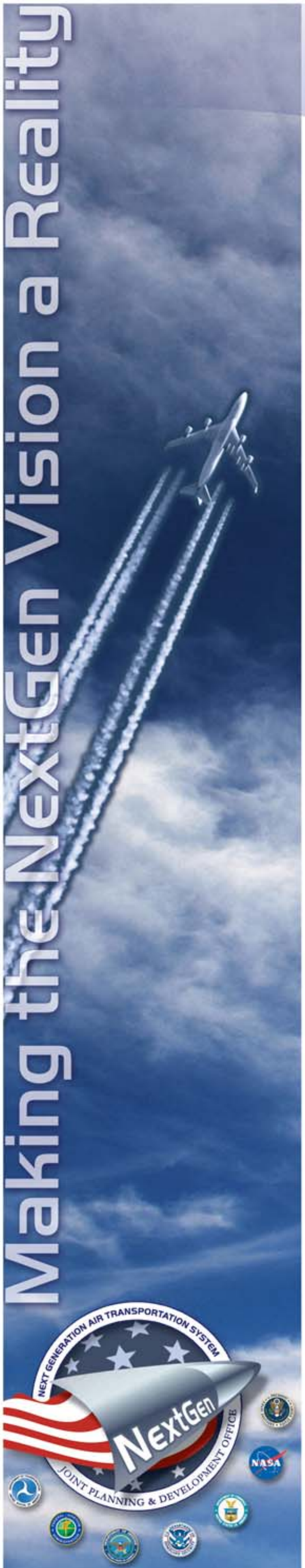

Joint Planning and Development Office

Business Case for the Next Generation Air Transportation System

Version 1.0

24 August 2007

NEXTGEN
Next Generation Air Transportation System

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PREFACE

The Joint Planning and Development Office (JPDO) developed this Business Case for the Next Generation Air Transportation System (NextGen) to inform business strategies and investment planning. The NextGen Business Case is intended to provide a characterization of the aviation environment and the motivation to move to NextGen, present an overview of the projected cost of NextGen implementation, and offer an indication of the benefits that are likely to accrue from the successful implementation of the operational concepts that comprise NextGen.

The Business Case represents an integration of data from a number of sources, including the Concept of Operations (ConOps) for the Next Generation Air Transportation System, analyses conducted by the JPDO System and Engineering Analysis Division, Federal Aviation Administration (FAA) and partner agency budget information, and aviation demand forecasts.

Booz Allen Hamilton, under contract to the FAA, gathered the data and analyses referenced in the plan and integrated the information to provide a succinct overview of the NextGen system and its associated costs and benefits. This Business Case presents a case for NextGen in a manner more akin to a commercial business case than that of a traditional government cost/benefit analysis. The plan's goal is to analyze the market situation, identify compelling business opportunities, communicate the NextGen implementation goal and how it can be attained, lay out the plan for reaching the stated goals, and present expected benefits and investments required to achieve those goals.

This document presents cost and benefits estimates that are based on the best data currently available. Because the path to NextGen will occur over nearly 20 years, cost data is necessarily much more precise for the near term and less so for the later time periods. Also, it is expected that in the near future, more accurate cost estimates for partner agencies other than the FAA will be available; however, because those estimates are not currently available, they were not included in this Business Case. Presently, benefits are expressed in terms of economic value. In addition to these benefits, JPDO and partner agencies are developing air transportation system benefit estimates for various systems, which will be made available upon completion.

EXECUTIVE SUMMARY

The Aviation Industry is Critical to the U.S. Economy: The aviation industry contributes approximately $640 billion to the U.S. economy—or 5.4 percent of the U.S. gross domestic produce (GDP)— and accounts for more than 9 million jobs[1] and about $314 billion in wages.[2] The industry is one of the strongest contributors to the U.S. trade balance, as represented by net aerospace exports that totaled more than $36 billion in 2005. Aerospace is also the third largest U.S. export category and one of the few in which the U.S. has a trade surplus.[3]

Air Traffic Control Problems Becoming Acute: The current air traffic system was built on technology that has reached the limits of its ability to handle more traffic. The current system is based on a foundation of technologies developed as far back as the 1940s and 1950s, and many of these systems have far exceeded their original life expectancy.

Fundamental Change in Air Traffic Control is Needed: While the current national airspace system (NAS) is safe and resilient, demand is now exceeding capacity in several areas of the country and forecasts indicate a doubling to tripling of demand by 2025. The Federal Aviation Administration (FAA) has implemented a spectrum of technology upgrades and procedural and airspace changes to maximize the use of available capacity. However, modernization programs that are primarily intended for "technology refresh" have reached the point of diminishing returns. A continued proliferation of patchwork upgrades to an already fragmented system simply cannot accommodate the exponential growth in air travel expected over the next 20 years—nor can it accommodate the evolving safety, security, environmental, and national defense objectives. For example, congestion already exacts a toll of $9.4 billion per year due to passenger delays[4], and that number could grow to $20 billion by 2025. For airlines, we estimate a $2 billion profit loss—funds that could otherwise be used for future fleet modernization and expansion.

A complete transformation of our nation's air transportation system is needed to facilitate the expected growth of the aviation transportation market and accommodate emerging industry trends and business models that are so vital to the U.S. economy. The Next Generation Air Transportation System (NextGen) will establish a scalable, flexible air transportation system that can adapt to market demands and provide an evolutionary pathway to a revolutionary future. The Joint Planning and Development Office (JPDO), created by Congress to coordinate the development of NextGen, has made significant progress in defining NextGen as embodied by: (a) the NextGen Concept of Operations (ConOps) that describes essential capabilities, (b) the NextGen Enterprise Architecture that provides a set of blueprints describing the state of NextGen in 2025 and how the enabling capabilities fit together, and (c) the NextGen Integrated Work Plan (IWP) that provides a more detailed framework for system requirements development, management, and implementation.

Plan to Transition to Next Generation Air Traffic System: An essential risk management element of the IWP is the detailed definition of a transformational pathway for NextGen

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[1] FAA
[2] FAA Business Outlook, 2008
[3] FAA
[4] "National Strategy to Reduce Congestion on America's Transportation Network", DOT, May 2006

implementation through stages that we refer to as epochs. *Epoch 1, Foundational Capabilities (2007-2011),* focuses on the development and implementation of mature foundational technologies and capabilities—and is well underway. Investments during this phase include the development and purchase of physical infrastructure and equipment to support systemwide use of digital communications, networking, and avionics. *Epoch 2, Hybrid System (2012-2018),* builds on this foundation and enables the aviation and aerospace industry to grow in response to market conditions and passenger demands rather than reacting to NAS constraints. Delivering specific NextGen capabilities during this second phase establishes the automation and procedures required to allow pilots to start playing a more active role in the system through self-separation, merging, and passing. *Epoch 3, NextGen Operations (2019-2025*), represents the expansion of NextGen capabilities into a nationwide system—resulting in a cohesive architecture that allows aviation services to be adapted and tailored to accommodate varying operational needs and demand profiles. In this final epoch, the system's physical transformation is completed, and the phase-out of outdated infrastructure is finished. As new partnerships, service delivery, and business models emerge, air transportation completely evolves beyond the NAS into an adaptable, scalable, and sustainable aviation system.

Benefits of a NextGen System: Preliminary benefits analyses indicate that NextGen capacity increases could yield economic growth of as much as $175 billion through 2025.[5] These benefits are not achievable without investments by the government and industry. Initial estimates of the FAA investment required to achieve the NextGen benefits is estimated at $15 billion to $22 billion through 2025.[6] Preliminary estimates for the collateral investments required from the aviation industry are projected to be $14 billion to $20 billion over this same timeframe.[7]

With such substantial benefits to the nation, it is clear that the investment in NextGen is both necessary and worthwhile. In addition to NextGen's economic impact, NextGen enables other enduring benefits that are more difficult to quantify—environmental improvements, safety enhancements, and national security and defense benefits. The investment requirements and benefits presented in this business case assume that NextGen capabilities will be developed, delivered, and financed under a business model similar to the current model used by FAA to manage the NAS. The JPDO will continue to refine NextGen benefit and cost estimates to develop implementation strategies that maximize economic value and minimize implementation risks.

5 FAA/NASA SEDF Study
6 JPDO PM Data
7 MITRE/CAASD NextGen Avionics Cost Picture (2007)

1. MARKET SITUATION

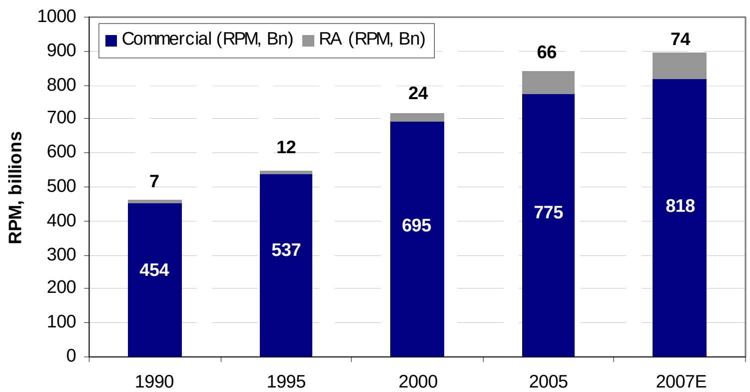
The aviation industry is a key contributor to the national economy and quality of life in the U.S.

The aviation and aerospace industries are a keystone of the U.S. economy. By providing air travel for approximately 750 million passengers annually, air transportation services promote economic growth and improvements to America's quality of life. The industry contributes $640 billion to the U.S. economy—or 5.4 percent of U.S. gross domestic product (GDP)—accounts for more than 9 million jobs[8] and about $314 billion in wages.[9] The industry has also been one of the strongest contributors to the U.S. trade balance—net aerospace exports totaled more than $36 billion in 2005. Aerospace is the third largest U.S. export category and one of the few in which the U.S. has a trade surplus.[10]

Demand for air travel has grown dramatically since the 1970s

As fares have declined more than 35% in real terms since 1978, the number of passengers has increased by about 175%.

As air travel continues to be the safest form of transportation,[11] and ticket prices have steadily declined since industry deregulation, consumer demand for air travel has increased substantially in the United States. Since the late 1970s, the number of commercial carriers has doubled, and low-cost carriers are currently injecting the market with a new breed of competition. Today, 85 percent of airline passengers have a choice of two or more carriers, compared with only 67 percent in 1978.[12] Further, the hub-and-spoke system led to growth in smaller markets that may not have been otherwise serviced in a linear route system. The broader population can now afford air travel, and commercial and regional carrier revenue passenger miles have grown more than 93 percent since 1990 (see Figure 1).



Source: FAA

Figure 1. Commercial and Regional Carriers Historical Revenue Passenger Miles

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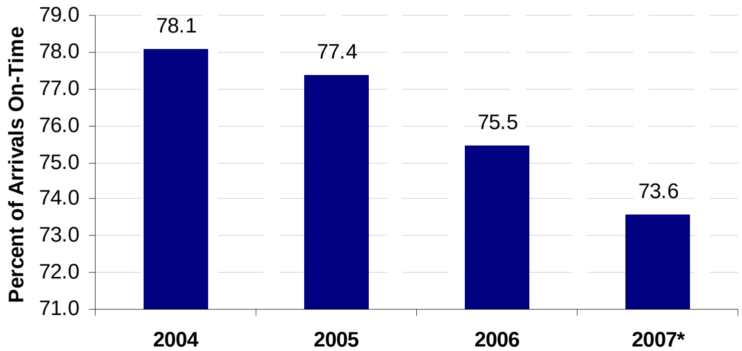
8 FAA
9 FAA Business Outlook, 2008
10 FAA
11 The FAA reports that between 2002 and 2006, U.S. scheduled air carriers transported over 3 billion passengers with a miniscule fatal accident rate of 0.023 per 100,000 flight departures.
12 Air Transport Association, Airline Handbook

The nation's air traffic control system is reaching capacity

There are clear signs that the current system is already under serious strain because of the growth in air traffic. The percentage of on-time arrivals has steadily declined each year since 2002, when 82 percent of flights arrived on time at the nation's 35 busiest airports. In 2006, the on-time arrival rate at those airports fell to 75 percent, and on-time arrivals are expected to continue to decline in 2007 (Figure 2). At the three most delayed airports in the nation—Newark, JFK, and LaGuardia—only 65 percent of arrivals were on-time and delays averaged 1 hour. Moreover, the current system is extremely sensitive to any unscheduled delays. As every traveler knows, even isolated weather delays create ripple effects throughout the country.[13]



**Data for 2007 includes the time period January 2007 through May 2007*
Source: Bureau of Transportation Statistics, FAA

Figure 2. 2004-2007 Percent On-Time Arrival Performance for All U.S. Airports

Demand for air travel will continue to grow

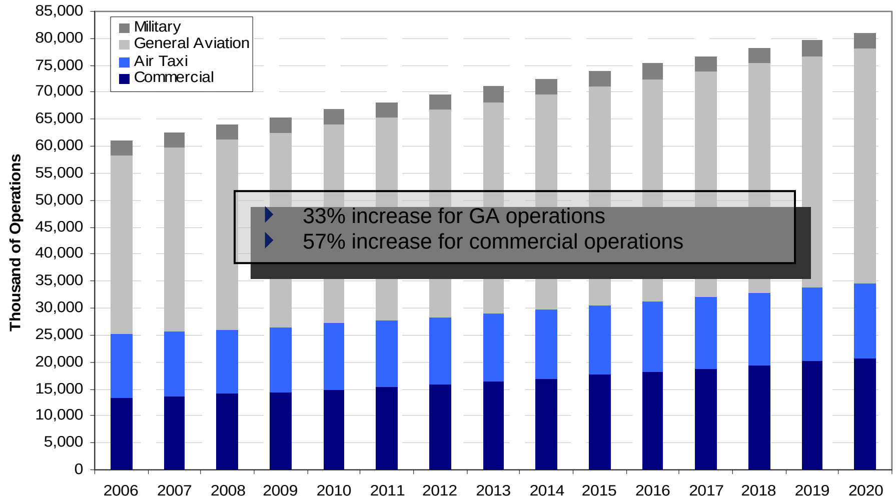
Between January and May 2007, the country's top-five airports experienced 171,222 flight delays, cancellations, or diversions—which account for more than 4.9 years of passenger delay time.

Air travel demand has rebounded since 9/11, and the upward trend is expected to continue for all segments of the market. Total commercial revenue passenger miles (RPM) are forecasted to increase 63 percent by 2020, and regional carrier RPMs are forecasted to more than double during the same period. Similarly, the total general aviation (GA) fleet is projected to increase more than 21 percent, and the GA turbine engine fleet is expected to grow nearly 65 percent by 2020. There is a wide range of estimates for the GA fleet that creates uncertainty for the potential burden on the ATM system. While the FAA projects 4,950 Very Light Jets (VLJ) to be added over the next 10 years, Forecast International estimates that 10,895 VLJs will be added to the fleet during the same period. If VLJ growth indeed meets industry expectations, this particular segment could pose a substantial burden on the air traffic control system. While fleet compositions continue to evolve, the FAA estimates that the number of aircraft operations at airports with FAA and contract traffic control service will grow significantly by 2020 (Figure 3).

Nationwide estimates may misrepresent the real impact to the air traffic control system. In heavily traveled areas, air travel is projected to increase between 100 percent and 300 percent by

[13] Mr. John Hayhurst, President, Air Traffic Management, The Boeing Company, Testimony to the United States House of Representatives, Subcommittee on Space and Aeronautics Committee on Science, July 2001.

2025.[14] For example, most of the East Coast, the Chicago area, the Midwest, and the Southwest are all projected to experience demand that is more than 200 percent current capacity.



Source: FAA

Figure 3. Total Combined Aircraft Operations at Airports with FAA and Contract Traffic Control Service

The future congestion issues are not only constrained to areas around major airports but also to the high-altitude air traffic routes throughout the country. This additional demand on the airspace will put additional strain on the current National Airspace System (NAS). Figure 4 illustrates this growth by 2025 under the assumption of a threefold increase in traffic.

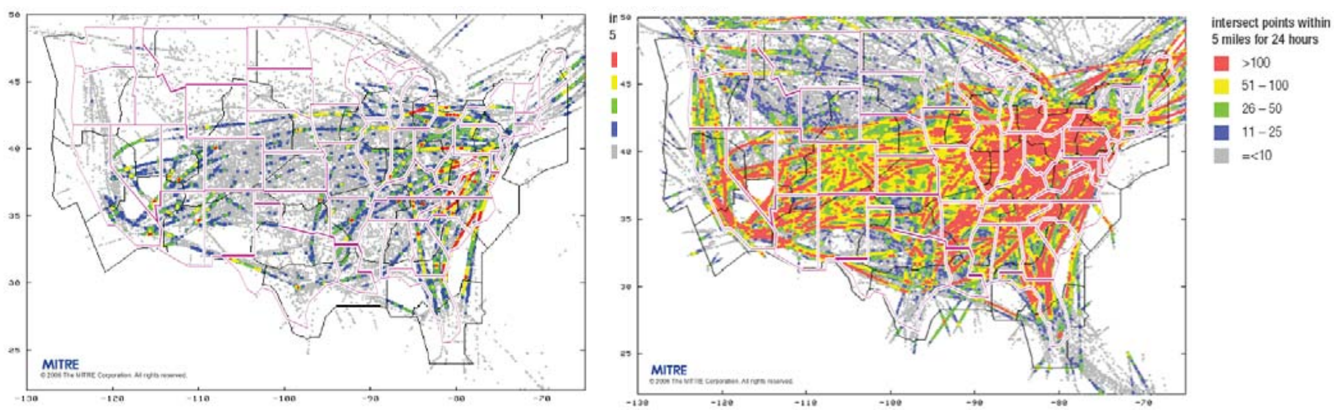


Figure 4. Unconstrained Air Traffic Growth Patterns

14 Borener, et al. "Can NGATS Meet the Demands of the Future?" Joint Planning and Development Office. January-March, 2006 quarterly issue of the ATCA Journal of Air Traffic Control.

Air traffic control system capacity cannot keep up with demand growth

> *We stand dangerously close to squandering the advantage bequeathed to us by prior generations of aerospace leaders.*
>
> *- Walker Commission Report, 2002*

The *Next Generation Air Transportation System 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 up to three times through the 2025, 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 triggered community concerns over aircraft noise, air quality, and congestion. To meet the need for increased capacity and efficiency while maintaining safety, new technologies and processes must be implemented.[15]

> *Currently, 60% to 70% of system delays are attributed to weather. Moreover, as traffic grows, weather-related delays will worsen. The FAA estimates that unless progress can be made on better weather forecasts, by 2014 there could be 29 days of delay worse than the worst delay day of 2006.*

The current air traffic system was built on technology that has reached the limits of its ability to handle more traffic. Although the U.S. has the safest aviation system in the world, the current system is based on a foundation of technologies developed as far back as the 1940s and 1950s, and many of these systems have far exceeded their original life expectancy. Traditional air traffic control is essentially the same as it was 50 years ago—a labor-intensive system in which aircraft are monitored and controlled by individual air traffic controllers using the basic tools of radar surveillance and analog radios. This system does not scale well; doubling or tripling its capacity means doubling or tripling the number of controllers and subdividing controlled airspace into ever-denser units. Even if that were possible, the required demand could not be met because just the workload associated with the constant frequency changes from small sector to ever-smaller sector would make the operation untenable. Also, in such a system, the opportunity for human error becomes a significant safety risk.

As air traffic grows, so do concerns over its impact on the environment. Current operational trends show that environmental impacts such as noise, air emissions, water pollution, land use, climate change, and fuel consumption will be primary constraints on the capacity and flexibility of the air transportation system unless these impacts are managed and mitigated. Environmental issues have resulted in the delay and/or downscaling of certain airport capacity projects over the past decade. Aircraft noise continues to be a primary area of concern. Similarly, air quality, water quality, and other environmental demands are a growing challenge to enabling significant capacity expansion without a detrimental impact to the environment. [16]

The FAA, industry analysts, and technical experts all agree that the existing system cannot accommodate the projected growth, and therefore must be overhauled.[17] In the past, adding more controllers solved many capacity issues, but such strategies can no longer cope with growing

15 Concept of Operations for the Next Generation Air Transportation System, Version 2.0, June 2007
16 Concept of Operations for the Next Generation Air Transportation System, Version 2.0, June 2007
17 www.smartskies.org

demand. [18] An FAA study by The MITRE Corporation shows that by the year 2025 as many as 14 to 27 airports and roughly 8 to 15 metropolitan areas will be capacity constrained.[19] Growth trends will continue to affect many of the same metropolitan areas such as Chicago Midway, LaGuardia, and Newark that historically have had a need for additional capacity. Figure 5 shows the potential areas that will need increased capacity if planned improvements (and aggressive technological improvement assumptions) are not realized. However, capacity constraints will not be isolated to particular cities. With severe congestion at major hubs, the number and duration of flight delays will change the face of air transportation in the United States.

Source: Capacity Needs in the National Airspace System – An Analysis of Airport and Metropolitan Area Demand and Operational Capacity in the Future. The MITRE Corporation Center for Advanced Aviation System Development, May 2007.

Figure 5. Airport and Metropolitan Areas that Need Additional Capacity in 2025

Severe air traffic congestion could handicap the U.S. economy. Individuals and businesses rely heavily on air transportation to ship and receive goods daily, and 25 percent of all companies' sales depend on air transport.[20] Therefore, if systemwide delays become too cumbersome, the entire business world, not only the airline industry, will be negatively affected.

System delays generate a huge cost to industry, passengers, shippers, and government. Cost statistics vary widely, but however stated, the sums are enormous.[21] In 2000, one of the worst years for flight delays, the average delay of 12 minutes per flight segment led to more than $9 billion in delay costs to commercial airlines. More recently, an average of 900 daily flight delays of 15 minutes or more costs the airlines and their customers more than $5 billion annually.[22]

[18] Air Transport Association
[19] Capacity Needs in the National Airspace System – An Analysis of Airport and Metropolitan Area Demand and Operational Capacity in the Future. The MITRE Corporation Center for Advanced Aviation System Development, May 2007.
[20] Air Transport Action Group, The economic and social benefits of air transport, 2005.
[21] Mr. John Hayhurst, President, Air Traffic Management, The Boeing Company, Testimony to the United States House of Representatives, Subcommittee on Space and Aeronautics Committee on Science, July 2001.
[22] Air Transport Association

In 2006, 116.5 million system delay minutes (up 5 percent from 2005) drove an estimated $7.7 billion in direct operating costs (up 11 percent from 2005) for U.S. airlines (see Table 1) [23]. The cost of aircraft block (taxi plus airborne) time was $65.80 per minute, 6 percent higher than in 2005. On average, extra fuel consumption and crew time are estimated at $42.55 per minute, followed by maintenance and aircraft ownership ($20.14 per minute) and all other costs ($3.10 per minute)..

Table 1. Cost of Flight Delays

Direct (Aircraft) Operating Costs Calendar Year 2006	$ Per Block Minute	Annual Delay Costs ($ millions)
Fuel	$28.31	$3,296
Crew - Pilots/Flight Attendants	14.25	1,659
Maintenance	10.97	1,277
Aircraft Ownership	9.18	1,069
Other	3.10	361
Total DOCs	**$65.80**	**$7,663**

Notes:

1. Costs based on data reported by U.S. passenger and cargo airlines with annual revenues of at least $100 million.
2. Arrival delay minutes taken from the FAA Aviation System Performance Metrics (ASPM 75) database.

[23] Air Transport Association

2. NEXTGEN INVESTMENT OPPORTUNITIES

The flying public continues to demand more choices, increased convenience, and better value. By 2016, the FAA projects a 27 percent increase in domestic flights, and passenger traffic between the U.S. and international destinations will grow by 70 percent;[24] worldwide traffic growth projections are roughly 80 percent.[25] These traffic growth projections raise serious questions about the ability of the NAS to supply the capacity to accommodate the increased demand of more flights. If traffic grows as expected, by 2014, delays in the U.S. will increase by 62 percent of 2004 levels, and could be even greater if weather conditions are more severe. Passengers will bear the brunt of these delays, which could conceivably double by 2014 because of missed connections and cancelled flights[26].

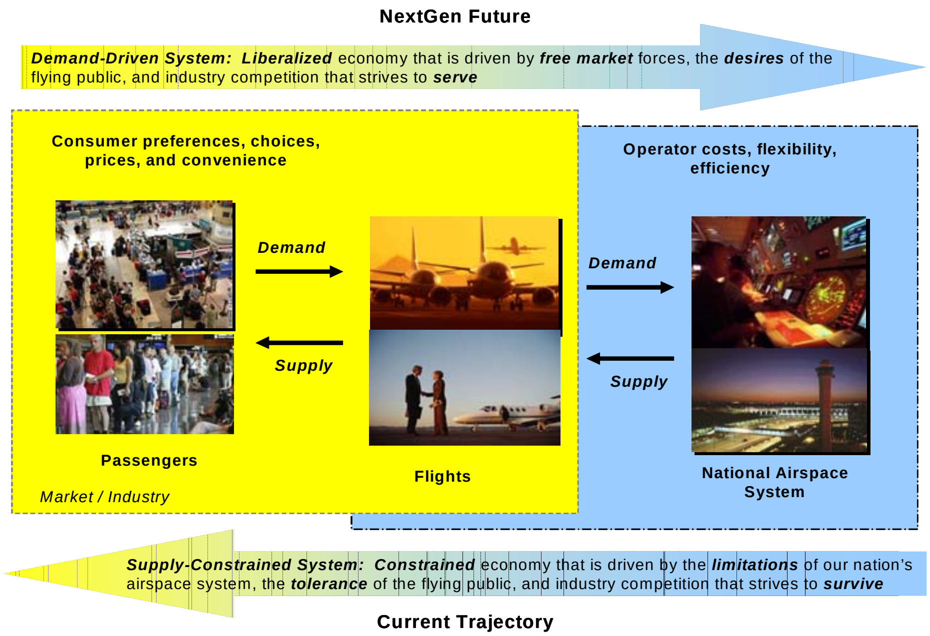


Figure 6. Aviation Market and Air Traffic Management Supply and Demand Dynamics

To serve the growing demand for air travel, the aviation industry requires more flexibility and fewer restrictions from our NAS. However, the current NAS infrastructure cannot accommodate increasing traffic demands that hamper the industry's ability to innovate and respond to market demands. The increases in traffic growth and current limitations of our NAS are already affecting industry behavior and market dynamics. The aviation industry is mired with challenges to adapt to the increasing constraints of our NAS (e.g., airspace capacity, airport capacity, weather, equipment outages) as manifested in fleet management decisions, cautious investments in internal research and development (IR&D), mergers and acquisitions, and unsustainable business and pricing models geared toward survival. For airlines, the FAA estimates $2 billion in lost profits that could have otherwise been used for future fleet modernization and expansion. For the economy, congestion already exacts a toll of $9.4 billion per year because of passenger

24 FAA API estimates
25 FAA ATO-P Strategy & performance Analysis Office
26 FAA ATO-P

delays,[27] and that number could grow to $20 billion by 2025.[28] Investing simply to maintain the "status quo" results in a constrained economy that is driven by the *limitations* of our nation's airspace system, the *tolerance* of the flying public, and industry consolidation and competition to *survive*. The impact of this supply /demand imbalance to consumers will be increased prices, decreased choices, and growing inconvenience (See Figure 6).

As a catalyst for economic growth and prosperity, our nation's airspace system must be scalable and adaptable. Merely investing in "technology refresh" programs, patchwork integration of decision support tools, and procedural solutions will not achieve this objective.

NextGen represents a complete transformation of our nation's airspace system to a performance-based, scalable, network-enabled system that minimizes operational constraints, providing a cohesive architecture that can adapt to the emerging demand profiles. NextGen will use technologies such as satellite-based navigation, surveillance, and networking, which are flexible and scalable. Investments in new technology provide the means to move from a command and control system, where controller workload is driven by directing aircraft step-by-step, to a more decentralized, user-driven, planned-in-advanced, strategic management concept.

The economic impact of the NextGen investment is characterized by a *liberalized* economy that is driven by *free market* forces, the *desires* of the flying public, and industry competition that strives to *serve* (rather than to survive).

NextGen provides a wide range of commercial opportunities for private firms, including small businesses. The projected demand for air travel offers new opportunities for industry to supply the aircraft, avionics, Air Traffic Management (ATM) infrastructure, and services to accommodate this demand. The commercial aviation industry can capitalize on this opportunity by modernizing its fleets to accommodate the emerging travel profiles and desires of the flying public. This dynamic creates opportunities for burgeoning aircraft operations and business models (e.g., VLJs, on-demand air taxi service, super-jumbo aircraft, on-demand point-to-point service) and encourages innovation and healthy competition. Increased opportunities are available for smaller companies that specialize in modeling and simulation, which is used to define system requirements. The output of these early activities will help lay the groundwork for large-scale system requirements to be implemented by major aerospace contractors. Investment opportunities in the early years of this transition will be focused in the avionics and

Passenger Airlines Strongly Support NextGen

"Civil aviation in the United States is at a tipping point. Over the next decade, commercial aviation either will continue to grow and fuel our entire national economy, driving upward of $1.2 trillion in U.S. economic activity and 11.4 million U.S. jobs, or it will slide into a troubled and unreliable system plagued by inadequate infrastructure and facilities that are unable to meet the demands of the flying and shipping public. The inescapable reality is that the ever growing demand of passengers and shippers for air transportation cannot continue to be met by the Federal Aviation Administration's outdated air traffic control (ATC) system. The Federal Aviation Administration (FAA) must develop and deploy the Next Generation Air Transportation System (NextGen) as quickly as possible."

-- James Whitehurst, COO, Delta Air Lines, Inc., July 2007.

[27] "National Strategy to Reduce Congestion on America's Transportation Network", DOT, May 2006
[28] Socio-economic demand forecast study, NASA and FAA, 2005

ground equipment required for precision navigation and surveillance. These opportunities will be followed rapidly by systems integration programs, facility consolidation, and ground infrastructure transformation projects. Service firms will also have many opportunities based on training needs for new technologies and contract support needed by those performing the technical work in support of the NextGen effort. The bottom line is that our NAS infrastructure must serve as a catalyst that stimulates these free market dynamics that are essential to a vibrant economy, rather than being a constraint that stifles innovation and competition.

NEXTGEN OPERATIONAL ENHANCEMENTS

NextGen is an evolutionary transformation of our nation's air transportation system that integrates a combination of new procedures and advances in the technology to improve service delivery to both civil and military users. 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. Figure 7 shows an overall operational view of the environment supported by NextGen.

With a focus on users, the NextGen is more agile in responding to user needs. Capacity is expanded to meet demand by investing in new infrastructure, shifting NextGen resources to meet demand, implementing more efficient procedures, and minimizing the effects of constraints, such as weather and special use airspace, on overall system capacity. The NextGen 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 to those required to address a safety or security need.

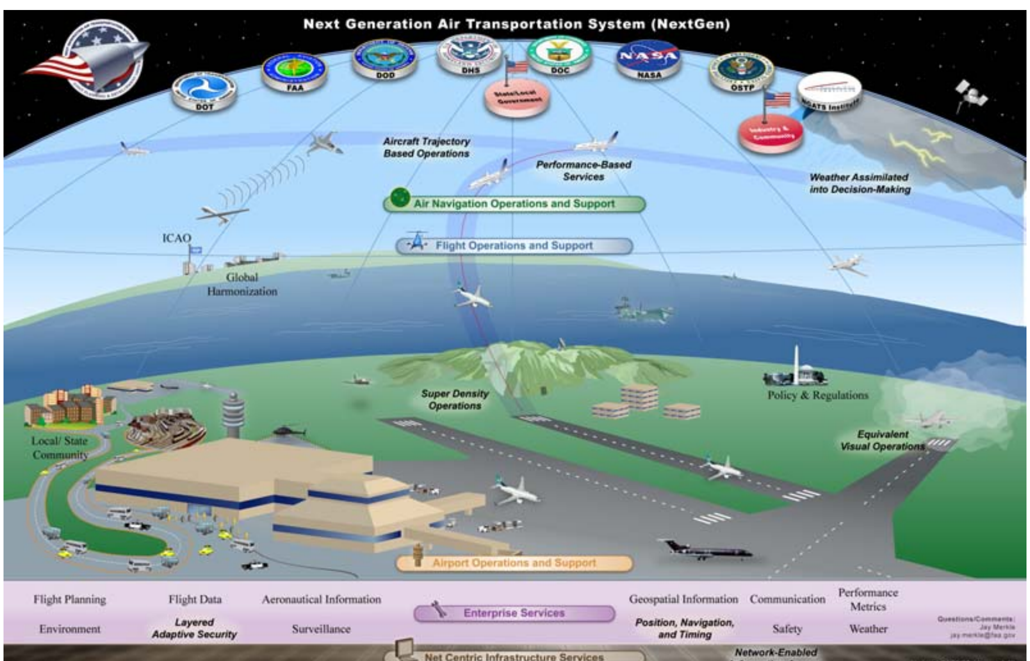


Figure 7. NextGen Operational View[29]

[29] This figure shows the operational view of the NextGen Enterprise Architecture. An "animated" version can be accessed at www.jpdo.aero and includes links to access additional details associated with each element of the architecture.

NextGen is designed to accommodate and address the aviation-related operational and strategic needs of the Department of Defense (DoD) such as global access and compatibility, airspace access for test, and training and readiness. NextGen also integrates homeland defense requirements such as non-cooperative surveillance and network-enabled intelligence integration. Lastly, DoD's acquisition and resource issues related to aviation, such as fleet certification and equipage, integration, and planning and investment for deployable air traffic control and landing systems, are addressed in NextGen.

The GA community's needs are also incorporated into NextGen. Issues such as maintaining access to the national airspace, preserving visual flight rules (VFR), limiting equipage costs, and limiting restricted airspace, all are taken into account in the NextGen implementation.[30]

The 2005 NextGen Vision briefing identifies eight key capabilities, shown in Table 2, that will help achieve these operational benefits and performance goals.

Table 2. NextGen Capabilities

Capability	Description
Network-Enabled Information Access	Information is available, securable, and usable in real time for different Communities of Interest and air transportation domains. This greater accessibility enables greater distribution of decision making, and improves the speed, efficiency, and quality of decisions and decision making.
Performance-Based Operations and Services	Regulations and procedural requirements are described in performance terms rather than in terms of specific technology or equipment.
Weather Assimilated into Decision Making	Weather information becomes an enabler for optimizing NextGen operations. Directly applying probabilistic weather information into ATM decision tools increases the effective use of weather information and minimizes the adverse effects of weather on operations.
Layered Adaptive Security	The security system is constructed of "layers of defense" to reduce threat, while minimally affecting efficient operations.
Positioning, Navigation, and Timing (PNT) Services	Instead of being driven by geographic constraints, PNT Services allow operators to define the desired flight path based on their own objectives.
Aircraft Trajectory-Based Operations (TBO)	These operations provide the ability 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	Operations are conducted regardless of visibility or direct visual observation. For aircraft, this capability enables increased accessibility on the airport surface and during arrival and departure operations.
Super-Density Operations	These operations achieve peak throughput performance at the busiest airports and in the busiest airspace.

30 Source: JPDO Briefing, July 2007

NEXTGEN IMPLEMENTATION PLANS

The JPDO has made significant progress in defining NextGen by developing key documents. Figure 8 lists these resources— the Concept of Operations (ConOps), an Enterprise Architecture, and the IWP— which will be used to manage the NextGen implementation.

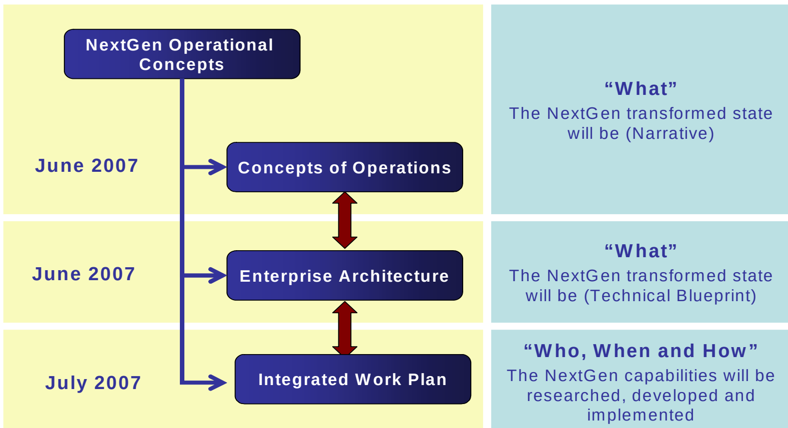


Figure 8. JPDO Management Tools

- The **NextGen ConOps** describes how NextGen will operate in 2025 and what it will look like from various stakeholders' perspectives. Version 2.0 of the ConOps, which is the foundational planning document for NextGen, was published on June 13, 2007. 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 national and global goals for air transportation.
- The **Enterprise Architecture** is much like a set of blueprints describing the state of NextGen in 2025. The architecture defines the key capabilities of NextGen, how they fit together, the timing of their implementation, and how they affect the aviation community. A version of the Enterprise Architecture that is synchronized with ConOps version 2.0 was published on June 22, 2007. The Enterprise Architecture is a 600-page technical document that describes the segments, capabilities, and the 260 operational activities and their relationships to the key target components of NextGen in 2025. It is a structured, disciplined approach to the ConOps. Each segment of the architecture contains specific details describing the operational activities, alignments, mappings, requirements, and connections to the ConOps. The architecture is intended as a tool for planning, negotiating, and understanding the dynamic, interrelated business processes and technical solutions that impact the aviation community. In summary, it is the systems documentation of NextGen.

- The **IWP** complements the ConOps and Enterprise Architecture by providing the programmatic and schedule details of the transition to NextGen. The IWP describes the transition from the current air traffic system to the future air transportation system. It is an evolutionary plan that illustrates how NextGen will be researched and developed, what commitments are required from major development partners, what policy actions are required, and what key decisions will be necessary along the way. The initial baseline of the IWP was made available on July 31, 2007.

NEXTGEN EXECUTION

NextGen is an evolutionary transformation of our NAS that will effect revolutionary change. An essential risk management element of the IWP is the detailed definition of a transformational pathway of implementation through stages that we refer to as epochs (shown in Figure 9). Epoch 1 is from 2007 to 2011, Epoch 2 from 2012 to 2018, and Epoch 3 from 2019 to 2025. This strategy is essential in defining requirements and interdependencies, communicating requirements to the user community and partner agencies, conducting applied research and development, managing implementation of key capabilities, and measuring progress.

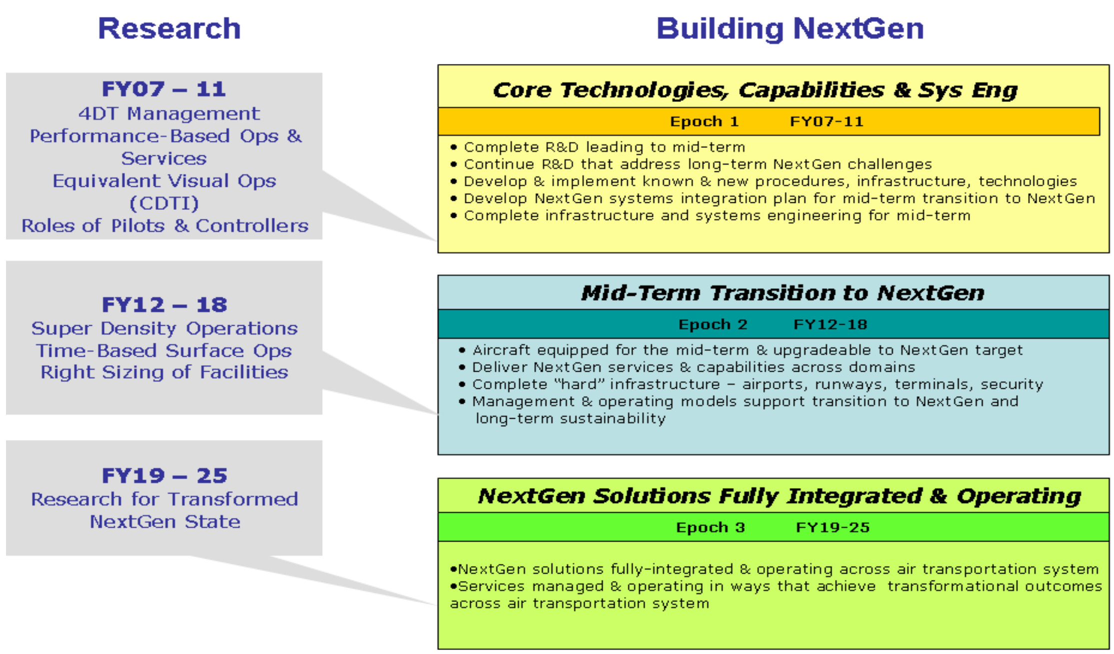


Figure 9. NextGen Epochs Description

These epochs will also facilitate the coordination and alignment of interagency research and development (R&D) to ensure cohesion among requirements and enhance systems integration. The first phase will establish the foundational NextGen infrastructure, the second phase will deliver primary NextGen operating capabilities, and the third phase will refine and extend system automation to achieve the additional benefits we foresee as we move to high-density operations.

Epoch 1 – Foundational Capabilities (2007-2011). Epoch 1 focuses on developing and implementing mature foundational technologies and capabilities—and is well underway. These initiatives are represented by current FAA programs that include the following:

- *Automatic Dependent Surveillance – Broadcast (ADS-B)* is the surveillance and navigation technology that will serve as the core of the NextGen system by delivering much more timely and precise information to the cockpit while for the first time giving pilots and controllers a common operational picture.
- *Required Navigation Performance (RNP)* is a satellite-based technology that is already delivering far greater precision in landing aircraft at major airports around the country and saving air carriers millions of dollars in fuel costs.
- *System Wide Information Management (SWIM)* will essentially serve as the World Wide Web of the NextGen system, allowing for vastly improved information exchange and improved cooperation among the government agencies with system responsibilities.
- *DataCom* is a new system that will allow enhanced data sharing between pilots and controllers and between aircraft.
- *Network-Enabled Weather* is an advanced, network-enabled forecasting system that will provide far more timely and accurate weather information on a much broader basis than is available today.

Taken together, these technologies provide the needed surveillance, navigation, and data exchange infrastructure to allow aircraft to safely use airspace in much closer proximity and with less weather-related disruption. During Epoch 1, procedures allowing more precisely navigated departures and arrivals increase capacity and safety while reducing fuel consumption, noise, and emissions. Epoch 1 capabilities also enable advanced airborne applications such as spacing and merging for approaches, optimized in-trail spacing, closely spaced parallel approaches, low visibility approach, low visibility surface operations, and reduced separation standards. Using NextGen RNP and Precision Area Navigation capabilities, coupled with ADS-B, has enabled pilot implementation of environmentally beneficial procedures. One effective procedure, the Continuous Descent Approach (CDA), keeps aircraft higher and at lower thrust for longer periods, thus eliminating the level segments in conventional "step down" approaches and significantly reducing noise, fuel burn, and carbon emissions.

Alaska's Capstone and ADS-B, a foundational NextGen Technology, can yield national improvements

- Alaska presents some of the most challenging geography in the U.S. It is larger than the combined area of the next three larger states (Texas, California, and Montana) or 21 of the smaller states. Alaska has more coastline than the combined total of the remaining states and more than 40 active volcanoes and volcanic fields. Alaska has 17 of the 20 highest peaks in the U.S. and 50 mountain ranges.
- For years, aviation, and general aviation in particular, has been a good alternative to tackle Alaska's vast geography. But relying on general aviation comes with price in terms of frequency of accidents. In response, the FAA led the development of Capstone, a program that provides pilots with state-of-the-art navigation and surveillance capabilities based on satellite and wireless data communication onboard the airplanes.
- The FAA recently announced that it will integrate the Alaskan Capstone project into the national Automatic Dependent Surveillance-Broadcast (ADS-B) program, accelerating the nationwide deployment of NextGen technology and the expected improvement in overall national safety.
- In fact, a key outcome of the Capstone program has been a ***40% reduction of general aviation accidents in Alaska***.
- Other Alaskan benefits that could be replicated at the national level include improving access into and out Alaska's communities and improving Alaska's aviation infrastructure. *Source: FAA*

Investments during this phase include the development and purchase of physical infrastructure—e.g., ground infrastructure equipment for ADS-B—to support systemwide use of digital communications, networking, and avionics. The private sector can develop and operate these capabilities as NextGen capabilities come online, but the FAA needs up-front investments to achieve critical mass. In this phase, aircraft will be equipped with the avionics required to exploit the advantages of NextGen system improvements. Late in this period, the consolidation of facilities will likely begin. With the maturing of technologies into production and the cost of building new facilities—the FAA's youngest en-route center is 47 years old—capital requirements will substantially ramp up at the end of this phase. Investments will also be required in the latter segments of Phase 1 to mitigate technical risks and encourage commercial investments in later phases, for example, by proving the feasibility of automation concepts so the investment case for industry is less risky.

Epoch 2 – Hybrid System (2012-2018). Epoch 2 builds on this foundation and enables the aviation and aerospace industry to grow in response to market conditions and passenger demands rather than reacting to NAS constraints. Delivering specific NextGen capabilities during this second phase will not only show users the promise of NextGen but will also meet the requirements of projected traffic demand (we expect to have one billion passengers moving through the system by 2015). In Epoch 2, the required automation and procedures are implemented to allow pilots a more active role in the system through self-separation, merging, and passing. The expansion of precision navigation capabilities, implementation of advanced weather capabilities, advanced data communications, and the development of the critical infrastructure for operations in high-density areas will result in greater operational flexibility and efficiency. NextGen trajectories are exchanged via data link, enabling initial trajectory-based operations and flexible airspace management and enhancing the integration of flow management with air traffic control. Collaboration and decision making are more seamless across domains, allowing more efficient airborne flow programs that reduce impact of weather. Anticipated advances in hardware and software will help deliver these new capabilities, but the cost of integrating large software-intensive systems will be significant. This approach, coupled with the major facility consolidation and replacement that will begin during this period, will drive capital needs across the system.

Epoch 3 – NextGen Operations (2019-2025). Epoch 3 represents the expansion of NextGen capabilities into a nationwide system—resulting in a cohesive architecture that allows aviation services to be adapted and tailored to accommodate varying operational needs and demand profiles. Epoch 3 essentially involves solidifying, expanding, and fine-tuning the changes made in Epoch 2 and completing the extension of NextGen to secondary airports. It will also allow for more complex, high-density operations across the system to take full advantage of the airspace and the precision provided by satellite-based technologies that will now be fully deployed. For example, we expect to increase the reliability of automated separation to extend four dimensionally managed operations from runway to runway and gate to gate. In this epoch, the physical transformation of the system is completed and the phase-out of outdated infrastructure is finished. As new partnerships and service delivery models emerge, air transportation will completely evolve beyond the NAS into an adaptable, scalable, and sustainable aviation system.

3. NEXTGEN BENEFITS AND COSTS

Investments in NextGen will result in increased system capacity and flexibility to accommodate the increasing demand for air transportation services and the increasing diversity of flight profiles. As part of developing the NextGen portfolio, FAA and JPDO are using modeling and simulation to measure and assess the benefits created by the new system while developing, evaluating, and refining required investments.

Preliminary benefits analyses indicate that NextGen capacity increases could yield economic growth of as much as $175 billion through 2025.[31] These benefits are not achievable without investments by the government and industry. Initial estimates of the FAA investment required to achieve the NextGen benefits are projected at $15 billion to $22 billion through 2025[32]. Preliminary estimates for the collateral investments required from the aviation industry are projected to be $14 billion to $20 billion during this same time frame[33]. These preliminary estimates represent the results of JPDO analyses completed to date and work to refine investment and benefits estimates continue. The evolution by NextGen epoch transformational capabilities and associated benefits is shown in Table 3.

Table 3. NextGen Capabilities by Epoch

Today's NAS	Epoch 1 Foundational Capabilities 2007-2011	Epoch 2 Hybrid System 2012-2018	Epoch 3 NextGen 2019-2025
• Mostly single-channel voice communications relying on analog technology • Limited by ground-based navigational aids. Aircraft zig-zags following the ground-based aids • Aging infrastructure • Reliance on ground-based surveillance (radar) • Rigid, sector-based, air traffic management constrained by human information processing limits • Highly susceptible to weather perturbations • Procedural control based on verbal controller clearance	• Beginning transition to digital data communications to ease frequency congestion and reduce error risk • Wider use of highly precise satellite-based navigation to reduce spacing; provide more direct routings • Development of procedures and standards to take advantage of satellite-based surveillance and navigation • Development of decision support automation to improve efficiency and safety • R&D to support implementation of Epoch 2 and beyond	• Use of digital data communications • Net-centric information management. Internet-like data flow for information access where and when needed • Expansion of precision navigation procedures to allow greater capacity in dense airspace • Flexible air space management. Resources can be applied where/when needed for most efficient service • Improved weather information available to reduce delays and improve safety • R&D to support implementation of Epoch 3	• Most communication is through digital data; much of it computer to computer • Navigation is satellite-based; path is not dictated by ground-based infrastructure • Integrated satellite-based surveillance with full situational awareness of all air vehicles • Airspace is managed dynamically; ATC services not tied to geographic location • Probabilistic weather information integrated into automation • Aircrafts able to choose their routes and manage their own separation • Aircraft able to operate in bad weather using synthetic vision

31 FAA/NASA SEDF Study
32 JPDO PM Data
33 MITRE/CAASD NextGen Avionics Cost Picture (2007)

The JPDO is assessing the portfolio of NextGen capabilities based on operational improvements that affect performance parameters by addressing all of these areas in ways that provide data and analysis of the impacts of NextGen for NAS stakeholders in the midterm and end state periods. These analyses are based on modeling and simulation of discrete changes in current NAS operations since the complete NextGen transformation of the nation's air transportation system are composed of individual enhancements within all aspects of the NAS, each of which must be both individually effective and effectively coordinated with all other enhancements.

Additional analyses still need to be completed to refine expected capacity increases, define direct user benefits derived from NextGen capabilities, and clearly bound the pool of aggregate NextGen benefits. The following paragraphs explain the JPDO analysis and benefit estimates completed to date, along with more qualitative descriptions of how these individual assessments and estimates fit within the larger NextGen vision.

NEXTGEN CAPACITY BENEFITS

NextGen will provide the necessary system capacity and scalability to accommodate growing demand for air transportation services that will accompany a growing economy. As previously stated, the efficient movement of people and cargo is vital to our national economy and international commerce. The inability of our air transportation system to serve market demands results in traffic delays and flight cancellations that have negative economic consequences. Air traffic delays also have other related consequences including adverse environmental impacts and implications for our nation's defense and security mission. Conversely, an air transportation system that provides the capacity and flexibility to accommodate emerging demand profiles is a catalyst for economic activity and growth; additional benefits include reduced carbon emissions and noise pollution and improved national security.

A fundamental way to measure the potential economic benefits of NextGen is to consider the demand forecast for the next 20 years and quantify how much of this demand can be accommodated with and without NextGen capabilities. Each flight represents quantifiable value to the economy. Passengers and cargo create demand for commercial aviation; the number of flights and their associated operational characteristics represent a demand on the air transportation system.

The joint FAA/NASA 2004 Socioeconomic Demand Forecast[34] (SEDF) study on aviation demand devised a method of translating air transportation system capacity into economic value related to consumer surplus. This study compared the capacity shortfall for the future baseline NAS with the capacity shortfall of a future NAS using assumed increases in airport and airspace capacities to represent the operational impact of the NextGen capabilities. This study translated the predicted capacity shortfall into an estimate of the potential opportunity cost for NextGen expressed through changes in consumer surplus received by passengers that would occur if NextGen were not implemented. Using data derived from the SEDF study, the JPDO estimates a rough-order-of-magnitude annual economic value of $3,000 per flight. Every additional flight accommodated by expected NextGen capacity gains represented an economic benefit, whereas every additional flight that cannot be accommodated represented an economic loss.

[34] NASA-FAA Socio-Economic Demand Forecast Study January 2004

Preliminary results from the SEDF study indicate that the cumulative positive impact to consumer surplus resulting from estimated NextGen capacity gains is expected to be up to $80 billion by the end of Epoch 2 (2018) and as much as $176 billion by the end of Epoch 3 (2025).

NEXTGEN WEATHER-RELATED BENEFITS

In addition to enabling increased capacity that is necessary to accommodate forecasted increased demand, NextGen also provides capabilities that reduce weather-related delays. Complex, dynamic systems such as our NAS will always experience some unavoidable disruptions. Weather is one significant source of disruption to system capacity, sometimes causing protracted delays and inefficient routes of flight. NextGen capabilities such as the Weather Cube will help mitigate portions of these weather-related delays, maximizing the economic value per flight even on the most challenging days.

NextGen performance benefits in bad weather were analyzed based on three actual days of NAS operations:

- February 19, 2004 (excellent weather and visibility throughout most of the continental U.S.)
- May 10, 2004 (moderate weather; a “medium” amount of total flight delay)
- July 27, 2004 (severe weather; the highest total delay observed during 2004).

Results suggest that NextGen decreases the average flight delay by a factor of 7 for the excellent weather condition, a factor of 14 in a moderate weather, and by a factor of about 4.5 in a severe weather day. The Air Transport Association estimates that each minute of delay costs approximately $50 per minute per flight (excluding passenger value of time). The demand set used for this analysis contains approximately 87,000 flights; therefore, the estimated delay savings enabled by NextGen is approximately $282 million a day in moderate weather and $239 million a day in severe weather**.**

NEXTGEN BENEFITS FOR MANAGING SPECIAL USE AIRSPACE

Another source of disruption to system capacity is special use airspace (SUA), such as the airspace periodically used by the military for training exercises. As shown in Figure 10, SUAs cover a substantial portion of the U.S. airspace. The volume of SUA airspace and the time that SUAs are active vary. When military operations or mission objectives dictate, SUAs are “hot” (active), and flights are restricted from flying through these portions of airspace resulting in longer routes of flight. When military objectives cease, SUAs are “cold” (inactive), and civilian flights are permitted to use this airspace, resulting in more direct and shorter routes of flight. While some of this disruption is unavoidable and necessary to accommodate military operations, a portion of this disruption can be mitigated through improved airspace management (e.g., more precise scheduling of SUA restrictions, more efficient definition of SUA boundaries). NextGen capabilities enable improved management of SUAs that can yield significant reductions in unnecessary flight deviations while offering the military more flexible and scalable use of the airspace. For example, the NextGen SWIM capability provides improved SUA status monitoring by flight dispatchers during the pre-flight planning phase. Using more precise SUA status monitoring, dispatchers can avoid unnecessary flight routings and the additional distance flown when SUAs are cold. To calculate potential economic benefits, the excess nautical miles were converted to time by dividing by the average speed of the aircraft in the cruise phase of flight. This excess time was converted to dollars and the result was annualized. The total cost of imperfect SUA information is approximately $45 million per year. Deploying SWIM capabilities as part of NextGen could eliminate some or all of these costs.

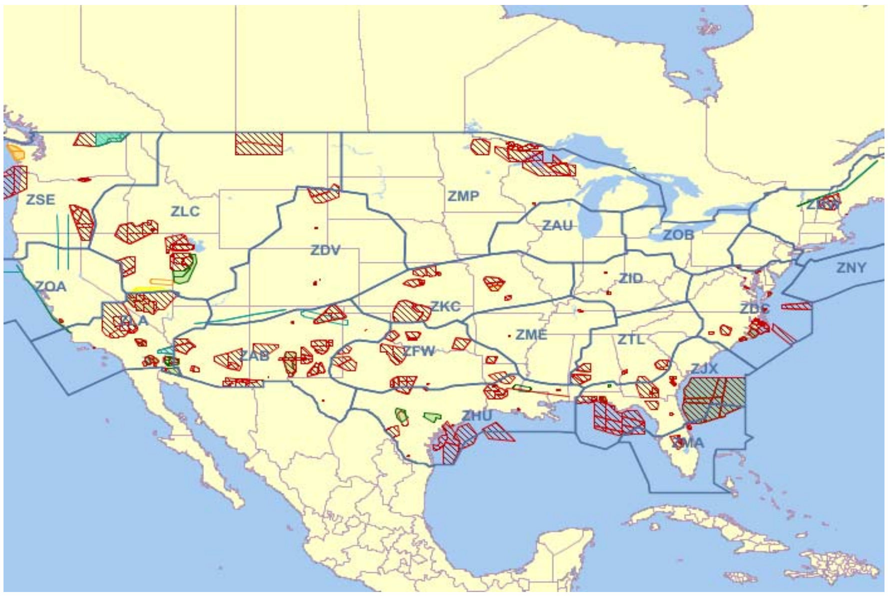


Figure 10. Major Special Use Airspace Areas

NEXTGEN ENVIRONMENTAL BENEFITS

By Epoch 2, NextGen operational improvements and fleet evolution will provide a number of environmental benefits such as fuel efficiency using CDAs and RNP arrivals and departures at the 34 FAA-designated Operational Evolution Partnership (OEP) airports within the continental United States. For example, in the terminal area, NextGen capabilities and improvements in aircraft engine technologies (fleet evolution) will produce a 15-to-21 percent improvement in fuel efficiency for arrivals compared to the baseline case; the overall improvement in fuel efficiency is estimated at 6 percent compared to the baseline.

UPS Reaps the Benefits of ADS-B

One of the early successes of NextGen technology is exemplified by UPS and its operations in Louisville, KY.

UPS will become the first U.S. airline to fly CDAs beyond trial basis. CDAs allow airlines to cut fuel burn, and reduce noise and emissions.

Some of the early benefits for UPS include saving nearly a million gallons of fuel per year (approximately $2 million); increasing Louisville airport capacity 10-15 percent; cutting noise (by 30 percent, up to six decibels); cutting emissions (NOx, oxides of nitrogen, by 34 percent below 3,000ft; CO2 emissions will be cut as well); and reducing flight distances (2 to 4 miles for every approach).

Source: Aviation Week & Space Technology

INVESTMENTS REQUIRED TO ACHIEVE NEXTGEN CAPABILITIES

To fully realize the capacity improvements and expected economic benefits resulting from NextGen, the FAA, other government agencies, and private industry must collaboratively invest in new technologies and infrastructure. The estimated FAA investment for NextGen implementation is estimated to be between $15 billion and $22 billion. The FAA and JPDO have developed initial estimates for each NextGen epoch (shown in Table 4).

Table 4. Preliminary FAA NextGen Capital Investment Estimate by Epoch

	Epoch 1	Epoch 2	Epoch 3	Total
FAA NextGen Capital Investment	$3.3B	$4.7B–$6.7B	$7B–$12B	$15B–$22B

The capital costs for NextGen are evolving. Epoch 1 estimates are well-defined and have been included in the FAA fiscal year 2008 reauthorization. The specificity and detail of cost estimates for NextGen investments in Epochs 2 and 3 continue to evolve now that the JPDO has released its Enterprise Architecture and completed its IWP.

NextGen implementation also requires a corresponding industry investment in new avionics that will interface with the NextGen infrastructure and allow aircraft operators to take full advantage of additional operational flexibility and capacity. The more aircraft that are equipped, the greater the *systemwide* benefits of NextGen. Early indications are that some air carriers are proactively aligning with the NextGen, but these early entrants need the right combination of infrastructure (systems and workforce), new procedures, FAA policy (mandates and incentives), as well as industry participation to encourage timely user equipage and pilot training to reap the full benefits of these significant investments.

Based on a preliminary analysis of NextGen avionics investment costs developed by MITRE's Center for Advanced Aviation System Development (CAASD), the JPDO estimated a probable range of $14 to $20 billion in total avionics costs to system users to meet NextGen air traffic management requirements. This analysis acknowledges that a wide range of costs is possible, depending on the bundling of avionics and the alignment of equipage schedules. This range reflects uncertainty about equipage costs for individual aircraft, the number of VLJs that will operate in high-performance airspace, and the amount of out-of-service time required for installation. Given this uncertainty, MITRE notes in its analysis that NextGen avionics cost estimates will rise over time

Early Adopters Of NextGen Capabilities Are Realizing Benefits Today.

Required Navigation Performance or RNP, a component of NextGen core capabilities, will benefit operators by increasing the acceptance rates at busy airports and enabling more efficient operational procedures.

Alaska Airlines, a pioneer in implementation of RNP, conducts RNP approaches at Palm Springs International Airport and in at least 29 instances has avoided weather-related diversions to other airports benefiting over 4,500 passengers.

Southwest Airlines will equip its entire 520 aircraft fleet for RNP, including retrofitting its 737 Classics; And it will use the procedures at the 63 airports it serves to cut fuel burn, emissions and noise. Air Transport Association President and CEO James May said this was an indication that "the entire industry is migrating as rapidly as possible to NextGen."

Delta Airlines is equipping 70% (about 400 aircraft) of its fleet and is experimenting with continuous descent approach (CDA, an RNP-enabled procedure) in Atlanta and saving $36 million a year in fuel with basic RNAV departures.

RNAV is saving operators $8.5 million per year and allowing 11 to 20 additional operations per hour at Dallas Fort Worth International Airport and 10 additional departures in Atlanta.

American Airlines will invest $100 million to equip its 757s and 767s(approximately 75% of its entire fleet) with RNP capability

Source: Air Transport World, Aviation Week, Air Line Pilot rather than shrink. MITRE also notes that this is a work in progress; hence, the numbers will change but the fact that costs are significant (more than $14 billion) will not.

These cost estimates are not yet mature enough to be mapped to specific epochs.

Development of cost estimates for required NextGen investments continues. The JPDO is working to integrate partner agency capital investments into overall estimates. The development of NextGen-specific operations and maintenance cost estimates is premature at this time, but JPDO is planning to develop appropriate NextGen life-cycle cost estimates that address legacy infrastructure operations and decommissioning.

It is important to recognize that the value of NextGen investments is time sensitive. The net-present value (NPV) of investments will decline if investments are delayed. This decline in the NPV is attributed to missed opportunities and added cost to the industry that is not recoverable.

4. SUMMARY

With such substantial benefits to the nation, it is clear that investing in NextGen is both necessary and worthwhile. In addition to NextGen's impact on the aviation market and GDP, the flexibility and scalability that NextGen offers will produce other enduring benefits, including environmental benefits, safety and security benefits, and benefits to our nation's homeland security and defense mission. The investment requirements and benefits presented in this business case assume that NextGen capabilities will be developed, delivered, and financed under a business model similar to the current model used by FAA to manage the NAS. The JPDO will continue to refine NextGen benefit and cost estimates to develop implementation strategies that maximize economic value and minimize implementation risks.