wide system supports all the environmental information management needs of NextGen.	Develop a concept for the transfer of environmental information across NextGen.
R-144	Research	7.4.2	These procedures are developed based on improved tools and information (e.g., real-time weather information) and increase airport efficiency and ensure the maximum number of aircraft operations can be accommodated within environmental limits (e.g., state implementation plan air quality requirements, land use compatibility guidance with aircraft noise exposure, or water quality regulations), without impacting capacity.	Develop improved terminal airspace operations to reduce air emissions and noise.
R-145	Research	7.4.2	These procedures are developed based on improved tools and information (e.g., real-time weather information) and increase airport efficiency and ensure the maximum number of aircraft operations can be accommodated within environmental limits (e.g., state implementation plan air quality requirements, land use compatibility guidance with aircraft noise exposure, or water quality regulations), without impacting capacity.	Research procedures to reduce the impacts of significant aviation noise and aircraft emissions in absolute terms, notwithstanding the growth in aviation.
R-146	Research	7.4.2	These procedures are developed based on improved tools and information (e.g., real-time weather information) and increase airport efficiency and ensure the maximum number of aircraft operations can be accommodated within environmental limits (e.g., state implementation plan air quality requirements, land use	Research airspace approaches to reduce the impacts of aviation noise in absolute terms, notwithstanding the growth in aviation.

Reference	Type	Section	Line Reference	Issue
			compatibility guidance with aircraft noise exposure, or water quality regulations), without impacting capacity.	
R-147	Research	7.4.2	These procedures are developed based on improved tools, information (e.g., real-time weather information), and increase airport efficiency. They ensure the maximum number of aircraft operations can be accommodated within environmental limits (e.g., state implementation plan air quality requirements, land use compatibility guidance with aircraft noise exposure, or water quality regulations) without impacting capacity.	Develop improved en route operations to reduce air emissions and noise in select areas sensitive to noise.
R-148	Research	7.4.2	For example, aircraft that have low noise and air emissions will have access to a wider selection of routes than those that do not have comparable technology.	Research how to obtain flexible, dynamically reprogrammable airspace capabilities consistent with NEPA requirements.
R-149	Research	7.4.3	For example, aircraft that have low noise and air emissions will have access to a wider selection of routes than those that do not have comparable technology.	Determine the impact of fleet replacement schedules, the emergence of new technologies, and air traffic system enhancements.
R-150	Research	7.4.5	Next generation metrics, based on improved scientific knowledge and computations of interdependent relationships and related benefit/costs, provide an enhanced platform for environmental decisions and mitigation. Metrics include new operating paradigms, e.g., very light jets and supersonic aircraft.	Identify enhanced metrics to assess the environmental and health impact of aircraft noise.
R-151	Research	8.3.1	The National Aviation Safety Policy assigns responsibility for safety at the highest levels of the organization, allowing delegation of day-to-day safety management but not of overall responsibility. It establishes safety management standards and ensures that safety management processes and practices are "… made consistent with the International Civil Aviation Organization (ICAO) standards."	Aviation Safety Policy: What should the scope and depth of this national level aviation safety policy be across the governmental agencies and aerospace industry? How should a national level aviation safety policy and associated strategy be established? What body should do this? What should its composition be? Should this body have authority over its participants?
R-152	Research	8.3.1	The National Aviation Safety Policy assigns responsibility for safety at the highest levels of the organization, allowing delegation of	Aviation Safety Policy: Should a national level aviation policy and strategy be mandated and/or enforced or should it be simply

Reference	Type	Section	Line Reference	Issue
			day-to-day safety management but not of overall responsibility. It establishes safety management standards and ensures that safety management processes and practices are "… made consistent with the International Civil Aviation Organization (ICAO) standards."	agreed to and voluntary by participants? Should it play only an advisory and coordination function?
R-153	Research	8.3.1	The National Aviation Safety Policy assigns responsibility for safety at the highest levels of the organization, allowing delegation of day-to-day safety management but not of overall responsibility. It establishes safety management standards and ensures that safety management processes and practices are "… made consistent with the International Civil Aviation Organization (ICAO) standards."	Aviation Safety Policy: What is the best mechanism/body to coordinate aviation safety research and safety enhancement activities (1) among government agencies and (2) nationally? Should this coordination be mandated and enforced? If so, how? Or should it be advisory and informational?
R-154	Research	8.3.2	These characteristics include, but are not limited to, management accountability, non-reprisal reporting, consistent use of safety risk management best practices, and sharing safety data and lessons learned.	Safety Culture: What are the attributes of a strong safety culture? How do we measure it? Where are we today? How do we transform the culture to get to where we want to be? What organizations have implemented safety culture improvements and how? How do we foster a safety culture across all NextGen stakeholders?
R-155	Research	8.3.3	Understanding the relative risks of the NextGen operations facilitates better prioritization of resources for safety research and enhancements.	Risk Assessment and Management: Determine how to relate operational safety data (e.g., incidents, operational errors) to hazards. What is the structure of the model to connect the right data to hazards? Determine the reasons for the current exceptionally good commercial aviation safety record. Determine whether we should establish a target level of safety at an individual capability level or at a system-of-systems level. How do we define target level of safety and how do we ensure that current levels of safety are maintained, given the propose 3x capacity increase? What are the best analytical methodologies to determine actual level of safety at individual capability and system-of-systems level? Determine necessary procedures that define

Reference	Type	Section	Line Reference	Issue
				how to set a safety level.
R-156	Research	8.3.3	Understanding the relative risks of the NextGen operations facilitates better prioritization of resources for safety research and enhancements.	Risk Assessment and Management: What is the relationship between required performance levels (such as RNP) and safety? How can this play in ensuring a safe system and safe operations?
R-157	Research	8.3.3	Understanding the relative risks of the NextGen operations facilitates better prioritization of resources for safety research and enhancements.	Risk Assessment and Management: Establish a baseline of the current safety risk in the air transportation system (including hazards and mitigation strategies). Determine the change in safety risk with the anticipated changes to the air transportation system and its operational environment in 2025. Improve risk assessment methodologies (e.g., data analysis, modeling, and simulations) expanding prognostic capabilities. Develop a high-level integrated model of the risk in the air transportation system.
R-158	Research	8.3.4	The safety relevant events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information.	Safety Assurance: What is the best mechanism for safety oversight of safety management programs within NextGen government stakeholders? Should it be an existing or new federal agency? If multiple oversight organizations, how will conflicting rulings be resolved? How will the oversight organization exercise authority if the multiple agencies cannot reach consensus on national safety priorities? Should the oversight organization have actual approval authority or must it remain advisory? What steps need to be taken to establish these oversight functions?
R-159	Research	8.3.4	The safety relevant events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information.	Safety Assurance: What authority does the oversight organization have with respect to the use and required implementation of safety management standards? What is the best method for measuring and monitoring the quality of safety management programs?
R-160	Research	8.3.4	The safety relevant events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place	Safety Assurance: What is the best way to ensure the consistency of requirements levied on NextGen industry stakeholders by the

Reference	Type	Section	Line Reference	Issue
			for protecting competitive information.	various government agencies? How will the best safety processes and practices be enforced and how will effectiveness of these be managed at a national level? What legal authorities are required? How are competing stakeholder interests/missions balanced?
R-161	Research	8.3.4	The safety relevant events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information.	Safety Assurance: Will delegating certification responsibilities result in equivalent, or higher, levels of safety? What is the correct or effective level of delegated certification to ensure safety, and how best to implement? How can the benefits and effectiveness of delegated certification be determined?
R-162	Research	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies, cross-fertilization of safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation.	Safety Information Sharing: What tools and infrastructure are necessary to facilitate the capability to share information? How should taxonomy differences be addressed? What is best practice for standardizing taxonomies? What are the best interoperability techniques? Do existing data sources support analysis and safety management activities? Where will the capability and its sensitive content reside?
R-163	Research	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies, cross-fertilization of safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation.	Safety Information Sharing: How will the analysis capability be developed? Who will determine what forensic, diagnostic, and/or prognostic analysis needs to be performed? What type and amount of information needs to be collected and shared for comprehensive analysis? What are existing forensic, diagnostic, and prognostic analytical tool requirements?
R-164	Research	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies, cross-fertilization of safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation.	Safety Information Sharing: What safeguards must be in place to protect safety information from misuse and to protect the sources of safety information? What can be done to assure that information is protected and shared across all government agencies and their customers? What changes in the legal system will be necessary to protect safety information and how

Reference	Type	Section	Line Reference	Issue
				will those changes be effected?
R-165	Research	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies.	Safety Information Sharing: What liability issues must be addressed with respect to collecting, reporting, sharing, handling, and misusing safety-related data? How should these liability issues be addressed while encouraging data sharing?
R-166	Research	9.4	System risk management is an integrated function within the overall NAS architecture that uses the components of the architecture as nodes for data gathering and reporting. Distributed and centralized computing systems are used to identify anomalous situations, circumstances that are accident precursors, and other potential hazards.	System risk baselines for the NAS and for its components do not exist. A baseline for acceptable risk for the NextGen system is, therefore, very difficult to construct. Analysis is required to both construct a system baseline and to define the acceptable risk levels for the future system.
R-167	Research	9.4	This relationship is dynamically updated to provide risk indicators for various operational conditions, including environment (weather, etc.), aircraft density, airspace complexity, aircraft performance, and other system component characteristic performance that may affect risk.	System component requirements are defined in terms of operational parameters; however, risk should be used as an additional component in defining performance requirements.
R-168	Research	5.3.2	UASs are used for making in-situ observations; performing weather reconnaissance missions such as scouting for favorable routes and collecting critical observations where and when needed; and collecting ionospheric data and radiation activity originating from space weather.	Is a system of UASs the optimum method for obtaining this critical observational data?
R-169	Research	5.3.3	En route weather reconnaissance UASs are equipped to collect and report in-flight weather data.	UAS weather sensor development and control.
R-170	Research	2.4.5	These rules specify the conflict resolution maneuver options for resolving the conflict with minimum disruption to the maneuvering aircraft and for preventing a conflict with a third aircraft in the short term.	It is difficult to understand the logic embodied in the conflict detection and resolution process with regard to air versus ground responsibilities. Questions regarding air and ground allocation of these functions must be resolved because the answers have a major impact on development costs for the various stakeholders. Text implies significant duplication of conflict resolution capability in air and ground systems, which is

Reference	Type	Section	Line Reference	Issue
				warranted only if economic or safety benefit cases can be made.
R-171	Research	3.5.5.5	The transition to satellite-based IAPs will free up airport surface movement areas previously constrained because of ground-based navigation systems (e.g., critical areas for instrument landing systems [ILS]). NextGen will require less ground-based radio navigation infrastructure to support IAPs than is used today with ILS and other systems.	Conduct research leading toward the potential for conducting commercial air carrier operations under severe weather conditions as low as zero visibility and zero ceiling. Will satellite-based IAPs allow for operations in these very low visibility conditions?
R-172	Research	6.3/C.2.3	Risk management is inherent to every element of Layered, Adaptive Security Services; it is conducted from the strategic to the tactical levels.	How does the SSP share IRM information with stakeholders that have different levels of clearances?
R-173	Research	6.3/C.2.2.6	Risks are measures of potential harm that encompasses threat.	How should the security envelope risk values be communicated to stakeholders?
R-174	Research	6.4.2/C.3.4	The airport security technologies and adjustable procedures are nominally transparent to passengers.	What are the checkpoint equipage standards required for different types of NextGen airports?
R-175	Research	6.4.2/C.3.4	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and informed for any contingency.	CBRNE threat detection profiles will need to be developed.
R-176	Research	6.4.3/C.5.3	In addition, integrated trip tracking, with access by authorized third-party organizations, provides custom services such as remote check-in and baggage transport and processing capabilities.	An overall set of ergonomic policies will need to be developed for CBRNE detection systems in the airports.
R-177	Research	6.4.4/C.6.9	Cradle-to-Grave Tracking/Integrity	Define the security requirements for operations at all cargo airports.
R-178	Research	6.4.4/C.6.9	Cradle-to-Grave Tracking/Integrity	Define the appropriate use of IED Defeat Technology to achieve the 100% screening of all cargo items at the needed schedule.
R-179	Research	3.3.2.2	To the extent possible, Customs and INS are integrated with security screening procedures and/or augmented by automation to ensure the necessary procedures are incorporated throughout the network of airports without unnecessary duplication.	What is the role of Customs/INS within a NextGen-enabled airport? How can these processes be automated, transformed, and made more efficient?
R-180	Research	6.4.2	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and	What security measures should be considered for UAS operations?

Reference	Type	Section	Line Reference	Issue
			informed for any contingency.	
R-181	Research	6.4.3	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	How will airport space requirements be allocated to the alarm resolution process?
R-182	Research	3.3.1	GSE will have defined operating areas on the ramp specific to its function.	GSE, such as baggage carts, fuel trucks, catering, and other airport vehicles, will be managed using real-time surveillance/tracking, integrated support systems, and enhanced communication capabilities. GSE will have defined operating areas on the ramp specific to its function.
R-183	Research	3.1.1	Federal, state, and local agencies must evolve to support the effective governance of NextGen airport operations to include regional considerations, given the many stakeholders with vital interests in a successful airport system.	Research is needed on policy options and organizational aspects needed to provide oversight and coordination for NextGen operations at all governmental levels.

Appendix D: Policy Issues

Note: The following policy issues are listed by chapter content; they are not listed in any priority order.

Reference	Type	Section	Line Reference	Issue
P-1	Policy	2.2.2	In addition, backup functions are distributed throughout the system, and there are layers of protection to allow for graceful degradation of services in the event of automation failures.	Develop policies concerning liability for delegated separation and self-separation operations.
P-2	Policy	2.3.2	A transparent set of strategies is in place to achieve overall performance objectives, including airspace management to maximize capacity when demand is high and, as required, flow management initiatives to ensure safe levels of traffic are not exceeded when capacity limits are reached.	Can automation ever be "responsible" for separation assurance, or is a human (flight operator or ANSP personnel) always required to assume responsibility?
P-3	Policy	2.3.2	A transparent set of strategies is in place to achieve overall performance objectives, including airspace management to maximize capacity when demand is high and, as required, flow management initiatives to ensure safe levels of traffic are not exceeded when capacity limits are reached.	What incentives and consequences exist to encourage desired behaviors by stakeholders?
P-4	Policy	2.4	Digital data communication and ground-based and airborne automation to create, exchange, and execute 4DTs are prerequisites for TBOs.	Address needed policy related to incentives for "early filing" of flight plan intent information. How do these requirements affect scheduled operations versus on-demand or unscheduled operations?
P-5	Policy	2.8.1	ICAO Planning and Implementation Regional Group (PIRG) or multilateral agreements coordinate planning and implementation of NextGen ANSP transformations to harmonize the application of technology and procedures.	Develop a framework for ANSP arbitration decisions, including representation of national policy in a transparent set of algorithms and metrics.

Reference	Type	Section	Line Reference	Issue
P-6	Policy	2.8.2	By decoupling geographic airspace and infrastructure constraints from aircraft operations, capacity managers have the flexibility to leverage resources across facilities to match staffing to traffic demand.	Develop policies to align treaty obligations and international processes for oceanic airspace with NextGen.
P-7	Policy	3.3.1	The security of the airport perimeter and surface will be improved, as discussed in Chapter 7, regarding security protocols.	What will be the role of the operator in terms of NAS defense?
P-8	Policy	3.3.2	Advances in common use systems will continue with existing trends towards automated issuance of boarding passes (whether paper or paperless) and faster processing of passengers.	Will meeters/greeters be permitted in secure boarding areas in the future? If so, what is the potential of biometric check-in processing at the gate?
P-10	Policy	3.4.3	The noninteroperability of many of the formats, and the difficulty of conversion between formats, also inhibit simple exchange of airport planning information.	Which organization(s) will maintain overall "ownership" of the central information repository for airports?
P-11	Policy	3.5.1	In addition to airport advocacy and fostering community support for airports, the program would seek to align federal airport programs toward the goal of long-term airport preservation.	Define NextGen Airport Preservation Program. Define federal role in protecting critical infrastructure, including linkages to NPIAS and airport advocacy. Analyze liability concerns with safety zones. Define applicability of airport traffic pattern in overall program. Incorporate recommendations of existing TRB/ACRP research, when available.
P-12	Policy	3.5.2	Policy, financing, and regulatory mechanisms will provide for both public and private ownership and management of airports, including access to the NAS through level-of-service agreements with the ANSP.	Define policy options for airport ownership, finance, and management under NextGen.

Reference	Type	Section	Line Reference	Issue
P-13	Policy	3.5.5	Sensors will be needed in the runway environment for the active detection and dissipation measurement of wake vortices, which will enable reduced aircraft separation during conditions when wake turbulence is not a hazard.	What is the role of the operator in providing weather information to the NAS? Is this an airport, NOAA, or ANSP function?
P-14	Policy	3.5.6	Note that the common use infrastructure is not intended as a federal mandate; each airport and its users will determine gate allocation based upon their specific needs, as well as factors related to efficiency, cost, and availability.	Common use gate assignment can improve capacity and foster airline competition. For example, common use gate assignments can reduce the frequency of occurrence of an aircraft arriving at a terminal and not having a gate available because its company's gates are all occupied, while other vacant gates leased to another carrier are available. In the interest of efficient use of resources, should the Federal Government have a policy of encouraging flexible/common use gates over single-use gates at airports with federal grant assurances?
P-15	Policy	4.1	Secure exchange of information includes access controls, trust relationships, associated policies, and mechanisms to provide appropriate access to information by authenticated COI users.	Mobile Routing and Domain Network Services: The NextGen unclassified domain operated by the FAA may be considered as the "root" domain to which the other domains will connect. The originating domain has the responsibility to establish policies to protect the interests of all interconnected domains and negotiate interconnection agreements. These agreements will include specification of the boundary protection between domains. Boundary protection includes firewalls and trusted guard technology (e.g., Radiant Mercury). The strength or trustworthiness of the boundary protection technology and the policy used to implement the interconnection will be part of the written agreement between the authorizing

Reference	Type	Section	Line Reference	Issue
				officials (AOs). The policy domains constituting NextGen include, but are not necessarily limited to, the following: FAA; DoD; DOC; DoJ DHS; NASA; airline operating companies; general aviation facilities; state, local, and tribal law enforcement and emergency responders; commercial air traffic communication providers; foreign civil aviation authorities; and the International Civil Aviation Organization (ICAO). Mechanism and support will be provided to support U.S. Computer Emergency Readiness Team (USCERT) coordination of defense against and responses to cyber attacks across the nation and protection of the nation's Internet infrastructure.
P-16	Policy	4.1	Maintenance of information assurance across security levels and domains is a critical feature of data availability.	Cross-Domain (e.g. Multi-Level Security Exchange/ Gateway Capability: Secure communication across security levels and domains is a critical feature. Information, perhaps intelligence, at various levels of classification and from a variety of users (domains) will require information assurance. In addition, different COIs have domains that require distinct requirements for information availability. (1) Connections between different security levels must fulfill three requirements: (1) provide users with the information they need while (2) securing classified/sensitive data from access by unauthorized persons and (3) protecting networks from intended/ unintended corruption by "malicious" or hidden code

Reference	Type	Section	Line Reference	Issue
				. Top Secret, Secret, Sensitive but Unclassified, and industry proprietary information must remain *protected* in the net-centric NextGen. The requirement for purity of COI's information may be founded legally, by proprietary preference, or through civil liberties concerns and policies.
P-17	Policy	4.3.4	When new information needs or capabilities are identified by the aviation community, the network conveys that information to the COI.	NextGen must be implemented in a way that encourages participation by incentives such as fuel savings, increased aircraft operations, or access to more air space. If such incentives for volunteer equipage are lacking, then a policy will need to be established that reflects a certain level of equipage mandate to enable the utilization of the full capability of net-centric operations. This is not restricted to aircraft; it includes ground fixed, ground mobile, other airborne, and satellite; connections to similar and dissimilar network backbones (to include backward compatibility to legacy systems); and the capability to provide a reduced performance for those systems that cannot equip because of economic, technological, international, or other considerations/agreements.
P-18	Policy	5.3.1	Weather information in the form of meteorological variables that are observed or forecasted (e.g., storm intensity, echo tops, etc.) must be translated into information that is directly relevant to NextGen users and service providers, such as the likelihood of a flight deviation, airspace permeability, and capacity.	What is the role of meteorological information from nations adjacent to the NAS and over the oceans?

Reference	Type	Section	Line Reference	Issue
P-19	Policy	5.3.1	In the NextGen, consistency and continuity in the common weather picture are ensured by centrally managed weather information that is government-distributed through the NextGen Network Enabled Weather (NNEW) "virtual database" capability.	What is the role of the information available from private weather providers in realizing the single authoritative weather source and in NextGen decision making? (Note: this is partially addressed in the text)
P-20	Policy	5.3.1	It is envisioned that various federal departments will develop directives that will prioritize specified surveillance coverage capabilities and requirements in these national interest areas.	Develop a policy for back-up needs/requirements for surveillance, including the completion of the necessary safety risk analysis.
P-21	Policy	5.6	These services also manage data related to a flight from the initial filing of a proposed flight to the closing of the flight plan and the archiving of the data to support performance management analyses.	Develop a policy that addresses the handling of archived data in order to protect privacy and proprietary information.
P-22	Policy	6.3/C.2.3	Risk management is inherent to every element of layered, adaptive security services; it is conducted from the strategic to the tactical levels.	How should the IRM NEI investments and their long term O&M be financed and coordinated?
P-24	Policy	6.3/C.2.2.6	Risks are measures of potential harm that encompasses threat, vulnerability, and consequence.	How should the research of aircraft security technologies be funded, and who should fund it?
P-25	Policy	6.3/C.2.2.6	Risks are measures of potential harm that encompasses threat, vulnerability, and consequence.	How should aircraft security technology be certified? How do we expedite the certification process? How do we integrate aircraft security and safety management process?
P-27	Policy	6.3/C.2.2.4	Since the terrorist has the freedom to choose targets and modes of attack, the NGATS security system must develop (but not necessarily universally deploy) operationally feasible mitigations to as many potential threats as possible.	What kinds of cargo screening can be conducted by third parties?
P-28	Policy	6.3/C.2.2.1	This doesn't mean that all noncommercial operations have to screen passengers or cargo for flights posing below threshold risk levels.	What process best addresses privacy and civil liberty concerns within the IRM Secure People capability?

Reference	Type	Section	Line Reference	Issue
P-29	Policy	6.3/C.2.2.1	This doesn't mean that all noncommercial operations have to screen passengers or cargo for flights posing below threshold risk levels.	What agency within the Federal Government has the responsibility and authority to mandate security processes for Secure People?
P-30	Policy	6.4.1/C.3.2.2	Aviation security risks are mitigated by identifying people who, whether travelers or aviation workers, are a potential threat, and preventing them from gaining access to the air transport system through prescreening/credentialing, screening, and intervention.	If the Government uses data mining from commercial data service providers to conduct prescreening, how are validity and privacy maintained?
P-31	Policy	6.4.1/C.3.2.3	Aviation security risks are mitigated by identifying people who, whether travelers or aviation workers, are a potential threat, and preventing them from gaining access to the air transport system through prescreening/credentialing, screening, and intervention.	Can federal credentialing be made a "condition of employment" or "condition of use" for an aviation industry worker or passenger? Who should bear the responsibility of credentialing cost?
P-32	Policy	6.4.1/C.3.2.3	The NGATS NEO permits more valid and faster credential verification.	Given the difficulty of cross-agency and cross-sector coordination, how are funding and compliance issues resolved?
P-33	Policy	6.4.2/C.3.4	The airport security technologies and adjustable procedures are nominally transparent to passengers.	What kind of certification standards should be imposed on CBRNE sensors? Will we accept less than 100% reliability in the accuracy of the CBRNE sensors?
P-36	Policy	6.4.2/C.4.2.1	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and informed for any contingency.	Who pays for various security-based infrastructure modifications to facilities?
P-38	Policy	6.4.2/C.4.3.3	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and informed for any contingency.	Who pays for these counter-measures? Are airborne defense systems a better approach?
P-39	Policy	6.4.2/C.4.6	The emergency response has been appropriately gamed and rehearsed to ensure that the responders are fully prepared and informed for any contingency.	What type of intelligence and data-sharing protocols between airports, state, and federal agencies are needed?

Reference	Type	Section	Line Reference	Issue
P-40	Policy	6.4.2/C.5.3.3	RTSS Facility	Policies and standards specific to the remote check-in functions need to be developed.
P-41	Policy	6.4.2/C.4.2.4	Commercial Spaceports	What international agreements or licensing procedures should be in place to provide for ensuring that spacecraft reentering the atmosphere over U.S. territory are screened and vetted?
P-42	Policy	6.4.2/C.4.4.1	Landside: Terminal Public and Commercial Roadways & Parking Lots	How are privacy issues managed in this area?
P-43	Policy	6.4.3/C.5.4	This section includes printing bag tags at remote locations for airport check-in, as well as provisions for RTSS to allow passengers to undergo full screenings at remote off-airport locations and then be transported directly to the sterile area of the airport terminal while their screened checked bags are transported directly to the aircraft.	How can identical versus equivalent checked baggage and checkpoint screening policies and procedures between the UDS and foreign governments be harmonized?
P-44	Policy	6.4.3/C.5.2.2	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	Alarm resolution policies, protocols, and procedures will need to be developed for the CBRNE threat.
P-46	Policy	6.4.3/C.5.2.3	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	Liability issues between the airports, the airlines, the ANSP, and the SSP need resolution.
P-47	Policy	6.4.3/C.5.2.3	Such screened baggage is available for direct transfer to other modes of transportation without further screening.	Policies and procedures will need to be developed for the containment and disposition of CBRNE threat objects considered to require disposal.
P-48	Policy	6.4.3/C.4.2.2	In addition, Integrated Trip Tracking, with access by authorized third-party organizations, provides custom services such as remote check-in and baggage transport and processing capabilities.	Who pays for the remote screening, and what liability agreements are possible for third-party operation to be economically feasible?

Reference	Type	Section	Line Reference	Issue
P-49	Policy	6.4.3/C.4.2.2	In addition, Integrated Trip Tracking, with access by authorized third-party organizations, provides custom services such as remote check-in and baggage transport and processing capabilities.	Screening and overall operational policies and procedures governing the RTSS or any off-site sterile area and transportation systems will need to be developed.
P-51	Policy	6.4.4/C.6.2	The NGATS vision for cargo security moves beyond that to also include freight vulnerability assessments (through the IRM process), identifying the risk level of cargo, use of sterile cargo packing areas, cargo transit safety and integrity, and CBRNE screening for air cargo.	What policies govern liabilities and participation in the SSCE and CSCE programs in which the shipper performs cargo screening?
P-53	Policy	6.4.4/C.6.9	Cradle-to-Grave Tracking/Integrity	Expand the definition of an Indirect Air Carrier to include businesses involved in indirect transport of cargo on larger airlines, regardless of the use of passenger or all cargo aircraft.
P-54	Policy	6.4.4/C.6.9	Cradle-to-Grave Tracking/Integrity	Liability: What are liabilities if cargo is screened via available screening technologies and a mishap/attack/accident occurs?
P-56	Policy	6.4.4/C.6.4	If any deviance from this process occurs, all cargo intended for air transport, whether on passenger flights or all cargo operations, must undergo CBRNE screening from either the SSP or a CSCE.	Alarm resolution protocols and procedures need to be prepared for the range of cargo packing options.
P-57	Policy	6.4.5/C.7.5.2	These risk management requirements include defining (almost always dynamically) the boundaries of Security Restricted Airspace (SRA) and Temporary Flight Restrictions (TFR), and the cooperative division of responsibilities between the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft, the security personnel on flights, and modifications/equipage to the aircraft.	How should the NEO security infrastructure be financed and maintained?

Reference	Type	Section	Line Reference	Issue
P-58	Policy	6.4.5/C.7.5.2	These risk management requirements include defining (almost always dynamically) the boundaries of Security Restricted Airspace (SRA) and Temporary Flight Restrictions (TFR), and the cooperative division of responsibilities between the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft, the security personnel on flights and modifications/equipage to the aircraft.	What are roles and responsibilities of the ANSP, SSP, and DSP for airspace security?
P-59	Policy	6.4.5/C.7.5.2	These risk management requirements include defining (almost always dynamically) the boundaries of Security Restricted Airspace (SRA) and Temporary Flight Restrictions (TFR), and the cooperative division of responsibilities between the DSP, SSP, and ANSP in the event of security events in flight or by airborne threat aircraft, the security personnel on flights and modifications/equipage to the aircraft.	How is classified information edited for dissemination to noncleared stakeholders (e.g., FOCs and flight operators)?
P-60	Policy	6.4.5/C.7.4	In addition, Secure Airspace implements airspace access and flight procedures based on a verification process that dynamically adjusts for aircraft performance capabilities.	How will noncooperative surveillance be performed, and who will manage/fund it?
P-61	Policy	6.4.5/C.7.4	The model combines credentialing data with performance data as part of developing the risk profile of the flight object.	What kind of data and capabilities does an aircraft broadcast capability have to possess?
P-62	Policy	6.4.6/C.8.5	The Secure Aircraft Service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods.	Who pays for any secure aircraft effort: the Government, the manufacturer, the airline, the owner, or another party? Will who pays determine liability in the event of an incident?
P-63	Policy	6.4.6/C.8.5	The Secure Aircraft Service increases the safety and security of aircraft in flight through a variety of hardware, software, personnel, and procedural methods.	Do different aircraft types have different applicable standards for defensive systems?

Reference	Type	Section	Line Reference	Issue
P-64	Policy	6.4.6/C.4.2.3	The threats that require mitigation are hijacking/ unauthorized diversion; internal explosive destruction; external attack; on-board CBRN or other attack of crew, passengers, or aircraft systems; aircraft use as a transport for CBNRE; and aircraft use as a Weapon of Mass Destruction (WMD).	Under what circumstances will privately operated general aviation airports be required to install sensors and other detection equipment to meet security requirements?
P-65	Policy	7.4	These services and capabilities are described in the following subsections. Each plays an important role in supporting the transformed operations of the NextGen.	Consider a framework by which the EMS process (or other regulatory procedure) makes the approval process for routes and new runways viable.
P-66	Policy	7.4.3	The models also help industry to understand how operational decisions influence proposed projects affecting aviation noise and emissions; they also help the public to understand how actions by Government and industry affect aviation noise and emissions.	What environmental metrics should be used to best assess impacts of aviation activities on the environment?
P-68	Policy	8.3	By applying these four safety management functions early, the JPDO and its partners ensure not only that the NextGen is safely operated, but that its systems and operations are designed and built to be as safe as possible.	Establish safety management standards for NextGen stakeholders.
P-69	Policy	8.3.1	The National Aviation Safety Policy assigns responsibility for safety at the highest levels of the organization, allowing delegation of day-to-day safety management but not of overall responsibility. It establishes safety management standards and ensures that safety management processes and practices are "… made consistent with the International Civil Aviation Organization (ICAO) standards."	Aviation Safety Policy: Establish a common, national-level aviation safety policy and strategy for the NextGen and its government and industry stakeholders.

Reference	Type	Section	Line Reference	Issue
P-70	Policy	8.3.1	The National Aviation Safety Policy assigns responsibility for safety at the highest levels of the organization, allowing delegation of day-to-day safety management but not of overall responsibility. It establishes safety management standards and ensures that safety management processes and practices are "… made consistent with the International Civil Aviation Organization (ICAO) standards."	Aviation Safety Policy: If determined beneficial or necessary, mandate all NextGen government and industry stakeholders to adopt an effective and auditable safety management program, and designate a body with responsibility for coordinating and implementing the national aviation safety policy.
P-71	Policy	8.3.1	The National Aviation Safety Policy assigns responsibility for safety at the highest levels of the organization, allowing delegation of day-to-day safety management but not of overall responsibility. It establishes safety management standards and ensures that safety management processes and practices are "… made consistent with the International Civil Aviation Organization (ICAO) standards."	Aviation Safety Policy: Establish a mechanism for sharing and coordinating aviation safety research and safety enhancement activities.
P-72	Policy	8.3.2	These characteristics include but are not limited to management accountability, nonreprisal reporting, consistent use of safety risk management best practices, and sharing safety data and lessons learned.	Safety Culture: Define and foster common attributes of a multiagency safety culture and implement a safety culture improvement effort.
P-73	Policy	8.3.4	The safety relevant events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information.	Safety Assurance: Designate an oversight body with jurisdiction and responsibility over NextGen stakeholders.
P-74	Policy	8.3.4	The safety relevant events and data are reported and shared without fear of disciplinary or legal action. Mechanisms are in place for protecting competitive information.	Safety Assurance: Policy for delegating certification responsibilities.

Reference	Type	Section	Line Reference	Issue
P-75	Policy	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies, cross-pollenization of safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation.	Safety Information Sharing: Mandate sharing of safety relevant data and information across NextGen stakeholders.
P-76	Policy	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies, cross-pollenization of safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation.	Safety Information Sharing: Protect data and information shared across NextGen stakeholders.
P-77	Policy	8.4	These services provide, among others, coordination of safety activities such as research and risk mitigation strategies, cross-pollenization of safety information and lessons learned (where appropriate), and regulatory oversight to assure the public of the safety of air transportation.	Safety Information Sharing: Address liability issues related to sharing accident and other failure data.
P-79	Policy	3.5.3	To achieve the proper balance, the future airport system will require the ability to integrate multiple planning processes and analyses to determine the appropriate airport infrastructure necessary to develop the future integrated airport system plan.	Collaboration must occur among the ANSP, airport operators, flight operators, and other stakeholders such as regulators when planning an airport for integration into NextGen. A major area of collaboration is in the planning of airport improvements to increase overall capacity.
P-80	Policy	2.2.2	Automation supports the migration from tactical to strategic decision making by assimilating data and supplying information, as well as by performing many routine tasks. Ultimately, the determination of when to fully automate and when to provide decision support is made to optimize overall system performance and ensure that service providers and flight operators perform well and can respond to off-nominal and emergency events when required.	What kind of certification standards and processes should be imposed on ground sensors/automation?

Reference	Type	Section	Line Reference	Issue
P-81	Policy	3.5.1	Within NextGen, a new Airport Preservation Program is needed to enhance the sustainability of at-risk airports.	What role should the Federal Government play in airport preservation initiatives such as land banking?
P-82	Policy	3.5.1	All are vital to the future success of NextGen. However, many airports are at risk from encroachment or closure, and preservation of these resources is vital to the success of NextGen.	What role should the Federal Government play in airport preservation initiatives such as land use encroachment protection?
P-83	Policy	3.5.1	The primary threats to airport preservation are land use encroachment of incompatible uses, conversion to nonairport uses, sustainable capital and operating finance mechanisms, and lack of community support.	What role should the Federal Government play in airport preservation initiatives such preventing airport conversions?
P-84	Policy	3.5.1	At a regional level, the identification of former military bases (e.g., as part of the Base Realignment and Closure process) that have potential civilian uses could continue to be an important component in enabling aviation growth.	What role should the Federal Government play in decisions regarding military base conversions?
P-85	Policy	3.5.2.4	Congestion management programs at major airports may be used to manage short-term situations where demand exceeds the available capacity of the airport infrastructure. A combination of regulatory and market-based mechanisms could be used to balance the competing needs of aircraft operators seeking airport access, for airports to provide a reasonable level of service, and for the ANSP to accurately predict the impact of the local congestion on the NAS and mitigate the ripple effects throughout the NAS.	Should ATMS congestion management techniques include discriminating by aircraft type or equipment, or should they be market driven?

Reference	Type	Section	Line Reference	Issue
P-86	Policy	3.5.2.4	Within the congestion management program, the roles and responsibilities of federal, state, and local government decision makers, as well as the airport operator, will need to be determined.	What are the roles of the airport operator/owner, the Federal Government, and the ANSP in enforcing regulatory and market-based congestion management programs not related to ATM? Who derives revenue resulting from such programs, and how is that revenue used?
P-87	Policy	5.3.1	Weather information in the form of meteorological variables that are observed or forecasted (e.g., storm intensity, echo tops) must be translated into information that is directly relevant to NextGen users and service providers, such as the likelihood of a flight deviation, airspace permeability, and capacity.	What policies need to be changed to permit the communication of weather information in an efficient and effective fashion without superfluous information (e.g. full legal descriptions)?
P-88	Policy	2.7	The adoption of performance standards rather than equipment standards encourages innovation in avionics suppliers to produce affordable capabilities supporting trajectory-based procedures and real-time flight information (e.g., weather, airspace configuration, traffic) in the cockpit.	What actions will be taken or policies enacted to minimize equipage certification and installation cost?
P-89	Policy	2.1.2	Airspace is a national resource to be used for the public good. Government mandates are an acceptable means of meeting public good objectives when incentives are insufficient.	Who decides when to stop perusing incentives (e.g. operational benefits in favor of mandates)? What metrics are used to make these decisions? Should positive benefit/cost ratios be required for each user and provider segment that must invest?
P-90	Policy	2.4	Digital data communication and ground-based and airborne automation to create, exchange, and execute 4DTs are prerequisites for TBOs.	Policies are need to ensure that ATC automation and avionics systems are interoperable when calculating, formatting, and communicating 4DT flight plans and related changes.
P-91	Policy	2.7.1	Digital data communications between flight operators and the ANSP are the norm in trajectory-based airspace	Develop policies regarding incentives for equipping aircraft for capabilities that improve capacity or ANSP productivity.

Reference	Type	Section	Line Reference	Issue
P-92	Policy	2.1.1.1	Delivery of services is no longer tied directly to the geographic location of the aircraft; ANSP personnel acquire needed information and communicate with flight operators independent of their facility location.	Develop policies for transforming the aircraft equipage paradigm to reduce both the cost and certification time of adding advanced capabilities in the aircraft.
P-93	Policy	2.3.2.1	As proposed changes are defined, the ANSP addresses U.S. or international regulatory and policy bodies in a more effective and streamlined manner than is possible today.	Develop streamlined U.S. regulatory and/or international system changes in such a way as to provide maximum flexibility and usability in the development of airspace, procedures, and capabilities within the operational airspace system

Appendix E: References

1. JPDO, *End State Vision of the Next Generation Air Transportation System*, July 2004.

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5. RTCA, *NAS Concept of Operations and Vision for the Future of Aviation*, Washington, D.C., 2002.

6. ICAO, *Global Air Traffic Management Operational Concept*, First Edition, Doc 9854, 2005.

7. FAA, *Roadmap for Performance-Based Navigation*, 2006.