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Avoiding Gridlock in the Skies: Issues and Options for Addressing Growth in Air Traffic

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Avoiding Gridlock in the Skies: Issues and Options for Addressing Growth in Air Traffic

Summary

A major challenge facing aviation policymakers is developing a strategy for increasing the capacity of the national airspace system to keep pace with projected growth in demand for air travel. While Transportation Secretary Norman Mineta's vision for the next generation air traffic system aspires to triple system capacity by 2025, FAA projections suggest that capacity enhancements will struggle to keep pace with growth in demand at major airports, in busy airspace around major metropolitan areas, and along certain busy high altitude corridors. Factors, including the continuing population shift into major metropolitan areas, the increased reliance on smaller jets in both airline and general aviation operations, and increased point-to-point service, are expected to spur growth in those aviation operations that impact high altitude airspace and contribute to increased congestion at capacity constrained airports.

The current aviation system is constrained by limited available capacity at critical major metropolitan airports and is increasingly unable to meet projected future demand. The system also is constrained by outdated technology and procedures that limit the utilization of available airspace. In addition to meeting these challenges, the FAA also faces internal challenges to meet future controller staffing needs given that almost half of its existing controller workforce is expected to retire over the next decade. The FAA also faces significant challenges in reforming its organizational culture which historically has been blamed for consistent cost overruns, schedule slips, and performance shortfalls in major air traffic modernization projects.

Two new organizations within the FAA — the Air Traffic Organization (ATO) and the Joint Planning and Development Office (JPDO) — are viewed as key elements of organizational reform that may be closely scrutinized by Congress and administration policymakers to ensure that they effectively manage the implementation of near term and long range capacity enhancement efforts. The key challenges for these organizations is to develop and execute capacity expansion plans that appropriately invest in airport infrastructure, air traffic system technology, and operational procedures to keep pace with expected growth in demand for air travel while maintaining or improving upon current levels of safety and efficiency. Possible strategies for meeting these objectives include implementing *free flight* concepts that will allow more autonomy and direct routing of aircraft to better optimize airspace utilization; safely reducing aircraft separation standards to increase capacity in crowded airspace; effectively implementing automation and decision aiding technologies to improve airspace utilization and traffic flow; and expanding and reconfiguring existing airport infrastructure. In addition, demand management strategies, such as curtailing peak hour flights or implementing slots or quotas may be examined as means to align demand with available capacity at congested airports. The FAA's investment strategy for meeting these capacity needs is also likely to be of considerable interest in future years as significant funding challenges may arise because of possible aviation trust fund shortages and a history of significant cost overruns on major airspace modernization projects. [This report will not be updated.]

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Avoiding Gridlock in the Skies: Issues and Options for Addressing Growth in Air Traffic

The demand for air travel over the next 15 years is expected to grow significantly necessitating the expansion of the national airspace system. Passenger boardings are expected to increase by almost 60% compared to pre-September 11, 2001 levels.[1] Systemwide, air traffic operations are expected to increase by about 15%, including a 30% growth in air transport and commercial operations. At the nation's 35 busiest airports, total operations are expected to increase more than 34% by 2020. To expand system capacity to meet this projected growth, the Department of Transportation has unveiled an ambitious plan calling for a threefold increase in systemwide capacity over the next 15 to 20 years. However, at least in the near-term, planned capacity enhancement projects are expected to lag slightly behind projected growth in aviation operations. Therefore, to meet future demand novel approaches may be needed to expand system capacity while maintaining system efficiency and safety.

Speaking before the Aero Club of Washington in January 2004, Secretary of Transportation Norman Mineta unveiled his plan for the future of the national airspace system and set the bar for expanding its capacity:

> Unless we act now, our leadership [in aviation and aerospace] is in jeopardy, and we could be facing gridlock in our national airspace. ...Therefore, I have launched an initiative to galvanize America's energies to design the Next Generation Air Transportation System. A cleaner, quieter system based on 21st century technology that will offer seamless security and added capacity to relieve congestion and secure America's place as a global leader in aviation's second century. ...We will harness technology in a way that triples the capacity of our aviation system over the next 15 to 20 years.[2]

Experts have expressed concerns that, unless the FAA addresses the impact of anticipated growth in air traffic, flight operations are likely to be constrained by under-capacity in the national airspace system, especially at the nation's busiest airports. While clearly a significant increase in capacity is likely to be needed, tripling system capacity — as Secretary Mineta's vision aspires to do — appears to be an extremely lofty goal to attain. Nonetheless, additional capacity is especially needed at several of the nations busiest airports that are already operating at or

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[1] Based on FAA Terminal Area Forecast (TAF) model. Pre-September 11, 2001 comparisons use 2000 data as the comparison basis.

[2] Remarks for the Honorable Norman Y. Mineta, Secretary of Transportation. *Securing America's Place as Global Leader in Aviation's Second Century.* Aero Club of Washington, Washington, DC, January 27, 2004. U.S. Department of Transportation, Office of Public Affairs.

slightly above their theoretical capacity limits during peak travel times and in poor weather scenarios.[3]

In fact, if capacity could be doubled over the next 20 years, these enhancements will likely be sufficient to provide enough headroom to accommodate projected growth in aviation operations for about the next 30 years. However, many remain skeptical whether even this goal is achievable and worry that, unless significant changes occur, the national airspace system is destined to be constrained by under-capacity at the nation's busiest airports and an inability to expand the infrastructure and effectively implement technology and procedural changes to air traffic operations to alleviate congestion and delay. These critics point to FAA's historic failures to effectively manage major acquisition projects, large looming costs for air traffic operations and capacity enhancement projects, and possible shortfalls in the aviation trust fund as major hurdles standing in the way of progress to fully implement the next generation air transportation system (NGATS).

Several challenges have been identified that may limit the FAA's ability to significantly increase the capacity of the national airspace system over the next 15 to 20 years. One significant challenge is overcoming FAA's traditional organizational culture that has, in the opinion of many, failed to effectively develop a comprehensive national strategy for enhancing capacity and failed to effectively manage major acquisition efforts designed to address capacity needs.[4] A second factor is that there is a relatively high degree of uncertainty and risk associated with many of the proposed programs designed to enhance capacity. While some of that risk can be tied to FAA's past performance in managing airspace modernization projects, it should also be recognized that the complexity of the technology and the national airspace system pose significant technical challenges that expose both short-term and long-range plans for enhancing aviation capacity to considerable risk. A third factor is the potential lack of available capital to fund capacity-related projects and programs. Possible revenue shortfalls in the airport and airways trust fund and potential cuts to the FAA's facilities and equipment account could significantly impede progress toward enhancing capacity. If these current funding challenges persist, FAA is likely to face difficult decisions in prioritizing capacity enhancing projects over the next several years.

This report examines: factors influencing the forecast growth and changing characteristics of flight operations in the national airspace system; factors affecting the ability to expand airport and airspace capacity to meet future demands; and the impact of capacity constraints on flight operations and aviation safety. This report also examines several possible strategies to expand system capacity, many of which are being implemented or evaluated by the FAA and Congress. These strategies fall into four broad categories: 1) airport expansion and infrastructure improvements; 2) technology options to improve traffic flow and safely reduce aircraft separation; 3)

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[3] See Federal Aviation Administration. *Airport Capacity Benchmark Report 2001.*

[4] See, especially, U.S. General Accounting Office. *Air Traffic Control: FAA's Modernization Efforts — Past, Present, and Future."* Statement of Gerald L. Dillingham, Director, Physical Infrastructure Issues Before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives, October 30, 2003.

strategic plans and tactical tools to improve traffic flow and respond to delay-inducing events; and 4) market based solutions to alter the demand characteristics of flight operations at busy airports and in congested airspace. Finally, this report examines the fiscal needs and funding challenges associated with implementing both near-term and long-term programs to improve aviation system capacity.

Factors Affecting Growth in Air Traffic Operations

Several factors are expected to affect the growth in air traffic operations over the next several years. Behind all of these factors is the country's overall economic growth. Another key underlying factor is the growth in U.S. population, and more importantly, the population shift into major metropolitan areas and corresponding economic growth in these areas. Additional factors include the increased use of smaller commuter jets, more point-to-point routes for airline service, and significant growth in business jet operations. The net result of these factors is a forecast average annual growth rate of about 4.4% in airborne hours for airlines (including all-cargo carriers), commuter operators, and business jets. These operations will most significantly impact the busiest commercial and general aviation reliever airports in the United States, airspace in major metropolitan areas, and certain busy high altitude corridors.

Impact of Overall Economic Growth on Aviation

Future demand for aviation is likely to closely track projected growth in gross domestic product (GDP). In fact, projected GDP growth is the main factor considered in FAA's forecast assumptions for aviation demand over the next 10 years and has historically been an excellent long-term predictor of growth in the aviation industry. Analysis of historic data from 1976 to 2003 indicate that the correlation between GDP and passenger boardings is 0.97, and the correlation between GDP and the total number of air carrier, air taxi, and other commercial operations is 0.94.[5] Over the past few years, however, this has not been the case. The response to the September 11, 2001 terrorist attacks, a decline in air travel during the initial phase of the U.S. war with Iraq, and impact from the 2003 severe acute respiratory syndrome (SARS) outbreak have all been identified as contributors to the significant decline in aviation operations over the past four years that could not have been foreseen. In fact, when the years between 2001 and 2003 are removed from the analysis, the correlation between GDP and passenger boardings rises to almost 0.99 and the correlation between GDP and commercial operations is almost 0.97. As the aviation industry recovers from these unprecedented events, passenger demand and operations are expected to resume a track of growth that closely parallels the forecast rise in GDP barring any unforeseen events that could significantly alter this projected growth pattern.

[5] CRS calculations of correlation between OMB historical data of GDP and FAA terminal area forecast (TAF) historical data of systemwide enplanements and operations. Correlation values measure how closely related two variable are and range between -1 and +1. Since the correlations between GDP and passenger boardings and GDP and flight operations are close to 1, these variables are considered to be closely related. However, this does not imply that there is any causal relationship between these variables.

While the FAA expects that other economic factors, such as the consumer price index (CPI) and fuel costs, will have a negligible impact on forecast growth in aviation operations over the next 10 years, anticipated changes in the shape of the aviation industry may raise the significance of these factors in predicting future demand for aviation operations. For example, rising fuel costs to the aviation industry could drive up airline ticket prices thus slowing demand for air travel. Such factors are likely to become more important considerations as the aviation industry shifts toward a consumer base consisting of more leisure travelers whose purchasing patterns tend to be more cost sensitive. Competition among low-cost carriers in a market of cost conscious consumers with ready access to ticket pricing data over the internet is likely to keep airline prices relatively low and demand high. The emergence of other aviation options for business consumers, such as fractional ownership programs for business jets and lower cost mini-jets, may result in further shift the demand characteristics for airline travel and alter the composition of operations in the national airspace system.

Population Growth in Metropolitan Areas

Since the end of World War II, major metropolitan areas have grown significantly (see **Figure 1**). By 2000, more than 80% of U.S. residents were living in metropolitan areas. Fifty of these metropolitan areas had populations greater than 1 million people and these areas were home to 57% of the total U.S. population.[6]

The resulting impact of the increasing population concentration in metropolitan areas on aviation is reflected by a high density of air traffic operations and concerns over capacity at a relatively small number of commercial and general aviation reliever airports located within these major metropolitan areas. In fact, out of more than 400 airports with commercial service in the United States, the FAA currently identifies only 35 commercial airports in its near-term strategic plan for enhancing the capacity of the national airspace system — the operational evolution plan (OEP).[7] All of the airports listed in the OEP are located in major metropolitan regions with more than one and one-half million inhabitants. These 35 airports, referred to as the OEP-35 airports, handled 57% of all commercial operations at towered airports between FY1999 and FY2002.

While capacity constraints, delays, and environmental considerations are likely to be the most significant issues for these large metropolitan airports, the continued availability and adequacy of service is likely to be a challenge for airports outside of these major population centers, many of which have already lost air service as a result of airline industry cutbacks.[8] In other words, while major metropolitan areas are likely to face challenges in meeting aviation capacity needs, airports in small cities

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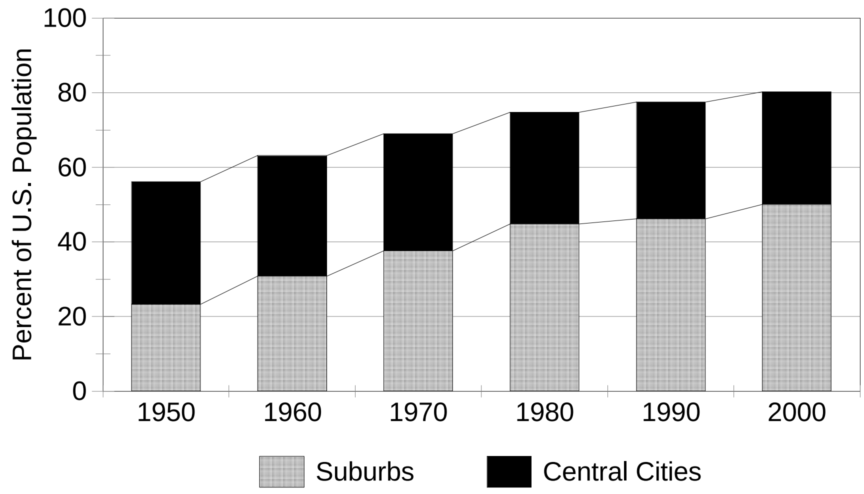
[6] Frank Hobbs and Nicole Stoops. *Demographic Trends in the 20th Century: Census 2000 Special Reports.* U.S. Department of Commerce, U.S. Census Bureau, CENSR-4, November 2002.

[7] Federal Aviation Administration. *Operational Evolution Plan (Version 6.0), 2004-2014.*

[8] Michael Allen. *Crisis in Small Community Air Service.* BACK Aviation Solutions: New Haven, CT.

may face difficulties in maintaining adequate air service. Thus, aviation capacity is largely a geographically specific issue affecting service to and from major metropolitan commercial and general aviation reliever airports and the flight corridors interconnecting these major population centers.

Figure 1. Population Growth in Metropolitan Areas Since 1950



Source: U.S. Census Bureau.

Besides population growth, high income growth in a metropolitan region may increase demand for both airline travel and business aviation. Recognizing the influence of both population and income growth in major metropolitan areas on air traffic demand characteristics, the FAA and the MITRE Corporation's Center for Advanced Aviation System Development (CASSD) recently released a detailed study of aviation capacity needs over the next 15 years.[9]

The study identified five airports across the country where additional capacity is already needed: Hartsfield-Jackson Atlanta International (ATL), Newark Liberty International (EWR), New York LaGuardia (LGA), Chicago O'Hare (ORD) and Philadelphia International (PHL). Atlanta, Georgia was identified as the one metropolitan area already in need of additional capacity because it lacks a second commercial airport to offload some of the ATL traffic. However, the study found that the completion of a fifth runway at ATL should meet Atlanta's additional capacity needs, at least until 2020.

The study concluded that by 2013, 15 airports will need additional capacity improvements, assuming planned enhancements at airports are completed before then. All three major airports in the New York metropolitan area (EWR, LGA, and Kennedy International (JFK)) made the list as did three airports in the Los Angeles

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[9] Federal Aviation Administration and The MITRE Corporation. *Capacity Needs in the National Airspace System: An Analysis of Airport and Metropolitan Area Demand and Operational Capacity in the Future.* June 2004.

area. If planned improvements don't occur, the total number of airports needing additional capacity may rise as high as 26.

According to the study, by 2020, the number of airports needing additional capacity will grow to 18 assuming planned enhancements stay on track before then. An additional 23 airports were identified as potentially needing additional capacity by 2020 if planned improvements are delayed or cancelled. For some metropolitan areas, the outlook is not particularly promising. In Los Angeles, for example, if planned enhancements don't occur, additional capacity will be needed at all major commercial airports and two key reliever airports. Even with the planned enhancements in place, the Los Angeles metropolitan area will face significant capacity constraints in the next 10 to 15 years.

While major metropolitan areas like Los Angeles and New York face significant challenges to meet aviation capacity needs over the next 15 years, capacity needs are not limited to the largest metropolitan areas and the current busiest airports. For example, the study found that the fast-growing metropolitan areas of Austin and San Antonio, Texas, and Tucson, Arizona, while not included in the OEP-35, are anticipated to have a significant need for additional capacity over the next 15 years spurred by large economic growth. In sum, the capacity needs study identifies significant challenges ahead for meeting aviation capacity demand in large and fast-growing metropolitan areas.

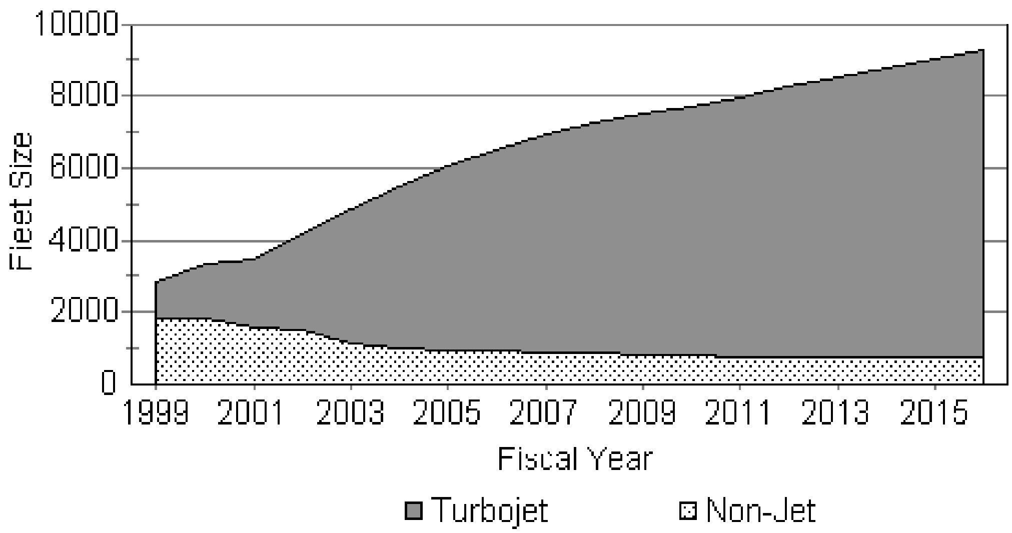
Increased Use of Smaller Jets

Besides population growth in metropolitan areas, the shift toward using more smaller jets in scheduled service and expansion of the business jet market is expected to increase the operational load of the national airspace system.

Many are anticipating the arrival of Airbus A-380, the world's largest commercial airliner, which is expected to enter service in 2006. However, the A-380 is targeted at long-range international operations and is expected to have a negligible impact on airspace capacity considerations domestically, especially since no domestic passenger airline has placed an order for even one of these airplanes to date. In fact, the projected trend in the domestic U.S. market is actually toward smaller jets rather than larger jets both in the airline industry and also in charter and general aviation operations. The net effect of large anticipated growth in the market and utilization of these smaller aircraft is an expected increase in traffic at both commercial and general aviation reliever airports.

Regional Jets. Regional and commuter airlines have been, and continue to convert their fleets from turboprop aircraft to faster regional jets that appeal to consumer demand for jet service. Regional jet manufacturers, chiefly Canadian maker Bombardier and Brazilian manufacturer Embraer, continue to produce large numbers of aircraft for the 50 to 90 seat regional market and are now developing larger aircraft that will seat up to 120 passengers to compete with the Boeing 717 and Airbus A319. FAA data indicate that the number of regional jets flown by regional and commuter carriers has increased by about 550% since 1998. The growth in regional jets is expected to continue, but at a reduced rate: the number of regional jets is expected to double compared to current fleet size by 2015. This increase in regional jets will only be slightly offset by a modest decline in the use of turboprop aircraft. Overall a net increase in regional and commuter fleet size of 50% over current levels is forecast (see **Figure 2**).

Figure 2. Fleet Composition for Regional and Commuter Operators (Passenger Aircraft > 30 Passenger Seats)



Source: FAA Aerospace Forecasts FY2005-2016.

While the size of the overall regional and commuter fleet (including turboprop and turbojet aircraft) is anticipated to increase by 50% over the next 10 years, the utilization of these aircraft is expected to increase by 60% over that same time period, indicating an increased reliance on these smaller airplanes. Like fleet size, utilization of commuter and regional jets is expected to increase more than twofold by 2015 (see **Figure 3**).

However, skeptical industry experts have questioned these optimistic growth projections for regional jets. These analysts point out that — along highly competitive routes with competition from low-cost carriers — operating small jets is more costly than operating larger jets simply because there are fewer revenue-generating seats to offset the fixed unit operating costs. They reason that, if cost, schedule, and other factors are relatively equal, consumers would rather travel on the larger jets anyway. Skeptical analysts also caution that airlines have over-bought regional jets in the 50 passenger seat size range, and there may soon be a glut of these 50-seat aircraft on the used aircraft market.[10]

Regional jets play a critical role in serving smaller markets. Their future, therefore, depends to a large extent on airlines finding ways to make a profit serving these markets. Since the regional jets have historically been run by network affiliates

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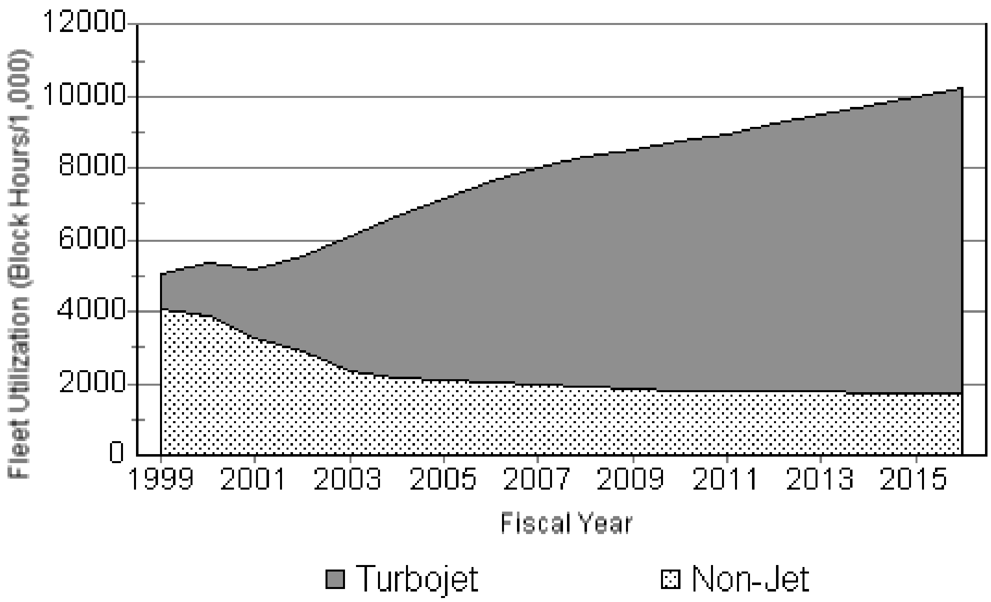
[10] Eric Torbenson. "Smaller jets lift profits, but have airlines overindulged?" *The Dallas Morning News*, June 5, 2004.

of major legacy air carriers, many of whom are now financially troubled, the once certain prospects of continued growth in the regional jet market reflected in the FAA forecasts is now much more doubtful. What there is greater certainty about, however, is the forecast growth in passenger volume that is driving these trends. How regional jets fit into the airlines strategic plans to meet this demand is much less certain. Perhaps they will grow as forecast, or perhaps they will be replaced by large passenger jets in many markets. If regional jet operations do grow as forecast, they are likely to have a very large impact on system capacity, especially at busy hub airports.

Figure 3. Fleet Utilization for Regional and Commuter Operators (Passenger Aircraft)



Source: FAA Aerospace Forecasts FY2005-2016.

Business Jets and Mini-Jets. While negligible growth is expected in operations of piston-engine and turboprop aircraft used for general aviation and air taxi operations over the next 10 years, significant growth in business jets and very small jet aircraft, referred to by many as mini-jets, is anticipated by some. Whether this trend plays out as some anticipate will largely depend on the overall health of the U.S. economy as the business jet marketplace has historically been very sensitive to economic conditions. From an air traffic management standpoint, this projected trend will likely have a large impact. These operations will likely place significant demands on high altitude airspace, congested airspace around major metropolitan areas, and particularly at general aviation reliever airports and those commercial airports that have a fair amount of general aviation operations in addition to commercial traffic.

Two specific trends are likely to spur continued growth in the business jet market. These trends are the proliferation of fractional ownership programs and the introduction of relatively low cost mini-jets. Both of these trends are viewed as opening up the aviation marketplace to many customers who previously viewed aircraft ownership as cost prohibitive. The increased flexibility in trip scheduling and available airports that business jets can operate in and out of, coupled with the ability to avoid many of the hassles of airline travel, such as parking, ticketing, and security screening, is likely to prompt business travelers and corporations to consider fractional ownership programs and mini-jets as alternatives to airline travel.

Fractional Ownership. One specific source of the large growth in business jet operations is the exponential growth in fractionally owned aircraft. In fractional ownership arrangements, corporations or individuals purchase an interest in as little as 1/16th of an airplane (or 1/32nd of a helicopter) and typically pay a fixed fee for operations and maintenance. Large fractional ownership management companies like NetJets and Bombardier Flexjet provide fractional owners with access to all comparable and smaller sized aircraft in their fleet thus providing owners with on-demand access to a entire fleet of business jets at a small fraction of the typical purchase and operating cost of just one airplane. In essence, this arrangement provides the fractional owner with a fixed number of hours of flight time usage in a jet of a particular size each year. More recent innovative approaches, such as the Marquis Jet Card program offered by NetJets, allow businesses and individuals to purchase flight time in 25-hour increments, thus providing access to business jets at an even lower cost than buying into a fractional ownership program.

Fractional ownership programs and charter flight-time purchase programs like the Marquis Jet Card are likely to attract a significant number of corporations and individuals to business aircraft operations who would have otherwise viewed the costs of owning and operating business aircraft to be prohibitive. The fractional ownership concept — although first introduced in the mid 1980s — was still virtually unheard of 10 years ago. However, over the past 10 years, fractional ownership programs have seen exponential growth (**see Figure 4**). In the last four years, fractional ownership has grown by 62%. This trend is expected to continue. Experts believe that only a small amount of the potential for fractional ownership has been developed so far, and forecasts estimate that the number of fractional shares will reach 7,000 and the total number of fractional aircraft will be about 1,200 by 2007. Fractional ownership is expected to account for about 100 aircraft deliveries per year through 2012. By then, fractional aircraft are expected to comprise almost 1/4th of the business aircraft market.[11]

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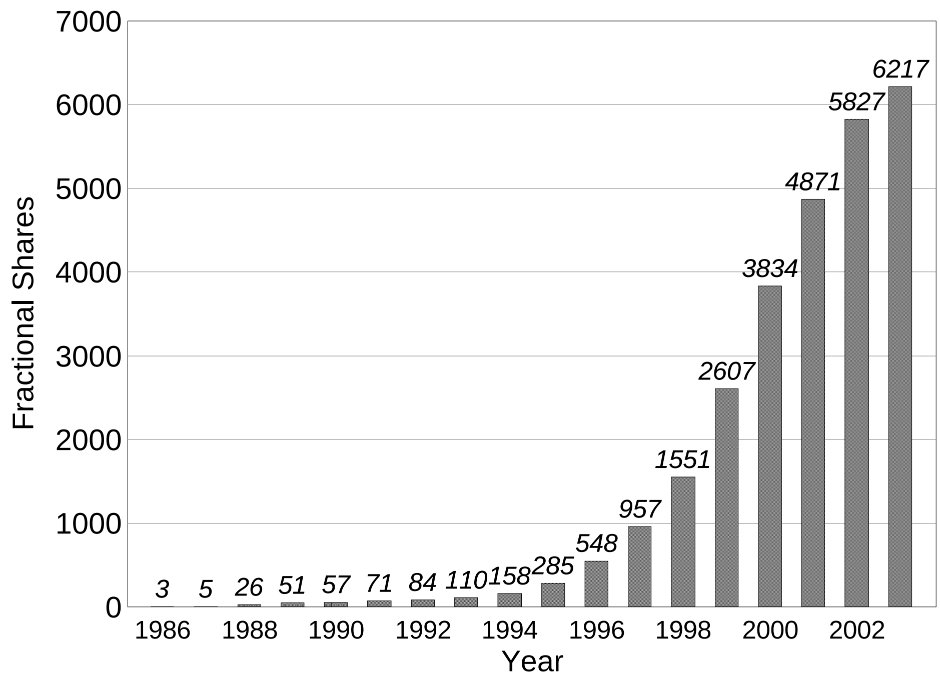
[11] National Business Aircraft Association. *NBAA Business Aviation Factbook 2004.* Washington, DC.

Figure 4. Fractional Ownership of Aircraft



Source: National Business Aircraft Association. *NBAA Business Aviation Factbook 2004.*

Very Light Jets. Another trend that is likely to attract new customers to the business jet marketplace in the near future is the anticipated entry of several low-cost very light jets (VLJs), with typical seating configurations for 5-6 passengers. The VLJs currently under development will have cruise airspeed capabilities of about 400 miles per hour and will fly along high altitude routes (above 18,000 feet) along with airliners and larger business jets. First generation mini-jets such as the Eclipse 500 jet and Adam Aircraft A700 Adamjet are expected to enter full scale production in 2007 and will sell in the $1-1.5 million price range. Not to be outdone by these new entrants, established business jet manufacturers like Cessna and Raytheon-Beechcraft, are now offering small entry-level jets as well.

These aircraft may not be limited to just private or business use. For example, Donald Burr, founder of People Express, and Robert Crandall, a former CEO of American Airlines, have teamed to form a startup air taxi corporation and placed a 75 aircraft order for the A700 AdamJet.[12] The mini-jet concept is too new to foresee whether they will attract a sizable market for air taxi operations. Historically, air taxi operations using small aircraft have met with only limited success anywhere besides Alaska, Hawaii, and in some western states because of consumer reluctance to fly on small airplanes. The ultimate success of ventures such as these will likely depend on

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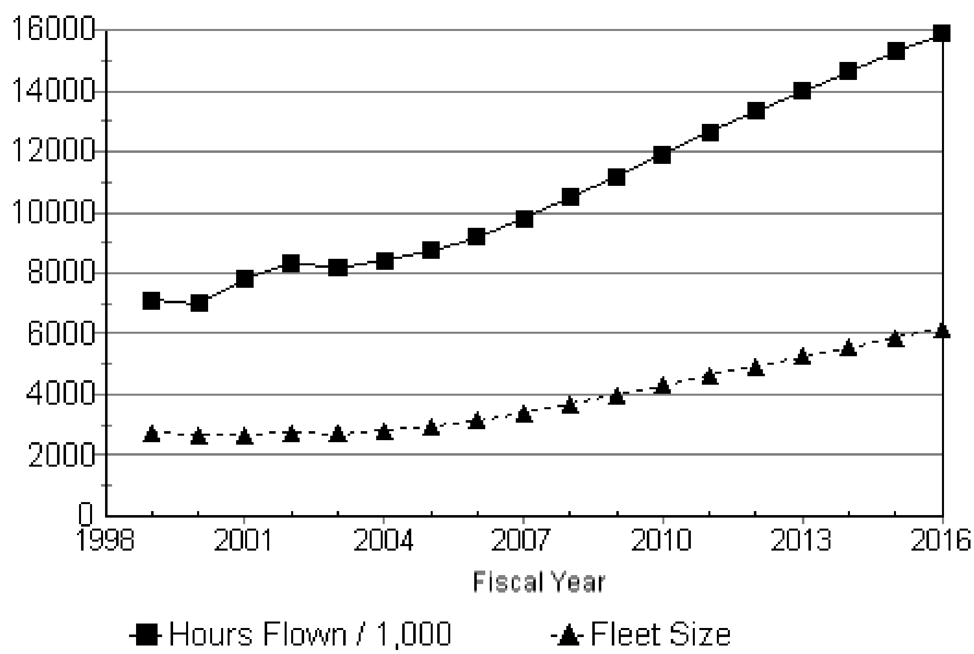
[12] Adam Aircraft Industries, Inc. *Adam Aircraft Announces $150 Million Order For Its New Breed Of Personal Jets.* Press Release. Englewood, CO, May 24, 2004.

the ability to establish a well proven safety record for these small jets. Success is also likely to depend heavily on identifying and exploiting niche markets where such service can provide a cost effective alternative to other modes of transportation.

While the overall impact of newly introduced and forthcoming mini-jets remains largely unknown, the market for mini-jets, particularly from fractional ownership programs and private owners appears promising for manufacturers. With so many companies vying for a stake in the mini-jet market, clearly there are great expectations of high demand for these airplanes.

The net effect of these trends — the proliferation of mini-jets and fractionally owned business jets — will likely be a significant increase in general aviation and air taxi jet operations. This is important because these operations, unlike typical general aviation operations using smaller piston-engine airplanes, will impact high altitude airspace and airspace around major metropolitan areas to a much greater extent. By 2015, the fleet size for general aviation and air taxi jets is expected to double and the total usage of these aircraft, expressed in terms of hours flown, is expected to increase by 80% (see Figure 5). This growth is significant because general aviation and air taxi operations — a sector that is not nearly as visible as the airlines to most observers — is expected to maintain about 20% of the share of those flight operations that impact congested airspace.

Figure 5. Historic Data and Forecast Growth for General Aviation and Air Taxi Turbojet Operations



Source: FAA Aerospace Forecasts FY2005-2016.

Low-Cost Carriers

Another trend that is already shaping growth in aviation operations is the increasing prevalence of low-cost passenger air carriers. Low-cost carriers is a term used to refer to airlines whose business models generally involve simplified pricing schemes and service along mostly point-to-point routes. Examples include AirTran, Spirit, Frontier, Independence Air, Southwest, and JetBlue. By comparison, legacy carriers, the other segment of the airline industry, employ business models that consists primarily of hub and spoke systems where smaller markets are linked to a carrier's network through large hub airports such as Atlanta, Chicago, Dallas-Fort Worth, Minneapolis-St. Paul, Detroit, Denver, Charlotte, and so on.

In a recent study comparing low-cost airlines to legacy carriers, the GAO found that, despite major efforts to cut expenses, legacy airlines have been unsuccessful in sufficiently reducing costs to be competitive with low cost carriers.[13] Unit costs, a key determinant of profitability in competitive markets, are significantly lower at low-cost airlines largely due to lower labor and asset-related costs. Consequently, several low cost carriers have been able to maintain profitability in the weak post-September 11, 2001 market for air travel whereas legacy carriers have collectively lost billions of dollars. In response to the growth of low-cost carriers, several major carriers have launched spinoff operations that mimic the business model of low-cost carriers. Examples include Delta's Song and United Airline's Ted.

Presently, with four legacy airlines in bankruptcy and escalating fuel prices, low-cost business models and practices have been adopted by many as a means of controlling costs. However, adopting a low-cost carrier model is not by any means a guarantee of success as demonstrated by the recent demise of Independence Air — a former regional partner of United Airlines that struggled in its short history as a low-cost competitor and closed its doors in early January 2006. Also, while United is forging ahead with its subsidiary, Ted, as part of Delta's restructuring, the Song brand is being eliminated, and Song airplanes are being reintegrated with Delta's mainline fleet. Over the past five years, the industry has been very dynamic, which likely created some oversupply of flights in the market placing additional strain on capacity. Many industry experts believe that this situation is unsustainable and that ultimately a marketplace with fewer carriers and higher load factors (filled seats on flights) will prevail. A sharp increase in fuel prices during 2005 has prompted airlines to restructure schedules to increase load factors as much as possible. While such factors may reduce congestion somewhat in the short term, this may be offset by the low-cost carrier model which relies more heavily on point-to-point service. This may result in an increased concentration of flights on very specific routes, such as between Northeast cities and Florida destinations, as compared to the hub-and-spoke model used by legacy carriers which, on the other hand, tends to concentrate operations at specific hub airports like Atlanta and Denver.

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[13] United States General Accounting Office. *Commercial Aviation: Despite Industry Turmoil, Low-Cost Airlines Are Growing and Profitable.* Statement of JayEtta Z. Hecker, Director, Physical Infrastructure — Testimony Before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives. GAO-04-837T, June 3, 2004.

Increased Point-to-Point Service

The hub and spoke system offers extensive flexibility in routing and centralizes operations in a manner that can limit the impact of maintenance and operations-related delays and cancellations at airlines' hub facilities. However, the hub and spoke system is susceptible to weather-related delays and cancellations due to thunderstorms, heavy snow, or other extreme weather conditions at hub locations. On the other hand, point-to-point service — favored by many of the low-cost carriers — is less susceptible to having weather-related delays impact large portions of their operations. However, this type of operation is more susceptible to maintenance- or operations-related delays because their network is more decentralized and therefore the availability of maintenance and operations support is more limited.

There is little doubt that, in order to survive, airlines will increasingly adopt low-cost strategies to control costs and maintain or achieve profitability. What is less certain is: to what degree will low cost airline operations continue to rely on point-to-point operations, and if and to what extent will growing low-cost carriers evolve their operations into a hub-and-spoke model? Given that there are advantages and disadvantages to both operational models, hybrid models that incorporate best business practices of each are likely to emerge.

To some degree legacy carriers are already implementing hybrid operational models as a means to reduce costs. For example, American Airlines has implemented what they call a rolling-hub or a hub de-peaking strategy, in which they have reduced the number of connecting flights through their main hubs such as Dallas-Forth Worth, TX (DFW). The strategy results in longer waits for connecting flights on average. While this strategy reduces operating costs by reducing the number of flights, because of the longer layovers it may be less appealing to consumers, especially in markets where alternative point-to-point service is available from low-cost carriers. While such a model may have the effect of reducing congestion at hubs, its long term system-wide impact on capacity will largely be determined by consumer demand characteristics which may favor point-to-point service in some cases, particularly along busy, competitive routes.

The ability to address national airspace system capacity needs to a large extent hinges on the ability of policymakers to foresee how these market-based trends will affect airline business practices in the future. In this evolving marketplace for aviation services, policymakers may need better tools for modeling and predicting market factors and examining the effects of capacity enhancement efforts in the larger context of changing demand characteristics on the aviation system . Nowhere is this more true than in predicting future traffic at major hubs, especially since a large proportion of these hub operations are tied to specific business practices of financially troubled air carriers.

The Future of Hubs

As low cost carriers continue to compete by offering more point-to-point service in selected markets and legacy carriers follow suit, experts have raised questions about the future prospects for some of the nation's busiest hub airports. For example, U.S. Airways significantly scaled back flight operations from its Pittsburgh (PIT) hub to cut costs.[14] Since PIT does not have a high volume of origination and destination passengers despite having a metropolitan area population of more than 2 million, it is unlikely that a competitor will pick up the slack. In the current economic environment, where legacy carriers operating hub-and-spoke networks continue to seek cost cutting measures, the outlook for just about any secondary hub is uncertain. For US Airways, who also operates hubs in Charlotte, North Carolina (CLT) and Philadelphia (PHL), PIT is seen as having very little strategic importance in its current restructuring plan and is not considered an attractive location for any other carrier to fill in the gaps left as US Airways scales back operations.[15]

For other secondary hubs, like Delta Airline's Salt Lake City (SLC) operation and Delta Connection's Cincinnati/Northern Kentucky (CVG) facility, the future is also uncertain. Prior to Delta's bankruptcy filing, traffic at SLC continued to lag behind other Delta hubs and Delta moved to reduce mainline flights there and increase the presence of its regional partner's Delta Connection flights. Whether large legacy carriers will be able to maintain and grow their multi-hub networks remains questionable, and in the short-term, more consolidation of hub operations may occur. What may also occur, with the shift toward more regional jet operations, is the expansion of regional jet hubs like Delta Connection's Cincinnati/Northern Kentucky (CVG) facility. Regional hubs, where regional partners can link to mainline flights, appeared to be a major focus of Delta's restructuring efforts prior to entering bankruptcy, although since filing for bankruptcy Delta has scaled back flights at CVG by almost 25%. Despite this change of course, other airlines may shift toward more regional jet operations and manufacturers remain optimistic about the utilization of larger regional jets in the 70-100 seat range as compared to declining utilization for 50-seat models. Northwest Airlines, also restructuring under bankruptcy protections, recently announced plans to launch a new low-cost subsidiary, tentatively named NewCo, in 2007 that will operate these larger regional jets.[16] If and how this restructuring will impact operations at Northwest's hubs in the long term remains unclear.

Knowing where future hubs operations will be concentrated is obviously of particular interest for understanding future capacity needs. However, besides the major hubs and major population centers, where continued high volumes of operations are likely, the long-range outlook for specific large airports may be hard to predict. For example, Saint Louis-Lambert Field (STL) lost its status as a major hub when American Airlines bought TWA. As a result, airline operations there have dropped by 60% there over the past four years. However, STL's geographically central location and existing hub infrastructure could make it an attractive hub location in the future for regional operations or perhaps an expanding low-cost carrier. While the location of possible future hubs is difficult to foresee, the impact of certain distributions of operations on the national airspace system can be modeled

[14] Steve Lott. "US Air May Cut One-Third of PIT Departures In November." *Aviation Daily,* July 21, 2004.

[15] "Are Hubs An Endangered Species?" *Airline Business Report, 22*(3), January 19, 2004.

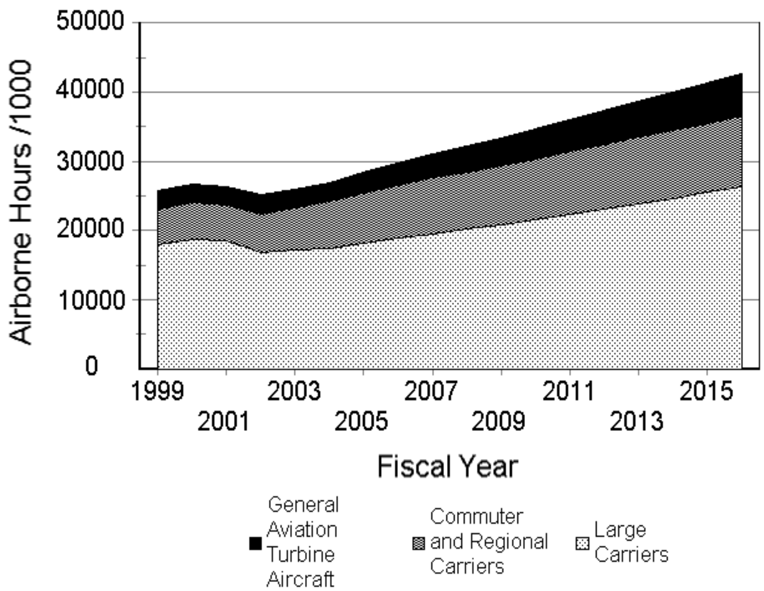
[16] "Northwest To Launch Low-Cost Carrier In '07." *Brandweek,* January 9, 2006.

and simulated so that decision-makers and airspace planners can be better poised to address different growth patterns in aviation operations as they unfold.

The Net Effect on Capacity Straining Operations

The aforementioned trends are expected to contribute to increased flight operations in capacity constrained areas of the national airspace system. The types of flight operations considered most likely to be limited by capacity constraints include operations: in high altitude airspace (airspace above 18,000 feet referred to as Class A airspace); in congested airspace around major metropolitan areas (Class B and some Class C airspace); and at busy commercial airports and general aviation reliever airports in major metropolitan areas. Flight operations of 1) airliners, 2) commuter and regional operators, and 3) general aviation turbine-powered aircraft are considered most likely to impact capacity constrained airports and airspace. Overall airborne hours in these three categories of operations are expected to increase by 44% over the next 10 years (see **Figure 6**). The largest percentage growth in airborne hours is expected to be in jet-powered general aviation aircraft (95%), followed distantly by large air carriers flying both passenger and cargo operations (39%). The expected growth in airborne hours among regional and commuter aircraft will not be quite as large, but will nonetheless be significant (34%). Large carrier operations, which currently represent 64% of total airborne hours among these three categories, will grow more slowly than general aviation jet and commuter and regional operations. By 2015, large carrier operations are expected to still make up 61% of these capacity straining operations, only three percent less than the current level. Nonetheless, the composition of flight operations 10 years from now could be quite different than today with smaller jets, and particularly general aviation turbojets, accounting for a larger percentage of the mix.

Figure 6. Historic Data and Forecast Growth in Airborne Hours



Source: FAA Aerospace Forecasts FY2005-2016.

Factors Affecting Airport and Airspace Capacity

Based on FAA forecasts and capacity growth assumptions, the projected growth in aviation operations is likely to outpace projected capacity expansion for the foreseeable future at major metropolitan airports, in crowded terminal airspace around major metropolitan regions, and along certain high altitude corridors. According to the latest version of the FAA's Operational Evolution Plan (OEP), while system-wide capacity has increased about 6.5% over the past four years, it is expected to increase by only 27% by 2013 compared to the effective capacity in 2000. While this reduction in projected capacity enhancement may simply be a reflection of different forecasting methods or assumptions or a reflection that capacity enhancements in the previous plan were realized sooner than expected, it could also be a preliminary indicator of a future slowing trend in capacity growth. There is a potential concern that beyond the 10-year time frame examined in the OEP, there may be a diminishing marginal gain in capacity over time. In other words, unless new approaches are applied to the problem of aviation capacity as part of a long term strategy, it may become more and more difficult to enhance system-wide capacity using methods applied in the OEP beyond this time frame. Several factors including available capacity at major airports, current airspace design, air traffic controller staffing, and the FAA's organizational culture could provide unique challenges to enhancing the capacity of the aviation system to meet the growth in demand for aircraft operations.

Available Capacity at Major Airports

To assess available capacity at the nations busiest airports, the FAA conducted capacity benchmark studies in 2001 and 2004, detailing the available capacity at these airports and comparing this available capacity to actual traffic levels.[17] In 2001, the FAA released its initial capacity benchmark report detailing the maximum number of hourly flights that can be accommodated at the nation's 31 busiest airports.[18] This study defined the envelope of aircraft arrival and departure rates at these airports under optimum, good weather, conditions and under reduced rate conditions when visibility requires radar separation standards and procedures to be implemented. The study found that many of the busiest airports, including the eight most delayed airports, operated close to their available capacity levels and sometimes exceeded these levels during peak hours, especially when these peak periods coincided with poor weather conditions. Capacity loss due to weather can be quite significant, but varies significantly from airport to airport depending on differences in runway configurations and foul weather procedures. Airports such as Cincinnati (CVG) and Minneapolis-St. Paul (MSP) have a minimal capacity loss during bad

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[17] Federal Aviation Administration. *Airport Capacity Benchmark Report 2001*; Federal Aviation Administration and The MITRE Corporation. *Airport Capacity Benchmark Report 2004.* September 2004.

[18] In earlier versions of FAA's OEP, only 31 airports were listed. The list of OEP airports has now grown to 35.

weather, whereas some airports, like STL and San Francisco (SFO), may lose as much as 40 percent of their available capacity when visibility drops.

The revised benchmark study released in September 2004, modified the methodology slightly to examine capacity under three different weather scenarios: optimum, marginal, and low visibility — instrument flight rules (IFR). The study was expanded to include the four airports added to the list of major airports in the operational evolution plan (OEP) and now provides benchmarks for all OEP-35 airports.

The 2001 benchmark study examined forward-looking projections of capacity enhancement by 2010 assuming planned runways and new technologies would be in place by that time while the 2004 benchmark study projected future benchmarks for the OEP-35 airports in 2013 under the same assumptions that planned capacity enhancement work was completed by that time. While the 2001 study found that many capacity enhancement projects, such as new runways and new technologies, were planned or underway, the cumulative capacity enhancement of these projects often fell short of keeping up with projected growth in demand. In fact, at each of the top six airports in terms of delays, projected growth was expected to outpace planned capacity enhancements, on average, by over 9% percent in good weather and by more than 10% during reduced visibility operations. Among the 8 airports identified in the study as experiencing significant passenger delays, growth in demand through 2010 was expected to average 14.8%, while runways and technologies were expected to increase capacity, on average, by only 8.6% in good weather and 7.7% during reduced visibility operations over this time period.[19] Not surprisingly, the benchmark study concluded that the top six most delayed airports plus Los Angeles International Airport (LAX) — ranked 12th overall in passenger delays at the time of the study — would continue to experience significant passenger delays through 2010. The 2004 benchmark study did not provide growth projections to make similar comparisons. However, based on the fact that the 2004 benchmark projections of capacity enhancement achievable by 2013 are comparable to those projected for 2010 in the 2001 benchmark, the expectation is that growth in aviation operations will continue to outpace system-wide capacity expansion.

Other trends observed in the 2001 benchmark study further indicate that, despite ongoing and planned expansion projects, many airports will be unable to keep up with projected growth in demand. For example, Orlando International Airport (MCO), the most popular domestic leisure travel destination, is expanding to address an anticipated growth in demand of 42 percent by 2010 compared to 2000 levels. However, the combined impact of both a new fourth runway, now in operation, and air traffic technologies is expected to enhance capacity by only 28% in good weather and 38% in poor weather. While this expansion is significant, it is not expected to keep pace with projected growth. While MCO is expected to see the largest increase in demand through 2010 of the 31 airports studied, several other airports are expected to be unable to increase capacity to meet their anticipated demand growth as well.

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[19] CRS calculations based on projections for each of the airports provided in: Department of Transportation, Federal Aviation Administration. *Airport Capacity Benchmark Report 2001.*

Of the 31 airports studied in the 2001 benchmark, only 6 are anticipated to grow their capacity at levels sufficient to clearly outpace projected growth in demand through 2010. One of those airports is the Atlanta Hartsfield-Jackson International Airport (ATL), where the addition of a fifth runway — expected to be completed in June 2006 — coupled with enhanced air traffic technologies and procedures is expected to increase capacity by 37% in good weather and 34% in restricted visibility by 2010. By comparison, projected growth at ATL during this period is expected to increase by 28%. Consequently, the study concludes that these actions are likely to alleviate delays.

For the past three years, the downturn in demand for aviation since September 11, 2001, has alleviated some of the need to implement this technology in the near term. However, anticipated future growth is likely to prompt the need for implementing these types of capacity-enhancing capabilities. The 2001 benchmark study concluded that new runways, which were planned at 14 of the 31 airports examined, can provide the most significant increases. Forecast increases on the order of 30 to 60 percent appear achievable at most airports from the addition of new runways. For some airports, that already have high capacity layouts like Denver (DEN), an additional runway provides a much smaller gain in capacity. And in some cases, new runways do not appear to be the solution to increasing capacity at all. Specifically, the 2004 benchmark points to Boston's Logan International Airport (BOS) as a location that will not be able to expand capacity by adding a new runway. The new runway at BOS, expected to open in 2006, is anticipated to have no impact whatsoever on increasing capacity. However, the new runway is expected to mitigate delays during poor weather assuming ground infrastructure and environmental constraints support the operational plans for this runway.

Despite some exceptions like Boston, building new runways is seen as having the largest system-wide impact on expanding capacity. In addition, technology enhancements are seen as providing additional capacity gains in the range of 3% to 8%, and procedural enhancements could provide another 5% to 10% gain in available capacity at airports. While technology and procedural solutions will play a small but important part of expanding capacity at airports, they are likely to play a more central role in expanding the capacity of en route and terminal airspace.

Airspace Design

The national airspace system has evolved over the years into its present day form consisting of a web of routes interconnected by ground based navigational aids called very high frequency omnidirectional range (VOR) stations. These routes, or airways, are often likened to highways in the sky. Along these airways, instead of using lanes, opposite direction traffic is separated by altitudes. However, restricting airplanes to airways does not make use of all available airspace. This can create congestion on the airways which is compounded by large vertical separation requirements implemented to keep aircraft at safe distances that were established decades ago to allow for errors in altitude equipment and altitude deviation by pilots that today can be effectively controlled by more precise instrumentation and cockpit automation to detect and prevent unintended altitude deviations. Also, following airways sometimes requires zig-zagging between points along the airway rather than proceeding directly to the destination airport. While, these maneuvers only add a few extra minutes to a typical flight, the additional fuel burn can be very significant for an airline or aircraft operator. Therefore, flying the most direct routes between origin and destination can be beneficial for air traffic management as well as operational efficiency. FAA is currently laying the regulatory and operational frameworks for such operations — referred to by many as free flight — based on precision satellite navigation capabilities using the Global Positioning System (GPS) augmented by ground-based signals to better pinpoint an aircraft's position in space.

Besides limitations imposed by the current airway system, high altitude airspace is also limited by the number of available altitudes, or flight levels (FLs), that airplanes can travel on. Opposite direction traffic has historically been separated by 2,000 foot altitude spacing above 18,000 feet to ensure adequate separation in cases of instrument or pilot error. However, with improved altitude measurement and monitoring capabilities, the FAA is phasing-in the use of 1,000 foot altitude spacing. This reduction in altitude spacing down to 1,000 feet, referred to as reduced vertical separation minimums or RVSM, has virtually the same effect as doubling the number of lanes on an interstate highway. RVSM is initially being implemented between 29,000 feet and 41,000 feet (FL290 to FL410). It has already been implemented between these altitudes on ocean-crossing flights, and will be implemented in domestic airspace by January 2005. Airplanes must meet special equipment requirements to operate at these altitudes. RVSM will likely be expanded to include all high altitude airspace (above 18,000 feet, specifically, FL180 to FL600) in the future.

In order to manage and control the flow of high altitude traffic, airspace is broken up into regions, or centers, which are further subdivided into sectors. One significant factor affecting the design of the national airspace system and its capacity is air traffic controller workload. Current demand characteristics result in a concentration of east-west operations in airspace between Chicago, Boston, and Washington, DC. The high altitude airspace monitored by controllers in Cleveland Center is especially busy as this tends to be the bottleneck for flights transiting between the West Coast and Chicago and cities in the Northeast. There is also a heavy concentration of north-south traffic between Norfolk and Richmond, Virginia and New York, and to a lesser extent along the California coast, especially between Los Angeles and San Francisco. In these areas controller workload and the segmentation of airspace to manage that workload can be a significant constraining factor affecting capacity in high altitude airspace.

The strategies that the FAA has adopted to address these constraints is heavily focused on the use of technology, automation, and pilot and controller decision aids along with airspace redesign to assist with both the management and control of air traffic in high altitude airspace. These initiatives are discussed in further detail in the section titled The "Free Flight" Concept**.**

Controller Staffing

Another challenge facing the FAA is maintaining an adequate staff of air traffic controllers (ATCs) to meet operational needs. In the past, between 1 and 2 % of the controller workforce became eligible for retirement each year. There is a current upward trend in the percentage of controllers that will be eligible for retirement, which has currently risen to between 3 and 4% per year and will peak at almost 10% per year in 2007 and remain above 5% per year through 2011. The FAA has estimated that 7,100 controllers, roughly 45% of its current workforce, will retire over the next eight years.[20]

Several factors are contributing to high demand for air traffic controllers over the next 10 years. Foremost is the hiring wave in the early 1980s that occurred following the 1981 dismissal of over 11,000 striking controllers. Since an air traffic controller career in the United States is structured around a 25-year service model, it is to be expected that those hired in 1982, as many current controllers were, would be at or near the end of their careers by 2007. Another factor is the lengthy training required to fully train and certify an air traffic controller which typically takes about two to four years to complete, depending on the area of specialization. As controllers retire, shortages of fully trained controllers for specific positions could occur, especially if staffing allocations and appropriate training is not initiated well in advance of anticipated retirements. Another factor affecting controller staffing is the high labor costs for ATCs. These high labor costs are heavily influenced by the fact that many controllers are at senior levels in the pay scale and under-staffing at many facilities requires extensive use of overtime.[21] The potential impact of these high labor rates on addressing staffing shortages is that it may take away from available funding needed to recruit, hire, and train the next generation of ATCs.

However, the number of air traffic controller positions is actually expected to increase only modestly — at a rate slightly greater than 1% per year — through 2012.[22] Therefore, other than addressing the pending wave of retirements and filling vacant slots at air traffic control facilities during that time, it is not expected that there will be significant expansion in the numbers of controllers needed. Rather, staffing requirements are expected to be relatively flat for the foreseeable future. In the long term, the increased use of automation and implementation of free flight concepts may reduce some demand for controllers and shift some controller functions to more strategic air traffic management positions. Airspace redesign to address controller workload in busy airspace could create a need for some additional controller positions. However, little overall growth in the total number of air traffic controller positions is anticipated. Future technological advances could, however, result in a shift in where controllers are needed. The implementation of free-flight concepts coupled with terminal airspace redesign in busy metropolitan areas may, for example, result in fewer controllers being needed to operate en route facilities and an increased demand for controllers in terminal radar approach control (TRACON) facilities, especially in major metropolitan areas.

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[20] U.S. General Accounting Office. *Federal Aviation Administration: Plan Still Needed to Meet Challenges to Effectively Managing Air Traffic Controller Workforce. Statement of JayEtta Z. Hecker, Director Physical Infrastructure Team Before the Subcommittee on Aviation, House Committee on Transportation and Infrastructure.* June 15, 2004, GAO-04-887T.

[21] Department of Transportation, Office of Inspector General. *FAA's Management of and Control Over Memorandums of Understanding*. AV-2003-059, September 12, 2003.

[22] Based on Bureau of Labor Statistics employment data for 2002 and 2012 projections.

Controller staffing is currently an issue of particular interest in Congress. Vision 100 (P.L. 108-176) requires the FAA to submit annual air traffic controller staffing plans, including strategies to address anticipated retirement and replacement of air traffic controllers and requires a comprehensive human capital workforce strategy to determine the most effective method for addressing the need for more air traffic controllers. The FAA's plan, released in December 2004, calls for hiring controllers at a faster rate over the next 10 years to offset the wave of retirements and improve selection and training. The FAA also anticipates that improved workload efficiency and scheduling practices will reduce projections of staffing needs by 10% over the next 10 years. However, the DOT Inspector General's office has noted that the FAA needs better location-specific projections of attrition rates to better gauge future staffing needs.[23] FAA's initial plan did not include this location-specific information on future staffing projections. However, the FAA is working on a detailed assessment of staffing needs for each facility based on size, complexity, and traffic volume.

Various options are under consideration to address the FAA's ATC staffing needs and funding challenges associated with meeting these staffing requirements.

One proposal offered has been to either grant age waivers to controllers allowing them to work beyond 56, or to raise the statutory retirement age. Proponents of raising the retirement age indicate that with better health and wellness of aging adults, controllers may be able to perform safely and efficiently at older ages. Research on cognitive performance of aging ATCs and the potential long term health effects of ATC workload and stress, however, is contentious and does not provide clear-cut answers to policy questions regarding the appropriate retirement ages for controllers. A similarly contentious issue is the mandatory retirement age of 60 for airline pilots. In both of these cases, the establishment of a retirement age is based loosely on the research findings of medical and performance studies of aging and long range effects of job-related stress, but is influenced by other factors such as annuity calculations for retirement.

In general, research shows a gradual decline in cognitive abilities beyond age 30 that becomes more pronounced in the span between 60 and 70 years. Not surprisingly, there are large individual differences that make pinpointing a specific age where skills and abilities to perform ATC tasks decline precipitously. While ATCs have to pass annual health exams, these only provide a very cursory evaluation of cognitive abilities. Therefore, the potential impact of raising the ATC retirement age above 56 or granting waivers on system safety is largely unknown. For this reason, proposals to raise the retirement age are likely to be contentious.

In the near term, raising the retirement age could put off the need to hire and train new ATCs for a few years and lessen the impact of pending retirements by

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[23] Statement of Alexis M. Stefani, Principal Assistant Inspector General, U.S. Department of Transportation. Before the Committee on Transportation and Infrastructure, Subcommittee on Aviation, United States House of Representatives. *Addressing Controller Attrition: Opportunities and Challenges Facing the Federal Aviation Administration*. June 15, 2004.

spreading them over a longer time span. Such a strategy could be effective in helping FAA to better meet annual hiring requirements.

Other proposals, such as modifying annuity calculations to reward ATCs for additional years of service beyond their eligible retirement date or providing retention bonuses as incentives to experienced controllers to stay in their positions may also be considered as tools to spread the projected retirement wave out over a greater number of years. However, any such proposal is likely to be controversial as it would create a funding impact that may limit the FAA's resources to hire and train replacement controllers. Also, many believe that ATC labor costs at the FAA are already too high.

Freezing or limiting wages of current controllers is also viewed by some as a possible option to free up funds for hiring and training new ATCs, but this option has several disadvantages. First, the cost savings would likely take a few years to have a great enough impact to provide the needed funding for hiring and training replacement ATCs. Second, such action may prompt current controllers to enter retirement at a faster rate, thus negating the intent of the action. And finally, freezing wages could have a negative effect on recruiting efforts if prospective applicants view it as an indicator of future salary potential with the FAA.

The FAA is also mulling the idea of requiring newly hired ATCs to pay for their initial training as a means to reduce the federal burden of training the next generation of air traffic controllers. While the FAA notes that many airline pilots must pay for their initial training, this option may significantly limit the pool of interested applicants for ATC positions, especially given that the marketplace for applicants with technical aptitude similar to that needed to be an ATC is highly competitive.

Another possible option for Congress is to provide special funding for the purposes of hiring and training the next generation of ATC specialists. FY2005 appropriations included $9.5 million for this purpose. For FY2006, the House bill included almost $25 million to increase the FAA workforce by 595 air traffic controllers. However, the final appropriations act (P.L. 109-115) did not include specific reference to this amount. Faced with budget constraints and rising operational costs, it is uncertain how the FAA will allocate funding to address the continuing need for succession planning, hiring, and training of air traffic controllers in the near term.

If controller shortages persist, there may be a need to increase overtime and perhaps impose mandatory overtime for controller staff. Such practices may impact safety because it may contribute to controller fatigue. Additionally, a 2002 GAO survey found that use of mandatory overtime may result in more controllers opting to retire earlier.[24] Thirty three percent of controllers indicated they would retire earlier if required to work additional overtime hours.

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[24] U.S. General Accounting Office. *Air Traffic Control: FAA Needs to Better Prepare for Impending Wave of Controller Attrition*. June 2002, GAO-02-591.

A more controversial option that has been proposed in various forms over the years is the partial or complete commercialization or privatization[25] of the air traffic control system, including ATC job functions. The FAA already uses commercial contractors to run about 218 non-radar towers throughout the country, including several airports that handle commercial operations. Proponents for privatizing the entire air traffic control system also note that many foreign countries including Canada, Great Britain, much of mainland Europe, and Australia operate their air traffic control systems under various forms of privatization. Besides addressing controller staffing issues, commercializing or privatizing the ATC is viewed by some as a means to potentially overcome perceived management deficiencies that have historically plagued FAA's handling of ATC systems acquisitions.

Critics of privatizing the ATC system fear that it could erode safety, although a recent DOT Inspector General's audit of the FAA's contract tower program found no identifiable difference in operational error rates between contract towers and FAA-run towers.[26] Language protecting the FAA air traffic control system from further privatization, except for maintaining and possibly expanding the contract tower program, was ultimately dropped from the FAA reauthorization bill (Vision 100; P.L. 108-176). As a concession for removing this language, the FAA had agreed to a moratorium on any further plans for privatization or commercialization of ATC functions during FY2004 which has now expired. Given the pending controller staffing shortages faced by the FAA, debate over ATC privatization may be revisited. However, any plan to commercialize or privatize operations at busy towers or any en route facilities is likely to be highly controversial.

FAA's Organizational Culture

Historically, poor planning, management, and oversight of major ATC-related acquisitions by the FAA has been blamed for cost overruns, schedule slips, and performance shortfalls of major systems designed to enhance the capacity of the national airspace system. FAA's poor track record in systems development has led many observers to speculate that the FAA's own organizational culture is the root cause of difficulties in meeting the challenges of enhancing aviation system capacity to keep pace with growth in air traffic operations. The GAO noted that over the years, inadequate management controls and human capital issues at the FAA have contributed to consistent cost overruns, schedule delays, and performance shortfalls of major air traffic control and management projects.[27] Similarly, the DOT Inspector

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[25] ATC commercialization, as used in this paper, refers to the outsourcing of some or all ATC functions to commercial vendors, whereas privatization encompasses both outsourcing of ATC functions and possible implementation of user fees or other revenue-generating mechanisms to fund ATC services. In recent congressional debate, the term privatization has been used to refer to legislative proposals calling for protections against privatization that would limit both commercialization and privatization of ATC functions.

[26] Department of Transportation, Office of Inspector General. *Safety, Cost, and Operational Metrics of the Federal Aviation Administration's Visual Flight Rule Towers.* AV-2003-057. September 4, 2003.

[27] U. S. General Accounting Office. *Air Traffic Control: FAA's Modernization Efforts —* (continued...)

General found that the FAA exhibited lax oversight of contracts and continued to operate with an ineffective vertical, hierarchical management structure. The DOT Inspector General also found that management inefficiencies persisted on major programs despite the fact that, in 1995, the FAA was statutorily exempted from many of the federal procurement regulations it had argued were hindering modernization efforts.[28]

The response of Congress to these concerns was twofold. First, AIR-21 (P.L. 106-181) mandated the creation of a Chief Operating Officer (COO) position within the FAA to oversee the strategic plans, operations, and budget of the air traffic control system. More recently, in Vision 100 (P.L. 108-176), Congress set forth a framework for the creation of a joint planning and development office to establish the long range national plan for the national airspace system and oversee the implementation of that plan. The Bush administration has responded to these mandates with the establishment of the Air Traffic Organization (ATO) within the FAA headed by the COO, and the creation of a multi-agency Joint Planning and Development Office (JPDO) headed by the FAA. While these steps formally restructure the FAA in significant ways, an important issue is whether these organizational changes will lead to meaningful changes within the FAA's organizational culture and enable the FAA to better meet the challenges it faces in expanding the capacity of the national airspace system.

Air Traffic Organization. The first COO of the ATO was finally hired and the ATO was formally established on February 8, 2004, almost four years after it was mandated under AIR-21. The new COO, Russell Chew, has indicated that the primary emphasis of the reorganization that has taken place within FAA to establish the ATO is designed to integrate acquisition and operations functions to make sure that major systems acquisitions are better tied to operational service needs and operational cost considerations.[29] The ATO is comprised of 10 service units, each run by a vice president that reports to the COO. The 10 service units are:

- Safety
- Communications
- Operations Planning
- Finance
- Acquisition and Business Services
- En Route and Oceanic Services
- Terminal Services
- Flight Services
- System Operations Services
- Technical Operations Services

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[27] (...continued)
Past, Present, and Future. Statement of Gerald L. Dillingham, Director, Physical Infrastructure Issues Before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives. October 30, 2003 (GAO-04-227T).

[28] Department of Transportation, Office of Inspector General. *Top Ten Management Issues.* Report PT-2001-017, January 18, 2001.

[29] "Russ Chew 101." *Aviation Week & Space Technology,* August 16, 2004, 46-48.

In addition to its internal safety office, the FAA created the Air Traffic Safety Oversight Service within its Office of Regulation and Certification, which is responsible for oversight and coordination of system safety functions within FAA, including the ATO.

Since the ATO has existed for less than one year, it is too early to fully assess its effectiveness. One indicator of the ATO's success is how well it is meeting its own performance objectives. In this regard, the results have thus far been mixed. The ATO has thus far failed to meet its goals for on-time arrivals and arrival efficiency.[30] However, the ATO has generally met its criterion to have air traffic equipment operationally available 99% of the time. However, a high profile ATC equipment outage in the busy southern California airspace in September 2004 due to maintenance errors highlighted the criticality of these systems and the need for extremely high reliability and available backup capabilities. With regard to safety, while it appears that some progress has been made to reduce the number of runway incursions, the National Transportation Safety Board (NTSB) has recently questioned the completeness and accuracy of the FAA's statistics on runway incursion incidents. Additionally, operational errors remain at higher than acceptable levels as defined in FAA's performance goals. The FAA's ability to meet performance objectives and the effectiveness of the ATO organization is likely to be an issue of continued interest for Congress as the ATO matures and more fully engages in addressing the operational challenges created by growth in aviation operations.

Joint Planning and Development Office. Another initiative to revamp FAA's organizational culture and approach to systems planning and acquisition is the creation of the Next Generation Air Transportation System Joint Planning and Development Office (JPDO). The JPDO was established under the most recent FAA reauthorization bill, Vision 100 (P.L. 108-176), and is charged with the task of establishing and executing the national plan for the next generation air transportation system (NGATS). Whereas the ATO is focused on the day-to-day operational aspects of running the existing national airspace system and implementing the short term capacity enhancement objectives defined in the OEP, the JPDO's focus is on long range planning to meet the anticipated capacity requirements of 2025.

Under a provision in Vision 100 (P.L. 108-176), the JPDO was required to submit its NGATS integrated plan to Congress by December 2004. That plan was unveiled by the JPDO on December 12, 2004.[31] Under the provisions of Vision 100, the JPDO is now responsible for overseeing the execution of the plan and coordinating research and development and implementation efforts among government agencies and industry to achieve the goals set forth in the plan. In developing and executing the NGATS integrated plan, FAA is required to work in conjunction with relevant programs in the Department of Defense, the National

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[30] Arrival efficiency is a measure of how well the actual arrival rate compares to the lesser of the scheduled arrival demand or the established arrival rate for an airport.

[31] Next Generation Air Transportation System Joint Planning and Development Office. *Next Generation Air Transportation System Integrated Plan.* December 12, 2004: Washington, DC.

Aeronautics and Space Administration, the Department of Commerce, and the Department of Homeland Security. The goals of implementing the NGATS plan include:

- Improving the safety, security, efficiency, quality, and affordability of aviation;
- Exploiting emerging ground-based and space-based communications, navigation, and surveillance technologies;
- Integrating data streams from multiple agencies and sources to enable situational awareness and seamless global operations for civil aviation, homeland security, and national security;
- Leveraging investments in civil aviation, homeland security, and national security and build upon current air traffic management and infrastructure initiatives to meet system performance requirements
- Accommodating and encouraging substantial growth in domestic and international transportation and anticipating and accommodating continued technological growth;
- Accommodating a wide range of aircraft operations, including airlines, air taxis, helicopters, general aviation, and unmanned aerial vehicles; and
- Designing airport approach and departure flight paths to reduce noise and emissions exposure of affected communities.

The NGATS integrated plan provides a top-level roadmap identifying core objectives and strategies for transforming the national airspace system to meet future capacity needs. The integrated plan outlines several goals for the NGATS including:

- Establishing innovative airport planning and management;
- Establishing a cost effective aviation security system without limiting mobility or civil liberties;
- Establishing an agile air traffic system;
- Establishing user specific situational awareness within the air traffic system;
- Establishing a comprehensive, proactive safety management approach;
- Developing environmentally friendly and sustainable air traffic technology;
- Developing a system-wide capability to reduce the impact of weather; and
- Harmonizing equipment and operations internationally.[32]

JPDO director, Charles Keegan, has indicated that the NGATS plan will rely heavily on increasing automation of air traffic functions and reducing system costs. However, the initial report is reported to contain few details on what technologies, operational changes, and integration schemes will be implemented to achieve these

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[32] David Hughes. "The 'Silent' Crisis." *Aviation Week & Space Technology*, October 25, 2004, 72-75.

objectives.[33] Providing too many details, however, could place artificial constraints on the plan by settling on specific technologies that may become obsolete before they are implemented. It is difficult to foresee how technology may evolve over the next ten years or what breakthrough technologies with application to air traffic management and control might emerge. Based on this, the apparent strategy the JPDO seems to be adopting is a rather broad framework, or architecture, for how emerging and future technologies may be integrated into the NGATS system. However, in adopting such a strategy there may be a risk of being too vague and not providing sufficient detail to be useful. Congressional oversight may specifically focus on whether the plan contains sufficient detail to measure progress over time toward achieving the end goal of increased capacity and efficiency in the national airspace system as well as whether the plan creates an organizational climate and facilitates partnerships with other government agencies and the aerospace industry to foster cooperative and collaborative work toward achieving this vision.

Cost Overruns

The FAA's original plan to modernize the air traffic control system, began in the early 1980s and was estimated to be completed by the early 1990s at a projected cost of $12 billion. A central element of that modernization effort, the advanced automation system (AAS) was ultimately scrapped in large part after large cost overruns, schedule delays, and failures to deliver promised capabilities and performance. According to the GAO, since then FAA's cost estimates have mushroomed and schedules have continued to slip. Over $35 billion have been spent so far on modernizing the national airspace system and the FAA estimates it will need an additional $16 billion through 2007 to complete key projects.[34]

In fairness to the FAA, it is important to point out that many of the system modernization projects included in its current efforts to increase system capacity were not even conceived of in the early 1980s. The efforts of the early 1980s that extended into the 1990s were largely aimed at improving the existing en route and terminal radar networks by upgrading hardware and software and providing controllers with improved workstations and consoles and rudimentary automation tools. These efforts focused largely on air traffic communications and surveillance, and largely did not address enhancement to navigation capabilities. The global positioning system's (GPS) network of navigation satellites did not exist when the program was initiated; therefore, programs like WAAS and free flight were not initially calculated into cost projections. GPS and GPS-related technologies, the enabling technologies allowing revolutionary new navigational concepts like *free flight* to be implemented, have only been considered as part of FAA's air traffic control modernization plans for the past 10-years or so. In essence, looking broadly at the current costs to enhance FAA facilities and equipment compared to past cost estimates is not a fair comparison. However, what is clear is that, on a program by program basis, FAA spending on ATC modernization efforts has been riddled with cost overruns and schedule slips.

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[33] *Ibid.*

[34] U.S. General Accounting Office. *Air Traffic Control: FAA's Modernization Efforts.*

The FAA's historic cost overruns and schedule slips in its AAS program throughout the 1980s and into the 1990s, well documented in GAO reports and DOT IG audits, gave the FAA a reputation as an ineffective manager of major systems acquisitions. The GAO has routinely found, and continues to identify inadequate cost controls, cost estimating, and cost accounting within FAA as a significant impediment to effective management of large scale acquisition programs. Also, the FAA still does not have a sufficiently detailed blueprint tying its major acquisition programs to modernization objectives for the air traffic control system, and does not adequately link these programs to both near term and long-range budget projections.[35]

One of the principal objectives of the new ATO and JPTO is to address these concerns. Time will tell if these new organizations are effective in meeting this objective, and it is likely that the work of these organizations will be a subject of considerable congressional interest over the next several years.

Russell Chew, the COO of the ATO, is well aware of the challenge faced by his organization. The ATO is facing a $5 billion shortfall in operations and a $3.2 billion shortfall in the airport and airways trust fund if operations and capital improvements continue to follow a "business as usual" approach.[36] Chew believes that the answer to the problem — given no foreseeable increase in aviation trust fund tax yield and a decreased reliance on general fund coffers to make up for trust fund shortfalls — is to focus on reducing unit costs for air traffic services. Chew's initiatives to reduce costs include

- Streamlining management and reducing overhead staff not directly involved in providing service;
- Improving productivity;
- Improving training efficiency;
- Improving infrastructure efficiency;
- Developing cost-saving cooperative efforts with the airline industry;
- Managing costs of growing system complexity effectively;
- Revamping telecommunications infrastructure;
- Using competitive sourcing to reduce flight service station operating costs; and
- Improving the management and oversight of time off, sick leave, and overtime.

The ATO faces major challenges to find savings in these areas to reduce overall air traffic service costs by 21%, which is what it projects the deficit would be over the next five years if they maintain the status quo. Only one of these efforts — revamping telecommunications infrastructure — is underway, and that is only expected to net a savings of about 1% annually. Chew noted that hard choices must

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[35] *Ibid.*

[36] David Hughes. "Affordable ATC Ops." *Aviation Week and Space Technology*. November 8, 2004, p. 46.

be made in the near future to achieve sustainable, cost-efficient air traffic services.[37] The decisions made by the ATO in meeting these challenges are likely to be a key topic for congressional oversight of the FAA.

Impact of Under-capacity on Flight Operations

To understand the need for increased capacity, it is important to examine the effects of under-capacity on flight operations. Examining past deficiencies in meeting aviation demand can help identify capacity needs on both a systemwide and an airport-by-airport level of analysis. Examination of these capacity strained periods can also provide useful data for modeling the potential benefits of capacity-enhancement proposals.

Presently, the effect of capacity constraints are beginning to be felt once again as demand for air travel returns to pre-September 11, 2001 levels. Throughout the summer of 2004, increased demand brought with it increased delays, but so far, system-wide operations and delays have not reached the level they were at during the summer of 2000.

The Summer of 2000

During the summer of 2000, record setting demand for air travel, a long bout with thunderstorms — particularly in the busy northeast corridor and at major hubs like Dallas-Fort Worth, Chicago, and Atlanta — and aircraft maintenance difficulties conspired to produce long delays and cancelled flights that wreaked havoc on many travelers' plans. This difficult time for travelers was followed by even more acute delays during the 2000 holiday season in December. During these periods, air travelers experienced the worst delays in U.S. aviation history and delays frequently exceeded acceptable levels.[38] Following this period, the U.S. economy entered a downturn that reduced demand for air travel. Meanwhile, the FAA was busy implementing near term solutions to avoid a repeat of the summer of 2000. The net result was less traffic volume and significantly fewer and shorter delays in the summer of 2001. Since then, airline travel significantly declined in the aftermath of the September 11, 2001 terrorist attacks and, as might be expected, delays have been significantly less in the past three years. Recent statistics released by the Department of Transportation's Bureau of Transportation Statistics indicate that delays are on the rise, although not to the level seen in the summer of 2000 (See **Figures 7 & 8**). While the decrease in demand for air travel from 2001 to 2004, in essence, bought the FAA additional time to study and implement near term solutions to alleviate congestion and delay, the effectiveness of these mitigation strategies remains largely undetermined and over the past two years key delay statistics have been steadily

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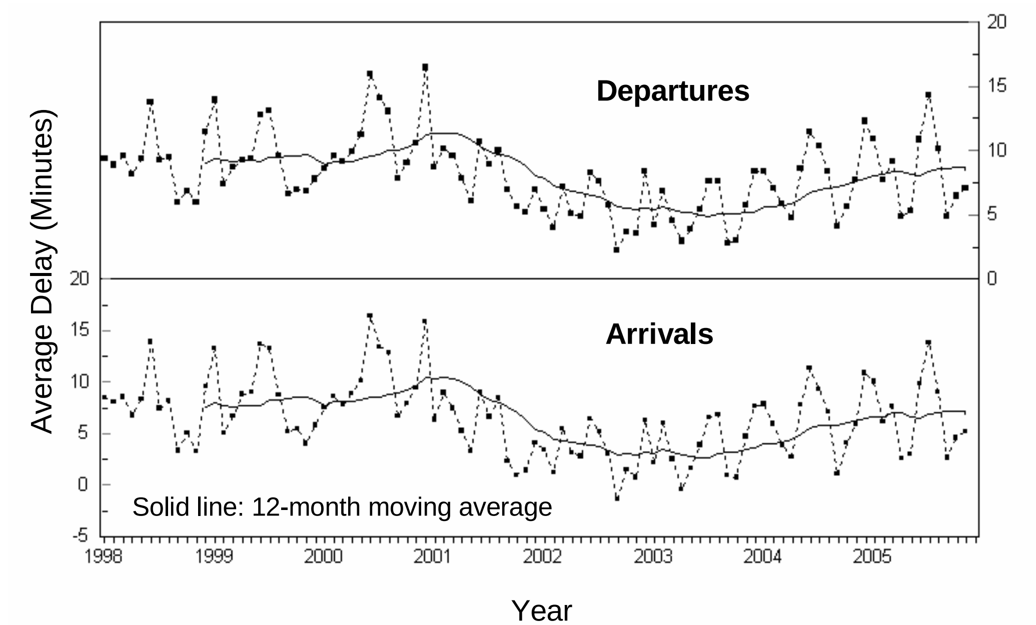
[37] *Ibid.*

[38] In the OEP, the FAA adopted a standard of maintaining an average delay of 14 minutes or less. Based on this standard, average delays in excess of 14 minutes are described as exceeding acceptable levels in this report.

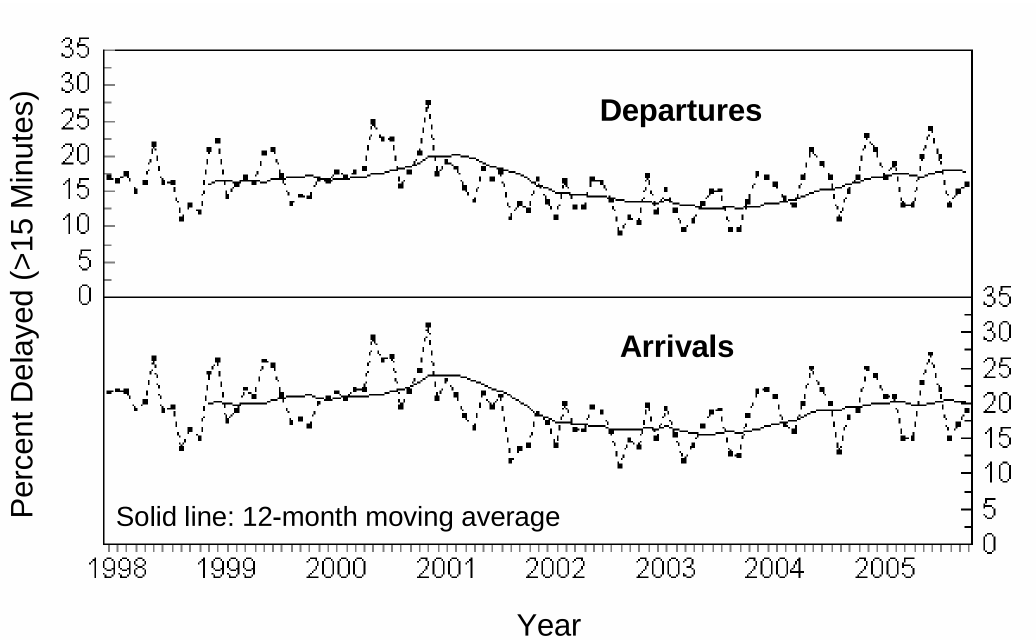
rising, a possible indicator of increasing strain on system capacity. As traffic volume increases and surpasses pre-September 11, 2001, levels over the next few years, the near term mitigation strategies to alleviate congestion and delay will receive the first real tests of their effectiveness.

Figure 7. Average Delay (1/1998 — 11/2005)



Source: Bureau of Transportation Statistics.

Figure 8. Percent of Flights Delayed (1/1998 — 11/2005)



Source: Bureau of Transportation Statistics.

Some Possible Delay Remedies

In examining the delay data in **Figures 7 & 8**, it is notable that while the monthly average departure delay has typically been greater than monthly average arrival delay, a greater proportion of arrivals are delayed more than 15 minutes compared to departures.[39] Thus, from a operational standpoint, airborne delays that impact arrival times, while less frequent than delays affecting departure times, are more likely to be longer in duration. Given that airborne delays are costly to airlines in terms of fuel costs, increased wear and tear on the engines, and so on, specific operational strategies to reduce these airborne delays would be particularly advantageous to airlines and other aircraft operators. FAA has been working with the airlines to take such steps to reduce airborne delays. Some examples include:

- Using ground holds to delay departures in order to better space arrivals at destination airports;
- Using decision aids to meter the flow of arrivals into busy airports; and
- Creating "express lanes" into and out of busy airports by holding traffic at satellite and reliever airports during peak travel hours.

It appears that these efforts were somewhat effective in staving off a repeat of delays such as those experienced in the summer of 2000, during the peak travel months of 2004 and 2005. However, the upward trend in delay statistics, especially arrival delays, during the peak summer and holiday travel seasons of 2004 and 2005, could be a forewarning that chronic delay conditions may return to the aviation system as operations surge past pre-September 11, 2001, levels over the next several years.

The Relationship Between Capacity and Delay

While the FAA continues to implement stopgap measures to mitigate delay in the current national airspace system, most observers recognize that the long term solutions to alleviating congestion and delay should address the underlying capacity constraints. Since delay is a key symptom of strain on system capacity, delay can be mitigated to some extent by investing in capacity-enhancing infrastructure and technologies. However, in practice, policymakers and system planners must balance a tradeoff between meeting demand for aviation services while maintaining delays within acceptable levels. Given that growth in aviation operations may easily outpace capacity enhancement of the national airspace system for the foreseeable future, policymakers will likely face tough choices in meeting demand without increasing delay.

The FAA's OEP (Version 6.0) projects a 27% overall capacity enhancement by 2013. However, this capacity enhancement assumes that an average system delay of 14 minutes is acceptable and does not seek to reduce this level of delay in its projections of future system capability. Rather, the FAA intends to increase capacity at what it has set as a threshold acceptable level of delay — the typical delays flyers

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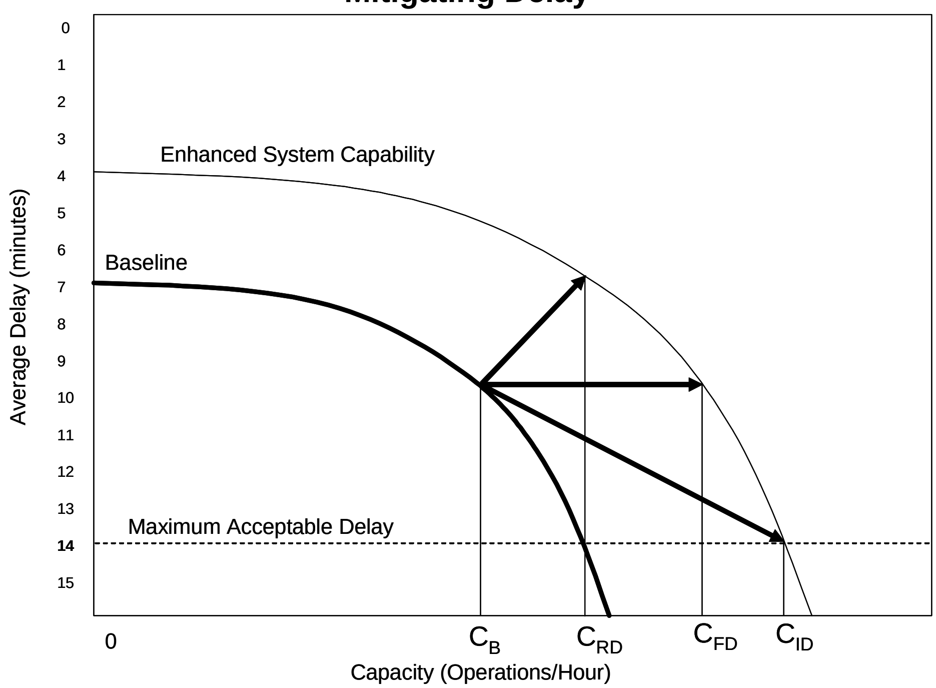
[39] Based on Bureau of Transportation Statistics delay data.

have grown accustomed to, but not the extent of delays experienced in the summer of 2000. The potential danger of this strategy is that with an emphasis on enhancing capacity to meet growth in demand, delay may increase significantly in a capacity-constrained system, especially if capacity enhancement efforts fall behind schedule or fail to fully meet expectations.

Figure 9 shows conceptually the tradeoff that exists between capacity and delay. In essence, these two metrics comprise elements that compete for system capability. In reality, the situation is much more complex since the relationship between capacity and delay is influenced significantly by external factors, such as weather and airline scheduling practices, that are either uncontrollable or not controlled directly within the system. Certainly, the relationship between capacity and delay and the influence of both system variables and external factors on these two metrics is very complex. While the tradeoff relationship between capacity and delay may be difficult to quantify or predict, the effect is relatively easy to conceptualize. Working from a baseline capacity (C_B), enhanced system capabilities can be projected to enhance capacity assuming a fixed level of delay (C_{FD}). The FAA chose to conceptualize capacity enhancement in this manner, selecting a fixed systemwide acceptable level of delay of 14 minutes — a figure never exceeded before the infamous summer of 2000 — as its target.

Figure 9. The Tradeoff Between Expanding Capacity and Mitigating Delay



Where, C_B is baseline capacity (that is, current available capacity);
C_{RD} is future capacity with a reduced delay;
C_{FD} is future capacity assuming a fixed delay; and
C_{ID} is future capacity assuming an increase in delay.

Source: Bureau of Transportation Statistics average delay data and FAA OEP (Version 6.0) fixed level of delay for assessing effective capacity.

While the FAA's objective is to meet growth in demand while maintaining delays at 14 minutes or less, consumer complaints tend to focus on system delays rather than available capacity. Therefore, reducing delay might be a reasonable objective for enhancing system capability. In **Figure 9,** it can be seen that, at least conceptually, capacity can be traded for a reduction in delay within the bounds of system capability. So, the capacity enhancement achievable with a reduced delay (C_{RD}) is not as large as the capacity reduction with a fixed delay (C_{FD}). However, delays could potentially be reduced along with a less significant gain in capacity (C_{RD}) if reducing delay was targeted as an objective of system enhancement. Conversely, capacity could grow larger, although not as significantly due to other constraining factors, if delays were allowed to increase. That is, the conceptual increase in capacity with increased delay (C_{ID}) is greater than the capacity enhancement with a fixed delay (C_{FD}).

As the capability of the national airspace system expands, it is largely a policy decision whether the enhanced capability will be used primarily for increasing capacity or for decreasing delay. However, the FAA's forecast that growth is expected to meet or exceed planned capacity improvements provides a reasonable justification for adopting a policy of projecting capacity expansion while attempting to maintain a fixed level of delay. Capacity is projected to, at best, parallel expected growth through 2010. Therefore, essentially all of the projected enhancements to be engineered into the national airspace system by that time will be needed to meet the forecast growth in aviation operations. Therefore, if demand is to be met, enhancements are not likely to be available for mitigating delay. Furthermore, system enhancement efforts are likely to have a greater impact on increasing capacity rather than decreasing existing delay, given that delay is constrained to a greater extent by external factors such as weather and airline scheduling practices that are more difficult to control. Also, given the complexity of tradeoffs between capacity and delay, using a fixed level of delay in projecting future effective capacity simplifies the comparison to baseline capacity levels. An alternative strategy, that would involve core conceptual changes in policy, would value system efficiency over capacity and target reducing delays. Such an approach may involve various market-based strategies, discussed later in this report, to reduce demand characteristics for aviation operations in addition to system enhancements targeting delay reduction. While a more efficient national airspace system may improve the satisfaction of many consumers, it is likely to increase associated costs by limiting the supply of aviation services. Therefore, such a shift in policy regarding the objectives for modernizing the national airspace system could be contentious.

Impact of Congestion on Aviation Safety

As demand for air transportation continues to grow, increasing flight operations may introduce additional risks to aviation safety that may need to be addressed if the system is to maintain or improve upon its current level of safety while at the same time addressing capacity needs. The FAA's ATO has identified two key indicators of safety in its performance-based plan: runway incursions and air traffic controller operational errors.

Runway Incursions

As traffic density at airports increases, so does the probability that an aircraft or ground vehicle will enter on to an active runway when an aircraft is taking off or landing unless steps are taken to effectively reduce the likelihood of such occurrences. The FAA refers to these breaches of runway safety that occur at towered airports as runway incursions.[40] Runway incursions pose a significant safety risk because they are the manifestations of human errors and pre-existing conditions that may well have led to a runway collision.

The potentially deadly consequences of a runway collision were highlighted most recently on October 8, 2001 when a Cessna business jet strayed on to the active runway in foggy conditions and was struck by a departing airliner at Milan, Italy's Linate Airport killing 118 people and injuring 4.[41] A year earlier, a Singapore Airlines 747 bound for Los Angeles mistakenly attempted to take off from Taiwan's Chiang Kai Shek International Airport using a partially closed runway at night during a typhoon. The airplane collided with construction equipment killing 83 of the 179 on board.[42] The world's deadliest aircraft accident (583 fatalities), the 1977 collision between two Boeing 747 aircraft on the Island of Tenerife, was also the result of a runway incursion during low visibility conditions.[43]

The United States has not been immune to such disasters. Since 1990, there have been four runway collisions in the United States involving large commercial airliners. The deadliest runway collision in the U.S. occurred at Los Angeles International Airport (LAX) on the night of February 1, 1991. A USAir Boeing 737 was cleared to land on a runway occupied by a commuter flight that was instructed to line up on the runway and await takeoff clearance. The National Transportation Safety Board (NTSB) determined that the accident was attributable to shortcomings in LAX's air traffic control management, procedures, and oversight, which ultimately led to the failure of the tower controller to maintain appropriate situational

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[40] The FAA defines a runway incursion as any occurrence in the airport runway environment involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing, or intending to land (See FAA Office of Runway Safety. *Runway Safety Report: Runway Incursion Trends at Towered Airports in the United States (FY1999-FY2002).* July 2003).

[41] Agenzia Nazionale per la Sicurezza del Volo (Italy). *Milano Linate, ground collision between Boeing MD-87, registration SE-DMA and Cessna 525-A, registration D-IEVX*. January 20, 2004.

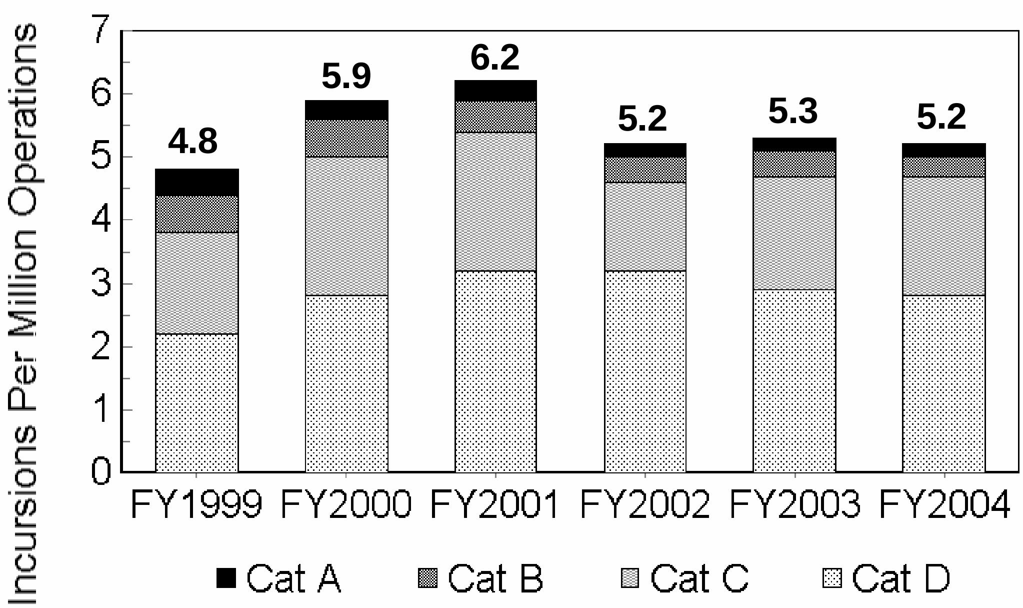
[42] Aviation Safety Council (Taiwan, Republic of China). *Crashed on a Partially Closed Runway During Takeoff — Singapore Airlines Flight 006 — Boeing 747-400, 9V-SPK — CKS Airport, Taoyuan, Taiwan, October 31, 2000.* Aircraft Accident Report ASC-AAR-02-04-001.

[43] Subsecretaria de Aviacion Civil (Spain). *KLM, B-747, PH-BUF and Pan-Am B-747, N736 — Collision at Tenerife Airport, Spain on 27 March 1977.* Madrid, Spain.

awareness.[44] Another notable runway collision occurred in the U.S. on November 22, 1994 when a TWA DC-9 collided with a twin-engine Cessna at St. Louis International Airport (STL), Missouri. Similar to the recent Milan crash, the NTSB found that the Cessna pilot had mistakenly taxied past the assigned runway and into the DC-9's path in foggy conditions. The NTSB further concluded that airport surface monitoring equipment could likely have prevented the collision.

Since FY1999, the rate of runway incursions at the nation's 35 busiest airports has remained relatively constant, slightly above 5 incursions per million flight operations.[45] Overall, the rate of incursions for commercial operations has averaged slightly more than 5.5 incursions per million flight operations. While the overall rate of runway incursions appears to be relatively constant since 1999, the FAA has noted that the severity of incursions declined during that period. That is, a decline in the most serious types of incursions — those classified by the FAA as having a significant or extreme collision potential (Category A and B incursions) — was observed, whereas the rates of less severe incursion incidents (Category C and D incursions) has remained relatively unchanged (see **Figure 10)**.

Figure 10, Runway Incursion Rate



Source: *FAA Runway Safety Report*, July 2003, August 2004, & August 2005.

While the FAA concluded that this trend demonstrates progress in mitigating the severity of runway incursions, such a conclusion may be premature. Given the low rate of these events (about 1 in every 3 to 5 million operations), it is difficult to

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[44] National Transportation Safety Board. *Runway collision of US Air Flight 1493, Boeing 737 and Skywest flight 5569 Fairchild Metroliner, Los Angeles, California, February 1, 1991* (AAR-91-08).

[45] See FAA Runway Safety Reports (July 2003, August 2004, and August 2005).

say for sure whether this reduction in incursion rate is meaningful and even more difficult to attribute it to specific actions taken to reduce the rate and severity of incursions. Furthermore, the reduction in severity levels observed between 2001 and 2002, has appeared to flatten. This may indicate that the effects of currently implemented mitigation strategies have already been largely realized. If this is the case, then more may need to be done to keep the overall numbers of Category A and B incursions to a minimum. This is because, even if the severe incursion rate is held constant, increasing number of operations will bring with them likely increases in the number of severe incursions. While more data is needed to draw meaningful conclusions regarding the reduction in risk of runway incursions, these trends are at least promising and the FAA is continuing its efforts to implement operational and technological approaches to further reduce runway incursions.

Of the OEP-35 airports, 7 had 15 or more incursions over the four year period from 2000-2003. These airports were: Chicago-O'Hare (ORD); Dallas-Fort Worth (DFW); Los Angeles International (LAX); Phoenix Sky Harbor (PHX); Boston Logan (BOS); Saint Louis (STL); and San Francisco International (SFO). Traffic density was certainly a major contributing factor in the number of runway incursions experienced at an airport. Four of these 7 airports were among the top 5 busiest airports in the United States. The FAA recognizes that traffic volume is a major factor in runway incursions since increases in operations increase the number of opportunities for error. However, the FAA found that annual fluctuations in traffic volume did not have predictable effects on runway incursions rates. Thus, traffic volume appears to interact with airport-specific characteristics to affect the likelihood of runway incursions in complex ways that are not yet fully understood.

The highest number of runway incursions (34), and the largest number of Category A & B incursions (12) over the 2000-2003 period for the OEP-35 airports was observed at LAX, which ranks fourth overall in number of operations and has a complex taxiway layout. However, LAX had no Category A & B incursions in 2003 suggesting that, while they have been unable to reduce the annual number of incursions at that airport, strategies to mitigate the severity of incursion incidents appear to be working there. Efforts to date have primarily focused on outreach to increase pilot runway safety awareness, improved signs, pavement markings, and lighting, and procedural modification to improve operational safety.

Besides high traffic density, the attributes that those airports experiencing higher numbers of runway incursions appear to share include complex taxiway and runway layouts; and complex taxi procedures. Some, but not all, of these airports have intersecting runways which also present opportunities for runway incursions to occur. The runway incursion risk of intersecting runways could have implications for capacity-enhancing operational procedures such as land and hold short operations (LASHO) in which pilots of landing aircraft are required to stop before reaching a crossing runway so that simultaneous operations can be conducted on both runways. Clearly, other airports share these attributes as well and procedures such as LASHO have been used safely for many years. Therefore, the specific factors that make an airport more vulnerable to runway incursions are not yet completely clear. How airport-specific factors such as infrastructure, procedures, operations, and environment interact with traffic density to define the runway incursion risk for a specific airport is not fully understood and continues to be scrutinized by the FAA and others to identify the influence of these various factors on runway incursion risk.[46]

The leading direct cause of runway incursions was pilot deviations, which account for about 53% of incursions involving commercial aircraft. Controller errors and deviations account for about 29% of runway incursions among incursions involving commercial aircraft and incursions occurring at the OEP-35 airports. Deviations by vehicles and pedestrians operating in the air operations area comprise the remaining runway incursions. Consequently, mitigation measures to reduce runway incursions are likely to have the greatest benefit if they can reduce the number of pilot deviations during surface movement. However, FAA's efforts to date in terms of high cost technology options — including ground radar (Airport Surface Detection Equipment (ASDE) and the Airport Movement Area Safety System (AMASS) — are primarily focused on improving air traffic controller situation awareness regarding traffic position and the potential for incursions.

In 2001, the NTSB evaluated the Airport Movement Area Safety System (AMASS) and determined that it was not capable of providing sufficient warning to prevent runway collisions in all instances and, as currently implemented, provides no capability to issue warnings directly to pilots and other vehicle operators.[47] In essence, the AMASS system inserts controllers into the decision cycle, thereby increasing the time needed for pilots to take evasive action to prevent a collision. Providing traffic information and alerting directly to pilots, as opposed to only alerting controllers, would be preferable in this regard. But, this is not what the NTSB's original recommendation sought. Rather the NTSB specifically asked the FAA to develop a system analogous to cockpit traffic collision avoidance systems (TCAS) to alert *controllers* to pending runway incursions.[48] However, TCAS provides alerts and conflict resolutions directly to *pilots*.

The NTSB assessment went on to conclude that FAA's efforts to curtail runway incursions largely through technological approaches aimed at improving air traffic controller situational awareness was an incomplete solution, and specifically called for specific actions to address recommended changes in operational procedures at airports. The NTSB's recommendations urged the FAA to install ground movement safety systems at all airports with passenger service that provide a direct warning capability to *pilots*, and demonstrate through computer simulations or other means that the system will, in fact, prevent runway incursions. The recommendations also included numerous suggested changes to operational procedures to: increase pilot and controller situation awareness and resolve ambiguities regarding runway crossing clearances; eliminate the practice of positioning an aircraft on a runway to await takeoff at night and in poor weather; modify phraseology of airport movement

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[46] FAA Office of Runway Safety. *Runway Safety Report*. (July 2003 and August 2004).

[47] Carol J. Carmody. *Testimony before the Committee on Transportation and Infrastructure, House of Representatives Regarding Runway Incursions*, June 26, 2001. Washington, DC: National Transportation Safety Board.

[48] National Transportation Safety Board. *Runway collision of Eastern Airlines Boeing 727, flight 111 and Epps Air Service Beechcraft King Air A1000, Atlanta Hartsfield International Airport, Atlanta, Georgia, January 18, 1990* (NTSB/AAR-91/03).

instructions to be consistent with international standards; and provide controllers with guidance on appropriate phraseology and speaking rates, especially when communicating with foreign flight crews.[49]

The FAA continues to address many of these procedural changes to enhance runway safety. However, the NTSB has expressed continued frustration with the FAA's progress. At a recent meeting, the NTSB questioned the completeness of the FAA's runway incursion incident reporting and cast doubt on FAA's claims that the incursion rate is declining.[50] Most observers agree that there is no single solution to mitigating runway incursions and continued investment in airport design, procedural modifications, pilot and controller training, and technology is needed to reduce the risk of runway accidents. Several mitigation strategies to reduce the potential for runway incursions are currently being implemented or are under study by the FAA and NASA. Mitigation strategies to reduce the risk of runway incursions can be placed into six general categories, as shown in **Table 1**. These various strategies are mainly aimed at improving pilot and controller situational awareness regarding: aircraft position relative to other aircraft and ground vehicles; aircraft and vehicle position relative to assigned taxi routes and active runways; and flight crew and vehicle operator understanding of taxi instructions and runway clearances. Other solutions seek to provide controllers and pilots with alerting and conflict resolution capabilities to predict and circumvent impending runway incursions or reduce the severity of incursions by reducing the risk that such an event could result in a collision.

Table 1. Mitigation Strategies to Prevent Runway Incursions and Reduce Their Severity

Mitigation Strategy	**Examples**
Markings, Signs, and Lighting	High Contrast Taxiway Markings and Hold Short Lines; Improved Visibility and Positioning of Signs; and Runway Status Lights
Increasing Pilot Positional Awareness	Cockpit Moving Map Displays; Airport Position Transmitting Devices; and Auditory Advisories and Audible Warnings

[49] National Transportation Safety Board. *Safety Recommendations A-00-66 through A-00-71*.

[50] National Transportation Safety Board. *NTSB calls for federal action to adopt "most wanted" safety improvements*. Press Release SB-04-33, November 9, 2004.

Increasing Pilot and ATC Traffic Awareness	Ground Surveillance Radar (e.g., Airport Surface Detection Equipment - Model X (ASDE-X)); and Cockpit Traffic Information Displays (e.g., Traffic Information Service (TIS), Cockpit Display of Traffic Information (CDTI))
Procedures and Training	Ramp worker training; Educational materials to flight crews and operators of ground vehicles and equipment; Modifying and standardizing taxi routes; and Modifying ATC phraseology
Warning Devices and Conflict Resolution Advisory Systems	Airport Movement Area Safety System (AMASS); and ASDE-X with conflict detection alerting capabilities
Airport Redesign/Reconfiguration	Perimeter taxiway construction; Eliminating or minimizing intersections where taxiways cross runways

Loss of Separation and Near Mid-Air Collisions

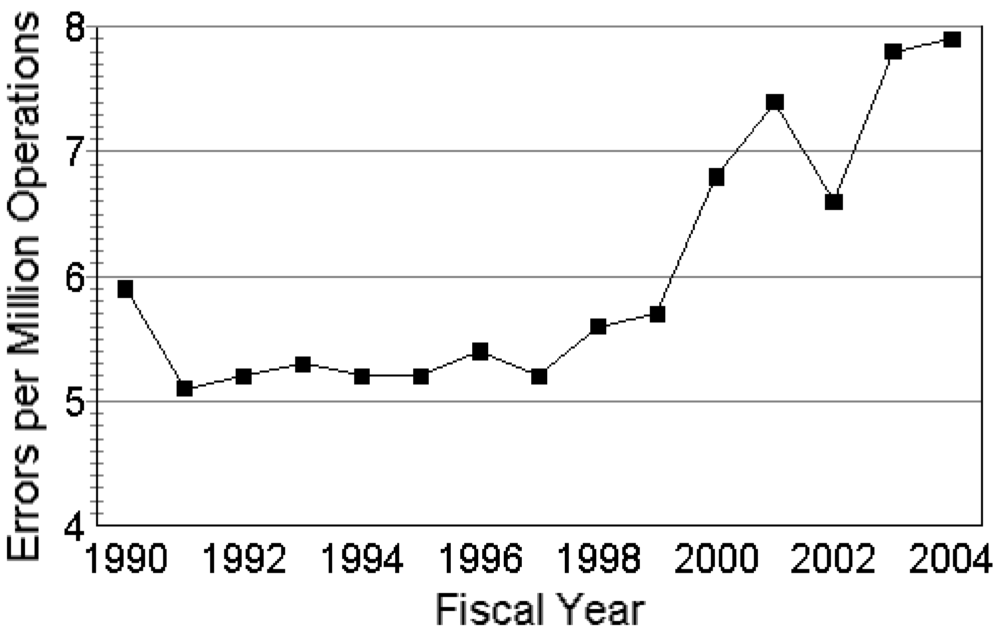
As runway incursions are indicators of safety risk associated with ground operations, breaches of required airborne separation between aircraft are indicators of safety risk during flight. These loss of separation incidents are a safety concern because they point to system failures and errors that could lead to a midair collision. A loss of separation caused by an air traffic control error is termed an operational error. Operational errors, like runway incursion, are placed into one of four categories (A, B, C & D) based on severity. Operational errors are reviewed and scored using a point system that considers factors such as: the vertical and horizontal separation between aircraft; whether the aircraft were on converging or diverging flight paths; the closure rate between aircraft; and whether ATC took corrective actions or TCAS (Traffic Collision Avoidance System) resolution advisories were issued.[51] The severity is then categorized as high, moderate, or low. Under recent changes by the FAA, these three levels of severity are now grouped into four categories, in the following manner:

- **Category A**: All high severity incidents
- **Category B**: All moderate severity incidents where ATC fails to take corrective action (uncontrolled)

[51] Federal Aviation Administration. *Air Traffic Quality Assurance.* Order 7210.56C, August 15, 2002.

- **Category C**: All moderate severity incidents where ATC takes appropriate corrective action (controlled); and
- **Category D**: All low severity incidents

There is growing concern over operational errors as annual operational error rates — expressed as the number of incidents per million flight operations — have been on the rise over the past five years and are up 35% compared to the previous five year period (see **Figure 11**). Furthermore, the severity of these operational errors has been regarded as being too high. Specifically, the DOT Inspector General reviewed severity ratings for 13 months of operational error data collected from May, 2001through May 2002 and found that 78 percent were classified as moderate severity, and 6% were classified as high severity, while only 22% were classified as low severity.[52] The DOT Inspector General's report concluded that much work needs to be done to reduce the severity of operational errors so that the large majority are low severity events.



Source: DOT Office of Inspector General. *Operational Errors* (AV-2003-040) and FAA Administrator's Fact Book (November 2005).

The DOT Inspector General also highlighted potential problems in the use of controllers-in-charge (CICs), a program using senior controllers rather than managers to supervise facility operations, which was greatly expanded in recent years. Their study found that while the use of CICs increased 13.6% between 2000 and 2001, the number of operational errors while CICs were on duty increased by 45.7%. While

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[52] Department of Transportation, Office of Inspector General. *Operational Errors and Runway Incursions: Progress Made, but the Number of Incidents is Still High and Presents Serious Safety Risks* (AV-2003-040), April 3, 2003.

other factors may have contributed to this rise in error rates, this trend may be an indicator that tighter controls and monitoring of the program may be needed.

Both the DOT Inspector General and the NTSB have criticized FAA policy and agreements with controllers that limits the use of remedial training following operational errors. FAA policy does not require the FAA to impose remedial training following a low severity operational error and prohibits follow-on training if the controller took corrective actions during the course of the event. Even for controllers who have moderate or high severity operational errors, remedial training is not required. Also, FAA policy prohibits supervisors from revoking or suspending controller certificates and facility ratings on the basis of performance deficiencies. In light of these findings, the DOT Inspector General concluded that FAA needs to strengthen its actions to address controller performance deficiencies highlighted by operational errors.

Even with improved oversight and safety regulation of air traffic facilities, operational errors can still pose serious safety risks. In essence backup capabilities are needed to assure aircraft separation by alerting controllers and pilots when a loss of separation occurs and poses a threat of collision between two aircraft. These aids include conflict alert (CA) algorithms to alert controllers to impending loss of separation events, and TCAS to provide pilots with traffic awareness and conflict resolutions for preventing midair collisions.

The August 31, 1986 collision of an Aeromexico D-9 and a small private plane over Cerritos, California highlighted growing concerns over the risk of mid-air collisions and prompted the FAA to promulgate regulations phasing in the use of airborne traffic collision avoidance systems (TCAS) on airliners and commuter aircraft.[53] Currently, FAA regulations stipulate that passenger air carrier flights be equipped with an operating TCAS system that provides visual and aural advisories of traffic conflicts. Additionally, all aircraft operating near the nation's busiest airports are required to use altitude report equipment (Mode C or Mode S transponders) that transmit aircraft position and altitude to TCAS devices.

Since these requirements have gone into effect, there has not been a mid-air collision involving a TCAS-equipped aircraft in U.S. airspace. However, TCAS is not required on all airplanes. Regulations stipulate that only passenger airliners and jet and turboprop air taxi and commuter flights with seating for 10 or more passengers must be equipped with TCA[54]S. Thus, most cargo aircraft, business jets, and many charter aircraft are not required to install or use TCAS.

One option to increase safety as operations increase in congested airspace would be to require the use of TCAS systems for other users of the aviation system. This may be particularly important given the large anticipated increases in business jet and

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[53] National Transportation Safety Board. *Collision of Aeronaves de Mexico, S.A. McDonnell Douglass DC-9-32, XA-JED and Piper PA-28-181, N4891F, Cerritos, California, August 31, 1986.* NTSB Report AAR-87-07.

[54] Title 14, Code of Federal Regulations §121.356, §135.180.

cargo jet operations over the next 10 years. However, alternative technologies — such as automated dependent surveillance-broadcast (ADS-B) with cockpit display of traffic information (CDTI) or Traffic Information Systems (TIS) — have the potential to offer TCAS-like capabilities at significantly lower cost, which may be particularly attractive to general aviation users of business jets and mini-jets. Thus, alternative technical standards for traffic awareness and alerting systems may be able to adequately address safety concerns regarding traffic collision avoidance in the near future. Congress may pursue the implementation of such systems through either legislation or oversight of FAA regulatory activities.

Possible Strategies for Enhancing Capacity While Maintaining Safety and Efficiency

There are numerous approaches to enhancing capacity of the national airspace system under development and evaluation. The core policy issue is determining the right mix for investing in airport infrastructure, technology, and modifications to operational procedures in order to grow capacity at a rate commensurate with growth in demand while at the same time maintaining the efficiency and safety that aviation consumers expect. The aviation community has invested a great deal in future concepts for air traffic management and control that are just beginning to mature and take shape in the operational framework of the national airspace system. Additionally, airports continue to expand and reconfigure to enhance their capacity and improve operational efficiency. However, these measures may not be enough to meet demand without eroding the efficiency and possibly the safety of air travel. Consequently, policymakers are continuing to evaluate market-based strategies to alter the demand characteristics for aviation operations so that operations can continue at a level that is safe and meets consumer expectations of efficiency in a resource constrained system.

The "Free-Flight" Concept

Over the next decade, the current model of the national airspace system is expected to change dramatically. Virtually all airliners and business jets now have onboard capabilities, such as area navigation equipment (RNAV), global positioning system (GPS) receivers, and inertial guidance systems that provide precise aircraft position data without sole reliance on ground-based VORs, thus allowing pilots to fly directly from airport to airport. However, allowing aircraft to fly direct to their destination presents significant challenges to air traffic managers and controllers that are currently being worked out under a concept called *free flight*. Since *free flight* is an evolving concept, the term is used both loosely to describe conceptual aspects of future air traffic systems allowing aircraft to fly along direct routes and deviate as needed to avoid weather and traffic, as well as more concretely to describe a suite of air traffic management (ATM) and air traffic control (ATC) tools being developed and tested by the FAA to allow greater flexibility in aircraft routing.

One step in the process toward implementing *free flight* is to redefine the structure of high altitude airspace around point-to-point direct routes that appropriately equipped aircraft can utilize. The FAA began doing this in July 2003, defining and charting high altitude routes — designated by international convention as "Q routes" in the U.S. and Canada — for use by aircraft with precision satellite navigation capabilities.[55]

One major challenge in implementing the *free flight* concept is defining how much autonomy each aircraft will have during the en route portion of flight. Currently, aircraft in high altitude airspace can only fly along the specific course and altitude profile that air traffic control has approved or cleared. Thus, in the present system, ATC has direct control over every aircraft in high altitude airspace. Under a *free flight* model it is likely that pilots would have some degree of autonomy regarding their flight path. For example, in the current system if a pilot sees a thunderstorm ahead, he or she must request a deviation around the storm from ATC. Under the proposed *free flight* model, the pilot may be able to deviate around the storm without formally receiving permission to do so by ATC. Similarly, pilots may have some degree of autonomy regarding deviations for traffic, altitudes and airspeeds deviations to avoid or mitigate turbulence and increase fuel economy, and so on. This would shift the ATC role for high altitude airspace from direct control to a supervisory control function, where ATC would monitor traffic in a given sector of airspace and resolve conflicts as well as provide advisories and instructions to maintain appropriate aircraft spacing and alleviate congestion at destination airports. In the future, the en route controller is also likely to take on a more active role as an interface between aircraft and air traffic management (ATM) functions within the FAA that will apply more complex analyses of the overall traffic picture to more efficiently control the flow of air traffic throughout the system.

A second major challenge in implementing a *free flight* model for the national airspace system is handling the transitions from the busy terminal airspace around an origin airport to the en route phase of flight along these routes and from the en route segment to the approach phase of flight when aircraft enter busy terminal airspace around a destination airport. The working concept to address this challenge is by using what are referred to as *pitch* and *catch* points to define specific transition points into and out from busy terminal airspace. Under this concept, aircraft would fly predefined departure routes — much as they do today, except with the aid of precision satellite navigation — to a *pitch* point where the would then proceed semi-autonomously via a direct routing to a *catch* point where they would enter the terminal airspace at the destination airport and follow predefined approach routes or

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[55] The FAA has defined advanced aircraft navigational performance capabilities broadly under the umbrella of what they call Area Navigation or RNAV equipment. By establishing performance standards in this manner, it does not limit operators to any specific technology to meet the required navigational performance to perform certain operations. In this sense, the FAA has moved away from technical standards and instead had adopted performance standards for future navigation capabilities. At present, the aircraft technology needed to meet these performance standards include Wide Area Augmentation System (WAAS) enabled GPS receivers and inertial reference units (IRUs). The use of ground-based RNAV systems developed in the 1970s that rely on VOR receivers and distance measuring equipment (DME) to navigate using more direct routing is being evaluated under this framework, but is not currently approved for high altitude airspace. In this report, the term precision satellite navigation capabilities refers to the WAAS enabled GPS technology which is one of two core enabling technologies of emerging *free flight* operational concepts in the U.S.

ATC instructions to arrive at the destination airport. Thus, at least in the near term, the *free flight* implementation that is most likely to emerge is one in which aircraft will operate semi-autonomously in high altitude airspace between *pitch* and *catch* points, and will operate under more direct control of ATC when transiting busy terminal airspace during departure and before landing.

The core enabling technology needed to implement navigation under a free flight system — precision satellite navigation — is already mature. The other element needed to enable *free flight* — assuring safe separation between aircraft — involves a more complex interplay between onboard technologies and air traffic management and control tools. Onboard technologies for traffic awareness and separation include TCAS systems which are already widely deployed. The other onboard technology for traffic awareness and separation in aircraft is Automatic Dependent Surveillance - Broadcast (ADS-B), a technology capable of broadcasting aircraft position information to other aircraft and to air traffic control and displaying traffic information in the cockpit. Unlike TCAS which uses onboard radar and radar-based air traffic control displays, ADS-B will rely predominantly on satellite-based aircraft position data using GPS. The potential advantage of this technology is that it can provide a common traffic picture, that is, the capability for pilots, and controllers, and air traffic managers to have shared situation awareness regarding nearby traffic and potential conflicts. Such a capability is seen as a step toward providing pilots with more autonomy regarding navigation and separation. While such technology has significant potential and has been implemented successfully in various operational tests performed under the FAA's Safe Flight 21 program, much work is still needed to create a system-wide infrastructure to support this technology. Much work is also still needed to develop decision support tools and automation that can assist air traffic managers, controllers, and pilots to handle traffic and weather conflicts. Finally, much work still needs to be done on the human factors and system design of a *free flight* system to more clearly define the roles and protocols for air traffic managers, controllers, and pilots.

The FAA is in the process of defining the regulatory structure to permit limited operations exploiting this technology. However, significant work is still needed to create a seamless, integrated *free flight* system throughout the domestic U.S. airspace. As shown in **Table 2**, there is still considerable risk associated with integrating and implementing *free flight* concepts in the national airspace system. At this point, this risk exists although the core enabling technologies are relatively mature, because extensive systems integration is still needed in order to utilize these technologies to provide seamless navigation, communications, surveillance, and air traffic management capabilities throughout the most complex airspace system in the world. Despite ongoing reform with the creation of the ATO and the JPDO, the FAA's capability to implement *free flight* also introduces an element of risk because of the FAA's history of cost overruns, schedule delays, and failures to meet performance objectives in managing large scale programs. Given the relatively high level of risk associated with implementing *free flight* concepts, this could be an area of continued congressional oversight over the next several years.

Table 2. Risk Elements and Considerations for Implementing Free Flight Concepts

Element	Risk Considerations
Technology	Core technologies (e.g., GPS, ADS-B) are mature; but Extensive systems integration, both hardware and software, is needed
Application Domain	Highly complex airspace system; Highly complex interactions between human operators (i.e., air traffic managers, controllers, and pilots); Extensive requirements for collaboration/information sharing; and Highly dynamic scenarios (e.g., weather and traffic flow variations)
Program Management	Historically, FAA programs have been plagued by cost overruns, schedule delays, and failures to meet performance objectives; Historically, FAA has "stovepiped" or compartmentalized projects with inadequate integration and inter-project collaboration; Historically, FAA has had inadequate and incomplete blueprints for system integration and technology investment strategies; ATO and JPDO were established to correct management deficiencies at FAA but are too new to assess their effectiveness; FAA is implementing incremental, spiral development processes and other acquisition reforms to address concerns

Reducing Separation Standards

In parallel with the FAA's efforts to introduce *free flight* concepts in the national airspace system, the FAA is implementing initiatives to reduce the separation between aircraft both in high altitude airspace and in the terminal environment, near airports. Reducing separation is seen as an important strategy for increasing capacity in congested airspace.

For example, reducing vertical separation from 2,000 feet to 1,000 feet in high altitude airspace[56] in essence doubles en route capacity, although actual capacity enhancement through RVSM is likely to be constrained to some degree by factors such as airspace configuration and air traffic controller workload that may limit the number of aircraft that can be handled within an air traffic control sector. Only with the advent of more autonomous means of navigation and surveillance of air traffic, using free-flight direct navigation concepts and pilot/controller decision aids for

[56] High altitude airspace, as used in this report, refers to airspace between 18,000 feet and 60,000 feet (Flight Level (FL) 180 to FL600, which is classified as Class A airspace.

example, will technology and operational procedures allow for this increase in capacity to be fully exploited. Nonetheless, in the near term, RVSM is expected to have numerous benefits including:

- Reduced fuel burn from improved routing, altitude selection, and delay reduction;
- Increased air traffic sector capacity, throughput, and efficiency;
- Increased controller flexibility for resolving weather and traffic conflicts;
- Decreased controller workload by providing controllers with more options;
- A reduction in conflict points in high density traffic areas; and
- Enhanced predictability by allowing aircraft to use requested altitudes.

In high altitude airspace, efforts are underway to reduce the vertical separation between aircraft from 2,000 feet to 1,000 feet. RVSM requirements are now in effect for many oceanic and international flights operated between 29,000 feet (FL290) and 41,000 feet (FL410). Domestic RVSM requirements covering the lower 48 states and Alaska will be required by January, 2005

The Domestic RVSM implementation will make six additional flight levels available for operations between FL 290-410. According to the FAA, RVSM has been shown to enhance aircraft operating efficiency by making more fuel/time efficient flight levels available and enhance air traffic control flexibility in addition to providing the potential for enhanced en route airspace capacity.

While RVSM is designed to target capacity expansion in high altitude airspace, reducing separation standards near airports is seen as an important strategy to improving capacity and efficiency of arrivals and departures. One major hurdle to overcome in implementing this strategy is that many airports have been built with runways that are too close together to support simultaneous arrivals using current separation requirements. Therefore, the FAA is working on technology and procedures to reduce the separation between aircraft operating to closely spaced parallel runways by providing pilots and controllers with precision aircraft and traffic position information that will allow operations to continue under visual separation rules during periods of marginal in-flight visibility. In the future, aircraft meeting specific levels of navigational accuracy — called required navigation performance, or RNP[57] in aviation parlance — may be able to use cockpit traffic displays in lieu

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[57] Required navigational performance (RNP) is a performance standard that defines the required position accuracy needed to keep the aircraft within a specified containment area, or bubble, 99.9% of the time. The required navigational performance is not tied to any specific technology, but sets a technical standard that can be met using various FAA-approved equipment. While precision satellite-based navigation is currently the principal technology for meeting RNP standards, these standards allow for the use of other technologies — including yet to be developed technologies — to meet navigational performance standards.

of out-the-window visual confirmation of traffic position to see and avoid nearby traffic approaching parallel runways in virtually all weather conditions.

Like *free flight*, reduced separation standards in the terminal environment near airports are likely to rely heavily on precision satellite navigation capabilities provided by the global positioning system (GPS) augmented by ground-based stations that provide increased precision in the GPS signal. The FAA has two systems for precision satellite navigation - the recently commissioned Wide Area Augmentation System (WAAS) that provides systemwide coverage and the higher resolution Local Area Augmentation System (LAAS) which may provide more precise navigation capability for precision landings during low visibility operations at selected airports. While WAAS is operationally available, LAAS is still in early testing phases of operational testing and there are some that still question whether the improvement in navigational accuracy of current LAAS systems over WAAS is enough to justify their cost.[58]

The FAA turned on the WAAS network on July 10, 2003 and is now phasing-in landing procedures that can exploit the precision vertical and lateral navigation capabilities of GPS/WAAS. WAAS is a milestone achievement because it offers the potential for precision vertical and lateral navigational guidance to practically any runway in the United States in addition to providing improved accuracy of aircraft position data needed to reduce aircraft separation standards.[59]

In terms of capacity enhancement, WAAS provides two key benefits. First, WAAS can be used as a means to allow more precise spacing of aircraft on approach to an airport. This can permit runway utilization to better approach optimal levels. In the future, the precision of WAAS enabled GPS position data may allow for the reduced separation of aircraft on approach and may also reduce the separation of aircraft arriving on closely spaced parallel runways. The second way WAAS can enhance capacity is by providing precision landing capabilities to many general aviation reliever airports. In poor weather, the only available landing sites with precision landing capabilities offered by current airport-based instrument landing systems (ILS) are often commercial airports and large general aviation reliever airports. Consequently, commercial airports often see increased general aviation activity during poor weather because general aviation aircraft are forced to use these landing facilities. With new instrument approach procedures exploiting WAAS-enabled GPS navigation, numerous other airports can potentially relieve commercial airports of general aviation traffic during reduced visibility conditions. Thus, the potential benefit of precision satellite navigation extends beyond providing the capability to reduce separation standards.

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[58] John Croft. "More WAAS, less LAAS." *Professional Pilot,* April 2003, pp. 60-64.

[59] While WAAS provides the capability for precision vertical guidance to virtually all runways, terrain, obstacles, noise abatement and other factors may limit its implementation at some airports.

Automation and Decision Aiding for Air Traffic Management

The future national airspace system is likely to make extensive use of automation and decision aiding tools to more efficiently manage traffic flow in a *free flight* environment with reduced aircraft separation. Many experts see automation and decision aiding tools as a core element of the next generation airspace system that will allow users to more fully exploit the capabilities of precision satellite navigation and enhanced communications and surveillance capabilities. According to the JPDO director, Charles Keegan, a central concept of the NGATS is to rely extensively on the automation of core air traffic management functions such as flow control and the metering or spacing of aircraft.[60]

The FAA and NASA are actively engaged in the research and development of several tools that may someday provide essential automation and decision aiding capabilities to air traffic managers, controllers, and pilots in the future national airspace system. One precursor to future decision aiding capabilities to enable users to exploit en route *free flight* concepts is the user request evaluation tool (URET) currently being deployed at en route air traffic facilities. URET predicts and notifies controllers of potential conflicts between aircraft or special activity airspace and provides conflict assessments of proposed flight path changes. Presently, URET has been deployed at six Air Route Traffic Control Centers (ARTCCs) as part of the first phase of FAA's *free flight* implementation and installation at the remaining 14 ARTCCs is underway as part of the second phase of *free flight* implementation. Another component of high altitude *free flight* enabling technology is the Traffic Management Advisor (TMA), a strategic planning tool for high altitude controllers and traffic management specialists. The TMA is used for arrival schedule planning to implement time based metering or sequencing of aircraft for the handoff between en route phases of flight and approach to airports in congested airspace. A related tool designed to also improve flow control is the passive final approach spacing tool or pFAST. As the name suggests, pFAST has been designed to serve as a decision aid for controllers to better optimize traffic flow during the final approach to a runway. While these tools are currently making their way into air traffic control centers and approach control facilities, they may not offer complete solutions to air traffic management. Extensive work is still likely to be needed to integrate these various tools and concepts on a system-wide level in order to enable more optimal utilization of airspace and more efficient flow of air traffic.

In the future, integrated air traffic management concepts and collaborative decision making are likely to increase in importance and allow the FAA to develop strategies and tactics for handling system-wide traffic flow. The FAA may increasingly rely on traffic management tools to aid strategic and tactical decision-making. The national playbook is one example of a traffic management tool currently implemented to give the FAA the ability to deploy specific situation-based tactics for handling capacity constraining conditions such as adverse weather. The national playbook provides the air traffic control system command center (ATCSCC), the nerve-center for FAA's air traffic management operations, other FAA facilities, and system users a common set of strategies for various scenarios.

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[60] David Hughes. "The 'Silent' Crisis".

The purpose of the national playbook is to aid the FAA and system users in expediting route coordination during the most common scenarios that occur during severe weather. The selected routes in the national playbook include textual and graphical depictions of specific routing tactics that have been vetted by air traffic control representatives from affected facilities involved in a given scenario.

Another operational tool that the FAA recently began implementing is the use of "express lanes" to temporarily increase the flow out of airports experiencing departure delays. The concept is that specific levels of delay will trigger the tactical implementation of these "express lanes." When this happens, air traffic controllers will hold up traffic to and from nearby satellite and reliever airports to allow departures from the major airport to flow more quickly through these "express lanes" in the sky that open up as a result. In the future, air traffic managers may rely more extensively on these strategies and tactics and rely more heavily on the use of automation and decision aiding tools to optimize airspace utilization and traffic flow management.

However, despite the FAA's focus on air traffic management technologies and methods to improve future airspace utilization and increase the efficiency of traffic flow, these efforts are not believed to be capable of fully addressing capacity needs by themselves. As discussed previously, one of the main challenges for meeting aviation capacity needs appears to be linked to the future capability to expand airport infrastructure, such as new runways and new airports, in major metropolitan areas where demand for air travel is expected to grow significantly over the next 25 years. While increased automation and decision aiding to support air traffic managers, controllers, and airspace users will help to optimize the utilization of underlying infrastructure, experts generally agree that expansion and reconfiguration of airport infrastructure is likely to provide the most substantial gains in available capacity of the national airspace system.

Airport Expansion and Reconfiguration

As the FAA notes, there are two main strategies for alleviating peak demand at airports: building new runways; and maximizing the use of existing runways.[61] As indicated from models in the FAA's capacity benchmark studies, new runways can significantly increase an airports capacity. Of the twelve OEP-35 airports building or planning new runways, those new runways are expected to net an average capacity improvement of 31% across all weather conditions.[62] By comparison, technology improvements at airports are expected to net more modest capacity increases in the 3 to 8 percent range.[63] Thus, any systemwide strategy to enhance capacity is likely to focus heavily on building new runways. Technology enhancements to improve the usage of existing infrastructure, while important, do not appear to be capable of keeping pace with near-term growth in airport operations.

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[61] Federal Aviation Administration. *Operational Evolution Plan (Version 6.0).*

[62] Based on FAA *Airport Capacity Benchmark Report 2004* data.

[63] Federal Aviation Administration. *Airport Capacity Benchmark Report 2001.*

Expanding capacity at airport level, either by adding new runways or by building new airports in metropolitan areas, requires extensive cooperation between the federal government, local and state entities, airport authorities, and industry and community stakeholders. For this reason, airport expansion plans are often contentious, time consuming, and challenging. The growing need for expanded airport infrastructure throughout the aviation system is pressuring the FAA and airport operators to seek more streamlined methods for planning and addressing regulatory compliance issues, such as environmental considerations, in the planning process. Partnerships and close cooperation between the FAA, airport operators, state and local governments and stakeholders, such as airlines and impacted communities, are likely to become more critical in determining the best course of action to expand regional capacity for aviation operations while minimizing environmental impacts and integrating proposed solutions with other regional transportation objectives. As a step toward addressing these challenges, Vison 100 (P.L. 108-176) included provisions to streamline the environmental review process for airport capacity enhancement projects by designating the DOT as the lead agency in these assessments and directing the Secretary of Transportation to develop a coordinated review process including simultaneous review by all involved government agencies. The objective of these provisions is to reduce the amount of time and number of reviews required for airport expansion projects.

One major hurdle for many airports in congested areas is available land. Many airports in major metropolitan areas lack the available land to build on. Moreover, the acquisition of surrounding land to accommodate new runways is often not a viable option, and even when it is, doing so is a time consuming and resource intensive process that often takes several years. Some experts believe that one alternative solution is to construct closely spaced parallel runways in hopes that technology will be able to provide the capability to operate these runways at high capacity levels under most, if not all, flyable weather conditions.[64] There are several challenges to doing this. Probably the most significant challenge is designing runways and taxiways for safe and efficient surface movement between multiple closely spaced parallel runways. There are complex operational challenges for handling arrivals that need to taxi across active runways, and safety concerns about runway incursions make the use of multiple, closely spaced parallel runways a particular challenge.

Another significant challenge is the separation requirements imposed to prevent wake turbulence encounters which currently limits the capacity of closely spaced runways significantly. Wing-tip vortices produced by heavy jets pose a danger to trailing aircraft that presently are dealt with by spacing aircraft several miles apart. Reducing this separation is an important element of optimizing the usage of closely spaced runways. Many experts see great promise in ongoing wake vortex research and development at NASA's Langley Research Center that may someday lead to the operational deployment of a wake turbulence prediction tool for airports.[65] However, reducing aircraft separation based on the use of such a tool in an airport environment

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[64] David Hughes. "2025 squeeze play." *Aviation Week & Space Technology,* November 15, 2004, p. 44-45.

[65] *Ibid.*

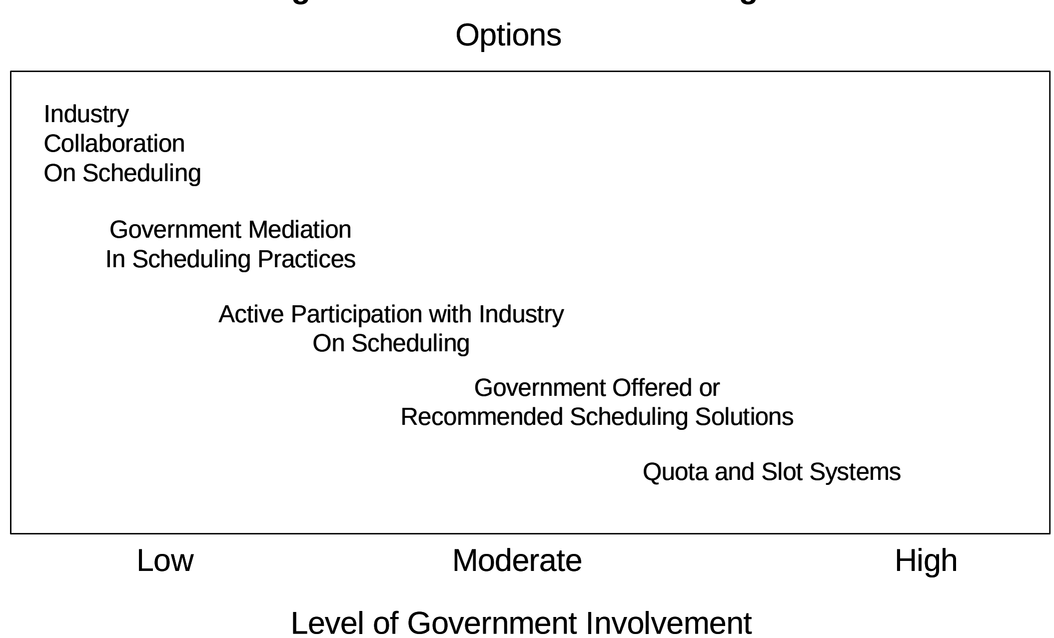
is still likely to be several years away. In addition to these challenges, significant human factors challenges related to controller workload and traffic situation awareness likely will need to be addressed before a viable means for reducing separation and conducting simultaneous operations on closely spaced runways can be implemented without compromising safety.

Market-Based Options

Data indicate that, at best, through airport expansion and improvements, and through implementation of technology solutions to enhance the capacity of the national airspace system, the FAA will struggle to keep pace with the growth in demand for air travel. Thus, there may be a growing need to examine alternative means to alleviate congestion and delay in the aviation system. One particular strategy that may be examined is the use of market-based approaches that, in essence, alter the demand characteristics of aviation operators in ways designed to make demand for aviation services more commensurate with available capacity in order to maintain efficiency and safety of operations.

These market-based options vary along a continuum of government involvement (see **Figure 12**). On one end of the continuum, airlines and other operators could be left to work it out amongst themselves to define market approaches and schedules that will cause minimal delay. In some cases, there could be limited government involvement in these activities, such as having the FAA or DOT serve as a mediator during discussions of scheduling or as an observer to ensure that there is no collusion or other violation of antitrust statutes and regulations and that no specific user groups are unfairly disadvantaged in establishing schedules and access to airports. The government may take a somewhat more active role in such activities by discussing air traffic concerns over proposed schedule options, or even, suggesting scheduling options based on air traffic management considerations and models of traffic flow.

Figure 12. Continuum of Government Involvement in Market-Based Strategies to Alleviate Aviation Congestion



Another way in which government could exert limited control over scheduling practices is to implement incentives for off-peak scheduling, or disincentives for operations during peak hours. Incentive programs could be accomplished through quota systems (for example, multiplying a landing or takeoff during peak hours by a weighting factor when calculating an operator's daily or monthly quota of operations at a specified airport). Incentive programs could also be implemented by increasing or imposing fees, such as landing fees or ATC impact fees, during peak hours. More direct government involvement may involve the use of slot systems where operators and air carriers are allocated limited access to certain congested airports. At the other end of the spectrum from no government involvement at all over airline scheduling practices, is government regulation of the airline industry, which was eliminated in 1978. Since it is likely that any proposal to re-regulate the airline industry would face strong opposition from both the airlines and consumers, such an option is not considered in this discussion of market-based approaches.

In the current debate over alleviating congestion at major airports, a significant policy question that remains is: what degree of government involvement in airline scheduling and airport access is most likely to provide an appropriate balance between equitable and efficient access to limited airport capacity on the one hand and fair and open competition between air carriers in desirable markets on the other? Options under consideration to address this issue fall into two broad categories: 1) strategies for curtailing peak hour demand at busy airports through various incentives or disincentives, and 2) the use of slots or quotas to allocate access at capacity-constrained airports.

De-peaking Strategies and Incentives. De-peaking strategies are designed to alleviate congestion and delay at airports during peak travel times. De-peaking strategies can be implemented with varying degrees of government involvement. With a minimal level of government involvement, airlines may negotiate schedules in a manner that would reduce delay under recently passed statutes that exempt airlines from antitrust laws to allow them to hold meetings for these purposes. Specifically, Vision 100 (P.L. 108-176 Sec. 423; Title 49 U.S.C. §40129) established a collaborative decision-making pilot program at two of the most capacity-constrained airports in the United States. Under the pilot program, airlines are provided special immunity from antitrust laws in order to hold collaborative discussions regarding flight scheduling in order to use air traffic capacity most effectively.

Under this program, airlines have negotiated peak hour schedules at Chicago's O'Hare airport (ORD) over the past several months with limited success. The FAA persuaded United Airlines and American Airlines to voluntarily cut peak hour flights at ORD, however there is concern that these concessions alone were not sufficient to alleviate congestion because other carriers have added peak time flights at ORD.[66] Consequently, the FAA has been working with industry to come up with an equitable schedule arrangement for addressing congestion at ORD. In a recent decision, the FAA has limited the number of unscheduled operations at ORD to 5 per hour, but

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[66] "Airline Overscheduling Still Hurting O'Hare, Controllers Say." *Aviation Daily*, July 15, 2004, pp. 1-2

some operators have criticized this measure because they assert that it disadvantages charter operators who are no longer able to use Meigs Field — a nearby general aviation reliever airport that was closed by the city of Chicago in the spring of 2004 — as well as operators who base or perform maintenance on their aircraft at ORD.

The process for managing schedules at ORD is increasingly leading the two legacy carriers who have curtailed operations to complain about losing market share to smaller low cost airlines that are expanding in the Chicago market. The ongoing frustrations in effectively managing schedule demand at ORD highlights the challenges of trying to do so in an equitable fashion that does not impact competition in the market. Ironically, the use of slots at ORD was eliminated in 2002 under provisions in AIR-21 (P.L. 106-181). The current scenario at O'Hare suggests that some government intervention to control schedules at some of the nations busiest airports may be needed in the near future. Whether this means a return to slots or some other form of economic regulation is likely to be an issue of considerable interest to Congress.

Despite the ongoing challenges with scheduling at ORD, there are some examples that suggest that airlines may find some instances where spreading operations out could provide business advantages by reducing operating costs. For example, a recent analysis of American Airlines de-peaking efforts at three of its main hubs — Dallas-Fort Worth (DFW); Chicago-O'Hare (ORD); and Miami International (MIA) — indicates that spreading flights out over the day rather than clumping them can improve operational efficiency. In reworking its schedule at DFW, American reduced daily departures by almost 10% compared to 2000 levels, but lost only 1.1% of available seats.[67] This analysis indicates that by de-peaking operations, carriers may be able to increase productivity, make more efficient use of gates, and consolidate terminal operations. Thus, there appears to be a viable business case for de-peaking operations in certain instances. Consequently, airlines may be quite willing to adopt de-peaking strategies that could serve a mutual benefit to both airline operations as well as FAA air traffic operations.

In cases where there are no clear cut business advantages to de-peaking operations and where no equitable solutions can be attained by airline industry collaboration and bargaining over flight schedules, the federal government and airport operators may look to specific de-peaking incentives such as peak hour pricing as a means to manage schedule demand. Few in the airline industry are in favor of such a system. The Air Transport Association (ATA), a trade organization representing major U.S. airlines, opposes congestion pricing schemes because they argue that these mechanisms siphon off revenues from airlines and put the money in the hands of the airports which are natural monopolies and do not have to compete in the highly competitive and price sensitive airline industry.[68] Similarly regional airlines, and general aviation operators object to peak hour pricing because they

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[67] Steve Lott. "Redistributing hub flights saves time, dollars." *Aviation Daily*, June 16, 2004, p. 5.

[68] "Airport Slot Auctioning 'Simulation Games' Will Pinpoint Service Disruptions." *Aviation Today*, July 19, 2004.

believe that such pricing schemes would unfairly limit access to major airports to large carriers who can pass along increased landing fees to a larger consumer base. There is concern that peak hour pricing may further limit air service to small communities served by regional carriers who will essentially be priced out of major airports.[69] Airport operators may also look less favorably on peak hour pricing schemes over alternatives such as slots and quotas, because a peak hour pricing scheme is more complex to manage and may not result in meeting scheduling objectives to the extent that can be achieved by implementing slots and quotas.[70]

Slots and Quotas. Since economic deregulation of the airline industry in 1978, slots have been used at a few busy airports as a method to control airport scheduling. Under AIR-21, statutory language was enacted phasing out the use of slots largely over concerns that slots could preferentially advantage well established carriers and made it difficult for new entrant carriers to gain a foothold in certain desirable markets. Under these provisions, the only airport that will continue to have a statutorily defined slot system for regulating flight schedules after January 2007 is Washington Reagan National Airport (DCA). However, with the phase out of statutory slot systems, policymakers will likely face challenges in managing demand to avoid strains on capacity that could induce congestion and increased delay.

It has been reported that the FAA is mulling the idea of implementing "auctions" for slots at New York's LaGuardia (LGA) after the statutory slot authorizations expire in January 2007 and possibly at other congested airports like ORD.[71] Under such a scheme, airlines would either pay up front fees or monthly leases for slot rights to operate at a given airport. Whether the FAA would need statutory authority to carry out such a scheme remains debatable. The FAA retains the authority to limit flight operations on the basis of safety and could likely implement such a scheme so long as it does not treat any airline or operator preferentially in allocating slots. However, concerns over the potential that the allocation of slots could result in unintended market imbalances or may disadvantage service to small communities could prompt congressional oversight or possible legislative action on the issue of airport slot allocations.

The ATA opposes such a system largely on the belief that current exceptions and variances for slots — such as those that currently exist for new entrant carriers and for flights serving small communities — undermines the purported basis of these schemes for managing operational demand at busy airports and instead melds facets of market controls that directly affect airline business practices. On the other hand, the Airport Council International - North America, a trade organization representing large airport operators, favors slot auctions over other schemes such as congestion pricing, noting that allocating slots is administratively easier to implement, and results in regular, predictable schedules with fixed numbers of flights that can be tied directly to available airport capacity. In contrast, congestion pricing schemes can be

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[69] See CRS Report RS20914, *Aviation Congestion: Proposed Non-Air Traffic Control Remedies.*

[70] "Airport Slot Auctioning." *Aviation Today*, July 19, 2004.

[71] *Ibid.*

difficult to manage and may have little or no impact on congestion if it does not correctly predict market factors and demand for peak travel times that may fluctuate based on a variety of market factors.[72]

Any debate on the issue is likely to rise in significance in the next two years, because the slot restrictions at New York's LaGuardia (LGA) and Kennedy (JFK) airports are set to expire at the beginning of 2007, under the same provisions of AIR-21 that eliminated slots at ORD in 2002.

Funding Challenges

Status of the Airport and Airways Trust Fund

One concern over available funding for aviation infrastructure enhancements and expansion is the status of the airport and airways trust fund (AATF). The AATF has experienced a recent drawdown in fund balances coupled with reduced revenues caused primarily by a decline in aviation ticket tax revenues from FY2000 through FY2003. Both the declining balances and the loss of revenues are indicators of possible future shortages of funding to pay for capacity enhancement projects. **Figure 13** shows the annual income and uncommitted end of year balances in the aviation trust fund since 1998. A modest decline in trust fund revenue between 1999 and 2003 is coupled with a precipitous decline in uncommitted trust fund balances since 2002. The effects of the economic decline in the aviation industry since 2000 are reflected in this trend. From 1999 through 2003, the aviation trust fund experienced about a $1.3 billion dollar decrease in revenue, roughly a 12% decline in annual revenues. More notable is the continuing decline in aviation trust fund's uncommitted end-of-year balances which have declined 66% compared to 2001 levels despite recent trust fund revenue increases. The continuing trend of declining trust fund balances is an indicator that costs for modernization efforts are exceeding annual revenues and interest flowing into the trust fund. There is also concern that the increasing costs of day-to-day operations and the increased reliance on the trust fund for FAA's operational costs is creating a strain on the trust fund. This is of particular concern if a greater proportion of air traffic operations are expected to be funded directly by the trust fund as the current administration hopes to achieve as opposed to partial funding from the general fund as is currently the case. Allocations for FAA operations between the trust fund and the general fund may become a significant policy issue for future appropriations cycles and the next FAA reauthorization.

Trust fund financial projections through FY2005 indicate continued declines in trust fund balances. Along with these declining balances, updated projections of trust fund revenues through 2007 identify a potential revenue shortfall of almost $12 billion compared to pre-September 11, 2001, revenue projections (see **Table 3)**. This is despite an expected rebound in revenues starting in FY2004 tied largely to increases in airline ridership. However, even with increases in airline passenger volume, the shift toward low cost carriers and discounted airfares, could reduce the

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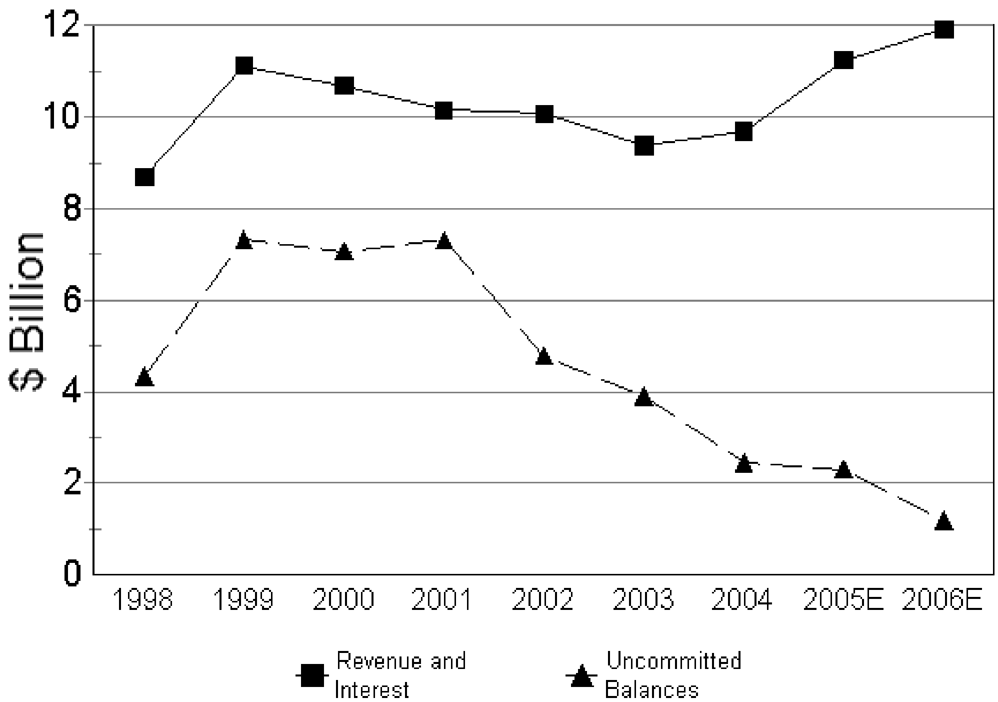
[72] *Ibid.*

trust fund income since a 7.5% tax levied on passenger tickets is the largest contributor to trust fund revenue. Consequently, revenue generated as a percentage of ticket cost may be lower than in the past despite increased passenger boardings. Further declines in tax revenue may occur as the result of increased reliance on point-to-point service. With more point-to point service, flyers may fly fewer trip segments thus lowering revenues generated by the per segment tax. In recent years, the passenger ticket tax and segment tax have comprised more than 60% of total aviation trust fund income. Thus, even with an anticipated recovery in the airline industry, trust fund income may still lag due to low-fare competition and increased point-to-point service. However, this effect could be offset by large growth in passenger boardings. If the growth in airline operations can outpace inflation over the next few years, it is likely that the trend of declining aviation trust fund balances could be reversed.

Figure 13. Income and Uncommitted End of Year Balances in the Airport and Airways Trust Fund



Source: Air Transport Association, Office of Economics. *Airport and Airways Trust Fund: Cash Flow and Balance: 1971 — Present.*

Table 3. Projected Aviation Trust Fund Revenues Before and After September 11, 2001

($ Billion)

	FY2003	FY2004	FY2005	FY2006	Total
April 2001 Estimate	12.9	13.7	14.5	15.4	56.5
February 2004 Estimate	9.3 *Actual*	10.4	11.1	11.7	42.5
Difference	-3.6	-3.3	-3.4	-3.7	-14.0

Source: Department of Transportation, Office of Inspector General, *Short and Long-term Efforts to Mitigate Flight Delays and Congestion.* Statement of the Honorable Kenneth M. Mead, Inspector General, U.S. Department of Transportation before the Committee on Commerce, Science, and Transportation, Subcommittee on Aviation, U.S. Senate. May 18, 2004.

While there is still over $2 billion in reserve in the aviation trust fund, the trend of declining trust fund balances and revenues may indicate potential shortfalls in the ability to fund future aviation infrastructure projects. The status of the trust fund is also impacted by the scope of outlays that it is used to support. Historically, trust fund outlays have been the sole funding source for aviation infrastructure improvements and enhancements to address capacity needs and safety requirements. However, many view the significant increase in use of the trust fund to pay for FAA's day-to-day operations over the past 15 years as a potential threat to the availability of funds for FAA's modernization efforts. Critics of using trust fund revenues for FAA's operations account argue that these activities should receive a greater percent of funding from the U.S. Treasury General Fund. However, others view the aviation system as a self-supporting entity whose program spending in all areas, including operations, should be met largely, if not entirely, by trust fund revenues. Therefore, one proposal to increase available funds for facilities and equipment upgrades and airport improvements is to increase the use of General Fund sources for FAA operations and perhaps even for capacity enhancement projects. Since many view aviation as a self-supporting system, like highway funding, all proposals to increase the General Fund share of aviation expenditures are likely to be controversial.[73]

Another option, albeit a highly controversial one, is to implement a fee-for-service schedule to pay for operational costs associated with running the national airspace system thus offsetting the strain that these operational costs impose on the aviation trust fund. Implementation of usage fees for air traffic services is one element of a concept of privatizing some or all air traffic service functions, although user fees are not unique to a privatized model of air traffic services and could be imposed in a government-run system as well. Usage fees for air traffic services levied on operators would ultimately be borne by operators and, in the case of

[73] For additional information, see the discussion of aviation trust fund issues in CRS Report 32498, *Vision 100: An Overview of the Century of Aviation Reauthorization Act (P.L. 108-176)*

airlines, passed along to passengers. Airlines note that with aviation taxes and fees already high, despite cost saving measures to trim operational expenses, they are unable to absorb additional tax burdens by further reducing operating costs.

The other difficulty with user fees is the cost and logistical challenge of implementing a fee-for-service operation and collecting user fees. Nonetheless, some claim that such an approach would create a more equitable system, arguing that the current aviation tax and fee structure results in imbalance in which airlines and their passengers pay more than their fair share while business jet operators in particular are able to use the system at only a small share of the associated costs.[74] General aviation lobbyists argue, to the contrary, that most general aviation users create little impact on the system and pay equitably through taxes levied on aviation fuels.[75] Further complicating the issue is the fact that air traffic services are safety-related, and as such, are in the interest of the general public. Therefore, some argue that some of the costs for these services should be borne by the general public as they currently are. This view has especially been highlighted in the aftermath of September 11, 2001 where air traffic services were seen as playing an important role in national security as well.

Another potential means to make additional funds available for aviation infrastructure is through increasing trust fund revenue, either by increasing aviation taxes destined for the trust fund or by increasing the tax base for the trust fund. Available options include raising the percent tariff on airfares; increasing fixed fees such as the per segment tax; or other aviation taxes. Aviation taxes are obviously a contentious issue, especially in the current economic climate of the aviation industry. The main source of trust fund revenue is the airline passenger ticket taxes, levied at 7.5% of the fare plus an additional inflation-adjusted fee charged per flight segment. Trust fund revenues are also derived from aviation fuel taxes, taxes on cargo shipments, and international arrival and departure taxes. Analysis by the ATA indicates that taxes and other government fees currently can make up more than 25% of the total cost of a typical $200 round-trip ticket.[76] By comparison, their analysis indicated that taxes and fees accounted for only 7% of the total ticket cost in 1972 and 15% of the cost in 1992. Therefore, the airline industry is understandably concerned that increasing revenue for the aviation trust fund by increasing taxes will further destabilize struggling airlines and makes this option extremely contentious. Implementing any of these options is likely to be unpopular with airlines and aviation consumers. As the ATA noted, "[t]axes and fees imposed on the industry, whether on airlines, airport or passengers, ultimately impact the industry's ability to meet consumer demand to grow and produce further economic expansion in all sectors of the economy."[77] Therefore, policymakers may consider alternatives to increasing taxes.

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[74] "Why should overtaxed fliers subsidize private planes?" Editorial. *USA Today,* April 14, 2004.

[75] Phil Boyer. "Current system works." Opinion. *USA Today,* April 14, 2004.

[76] Airline Transport Association. "Statement on the State of the Airline Industry." Airline Transport Association, Washington, DC.

[77] *Ibid.* p. 40.

An alternative strategy may be to lower taxes, either temporarily or permanently, to reduce the tax burden and stimulate growth in the industry. While lowering aviation taxes in an effort to increase the tax base is a possible option, many view this as a counter-intuitive approach that offers no guarantee that short-term tax revenue losses will be offset in the long-term from the increase in tax base attributable to the tax cut.

Another possible option is to reduce aviation trust fund outlays in other areas. For example, trust fund outlays for airport construction is apportioned using formulas based on the airport's level of commercial aviation activity under the FAA's airport improvement program (AIP). Capacity enhancements are funded through a variety of other sources including airport passenger facility charges (PFCs); other airport revenue from the leasing of commercial space and so on; state grants; and bonds. Outlays from the aviation trust fund could be reduced by altering AIP funding formulas thus increasing the reliance on these other funding sources for airport infrastructure improvements. However, this option may be unpopular because it may further limit the federal role in capacity enhancement projects. Also, large and medium sized airports, those most directly affected by capacity constraints, are not particularly reliant on AIP funds anyway. A study by the GAO found that AIP funds covered only 10.6% of development funding at 71 large and mid-sized airports, compared to 50.5% of development costs at other national system airports.[78] Another possible option could be to use general fund resources to pay for FAA research and development as opposed to relying on trust fund revenue for these activities. Advocates for such a proposal may argue that research and development activities have the potential to benefit all citizens, not just aviation systems users. However, even if policymakers were to agree and fund FAA research and development from the general fund, this would likely have little overall impact on the status of the trust fund because research and development currently accounts for about $130 million annually, slightly less than 1% of the total FAA budget.

Near-term projections indicate that aviation trust fund revenues will not keep pace with spending needs for air traffic operations and modernization efforts. Consequently, the FAA expects that it will have considerably less funding to finance new capabilities in its operating budget. Therefore, the FAA is prioritizing programs based on both anticipated capacity gains as well as cost efficiencies, and recognizes that it will need to discontinue low-priority programs.[79] Several elements of the FAA's facilities and equipment account, the funding source for airspace modernization technologies, have been the subject of this prioritizing and cost-cutting process.

FAA's Facilities and Equipment Account

One potentially contentious issue that reemerged in the FY2005 appropriations process and may be a topic of considerable scrutiny in future year budgets is funding

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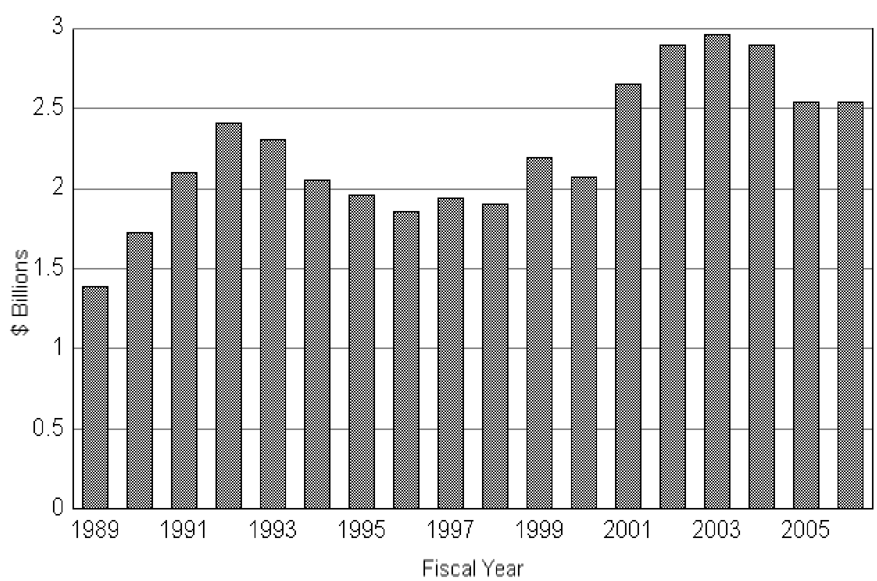
[78] U.S. General Accounting Office. *Airport Financing: Funding Sources for Airport Development.* GAO/RCED-98-71. March 12, 1998.

[79] Federal Aviation Administration. *National Airspace System Operational Evolution Plan 2004-2014.* Executive Summary - January 2004 (Version 6.0)

for FAA's Facilities and Equipment (F&E) account. This account pays for capacity enhancement projects related to air traffic control and navigation. As seen in **Figure 14**, the F&E account has grown over recent years, peaking at just under $3 billion in FY2003. **Figure 14** shows that F&E funding has historically followed a cyclical trend that appears to be on about a 10-year cycle. Such a trend is to be expected, given that technologies to modernize air traffic operations take time to mature and go through lengthy development and testing. Thus, surges in funding levels could be expected during periods when these technologies reach maturity and are deployed in large numbers and integrated into the national airspace system. The GAO noted in a 1994 report that F&E appropriations rose sharply between FY1982 and FY1985, then declined briefly in FY1986 and FY1987, before increasing sharply again at an inflation-adjusted rate of 11 percent annually, peaking in 1992.[80] This crescendo in funding during the late 1980s and early 1990s that peaked in 1992 can be tied to work conducted under FAA's advanced automation system (AAS), a costly and controversial program to modernize the FAA's en route and terminal radar control facilities that was to be completed during that time frame. The current peak in FY2003 can be tied to the maturation and rollout of two key programs: (1) the standard terminal automation replacement system (STARS) — a technology to upgrade the radar consoles in TRACON facilities; and (2) the commissioning of WAAS — a system to improve the accuracy of GPS navigation signals. Therefore, given the cyclical nature of F&E funding, lower funding requests for FY2005 and FY2006 might be expected.

Figure 14. FAA Facilities and Equipment Funding



Source: Appropriations Conference Reports; FAA Budget Estimates; and CRS Report RS20177, *Airport and Airway Trust Fund Issues in the 106th Congress.*

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[80] U.S. General Accounting Office. *FAA Budget: Management Attention Needed for Future Investment Decisions.* Statement of the Record by Allen Li, Before the Subcommittee on Transportation and Related Agencies, Committee on Appropriations, U.S. Senate, April 21, 1994. GAO-T-RCED-94-195.

However, the present decrease in F&E funding for FY2005 and FY2006 — about a 12% cut compared to FY2004 levels — is seen as somewhat controversial because significant work still needs to be done on communications, navigation, and air traffic control projects to keep pace with OEP targets for the next ten years. Furthermore, the FAA faces large funding needs if it is to: deploy next generation radar sites; equip ATC facilities with enhanced weather information systems; fully deploy STARS; and move forward with testing and implementation of free flight concepts over the next few years. The FAA has cut funding to several lower priority programs, particularly communications related programs like: NEXCOM — a program to provide digital voice and data channels and broaden available very high frequency (VHF) radio spectrum for air to ground communications; and controller-pilot data link communications (CPDLC) — a tool that will provide text messaging capabilities between pilots and controllers. The FAA argues that these cuts are reasonable because they are not running out of VHF spectrum as quickly as anticipated, and financially strapped airlines are not ready to make the necessary investment in CPDLC. One major question that may be raised by Congress is whether the FAA is effectively managing its F&E dollars, which it has not done a good job of in the past as discussed earlier in the section on cost overruns.

One option to enable future spending on facilities and equipment is to use airport improvement program (AIP) funds, rather than F&E funds, to pay for airport-specific facility acquisitions. This has both positive and negative implications for airports. On the positive side, it can help assure or expedite the acquisition of needed or wanted equipment to enhance capacity or improve safety at an airport. On the other hand, use of AIP funds for equipment purchases may take funds away from runway construction or other planned capital improvement projects. This may result in an increased reliance on local airport funds to keep projects on track. If local funds are unavailable or if schedules are allowed to slip for funding-related reasons, then capital improvements to meet capacity needs may lag behind growth in demand at specific airports. Also, as previously noted, with declining balances in the aviation trust fund, it may be difficult to meet additional program funding needs with federal dollars thereby increasing the cost burden on airports. Besides the cost implications to airports, this could also result in implementation of F&E programs based on local priorities which may not be the same as the federal priorities for enhancing the national airspace system as a whole.

Summary of Findings

This report has identified several factors affecting aviation growth and the ability to meet that growth by enhancing the capability and capacity of the national airspace system. Below is a summary of findings detailed in this report regarding aviation growth, capacity needs, and factors affecting the FAA's ability to address these capacity needs.

- Aviation capacity needs are geographically specific, affecting airports and airspace in several major metropolitan areas and certain high altitude flight corridors.

- Growth trends in aviation operations in major metropolitan regions will continue to strain capacity for the foreseeable future. Current FAA short-term plans for capacity growth will, generally, lag slightly behind forecast growth in demand in these capacity constrained regions.

- Despite an optimistic long-range vision to triple system capacity, fully implementing FAA's OEP will likely only yield about a 27% increase in capacity by 2013 as compared to available capacity during the summer of 2000. This projected capacity enhancement will barely keep pace with forecast growth. Also, delays will not be reduced at this level of capacity enhancement since FAA's forecast model assumes that the prevailing acceptable level of 14 minutes of average delay is maintained.

- Capacity constraints have an impact on system efficiency as measured by delay, as well as on system safety as indicated by metrics such as runway incursions and operational errors.

- Controller staffing shortages and high labor costs for air traffic services may become an impediment to meeting future capacity needs. The FAA currently does not have a strategic plan in place to hire and retain adequate numbers of controllers to replace an aging controller workforce. Under Vision 100 the FAA was directed to develop such a plan and language in FY2005 appropriations bills would provide funding to hire and train new controllers.

- Meeting future capacity needs will likely require a comprehensive systems approach using appropriate options that may include new runways and airport configurations; additional airports; airspace redesign; operational tools and decision aids; the use of technologies to increase system throughput; and market-based strategies to alter the demand characteristics of operations likely to cause congestion and delay.

- Airport improvement projects, such as adding runways or reconfiguring taxi routes, are seen as one of the most effective ways to alleviate airport-specific congestion and delay. However, these projects often take many years to plan, require buy-in from local authorities, and may involve lengthy environmental and economic impact assessment processes. Similarly, airspace redesign can be an effective tool for enhancing system capacity, but requires lengthy study and evaluation of operational and environmental impacts before implementation.

- Core technologies to improve system throughput, such as GPS and ADS-B, are generally mature, but significant work on complex systems integration is needed to effectively exploit these technologies in a manner that will optimize NAS capacity.

- Based on past FAA program management efforts that have resulted in cost overruns, schedule delays, and performance deficiencies in major systems acquisitions, systems integration programs to enhance the capacity of the national airspace system are regarded as high risk.

- Both the ATO and JPDO are too new to assess whether they will be effective in overcoming the organizational factors identified as impediments to effective management of NAS modernization efforts.

- A reduction in aviation trust fund revenues may cause the FAA to suspend work or scale back low priority programs in the near-term and search for ways to reduce unit costs for air traffic services by about 21%. In the long term, continued aviation trust fund revenue shortfalls — a possible result of low-cost airfares — could result in a lack of funds for critical capacity enhancement projects. However, growth in airline ridership could reverse this trend and provide needed funding.

- The long range next generation air transport system (NGATS) plan is likely to focus on automation and collaborative decision making tools for air traffic management (ATM) and expanded free flight concepts. While the plan is being designed to maximize flexibility for incorporating new, unforeseen technologies into the future airspace system, the plan may lack sufficient detail and focus to guide and monitor progress toward implementation of the NGATS.