Federal Aviation Administration

Capacity Needs in the National Airspace System

2007- 2025

An Analysis of Airports and Metropolitan Area Demand and Operational Capacity in the Future

May 2007

The MITRE Corporation
Center for Advanced Aviation System Development

HQ-009107.indd

U.S. Department
of Transportation
Federal Aviation Administration

Office of the Administrator

**800 Independence Ave., SW.
Washington, DC 20591**

May 2007

Thanks for your interest in America's airports.

Throughout these pages, we've got a good story to tell about the efforts to expand capacity at our most bustling facilities. Congestion is binding many of them. Come read what the FAA and airports around the country are doing to break that grip and keep the planes moving.

We've taken a frank look at where the capacity hot spots are going to be with this latest study, our first update to a situation we initially examined three years ago. I'm pleased to report that progress has been made since we issued the report in 2004. Since that time six new runways at the Nation's largest airports have opened. In fact, 14 new runways have opened since 2000.

This latest endeavor gives us even better insight into where those choke points are today, and where they're going to be tomorrow. With a better understanding, we can work with communities large and small to determine what the next steps are going to be.

Our data indicate that many existing airports will need to be expanded to meet future demand. The metropolitan areas that have traditionally driven aviation demand will continue to do so. Unfortunately, we have metropolitan areas on both coasts with critical capacity problems that are becoming more chronic. In the last 40 years, two new major commercial service airports have opened in the United States, Dallas-Fort Worth and Denver International. We may need to add as many as four more in the next 20 or 30 years. Atlanta, Chicago, Las Vegas and San Diego are among the likely candidates.

Is all of this construction boosting capacity? Absolutely. We now have hundreds of thousands of takeoffs and landings we didn't have just a few years ago. Is it going to be enough down the road? No. We've got to do more. This study confirms it.

While we have taken some airports off our watch list because of the strides they're making, there's still a significant number out there that are going to need more capacity in the years ahead.

Improvement plans must continue to move forward to avoid a repeat of 2006. That was a record year for delays, with more than 490,000 flights that didn't make it on time. Truth is, 2007 isn't looking any better.

In addition to building new runways and airports, we need to expand regional planning in key areas of our country and examine the role of congestion management measures in the few locations where expanding airport capacity is unlikely.

We've already got 18 of our biggest airports back to pre-9/11 levels. We're projecting that we'll add four more to the list – Baltimore, Detroit, Newark and Phoenix – in just the next couple of years.

With this report, we also looked at how some of the transformational concepts of the NextGen air traffic system might help alleviate congestion at the busiest 35 airports, and the news was very encouraging. Every single one of them experienced a drop in delays. The anticipated benefits of NextGen are critically important as efficiency enhancements for airports with planned runway improvements and even more so for airports in the National Airspace System where geographic and other constraints prevent physical expansion of the airfield. In addition, NextGen is critical to handling traffic volume and ensuring smooth, high capacity aircraft flows between airports. It also enhances our ability to meet our capacity requirements in ways that cause less harm to the environment and less disturbance to our neighbors – so the expansion of the airspace is beneficial to everyone.

I invite you to keep reading what we have in store to relieve airport congestion. Local communities and the FAA will continue to stay hard at it. This study will keep us one step ahead of the curve, and let me assure you, remain there.

Marion C. Blakey
Administrator

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INTRODUCTION

In 2003, the Federal Aviation Administration (FAA) convened a team to begin the Future Airport Capacity Task (FACT). The team was led by the FAA's Airports organization (ARP) and included representatives from the Air Traffic Organization (ATO) and the MITRE Corporation's Center for Advanced Aviation System Development (CAASD). FACT is an assessment of the future capacity of the Nation's airports and metropolitan areas. Its goal is to determine which airports and metropolitan areas have the greatest need for additional capacity. By embarking on this initiative, the FAA wanted to assure that the long-term capacity of the U.S. aviation system matched forecasts of demand.

This document is the first update to the original study, *Capacity Needs in the National Airspace System, An Analysis of Airport and Metropolitan Area Demand and Operational Capacity in the Future* (FACT 1), published in 2004. This update is called FACT 2. In response to comments received about the original study, the FACT 2 report provides more transparency in the methodology and analysis. It includes updated data, revised timeframes, and refined analytical methods. Further, specific results and assumptions were shared with those airports identified from the analysis to gather additional input that might impact the findings.

Both FACT studies began with an analysis of 291 commercial service airports (the 35 airports, primarily the Nation's large hubs, contained in the *Operational Evolution Plan* (OEP)[1], and an additional 256 commercial service airports) as well as 223 metropolitan areas across the county. Based on this initial analysis, the team identified 56 airports for more detailed study (the 35 OEP airports and 21 non-OEP airports). The non-OEP airports were identified using conservative assumptions about fleet mix and airport operations to estimate potential capacity constraints at the individual airport or within a metropolitan area. The same 56 airports were analyzed in both FACT studies. Appendix A provides a list of these airports. The study also identified multiple metropolitan areas, described in Appendix B, which may also face potential capacity constraints.

Traffic in the National Airspace System (NAS) was modeled using projections of future enplanements and operations from two different sources: the FAA's Terminal Area Forecast (TAF) and CAASD's experimental model of origin and destination traffic. The TAF assesses traffic on an airport-by-airport basis based on the economic and demographic characteristics of the airport metropolitan area.

CAASD's model also assesses traffic based on economic and demographic trends. Unlike the TAF, however, the CAASD model produces forecasts of traffic for individual pairs of origin and destination metropolitan areas. Socio-economic trend information, including changes in demographics, income, market power, and other factors, were considered as part of this analysis. Passenger demand was estimated as originating in, or traveling to, a metropolitan area rather than just a specific airport. This passenger demand was then translated into airport operations through a route selection process (direct or via a third airport) and by determining the correct aircraft

[1] The OEP is now known as the *Operational Evolution Partnership*—the FAA's plan for implementing the Next Generation Air Transportation System (NextGen) vision cast by the multi-agency Joint Planning and Development Office. OEP is an expansion of the existing *Operational Evolution Plan*—the agency's chief capacity-enhancement document since 2001—and has become the agency's "one plan" for providing continuity between what is and what is to come. This plan is specifically for FAA and the capabilities the agency is responsible for contributing to NextGen. The OEP already has cross-agency and community support and has a proven monitoring process in place. The new OEP will harmonize existing FAA plans and concepts and will provide a tangible foundation against which the agency and our partners can chart the future.

fleet necessary to handle the passenger traffic. This additional estimate of future traffic levels was then utilized as part of the demand/capacity analysis (see Appendix D for a detailed explanation of the methodology used in this analysis).

The FACT 2 analysis identified a significant number of U.S. airports that can be expected to require additional capacity in the future if demand reaches forecast levels. This finding not only highlights the importance of moving forward with current improvement plans, and keeping such plans on schedule, but seeking new solutions to add even more capacity than is currently planned.

WHAT HAS CHANGED SINCE FACT 1?

The FAA has undertaken an update to the FACT 1 analysis in order to identify airports that may have capacity needs in the future, even after accounting for their enhancement plans. The update includes new forecasts, enhanced capacity plans, improved criteria and a modified methodology. In addition, the FAA tracks the performance of the NAS, analyzes current trends, estimates future performance, identifies airports and airspace where performance enhancements may be necessary, and works with the local communities to address their current and future capacity and enhancement needs.

Through these efforts and together with the detailed modeling, a set of airports and metropolitan areas needing improvements, both now and in the future, were identified. By completing an analysis, such as FACT 2, the FAA has the broadest understanding of future airport capacity needs in the coming years.

This section identifies several changes made to the FACT process since the publication of the original FACT report.

Next Generation Air Transportation System (NextGen)

The FACT 1 analysis revealed that many of our hub airports and their associated metropolitan areas could be expected to experience capacity constraints (i.e. unacceptable levels of delay) by 2013 and 2020, even if the planned improvements envisioned at that time were completed. The underlying message was that additional efforts beyond those already identified would be needed to increase the capacity of our National Airspace System (NAS). A similar message was included in the FAA's 2003 Reauthorization Plan and resulted in the formation of the Joint Planning and Development Office (JPDO). Congress charged the JPDO with creating and carrying out an integrated plan for NextGen. *A key objective of FACT 2 is to begin to study the benefits of some initial NextGen concepts and how they might provide additional airport capacity, and thereby reduce delays, through enhanced air traffic control (ATC) techniques and technologies.*

A meeting was held in July 2006 between FACT team members and JPDO personnel to identify a few initial NextGen concepts that could be modeled in the FACT analysis. Some of these measures included a revision of separation standards, independent operations on parallel runways spaced more closely than possible today, reduction of in-trail wake vortex separation requirements and use of equivalent visual techniques. NextGen is a broad set of concepts and investments that address every aspect of the NAS, therefore the JPDO analyses of NextGen impacts result in a wide range of benefits that extend beyond the impact of runway improvements.

The FACT 2 study examines a limited set of NextGen concepts that focus on capacity improvements for airborne operations in the airport vicinity; it did not include

NextGen concepts for en route or oceanic operations, or changes to operations on the airport surface. Initial benefits of the airport capacity concepts are presented in this document. Even greater benefits beyond what was modeled in the study would be expected once full NextGen concepts are analyzed.

Stakeholder Feedback

Another key objective of this update is to apply important feedback received from industry stakeholders about the FACT 1 study. An Industry Stakeholder Roundtable meeting was held in September 2005 to explain the FACT methodology and criteria, discuss changes in the aviation industry since the release of the first study, and solicit feedback on what could be done differently in the FACT 2 analysis. The industry panel, which included representatives from aviation associations, consultants, and local airport operators, found the FACT methodology was sound and the report shows promise as a tool for strategic planning at both the national and local levels. Suggestions for improvements included providing more detail about the analytical results, incorporating more specific local airport usage and fleet mix data for the non-OEP airports, and using the same methodology and criteria for all studied airports (OEP and non-OEP).

The FACT 2 team gathered operational data for the airports through surveys to local air traffic controllers and regional FAA personnel and, in some instances, conversations with airport operators. Much of this data was used to further define airfield capacities, particularly at the non-OEP airports. Based on the feedback received from industry stakeholders, as well as the new data and input from the JPDO, the FACT methodology and criteria were revised accordingly.

New Runways and Extensions

Since the first FACT report was published, six new runways have opened at ATL, BOS, CVG, LAX, MSP, and STL[2]. At other airports, key runway projects have been approved and are scheduled to open by 2010, including new runways or extensions at CLT, IAD, LAX, ORD, PHL, and SEA. For example, Runway 17/35 at PHL is being extended, an end-around taxiway was completed at ATL, and another is under construction at DFW. Most significantly, the O'Hare Modernization Program (OMP), a complete reconfiguration of the runways at ORD, has been approved and construction has begun. Runway improvements have been proposed at other airports, as well, and numerous site-specific studies are underway.

Updated Forecast Data

The FACT analysis uses two different forecasts of future traffic levels: the FAA's Terminal Area Forecast (TAF)[3] and CAASD's Future Air Traffic Estimator[4] (FATE) forecast. The original FACT study was based on the TAF released in 2003; the FACT 2 study used the TAF released in March 2006. As the economy and the aviation industry have recovered from the decline following September 11, 2001, patterns of airport activity have changed. Thus, the two TAF forecasts show different traffic levels and patterns. Similarly, the FATE forecast was updated and refined since the first FACT report to reflect these and other changes.

[2] This report identifies airports with their three-letter FAA location identifiers. For a complete list, see Appendix A.
[3] The FAA updates the TAF every year.
[4] Bhadra, D. et.al., "Future Air Traffic Timetable Estimator", *Journal of Aircraft,* Volume 42, Number 2, pp.320-328, March-April 2005. The name of the model has been changed to reflect improvements since the first FACT study was conducted.

Revised Timeframes and Expected Improvements

The FACT estimates of future capacity needs incorporate the best available information about planned improvements to the air traffic management (ATM) system, as well as runway and airport improvements. FACT 2 is consistent with OEP, version 8.0 (OEP v8.0),[5] which was released in May 2006 and extends to the year 2015.

Planning for the time period beyond the end of the OEP has also progressed since the release of the first FACT study. In recent years, the JPDO has brought together the FAA, NASA, the Department of Defense, other government organizations, and members of the aviation community to develop operational concepts. To harmonize with the time horizons of the OEP and NextGen, the mid- and long-term planning periods for FACT 2 have been aligned to 2015 and 2025, respectively.

Planned Improvements

The FACT 2 analysis includes planned improvements affecting runway capacity for two future planning periods, 2015 and 2025. The planned improvements include the following (Appendix C contains a list of planned improvements by airport modeled in this analysis):

- **New or Extended Runways.** New or extended runways were included as planned improvements. The OEP v8.0 and airport-specific planning documents were used to incorporate the runway improvements in either the 2015 or 2025 planning period.

- **New or Revised ATC Procedures.** If a new or revised ATC procedure was listed in the OEP v8.0 or defined by the FACT 2 analysis as consistent with a NextGen concept, it was modeled as an improvement in this study. However, the modeled improvements that were consistent with NextGen concepts were applied only to the 35 OEP airports plus one non-OEP airport[6] and then only in the 2025 planning scenario. This decision was made in conjunction with the JPDO because the NextGen concepts are still in the early planning stages. As the NextGen concepts are further developed, it is reasonable to assume the ATC benefits will be realized throughout most of the NAS.

- **Airspace Redesign.** Improvements derived from the redesign of the airspace surrounding an airport were included in the 2015 or 2025 scenario based on the best information available. The redesign itself was not performed as part of this analysis.

- **Other Assumptions.** The FACT 2 analysis assumed existing environmental restrictions that impact runway capacity, such as noise abatement procedures, would continue through the FACT planning periods. Planned taxiway, terminal, or ground access improvements were not included in this analysis because they were outside the scope of the models used.

Additional Data and Refined Methodology

The FACT 2 study includes additional airport data, especially for the non-OEP airports, and refined analytical methods. The first FACT study focused on detailed analysis of the 35 OEP airports and a less detailed analysis for the other 256 airports

[5] The first FACT study referenced OEP, version 5.0

[6] Because OAK already had known capacity constraints, new or revised ATC procedures were applied at that location as well.

analyzed. Because of limited availability of data for non-OEP airports at the time, conservative assumptions were used to estimate the capacity of the 256 non-OEP airports. Based on these conservative assumptions, 21 non-OEP airports were identified in FACT 1 as having the potential to be either capacity constrained or were within a known capacity constrained metropolitan area. This updated study includes Annual Service Volumes (ASVs) and detailed benchmark-type capacities for the same 21 non-OEP airports identified in FACT 1. These analyses revealed, in many cases, that the non-OEP airports made more effective use of their runways than had originally been assumed, had plans for runway construction that had not been factored into the original analysis, or had different ATC procedures than those previously used. *As a result, this updated study shows that some of the non-OEP airports have higher capacities than originally presumed and thus less need for additional capacity.*

By using the same approach for calculating ASVs and benchmark capacities at the 56 airports, all the airports could be evaluated with the same criteria. Previously, criteria for the non-OEP airports were less stringent, and so more of these airports were judged to be capacity constrained in the future. The methodology and criteria used in the original study has since been refined and, in the FACT 2 analysis, the following metrics were applied to all 56 airports:

- **ASV Ratio:** the ratio of future demand to the Annual Service Volume for the airport, where the ASV is based on a 7-minute average delay per operation (arrival and departure)
- **Scheduled Arrival Delay:** the average delay per arrival operation at the airport as calculated by a simulation of daily traffic across the NAS
- **Arrival Queue Delay:** the average delay while waiting to land after arriving at an airport
- **Departure Queue Delay:** the average delay while waiting to depart, caused by factors at the departure airport
- **Local Delay:** The proportion of the delay that is due to local factors (as opposed to propagation from other airports)

To apply the above metrics uniformly to all 56 airports, assumptions were made about airport operations and individual facilities, common to a system-wide modeling process. To better understand the initial results, the team conducted a validation phase. The purpose of the validation was to ensure the operational data was accurate and the assumptions made were reasonable and consistent with observed current conditions. This additional step allowed the FACT team to incorporate additional information into the FACT analysis. Appendix D explains these and additional criteria in more detail.

COORDINATION WITH AFFECTED AIRPORTS

In February and March 2007, the FACT 2 analysis was coordinated with each of the airports identified as needing additional capacity in the future and with airports that were identified in FACT 1 but not FACT 2, some 24 airports in total. Each airport sponsor was provided the assumptions used in the analysis as well as the preliminary results for each facility. In most cases, the airport sponsor agreed with the FACT 2 assumptions. Others thought the analysis might have under- or overestimated the airfield capacity based on changes to operating procedures or reduced constraints. In

such cases, further investigation was performed and adjustments were made as appropriate.

Although each airport coordination meeting was different, there were a few important issues raised by a number of the airport sponsors.

- **An airport's runways are not necessarily the limiting capacity factor.** Often, taxiways and terminal gates can limit the annual number of operations more than runway capacity by itself. However, the present analysis did not consider potential limitations imposed by the taxiway or terminal infrastructure.

- **Airspace limitations also impact capacity.** The ability of the airspace around many of the airports to accommodate more arrivals and departures may be limited, especially where there are several major airports in the same area (Southern California, Northern California, Chicago, New York, Philadelphia, and Southern Florida). Enroute airspace congestion may also impose departure delays. In other cases, operational flexibility may be affected by nearby military airspace or environmentally sensitive areas.

FINDINGS OF THE FACT 2 STUDY

Although the FACT 1 and FACT 2 findings were consistent in many important ways, they were not identical. For instance, because of a decline in the number of small and medium hub airports expected to face capacity issues once planned improvements are implemented, the FACT 2 analysis found the total number of airports and metropolitan areas needing additional capacity beyond what is currently planned was lower than reported in FACT 1. The FACT 2 analysis also identified a greater number of large hub airports that will need additional capacity beyond what is currently planned. Not surprisingly, FACT 2 also found that many of our country's largest and fastest growing metropolitan areas will need to boost capacity.

Some of the differences between FACT 1 and FACT 2 were the direct and very positive result of implemented or planned capacity improvements at all sizes of airports studied, such as the construction or extension of runways and enhanced air traffic control procedures. Other variances reflected changes in traffic forecasts, improved methodology, and a better understanding of operations at several affected airports.

Recognizing that this study focuses on airfield capacity, new runways typically provide the greatest capacity enhancement in the airport environment, and more will be needed to manage delays throughout the NAS. Some communities, however, are constrained from building runways or implementing other airfield projects to enhance capacity. In such cases, NextGen, which includes various technology advancements planned to transform how we move people and goods, will be required to provide solutions for additional capacity. The initial NextGen concepts modeled in this study for the 2025 scenario show a reduction in certain delays throughout the NAS (see "Capacity Needs in 2025" below). Air traffic management improvements, such as those initially defined by the OEP and JPDO (e.g. reduced runway spacing), will help reduce delays. However, research on these air traffic management improvements, such as reduced separation between aircraft or closer runway spacing at airports, is still required to determine their characteristics and feasibility.

Because of time and resource limitations, and because it was necessary to use a common set of criteria for each airport studied, it was not possible to model all

aspects of an operation at each individual airport. For example, some airports may have taxiway limitations that cause significant operational restrictions on the surface. Others may have many different runway configurations used throughout the year. However, the FACT 2 analysis did not consider surface constraints, and the system-wide modeling was limited to the three most common runway configurations (as determined by select weather conditions). In both cases, the performance of an individual airport may not be fully represented, and some future problems may not be captured or identified. Although a study such as FACT 2 is good at identifying likely areas where improvements are necessary, the limitations discussed above do influence the overall results.

The FACT 2 analysis should be considered in combination with studies being prepared for specific airports. These studies are focused specifically at the airports of interest and may be more detailed and take into consideration additional constraints not accounted for in the FACT 2 report. Furthermore, inclusion of a project for which there is an ongoing EIS should not be construed as pre-determination of approval by the FAA, but rather as a “what-if” assessment of potential benefit. Environmental restrictions, where they presently exist, were assumed to continue unchanged.

When interpreting the results of this report and comparing them to the findings of FACT 1 or site-specific studies, it is important to keep the purpose of the FACT process and the changes made since FACT 1 in mind. FACT is a system-wide analysis. It is intended to provide the FAA with data about the timing and need for infrastructure improvements at the national level for agency planning purposes. The FACT analysis cannot replace site-specific studies that might examine capacity issues in much greater detail and are thus more accurate reflections of the situation at a particular location or within a specific regional system.

Capacity Needs in 2007

The FACT 2 analysis identified four airports and one metropolitan area[7] that currently need additional capacity. These airports and metropolitan area are shown on Figure 1 and listed in Table 1.

Figure 1 Airports and Metropolitan Areas Needing Capacity 2007

The FACT 2 study identified the New York Metropolitan Area as well as EWR and LGA as needing additional capacity in 2007. Both airports have experienced high delays for a considerable length of time. The redesign of the airspace should help, but will not provide a long-term solution as demonstrated by the 2015 and 2025 analyses. Additional capacity within the New York Metropolitan Area is needed.

Although ORD is shown as needing additional capacity in 2007, the completion of the O'Hare Modernization Program will reduce delays to the point that the airport will not be capacity constrained in the future. The Chicago Metropolitan Area was not identified as needing additional capacity in 2007 due to the capacity provided by other local airports[8].

Table 1 provides a comparison of the 2003 (FACT 1) and 2007 (FACT 2) study results. The comparison shows several airports and metropolitan areas that continue to have capacity problems, as well as those airports that would not be constrained if the planned improvements are implemented (this comparison is shown graphically in Appendix E).

[7] The FACT 2 study assessed the combined capacity of the airports within a metropolitan area that currently accommodates at least 5 percent of the local Origin and Destination (O&D) traffic, or 500,000 annual passengers (see metropolitan area methodology in Appendix D).

[8] The Chicago Metropolitan Area includes GYY, MDW, MKE, ORD, and RFD to be consistent with the EIS metropolitan definition used for the OMP.

Table 1
Comparison to FACT 1 Results for 2003

● Continues to need additional capacity based on the results of both studies

⊕ Identified with the new FACT 2 criteria

⊗ No longer identified as needing additional capacity

Airports Needing Additional Capacity	2003 (FACT 1)	2007 (FACT 2)
⊕ Fort Lauderdale-Hollywood International (FLL)		✓
⊗ Hartsfield-Jackson Atlanta International (ATL)	✓	
● LaGuardia (LGA)	✓	✓
● Newark Liberty International (EWR)	✓	✓
● O'Hare International (ORD)	✓	✓
⊗ Philadelphia International (PHL)	✓	
Total	**5**	**4**

Metropolitan Areas Needing Additional Capacity	2003 (FACT 1)	2007 (FACT 2)
⊗ Atlanta	✓	
⊕ New York		✓
Total	**1**	**1**

Three airports were identified in the 2003 (FACT 1) and 2007 (FACT 2) studies as being capacity constrained (●). Both LGA and EWR experience significant delays and will continue to do so until additional capacity is added. However, geographic and airspace constraints will make this difficult. ORD was also identified in both studies. However, the O'Hare Modernization Program is underway and new runways are expected to open within the next few years.

Two airports were identified in FACT 1 that are not listed in the FACT 2 study (⊗). ATL recently opened a new runway adding additional capacity. PHL was not identified as capacity constrained in the 2007, yet the airport experienced significant levels of delay in the latter half of 2006. Some of the delays at PHL were due to airspace congestion and operational issues that were not captured by the FACT analysis.

Capacity Needs in 2015

The capacity needs in the 2015 mid-term planning period were estimated in two ways: (1) assuming the planned ATC and runway improvements are completed by 2015 and (2) assuming continued demand growth but no new capacity improvements to the existing system. By comparing the two scenarios, it is possible to identify where additional capacity will be needed in the future, what effect the improvements that are currently underway or in the planning process will have on future capacity needs, and where new planning efforts will be needed to provide even greater capacity beyond what is currently in the construction or planning process. The results are shown on Figure 2 and Figure 3 and listed in Table 2. The results are also compared to the FACT 1 results in Table 3.

The planned improvements for 2015 included new or extended runways, new or revised ATC procedures, airspace redesign, and improved ATC technology. ATC procedures and technology are consistent with OEP v8.0. Likewise, runway improvements at the 35 OEP airports were considered if they appeared in the OEP. Other runway improvements were considered if the available information indicated they were likely to be completed by 2015 (Appendix C contains a listing of the detailed improvements modeled in 2015).

Figure 2 Airports and Metropolitan Areas Needing Additional Capacity in 2015 after Planned Improvements

6 airports that need additional capacity in 2015

4 metro areas that need additional capacity in 2015

By adding the additional capacity gained from the planned improvements expected by 2015 to the 2007 capacity and measuring this against the forecast demand for 2015, the FACT 2 analysis identified six airports and four metropolitan areas that will need additional capacity beyond what is already planned (See Table 2).

Figure 3 Airports and Metropolitan Areas Needing Additional Capacity in 2015 if Planned Improvements Do Not Occur

18 airports that need additional capacity in 2015

7 metro areas that need additional capacity in 2015

Measuring the 2007 capacity against the forecast demand for the 2015 mid-term planning period reveals that 18 airports and seven metropolitan areas will need additional capacity if the existing airfield configurations remain constant without any capacity enhancements (see Table 2).

Table 2 Airports and Metropolitan Areas Needing Additional Capacity in 2015 after and without Planned Improvements

Airports Needing Additional Capacity	After Planned Improvements	Without Planned Improvements
Charlotte Douglas International (CLT)		♦
Fort Lauderdale-Hollywood Int'l (FLL)		♦
George Bush Intercontinental (IAH)		♦
John F. Kennedy International (JFK)		♦
John Wayne-Orange County (SNA)	♦	♦
LaGuardia (LGA)	♦	♦
Long Beach-Daugherty Field (LGB)	♦	♦
McCarran International (LAS)		♦
Metropolitan Oakland International (OAK)	♦	♦
Midway Airport (MDW)		♦
Newark Liberty International (EWR)	♦	♦
O'Hare International (ORD)		♦
Palm Beach International (PBI)		♦
Philadelphia International (PHL)	♦	♦
Phoenix Sky Harbor International (PHX)		♦
T.F. Green (PVD)		♦
Tucson International (TUS)		♦
William P. Hobby (HOU)		♦
Total	**6**	**18**

Metropolitan Areas Needing Additional Capacity	After Planned Improvements	Without Planned Improvements
Charlotte		♦
Chicago		♦
Las Vegas		♦
Los Angeles	♦	♦
New York	♦	♦
Philadelphia	♦	♦
San Francisco	♦	♦
Total	**4**	**7**

Needed Capacity beyond what is Currently Planned for 2015

By adding the additional capacity gained from the planned improvements expected by 2015 to the 2007 capacity and measuring this against the forecast demand for 2015, the FACT 2 analysis identified six airports and four metropolitan areas that will need additional capacity beyond what is already planned (see Figure 2 and Table 2)[9].

- EWR and LGA: The Port Authority of New York and New Jersey is planning to assume operation of Stewart International Airport (SWF), about 55 miles north of New York City, to expand air service to the New York Metropolitan Area. It is too early to determine whether this will result in a sufficient reduction in delays to avoid the need for additional capacity enhancements within the New York Metropolitan Area. It is likely, however, that additional capacity enhancements will still be needed at both airports.

- PHL: An EIS for the complete reconfiguration of its airfield is currently being prepared. However, because the final alternative for this extensive project has not been identified, new capacity information was not available for this study. Therefore, the proposed airfield reconfiguration was not included in the 2015 analysis.

- OAK: Geographic, terrain, and airspace issues continue to constrain airports like OAK. These issues limit the airport's ability to add additional runway capacity. A regional solution in conjunction with other airports in the Bay Area may be needed.

- LGB and SNA: Both airports have operational and noise restrictions that limit the number of operations at each facility. If these restrictions remain in place, the operational levels forecasted for these airports in 2015 will likely not be reached. Thus, the actual future delays will likely be less than the criteria established for this analysis. However, this may mean that significant demand will go unsatisfied.

- Based on the six airports identified in the 2015 mid-term planning period, the metropolitan areas surrounding these airports were assessed. The analysis found that four metropolitan areas did not have sufficient capacity to meet the anticipated demand in 2015: Los Angeles, New York, Philadelphia, and San Francisco.

Table 3 provides a comparison of the 2013 (FACT 1) and 2015 (FACT 2) study results. The comparison shows several airports and metropolitan areas that continue to have capacity problems even with changing forecasts and modified evaluation criteria, as well as those airports that would not be constrained if the planned improvements are implemented (this comparison is shown graphically in Appendix E).

[9] Capacity and delay estimates are specific to the planning years identified (i.e. 2007, 2015, and 2025). Intermediate years were not analyzed.

Table 3
Comparison to FACT 1 Results for 2013 after Planned Improvements

● Continues to need additional capacity based on the results of both studies

⊕ Identified with the new FACT 2 criteria

⊗ No longer identified as needing additional capacity

Airports Needing Additional Capacity	2013 (FACT 1)	2015 (FACT 2)
⊗ Albuquerque International Sunport (ABQ)	✓	
⊗ Bob Hope (BUR)	✓	
⊗ Fort Lauderdale-Hollywood International (FLL)	✓	
⊗ John F. Kennedy International (JFK)	✓	
● John Wayne-Orange County (SNA)	✓	✓
● LaGuardia (LGA)	✓	✓
● Long Beach-Daugherty Field (LGB)	✓	✓
● Metropolitan Oakland International (OAK)	✓	✓
● Newark Liberty International (EWR)	✓	✓
⊗ O'Hare International (ORD)	✓	
⊗ Palm Beach International (PBI)	✓	
● Philadelphia International (PHL)	✓	✓
⊗ San Antonio International (SAT)	✓	
⊗ Tucson International (TUS)	✓	
⊗ William P. Hobby (HOU)	✓	
Total	**15**	**6**

Metropolitan Areas Needing Additional Capacity	2013 (FACT 1)	2015 (FACT 2)
⊗ Austin-San Antonio	✓	
⊗ Chicago	✓	
● Los Angeles	✓	✓
● New York	✓	✓
⊕ Philadelphia		✓
● San Francisco	✓	✓
⊗ South Florida	✓	
⊗ Tucson	✓	
Total	**7**	**4**

Six airports were identified in both 2013 and 2015 (●). Not surprisingly, these are located within high-traffic areas in the Northeast and west coast areas. While it is clear that additional capacity is needed in these areas, existing geography, terrain, and airspace constraints may make potential solutions difficult to implement.

Some of the airports that were listed in FACT 1 but are not listed in FACT 2 (⊗) have initiated plans to enhance capacity and improve airfield operations since FACT 1. If implemented, these plans will reduce the number of capacity constrained airports.

Airports and Metropolitan Areas Adding Capacity by 2015

A comparison of the airports needing additional capacity with and without planned improvements in 2015 reveals that 12 airports come off the list of capacity constrained airports if the planned improvements are completed; the planned improvements for each airport are as follows:

- The redesign of the terminal airspace in the New York and Chicago areas will reduce current operational constraints at JFK and MDW resulting in additional airfield capacity.
- Improved threshold delivery accuracy (i.e. RNAV arrival routes) will enhance the arrival capacity at LAS.
- New runways will improve airfield capacity at ORD and CLT.

- Various airfield improvements planned for FLL, HOU, IAH, PBI, PVD, SAT, and TUS will improve airport capacity. Site-specific studies are underway to evaluate these improvements.

Capacity Needs in 2025

The capacity needs in the 2025 long-term planning period were estimated assuming (1) that the planned improvements will be completed by 2025; and (2) the demand will continue to grow with no capacity improvements added to the existing system. The planned improvements for 2025 included new or extended runways, new or revised ATC procedures, airspace redesign, and improved ATC technology. ATC procedures and technology are consistent with the assumed NextGen concepts (Appendix C contains a listing of the detailed improvements modeled in 2025).

A key difference between the 2015 analysis and the 2025 analysis is the addition of NextGen improvements and how these improvements might reduce delay at the studied airports.

Benefits of NextGen

NextGen refers to an initiative started in 2003 to transform the U.S. air transportation system by 2025. In contrast to today's system, NextGen will be more flexible, resilient, scalable, and adaptive as well as highly automated. Aircraft will be able to use information technology in a more robust way, with enhanced capabilities in the cockpit, better navigation and landing capabilities, and far more comprehensive and accurate knowledge of weather and traffic conditions.

The JPDO identified eight "key capabilities" that will play a major role in the future air system:

- Network Enabled Information Access
- Performance Based Services
- Weather Assimilated Into Decision Making
- Layered, Adaptive Security
- Broad Area Precision Navigation
- Airport Trajectory-Based Operations
- Equivalent Visual Operations
- Super Density Operations

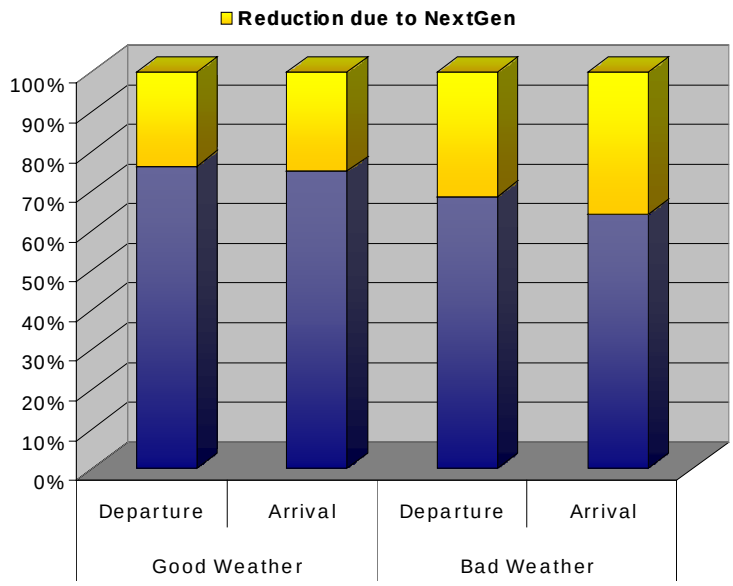
The improvements that were modeled in FACT 2 were based on the concepts for Equivalent Visual Operations and Super Density Operations, thus the modeled improvements represent a subset of the overall NextGen concept that deal with capacity. These procedural improvements might be enabled by other key capabilities, such as Precision Navigation or Performance Based Services, but many of the important features of NextGen were not directly addressed by this analysis. FACT 2 therefore should not be viewed as a comprehensive analysis of all the NextGen improvements. As NextGen concepts are still being developed, actual operations in 2025 may be different from those analyzed. Some improvements may be added, others removed, and still others modified or changed in some way. As the NextGen assumptions are refined over the years, this analysis can be updated to account for the most recent plans at that time.

In the 2025 scenario, ATC enhancements consistent with NextGen were modeled at all 35 OEP airports plus OAK. For this study, it was assumed the NextGen technologies and procedures would first be implemented at the busiest or most

delayed airports[10]. Runway improvements expected at all the airports were also modeled. Nevertheless, these NextGen concepts produced quantifiable delay reductions at nearly all 56 airports included in this study, either directly or by reducing delays at the airport that flights are going to or coming from.

Two scenarios were used to estimate the benefits of NextGen within the limited parameters of this analysis: arrival and departure queue delay and schedule arrival delay. Queue delay was estimated by first modeling the 56 airports with the 2015 ATC improvements plus all new runways expected to be opened by 2025. Then the same scenario was modeled again, but with NextGen concepts for the terminal area and airport ATC procedures. This subset of the overall NextGen concept had a significant effect on airport delays. Looking at the arrival and departure queue delay in the simulation (the delay incurred waiting to land or take off at the airport), the addition of the NextGen improvements reduced the total minutes of queue delay at the 56 airports by 25 to 35 percent (see Figure 4).

Figure 4 Total Queue Delay at the 56 Airports with and without NextGen Improvements (2025)



Although only a subset of the NextGen capacity improvements were analyzed in FACT 2, the benefits they provide are nonetheless significant. These benefits are important efficiency improvements for airports with planned runway improvements as well as for airports where geographic and other constraints prevent physical expansion of the airfield.

Building on these initial findings, the JPDO will continue to analyze the benefit potential for the complete set of NextGen solutions and integrate these results with the FACT analysis as the NextGen plans mature. The JPDO anticipates that NextGen will provide significant improvements in capacity system-wide, allowing for significant efficiency improvements at runways, and better system-wide flow management that may result in fewer airports requiring additional runway capacity in the 2025 timeframe. Likewise, improvements that will improve weather prediction and system response to weather events will translate to improvements in the reliability of airport capacity.

The FACT 2 results for the 2025 planning period, with and without the planned improvements follow.

[10] The NextGen JPDO analysis is not limited only to the busiest or most delayed airports.

Figure 5 Airports and Metropolitan Areas Needing Capacity in 2025 after Planned Improvements

14 airports that need additional capacity in 2025

8 metro areas that need additional capacity in 2025

After including the additional capacity gained from the planned improvements expected by 2025 (including assumed NextGen concepts) to the 2007 capacity and measuring this against the forecast demand for 2025, the FACT 2 analysis still identified 14 airports and eight metropolitan areas that will need additional capacity beyond what is currently planned (see Table 4). *This analysis shows why additional solutions such as new runways, new airports, regional emphasis, congestion management, multi-modal planning, and NextGen are so important.*

Figure 6 Airports and Metropolitan Areas Needing Capacity in 2025 if Planned Improvements Do Not Occur

27 airports that need additional capacity in 2025

15 metro areas that need additional capacity in 2025

Measuring the 2007 capacity against the forecast demand for the 2025 mid-term planning period reveals that 27 airports and 15 metropolitan areas will need additional capacity if the existing airfield configurations remain constant without any capacity improvements (see Table 4). *This analysis underscores the importance of implementing the current planned improvements in order to avoid capacity shortfalls in the future.*

Table 4
Airports and Metropolitan Areas Needing Additional Capacity in 2025 after and without Planned Improvements

Airports Needing Additional Capacity	After Planned Improvements	Without Planned Improvements
Boston Logan International (BOS)		♦
Charlotte Douglas International (CLT)		♦
Fort Lauderdale-Hollywood Int'l (FLL)	♦	♦
George Bush Intercontinental (IAH)		♦
Hartsfield-Jackson Atlanta Int'l (ATL)	♦	♦
John F. Kennedy International (JFK)	♦	♦
John Wayne-Orange County (SNA)	♦	♦
LaGuardia (LGA)	♦	♦
Long Beach-Daugherty Field (LGB)	♦	♦
Los Angeles International (LAX)		♦
McCarran International (LAS)	♦	♦
Metropolitan Oakland Int'l (OAK)	♦	♦
Midway Airport (MDW)	♦	♦
Minneapolis-St. Paul Int'l (MSP)		♦
Newark Liberty International (EWR)	♦	♦
O'Hare International (ORD)		♦
Palm Beach International (PBI)		♦
Philadelphia International (PHL)	♦	♦
Phoenix Sky Harbor International (PHX)	♦	♦
San Antonio International (SAT)		♦
San Diego International (SAN)	♦	♦
San Francisco International (SFO)	♦	♦
Seattle-Tacoma International (SEA)		♦
T.F. Green (PVD)		♦
Tucson International (TUS)		♦
Washington Dulles International (IAD)		♦
William P. Hobby (HOU)		♦
Total	**14**	**27**

Metropolitan Areas Needing Additional Capacity	After Planned Improvements	Without Planned Improvements
Atlanta	♦	♦
Charlotte		♦
Chicago		♦
Houston		♦
Las Vegas	♦	♦
Los Angeles	♦	♦
Minneapolis-St. Paul		♦
New York	♦	♦
Philadelphia	♦	♦
Phoenix	♦	♦
Seattle		♦
San Diego	♦	♦
San Francisco	♦	♦
South Florida		♦
Washington-Baltimore		♦
Total	**8**	**15**

Needed Capacity beyond what is Currently Planned for 2025

The FACT 2 analysis identified 14 airports and eight metropolitan areas that will need additional capacity beyond what is already planned (see Figure 6 and Table 4)[11]. Six of these airports and four metropolitan areas are a continuation of the additional capacity needs identified in the 2015 scenario. The remaining eight airports and four metropolitan areas that will need additional capacity beyond what is currently planned for 2025 include:

- ATL: While ATL should be lauded for the increased capacity added by its new runway and end-around taxiway, the metropolitan area is expected to need additional capacity improvements to meet forecast demand for 2025.

- FLL: The airport is in the process of preparing an EIS for needed runway enhancements. However, more capacity may be needed by 2025 if demand continues to increase as forecast.

- JFK: Although the Port Authority of New York and New Jersey is planning to assume the operation of Stewart International Airport north of New York City, it is too early to determine whether this will offset the need for additional capacity enhancements. Additional options to increase capacity should be considered.

- LAS: Local plans indicate that LAS will exceed its operational capacity before the 2025 planning period. Fortunately, plans are progressing for a new secondary commercial airport for the Las Vegas Metropolitan Area to supplement LAS. The new airport was not included in the FACT analysis as many of the details are still being assessed in an ongoing EIS.

- MDW: The O'Hare Modernization Program may help offset some of the additional activity forecast for MDW, but additional solutions may be needed as well, including a new airport that is now being considered.

- PHX: Additional runway capacity will be needed if demand continues to grow as forecast. The City of Phoenix Aviation Department is working with Williams Gateway Airport (IWA), in nearby Mesa, to increase the use of this airport for scheduled commercial service.

- SAN and SFO: Geographic, terrain, airfield, and airspace issues continue to constrain airports like SAN and SFO. SAN is continuing to investigate capacity enhancements and estimates the airport will exceed its operational capacity before the 2025 planning period. SFO has similar constraints and is participating in a regional planning effort to address capacity needs within the Bay Area.

- The four metropolitan areas that face capacity constraints, in addition to those identified in 2015, are Atlanta, Las Vegas, Phoenix, and San Diego.

A comparison of the 2020 (FACT 1) and 2025 (FACT 2) study results is provided in Table 5. A graphic comparison is provided in Appendix E.

[11] Capacity and delay estimates are specific to the planning years identified (i.e. 2007, 2015, and 2025). Intermediate years were not analyzed.

Table 5
Comparison to FACT 1 Results for 2020 after Planned Improvements

● Continues to need additional capacity based on the results of both studies

⊕ Identified with the new FACT 2 criteria

⊗ No longer identified as needing additional capacity

Airports Needing Additional Capacity	2020 (FACT 1)	2025 (FACT 2)
⊗ Albuquerque International Sunport (ABQ)	✓	
⊗ Birmingham International (BHM)	✓	
⊗ Bob Hope (BUR)	✓	
⊗ Bradley International (BDL)	✓	
⊕ Fort Lauderdale-Hollywood International (FLL)		✓
● Hartsfield-Jackson Atlanta International (ATL)	✓	✓
⊕ John F. Kennedy International (JFK)		✓
● John Wayne-Orange County (SNA)	✓	✓
● LaGuardia (LGA)	✓	✓
● Long Beach-Daugherty Field (LGB)	✓	✓
⊗ Long Island MacArthur International (ISP)	✓	
● McCarran International (LAS)	✓	✓
● Metropolitan Oakland International (OAK)	✓	✓
● Midway Airport (MDW)	✓	✓
● Newark Liberty International (EWR)	✓	✓
⊗ Ontario International (ONT)	✓	
⊕ Philadelphia International (PHL)		✓
⊕ Phoenix Sky Harbor International (PHX)		✓
⊗ San Antonio International (SAT)	✓	
⊕ San Diego International (SAN)		✓
⊕ San Francisco International (SFO)		✓
⊗ T.F. Green (PVD)	✓	
⊗ Tucson International (TUS)	✓	
⊗ William P. Hobby (HOU)	✓	
Total	**18**	**14**

Metropolitan Areas Needing Additional Capacity	2020 (FACT 1)	2025 (FACT 2)
● Atlanta	✓	✓
⊗ Austin-San Antonio	✓	
⊗ Birmingham	✓	
● Las Vegas	✓	✓
● Los Angeles	✓	✓
● New York	✓	✓
⊕ Philadelphia		✓
⊕ Phoenix		✓
⊕ San Diego		✓
● San Francisco	✓	✓
⊗ Tucson	✓	
Total	**8**	**8**

Eight airports were identified in both 2020 and 2025 (●). Airports in the northeast and west coast continue to have capacity constraints. By 2025, however, high-traffic airports in the South, Midwest, and West will also experience capacity constraints.

Many of the airports that were listed in FACT 1 but are not listed in FACT 2 (⊗) have now initiated plans to enhance capacity and improve airfield operations. Others will need to gauge future growth to estimate needed improvements.

Airports and Metropolitan Areas Adding Capacity by 2025

A comparison of the airports needing additional capacity with and without planned improvements in 2025 reveals that 13 airports come off the list of capacity constrained airports if the planned improvements are completed; these are as follows:

- IAD, ORD, and SEA have runway construction projects underway that will reduce delays by 2025.
- CLT plans to start construction on a new runway in 2008.
- MSP will benefit from ATC improvements and reduced delays at other airports.
- Delays at BOS, ORD, and LAX, and many other airports, are expected to decrease due to the assumed NextGen improvements used in this analysis.
- FLL, HOU, IAH, PBI, PVD, SAT, and TUS all have environmental studies underway to provide airfield capacity improvements.

AIRPORTS WITH CAPACITY OR DELAY CONSTRAINTS TO BE MONITORED IN THE NEAR TERM

The FAA believes the criteria used in this study have appropriately identified locations where additional capacity enhancements will be required. However, any study that attempts to identify future capacity constraints may not capture all the dynamics associated with the aviation industry and growth in demand. While the criteria provide a useful filter for determining the most significant capacity needs, the FACT methodology is not intended to identify and assess *all* airport capacity needs.

Therefore, the findings in this report should not be considered a substitute for more detailed regional and airport-specific capacity studies. Such detailed studies should be conducted to confirm the FACT 2 findings and provide a more thorough understanding of issues existing at particular airports. The FAA acknowledges that airports not identified in this study may still face capacity or other operational issues that will require future airport enhancements or that listed airports may become capacity constrained earlier than this analysis indicates.

Because the aviation industry is constantly changing, and some changes can be significant and swift, those airports that met several, but not all, of the criteria used in this analysis should be monitored to gauge the effects of potential changes on future delay. Considering the long lead time required to implement capacity enhancements, it is important to monitor those airports within the near term (2007 to 2015) as changes could expedite the need for additional capacity. Airports that almost meet the modeling criteria in the 2015 planning period *after planned improvements*, and thus should be monitored in the short term, are as follows:

Airports to be Monitored Between 2007 and 2015

- Baltimore/Washington Thurgood Marshall International (BWI)
- Hartsfield-Jackson Atlanta International (ATL)
- McCarran International (LAS)
- Midway International (MDW)
- San Antonio International (SAT)
- San Diego International (SAN)

CONCLUSIONS AND RECOMMENDATIONS

The FACT 2 analysis identified airports that will need additional capacity in two future time periods, 2015 and 2025. This assessment was based on current demand forecasts, plans for new or extended runways, and proposals for runway and ATC system improvements.

Six new runways have been commissioned at some of the busiest airports in the United States. since the FACT 1 report was published in 2004, which has helped to reduce the need for additional capacity in the future. Also, local airport authorities in several cities have responded to the findings of FACT 1 by advancing improvement plans for their airports. Several new runways are on the drawing boards and are expected to be open for traffic before 2015.

Forecasts of future demand have also changed since the FACT 1 report was published, with higher forecasts for some airports and significantly lower forecasts for others. These differences, plus the effect of two to five more years of traffic growth, should be kept in mind when comparing FACT 2 results to FACT 1.

In this study, 18 airports around the country are identified as needing additional capacity by 2015, and 27 by 2025, if the airport system remains the same as it is today without the planned improvements. The various improvements considered by this study, ranging from runways under construction to concepts for the future ATC system, would reduce these numbers from 18 to 6 in 2015, and from 27 to 14 in 2025. There would be significant reductions in delay levels at all 35 OEP airports and most of the non-OEP airports studied, even those still identified as capacity-constrained. As in FACT 1, the FACT 2 results indicate that current improvement plans at many airports must continue to move forward to avoid even worse capacity shortfalls.

Meeting the future capacity needs of the Nation's airports will require innovative approaches, as well as continued emphasis on airport expansion and technological improvements. The following are some of the approaches that have been identified by the FAA for further investigation:

- **New Runways.** Clearly, the most direct response to an expected capacity limitation is the expansion of existing airports to meet forecast demand but this is rarely a straightforward process, especially near major population centers. Although there have been several initiatives to streamline the airport project development process, there is still a considerable amount of lead-time necessary to implement planned airport capacity improvements. Master planning, environmental studies, and land acquisition need to be conducted

as far in advance as possible to reduce the time and expense associated with moving a project through the development process.

- **New Commercial Service Airports.** In the past forty years, two new major commercial service airports have been built in the United States, DEN and DFW. There is likely to be a need for as many as four more major commercial service airports across the country during the next two to three decades in regions where existing commercial service airports are constrained from additional development but air travel demand is expected to exceed available capacity. New supplemental or replacement commercial service airports may be needed. Among the metropolitan areas where new airports are being considered, or might be considered, are Atlanta, Chicago, Las Vegas, and San Diego.

- **Regional Solutions.** Studies of regional traffic and development alternatives have been used to analyze specific air travel behavior within defined regions that experience significant congestion, including San Francisco, the Los Angeles basin, New York, and Boston. Several of these regions have ongoing study efforts in place. These initiatives should continue, and may need additional emphasis.

- **Congestion Management.** Fortunately, we can add capacity to solve most of our problems. However, in some cases runway construction may not be a viable alternative. Today, LGA is a good example. In the next 10 years, the San Francisco Bay area will serve as an additional example of a capacity-constrained metropolitan area where runway construction may not be an option. In these cases, demand management, regulatory or economic solutions, and other market mechanisms may need to be investigated.

- **High-Density Corridors and Multi-Modal Planning.** Even with the planned improvements, the FACT 2 analysis identified significant and chronic capacity problems on the east and west coasts. The impact of these capacity problems is manifested as delays throughout the system. Weather, peak travel periods, and other factors will exacerbate the problem. The demand for travel in these high-density corridors may require consideration of high-speed ground modes as well as short-haul air travel. For example, it would be useful to know the impact of short-haul travel between SAN, SFO, LAX, LAS, and PHX. In order to adequately plan for airport and multi-modal transportation improvements and infrastructure investment needed to satisfy this corridor-level travel demand, it will be necessary to better understand the travel behavior and options for accommodating demand in the country's busiest travel corridors.

  The Board of Governors of the Airport Cooperative Research Program (ACRP) has unanimously approved undertaking an FAA suggested study to examine multi-modal travel behavior and the impact of travel demand on high-density travel corridors linking mega-regions on the east and west coasts. The National Academy of Sciences' Transportation Research Board (TRB) administers the ACRP and is pursing this as a quick response study. TRB expects to award a contract for the study in the summer of 2007.

- **NextGen.** An attempt was made in this study to simulate the impact of certain NextGen concepts on airport operations. Although FACT 2 did not model airspace and enroute changes, the results provide a glimpse of the potential benefit of implementing NextGen throughout the NAS. Forecast delay reductions varied by airport, but all 35 OEP airports saw benefits, and

some experienced significant delay reduction. These findings indicate that the FAA should move forward aggressively to develop the NextGen concepts, assess system benefits and costs, and identify appropriate methods of financing the improvements. ATC improvements of NextGen are especially relevant at capacity-constrained airports where runway expansion or new runway construction is not an option.

This study has identified a number of airports where additional capacity will be needed to handle expected future demand. The solution at each airport will be different, and can only be identified through consideration of local factors and concerns. The FAA is prepared to work with local airport operators to address their capacity and demand issues and to seek innovative approaches to their needs.

APPENDIX A: STUDY AIRPORTS

The following is a listing of the 56 airports included in this analysis:

OEP	ID	Airport Name
	ABQ	Albuquerque International Sunport
◆	ATL	Hartsfield-Jackson Atlanta International
	AUS	Austin Bergstrom International
	BDL	Bradley International
	BHM	Birmingham International
◆	BOS	Logan International
	BUR	Bob Hope
◆	BWI	Baltimore/Washington International Thurgood Marshall
◆	CLE	Cleveland Hopkins International
◆	CLT	Charlotte Douglas International
◆	CVG	Cincinnati/Northern Kentucky International
◆	DCA	Ronald Reagan Washington National
◆	DEN	Denver International
◆	DFW	Dallas/Fort Worth International
◆	DTW	Detroit Metropolitan Wayne County International
◆	EWR	Newark Liberty International
◆	FLL	Fort Lauderdale-Hollywood International
	GYY	Gary Chicago International
◆	HNL	Honolulu International
	HOU	William P. Hobby
	HPN	Westchester County
◆	IAD	Washington Dulles International
◆	IAH	George Bush Intercontinental
	ISP	Long Island MacArthur International
◆	JFK	John F. Kennedy International
◆	LAS	McCarran International
◆	LAX	Los Angeles International
◆	LGA	LaGuardia
	LGB	Long Beach-Daugherty Field
◆	MCO	Orlando International
◆	MDW	Midway International
◆	MEM	Memphis International
◆	MIA	Miami International
	MKE	General Mitchell International
◆	MSP	Minneapolis-St. Paul International
◆	OAK	Metropolitan Oakland International
	ONT	Ontario International
◆	ORD	O'Hare International
	PBI	Palm Beach International
◆	PDX	Portland International
◆	PHL	Philadelphia International
◆	PHX	Phoenix Sky Harbor International
◆	PIT	Pittsburgh International
	PVD	T.F. Green
	RFD	Chicago Rockford International
◆	SAN	San Diego International
	SAT	San Antonio International
◆	SEA	Seattle-Tacoma International
◆	SFO	San Francisco International
	SJC	Mineta San José International
◆	SLC	Salt Lake City International
	SNA	John Wayne-Orange County
	STL	Lambert-St. Louis International
	SWF	Stewart International
◆	TPA	Tampa International
	TUS	Tucson International

APPENDIX B: METROPOLITAN AREAS AND ASSOCIATED AIRPORTS

The following is a list of the metropolitan areas and their associated commercial airports that were referenced in this report.

Atlanta	ATL	Hartsfield-Jackson Atlanta International
Charlotte	CLT	Charlotte Douglas International
Chicago[12]	GYY	Gary Chicago International
	MDW	Midway International
	MKE	General Mitchell International
	ORD	O'Hare International
	RFD	Chicago Rockford International
Houston	HOU	William P. Hobby
	IAH	George Bush Intercontinental
Los Angeles	BUR	Bob Hope
	LGB	Long Beach-Daugherty Field
	LAX	Los Angeles International
	ONT	Ontario International
	PSP	Palm Springs International
	SNA	John Wayne-Orange County
Las Vegas	LAS	McCarren International
Minneapolis-St. Paul	MSP	Minneapolis-St. Paul International
New York	EWR	Newark Liberty International
	ISP	Long Island MacArthur International
	JFK	John F. Kennedy International
	LGA	LaGuardia
Philadelphia	PHL	Philadelphia International
Phoenix	PHX	Phoenix Sky Harbor International
San Diego	SAN	San Diego International
San Francisco	OAK	Metropolitan Oakland International
	SFO	San Francisco International
	SJC	Mineta San José International
Seattle	SEA	Seattle-Tacoma International
South Florida	FLL	Fort Lauderdale-Hollywood International
	MIA	Miami International
	PBI	Palm Beach International
Washington-Baltimore	BWI	Baltimore/Washington International Thurgood Marshall
	DCA	Ronald Reagan Washington National
	IAD	Washington Dulles International

[12] GYY, MKE, and RFD airports were added to the Chicago Metropolitan Area in order to be consistent with the EIS metropolitan area definition used for the OMP.

APPENDIX C: PLANNED IMPROVEMENTS

Figure C1 - Capacity Assumptions–OEP Airports: Detailed Improvements Modeled in 2015 and 2025

	ATL	BOS	BWI	CLE	CLT	CVG	DCA	DEN	DFW	DTW	EWR	FLL	HNL	IAD	IAH	JFK	LAS	LAX	LGA	MCO	MDW	MEM	MIA	MSP	ORD	PDX	PHL	PHX	PIT	SAN	SEA	SFO	SLC	STL	TPA
Reduced Separation Standards -- use visual separation in MMC -- use 2/3/4/5 NM in IMC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x*	x	x	x	x	◊* x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Improved threshold delivery accuracy	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊	◊
1.5 NM Departure/Arrival separation (IMC) -- spacing < 2500 ft or same runway	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Independent parallel approaches (IMC) -- spacing 2500-4299 ft												x												▲		x		x			x			▲	
Triple indep. parallel approaches (IMC)	▲					▲		▲	▲	x				◊	▲					◊					◊								x		
"Mixed triple" independent/dependent parallel approaches (IMC)					x																														
Paired approaches, e.g. SOIA -- MMC (spacing 700-2499 ft)	x	◊		▲							◊						x	x					x			◊					◊	▲			
-- IMC (spacing 1200-2499 ft)		x																																	
Dependent Approaches -- MMC/IMC (700-2500 ft spacing) -- 1.5 NM diagonal behind Small, Large -- wake vortex sep behind B757/Heavy											x							x		x			x									x		◊	x
LAHSO (all weather) if >7000 ft to intersection		▲											x				x						x												
Simultaneous Converging Approaches (IMC)																	x							x											
Standard Departure/Departure separations (no departure constraints)		x										x				◊	x									x				x		x	x		
Independent parallel departures (IMC) -- no wake vortex separation behind Small/Large (700-2500 ft spacing)											x						x			x			x									x		◊	x
New/extended runways (since 2002)	▲	◊	x	▲	x	▲		▲ x	▲ x			◊		◊ x	▲ x					▲			▲	▲	◊		◊				◊			▲	x

▲ Included in 2006 capacity
◊ 2015 capacity improvement
x 2025 capacity improvement

x* Visual separations applied in VMC and MMC (2025)
◊* Visual separations applied in VMC (2015)

Figure C2 - Capacity Assumptions–Non-OEP Airports: Detailed Improvements Modeled in 2015 and 2025

	ABQ	AUS	BDL	BHM	BUR	GYY	HOU	HPN	ISP	LGB	MKE	OAK	ONT	PBI	PVD	RFD	SAT	SJC	SNA	SWF	TUS
Reduced Separation Standards -- use visual separation in MMC -- use 2/3/4/5 NM in IMC												x									
Improved threshold delivery accuracy												x									
1.5 NM Departure/Arrival separation (IMC) -- spacing < 2500 ft or same runway												x									
Independent parallel approaches (IMC) -- spacing 2500-4299 ft																					
Triple independent parallel approaches (IMC)																					
"Mixed triple" independent/dependent parallel approaches (IMC)																					
Paired approaches, e.g. SOIA -- MMC (spacing 700-2499 ft)												x									
-- IMC (spacing 1200-2499 ft)																					
Dependent Approaches -- MMC/IMC (700-2500 ft spacing) -- 1.5 NM diagonal behind Small, Large -- wake vortex sep behind B757/Heavy												x									
LAHSO (all weather) if >7000 ft to intersection																					
Simultaneous Converging Approaches (IMC)												x									
Standard Departure/Departure separations (no departure constraints)																					
Independent parallel departures (IMC) -- no wake vortex separation behind Small/Large (700-2500 ft spacing)												x									
New/extended runways (since 2002)							x				◊			◊			x				◊

◊ 2015 capacity improvement
x 2025 capacity improvement

Note: 2025 ATM improvements are assumed only for airports that would otherwise be capacity constrained.

APPENDIX D: METHODOLOGY

Introduction

The FACT 2 study required extensive amounts of information and detailed analysis. Forecasts of future traffic levels were needed, based on growth in populations, economic activity, and traffic demand. An understanding of current operations as well as the amount of capacity provided at individual airports was necessary. In addition, the FACT study looked at the effect of new technologies, airspace, and runways on operations and capacity. This Appendix documents the approach used for modeling future demand and capacity, and describes the criteria used to identify airport and metropolitan areas as capacity constrained.

The modeling process described herein produced an initial list of airports needing additional capacity in the mid- and long-term future (2015 and 2025). Recognizing that a system-wide modeling process provides only limited information about specific airport operations and individual facilities, the initial findings of the modeling process were then augmented with information obtained through a validation process. The purpose of the validation was to ensure the operational data was accurate and the assumptions made were reasonable and consistent with observed current conditions. The validation process involved a review of the modeling assumptions and preliminary outputs with airport operators, and in some instances, with air traffic control personnel. The validation process also involved a review of appropriate sections of Federal decision documents and associated analyses, such as master plans, airport capital improvement plans, and environmental studies. As a result, airports such as HOU, IAH, PBI, PVD, SAT and TUS were identified after examining the FACT 1 and FACT 2 results together with previous airport site-specific modeling and data gathered through the validation process. Planned improvements for these airports were assessed using a combination of systemwide and site-specific modeling.

Information gathered from these Federal findings and/or commitments was used in addition to the modeling as these documents are often the most reliable source of information about the timing and need for planned improvements. This additional step allowed the FACT team to incorporate additional information the models were not designed to provide. In total, this process served as a proof-of-concept validation.

The final list of airports identified in this report as capacity constrained was developed based on the results of the modeling and validation process, as well as those airports already known to have capacity issues in the future.

Modeling Future Airport Demand

For this study, two different estimates of future operations were used: the FAA's Terminal Area Forecast (TAF), and CAASD's Future Air Traffic Estimator (FATE). Both are described below.

Terminal Area Forecast

The principal forecast of future operations was the *Terminal Area Forecast* (TAF), prepared by the FAA Office of Aviation Policy and Plans (APO). The TAF makes projections of future enplanements and operations on an airport-by-airport basis.

Several key inputs into the TAF are forecasts of local economic and demographic growth, local fares, and assumptions about dominant carrier behavior.

This analysis used the 2005 TAF, published by the FAA in March 2006. This was the current version at the time the analysis was performed.

Forecasted traffic levels in the TAF at the 56 study airports were used to develop a daily "schedule" for all flights in the NAS. This demand schedule was then used as an input into a simulation model that produced delay estimates. The annual demand forecasts in the TAF were also compared directly with future estimates of annualized airport capacity.

Future Air Traffic Estimator

As a secondary source of information, this analysis also considered demand estimates produced by CAASD's experimental bottom-up model of origin and destination (O&D) traffic.[13] This socio-economic model, known as the Future Air Traffic Estimator (FATE), is based on the economic and demographic characteristics of individual pairs of origin-destination metropolitan areas. This is a different approach than that taken by the TAF, as it estimates the amount of passenger traffic *between* metropolitan areas rather than estimating demand at individual airports. Population, income, and market structure all influence passenger demand, as does a host of other factors. Inputs to the model include socio-economic forecasts from the consultancy Global Insight,[14] as well as historical data on O&D traffic from the Department of Transportation[15].

As shown in Figure D1, the FATE socio-economic model begins by forecasting O&D passengers between metropolitan areas. Then, for each origin-destination pair, passengers are allocated among available routes, taking into account the existing air carrier network structure. Note that if there are multiple airports within a metropolitan area, passengers are assigned to one of them as part of this "airport choice" process. This process is then repeated for all O&D pairs in the conterminous United States.

At this point, there is an estimate of future passenger demand between individual airport pairs, including those passengers connecting through hubs, based on a "route choice model". In order to translate the passenger forecasts into operation forecasts, aircraft must be assigned to each airport pair. The size of the aircraft assigned depends on the distance to be flown and the total number of passengers. Additional operations are also incorporated to include international, charter, general aviation, military, and cargo traffic.

The output of the model is a set of forecasts of daily and annual passengers and operations between every airport pair in the conterminous United States.

[13] Bhadra, D. et al., *Future Air Traffic Timetable Estimator*, Journal of Aircraft, Volume 42, Number 2, pp. 320-328, March-April 2005. The name of the model has been changed to reflect improvements since the first FACT study was performed.

[14] Global Insight is a consulting firm providing economic and financial data and forecasts. For more information, see http://www.globalinsight.com.

[15] For more information, see http://www.transtats.bts.gov.

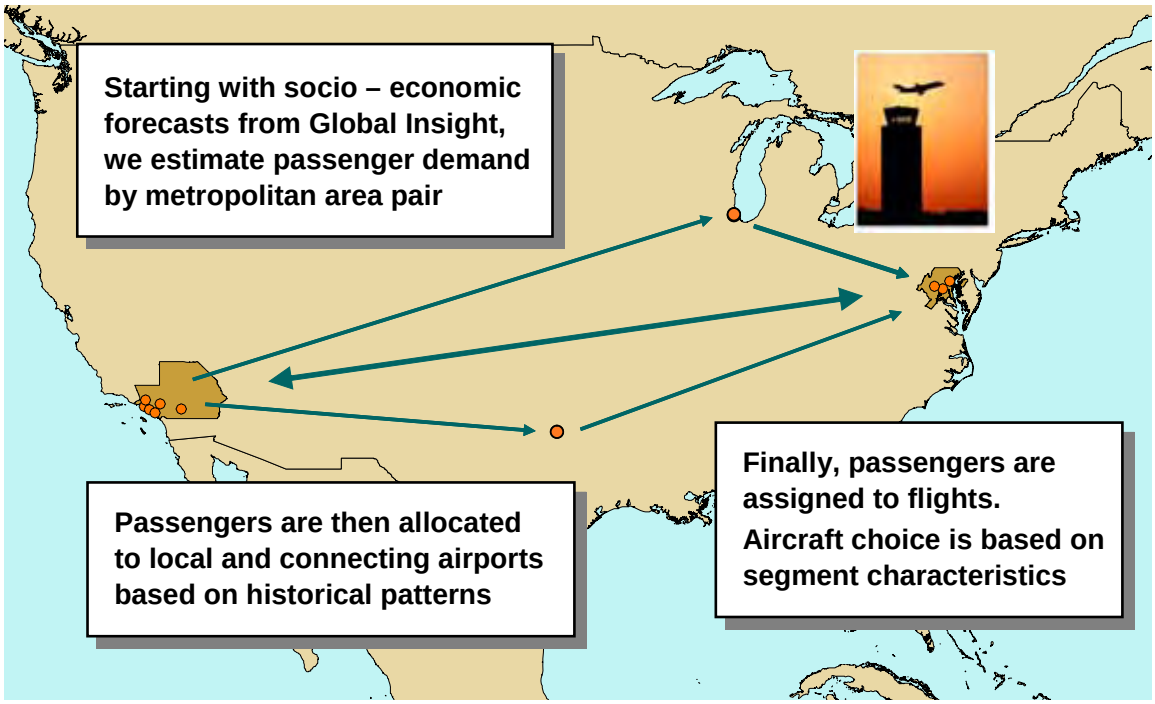


Figure D1 – Future Air Traffic Estimator (FATE) Model

The FATE model was used to generate annual counts of airport operations in 2015 and 2025 based on actual traffic data from selected dates in 2003 and 2004. The FATE forecasts were helpful in validating the results obtained with the TAF.

Modeling Current and Future Airport Capacity

Assessing an airport's capacity requires a comprehensive understanding of its present-day operations and limitations, as well as some assumptions about how the major characteristics influencing capacity are expected to change over time. One methodology for doing this is found in the 2004 *Airport Capacity Benchmark Report*[16], which provides a set of hourly arrival and departure rates under various weather conditions. This information can then be used as an input into other models, which in turn produce well-defined measures of airport performance (primarily average delays) under given assumptions.

Modeling Current Capacity

The FACT 2 analysis updated and enhanced the benchmark capacities reported in the 2004 benchmark report in several ways:

- Twenty-one non-OEP airports[17] identified in the original FACT report had not previously been benchmarked in a manner similar to the 35 OEP airports. Much more detailed analyses, including the use of surveys and modeling for

[16] *Airport Capacity Benchmark Report 2004,* U.S. Department of Transportation, Federal Aviation Administration, The MITRE Corporation Center for Advanced Aviation System Development, October 2004. See http://www.faa.gov/events/benchmarks/2004download.htm.

[17] ABQ, AUS, BDL, BHM, BUR, GYY, HPN, HOU, ISP, LGB, MKE, OAK, ONT, PBI, PVD, RFD, SAT, SJC, SNA, SWF, and TUS.

each facility, were completed for these non-OEP airports. Benchmarks were calculated at each facility for three weather conditions: VMC, MMC, and IMC.

- Present-day capacities at the 35 OEP airports were updated to include any enhancements implemented at the airports since the 2004 benchmark analysis was completed, such as new runways or new operational procedures.

To produce the capacity estimates necessary for the FACT analysis, the team utilized the Enhanced Airfield Capacity Model (E-ACM), a MITRE-developed update to the widely used FAA Airfield Capacity Model[18]. The E-ACM calculates the average number of arrivals and departures that can be expected during busy periods at an airport based on air traffic control (ATC) procedures, including separation minima, and the probabilistic characteristics of aircraft performance.

One input to the E-ACM is the mix of weight classes (e.g., Small, Large, and Heavy) for the aircraft using the airport. For the purpose of running the E-ACM, the fleet mix at each airport today was assumed to continue in the future. That is, no fleet mix changes were estimated as part of the *capacity* analysis. However, both estimates of future demand used in this report, TAF and FATE, allowed changes to the fleet mix to occur in future time periods.

Benchmark capacities were calculated for only one airport configuration in each weather condition, the one most commonly used. This information was obtained from reported configuration data as well as through the use of survey responses from each individual facility. Although other configurations with less capacity might significantly affect annual performance, this would not be reflected in the benchmark results.

Finally, the calculated capacities were compared to historical data and were reviewed by the individual facilities in an attempt to assure that they were accurate approximations of actual airport operations. Capacities were recalculated in several cases based on updated information provided by the facilities.

Modeling Future Capacity

With 2007 as the present-day baseline, the FACT analysis formulated a set of assumptions about what capacity-enhancing changes could be reasonably expected in the future. The assumed improvements include changes such as new runways, technologies, or ATC procedures as well as airspace redesign. In its examination of future capacity requirements, the FACT analysis focused on the years 2015 and 2025.

The 2004 benchmark report had estimated future capacity at the 35 OEP airports in the year 2013 based on the FAA's *Operational Evolution Plan (OEP),* version 5.0. The FACT 2 study developed capacities for 2015 that included the enhancements described in the updated OEP version 8.0[19].

[18] For more information on the FAA model, see Swedish, W. J., February 1981, *Upgraded FAA Airfield Capacity Model—Volume I: Supplemental User's Guide*, MTR-81W016, Vol. I, The MITRE Corporation, McLean, VA.

[19] *Operational Evolution Plan*, Federal Aviation Administration, May 2006. See http://www.faa.gov/programs/oep/v8/Executive%20Summary/Executive%20Summary%20v8.pdf.

The 2015 evaluation assumed that all new runways and airspace, technology, and procedural improvements outlined in the FAA's OEP v8.0 would be implemented at the top 35 airports and would provide the expected benefits. In addition, the O'Hare Modernization Program[20] (OMP) and an extension to Runway 9R/27L at FLL were assumed to be completed by 2015.

It is important to note that not every proposed runway project is included in the OEP. For example, OEP v8.0 did not include all new runways included in the OMP[21] for ORD because detailed construction schedules had not yet been finalized. However, the FAA has approved the runways and published Records of Decision (RODs) for them, so there is a high level of confidence that they will be completed by 2015.

Technical improvements included in OEP v8.0 such as Simultaneous Offset Instrument Approaches (SOIA) at SFO, Traffic Management Advisor (TMA), Time Based Metering (TBM) and Area Navigation (RNAV) arrival routes were also assumed to increase capacity at most airports. For the 21 non-OEP airports, only new runways planned for completion by 2015 (based on a survey of the airports), not technological or procedural enhancements were considered.

For the long term (2025), the capacity assessment took into account any current planning at the 56 airports for additional runways and reconfigurations, again based on survey information. Assumptions about future technology and procedures were based on various research proposals, extrapolations from the latest OEP, and through a review of the proposed Next Generation Air Transportation System also known as NextGen[22]. These technological improvements were included in the analysis of the 35 OEP airports, as well as at OAK (we assumed that the NextGen improvements would only be implemented at a non-OEP airport if the airport had been identified as needing additional capacity otherwise).

The FACT team coordinated the assumptions about the 2025 enhancements with the Agile Air Traffic Management (ATM) Integrated Product Team (IPT)[23], the Airports IPT[24], and the Evaluation and Analysis Division (EAD)[25] of the JPDO. It is important to note that NextGen definition and planning is still in its early stages at the JPDO. Although the set of improvements considered by this report was deemed to be reasonable and consistent with those being considered by the JPDO, they do not necessarily represent the final vision of NextGen. Over time, as JPDO plans solidify, enhancement plans are expected to change.

Capacity improvements assumed for 2025 included some that were applied to all the OEP airports and OAK, such as reduced radar separation minima and controller aids to improve separation accuracy. Other new procedures were specific to a given runway configuration, such as SOIA-type approaches to closely spaced parallel runways in instrument conditions. For the other non-OEP airports, only planned new runways were considered. Figures C1 and C2 show the improvements modeled at each of the 56 airports for 2015 and 2025.

[20] See http://www.flychicago.com, select "O'Hare Modernization Program."
[21] See http://egov.cityofchicago.org/webportal/COCWebPortal/COC_ATTACH/final_alp.pdf.
[22] See JPDO's *NextGen Concept of Operations* at http://www.jpdo.aero/pdf/NextGenConOpsv12.pdf.
[23] The Agile ATM IPT is now known as the Air Navigation Services Working Group.
[24] The Airports IPT is now known as the Airport Working Group.
[25] The Evaluation and Analysis Division is now known as the Systems and Engineering Analysis Division.

While the assumed improvements would hopefully be implemented in time to accommodate the forecast 2025 demand, their availability and effectiveness is by no means guaranteed. It would be prudent for airports to consider other means to handle future traffic growth and not to rely on these developmental concepts.

Incorporating Operational Constraints

Current constraints on operations at each airport were also taken into consideration in the assessment of current and future capacity. For example, constraints might be placed upon operations due to noise mitigation, airspace restrictions, or limited arrival and departure procedures. Noise mitigation constraints were assumed to continue in future years. It was assumed that some airspace limitations (but not those caused by terrain, for example) could be alleviated with navigational or procedural improvements in the future, as could some arrival and departure restrictions.

Identifying Airports Needing Additional Capacity

Several different methods were used to determine whether the future airport capacity could accommodate the expected future demand without excessive delays. The following section describes the methods used to evaluate future operational performance at the airports, and also the criteria used to determine whether operational improvements were required. The two principal methods used were Annual Service Volume for individual airports and the NAS-Wide Simulation Model, which is a simulation of operations across the National Airspace System (NAS).

Estimating Future Performance at Individual Airports

Annual Service Volume

Annual Service Volume[26] (ASV) is the annual level of traffic that results in a given level of average delay. An ASV analysis allows decision makers to make a tradeoff between annual levels of traffic and acceptable levels of delay: as traffic levels grow in the analysis, the average delay level also increases. This is an important point because the higher the “allowable” delay limit is at an airport, the higher the level of traffic it can handle, as measured by the ASV.

ASV is determined by calculating the amount of delay that is produced at different levels of traffic, and then determining which traffic level had produced the target delay level. In the original study, the level of delay chosen as appropriate for a given airport depended on that airport’s historical levels of delay. The ASVs for some airports were thus based on higher, or lower, levels of delay than other airports. For greater consistency in this analysis, a single level of delay was utilized at *all* airports: ASVs were based on an estimate of 7 minutes of delay per flight, on average. It should be noted that this is higher than the value of 4 minutes average delay per flight that is typically used in airport planning; the higher level was selected because the analysis is intended to identify airports with excessive delay levels.

The ASV analysis considers multiple runway configurations and utilizes an annual estimation of weather conditions for each configuration in its calculation. Future levels of ASV (for the 2015 and 2025 planning periods) incorporate planned runway

[26] ASV studies are typically conducted by the Federal Aviation Administration’s William J. Hughes Technical Center using the Runway Delay Simulation Model (RDSIM).

improvements and/or additions, as well as technological or procedural improvements at selected locations. ASV estimates are time consuming and expensive to produce, especially for multiple time periods. ASVs have been prepared for all 56 airports for current operations and for planned new runways, but ASVs that included the procedural improvements assumed for 2025 were only prepared when needed. This will be explained further below.

NAS-Wide Simulation Model

Another method for evaluating the future performance of airports is by using a simulation model to estimate future levels of delay. Here, capacity information from the updated airport capacity benchmarks was used as an input to a simulation of daily traffic between airports in the NAS, where the daily traffic schedule is derived from future demand forecasts in the TAF. Average delay and other metrics are then calculated for individual airports. High levels of expected delay indicate a potential need for additional capacity, while lower levels of delay could indicate adequate capacity to meet demand expectations. While the ASV model determines the traffic level that would produce a specific level of delay, the NAS-Wide analysis calculates the level of delay that would result from a specific level of traffic in each time period.

The simulation model used by the FACT analysis is a network queuing model of the NAS. This model takes demand, capacity, airspace data, and other information as input and produces an estimate of various measures of performance. Because this is a network model and flights move from airport to airport throughout the day, the performance of one airport influences the perceived performance of the other airports. For example, reducing departure delay at airport A with the addition of a capacity improvement also improves the arrival delay (relative to scheduled arrival time) at airport B, as arrivals at B are no longer being delayed upon departure from A. It is this interaction between airports and other system resources that makes system-wide modeling a powerful tool in capacity analyses.

In order to properly account for the interaction between demand and capacity, the NAS-Wide model used in the FACT study simulates all traffic through the NAS, not just traffic between certain airports of interest. Demand information is derived from various sources including the *Official Airline Guide*[27] and estimates of general aviation, cargo, and commuter traffic based on historical levels. Future operational levels of traffic are created by growing today's operations to meet growth rates estimated in different forecasts such as the FAA's TAF.

Capacity estimates come from detailed modeling using other tools such as the E-ACM. It is important to consider the interaction between the improvements being modeled when using such tools. It is possible that different improvements may provide similar benefits under like conditions. If these interactions are not accounted for properly, capacity estimates may be too high. By using a network model, the interaction between demand and capacity at a single airport, as well as across airports, can be accounted for.

Criteria for Identifying Capacity-Constrained Airports

The purpose of this analysis was to look across multiple models, with separate criteria for each, to determine a *common set of airports* identified by each model as

[27] *Official Airline Guide*—Source of flight schedule information. See http://www.oag.com.

needing additional capacity in the future. The approach used had to be broad enough to analyze many airports across the entire NAS, while utilizing a *consistent* set of criteria to identify the future performance for each airport. Local conditions may result in unique operational problems that could not be accounted for by the models as used. In such cases, the results of this analysis should be considered in combination with more detailed site-specific analyses.

To be identified by this analysis of future capacity, an airport was required to be identified by each study as being capacity-constrained; this strict requirement was based on an acknowledgement that each study made use of a different set of criteria to determine whether an airport might need additional capacity. In the end, the process produced a *conservative* list of airports with the clearest need for additional capacity. However, airports that were not identified in this analysis may still need more capacity in the future and should not stop planning for future facility improvements.

The criteria for identifying an airport as needing additional capacity have been refined since the original FACT report. This was done to account for performance aspects not originally considered. The performance characteristics considered in this analysis and how they differ from those used in the original report are described below.

Criteria for the 35 OEP Airports Expanded to All 56 FACT Airports

In the original report, the information available for, and the knowledge of, the OEP airports was much more extensive than what was available for the non-OEP airports. Because of this, the criteria used for the OEP airports were much more stringent than the criteria used for the smaller airports in the original assessment. Since then, extensive modeling and analysis has been completed for the non-OEP airports. Any airport identified as needing additional capacity in the original report, as well as those airports in metropolitan areas identified as needing additional capacity, were modeled and analyzed at the same level of detail as the OEP airports. In total, 56 airports were analyzed: the original 35 OEP facilities plus 21 additional airports.

Refined Identification Criteria

To identify which of the 56 airports are expected to need additional capacity in the future, the FACT 2 analysis used the following criteria:

- **Annual Service Volume Ratio** was estimated at 0.8 or above (annual demand at least 80 percent of ASV based on 7 minutes average delay)
- **Scheduled Arrival Delay** was estimated at 12 minutes per flight or above, on an annual basis, *and either*
    - **Local Scheduled Arrival Delay** was estimated at 50 percent or more of the total Scheduled Arrival Delay in good or bad weather conditions, *or*
    - **Arrival Queue Delay** (delay waiting to land after arriving at an airport) was estimated at 12 minutes per flight or above in good or bad weather conditions

- Or as an alternative to the Scheduled Arrival Delay criterion, **Departure Queue Delay** (delay waiting to depart while at the departure airport) was estimated at 12 minutes per flight or above in good or bad weather conditions

To be identified as a capacity-constrained airport in the future, an airport was required to satisfy the ASV criterion, and either the Scheduled Arrival Delay criterion or the Departure Queue Delay criterion described above, using the traffic levels in the TAF released in 2006. As an additional analysis, the FATE forecast was also applied to the ASV criterion as well as the Scheduled Arrival Delay criterion. Other criteria were not estimated using the FATE forecast because similar modeling had already been completed with the TAF. If any of the required criteria was not satisfied, an airport was not identified.

The FACT analysis required that an airport be identified as needing additional capacity according to both the ASV criterion and the NAS-Wide criterion, for both the TAF and the FATE forecasts. The NAS-Wide simulation modeling results for 2025 were produced first. If the NAS-Wide criteria for an airport indicated that additional capacity may be required in 2025, only then were 2025 ASV results calculated for that airport. Otherwise, the 2025 ASV for that airport was not produced.

From the list of criteria above, only two, the ASV ratio and the Scheduled Arrival Delay criteria, were used in the original study. Since that time, additional metrics were added to further refine the study results. The rationale for adding the new metrics and criteria is described below.

Local Scheduled Arrival Delay. This metric is based on a NAS-Wide simulation model. Flights take off from an origin airport, fly through the system, and land at a destination airport. When flights arrive at their destination airport, they may have incurred delay relative to their scheduled arrival time along the way. If so, that delay may have been incurred at their origin airport, en route, or at their destination airport. Problems that exist at an origin airport may thus impact Scheduled Arrival Delay at the destination airport. Incorporating a criterion that at least 50 percent of the Schedule Arrival Delay was caused locally (i.e. by the arrival airport) was an attempt to avoid identifying airports where high delays are caused primarily by problems at other airports. Since these delays cannot be resolved by improvements at the arrival airport, the arrival airport should not be identified.

Arrival Queue Delay. This criterion was added to capture significant airport delays that are caused locally, even when at least 50 percent of the Scheduled Arrival Delay was not Local Scheduled Arrival Delay. For example, suppose one airport had an average Scheduled Arrival Delay of 32 minutes, and 40 percent, or 12.8 minutes, of that delay was caused locally. Even though this airport fails the criterion that at least 50 percent of the delay must be caused locally, it still has a significant amount of delay. By adding the Arrival Queue Delay criterion, airports with significant locally caused delays will be identified. It is important to note that this is Arrival *Queue* Delay, not Scheduled Delay. Queue delay is taken while waiting for use of an arrival runway. It is *all* caused locally, so 12 minutes per flight is a significant amount of delay compared to 12 minutes of scheduled delay, which may be incurred at various points along a flight.

Departure Queue Delay. This criterion was added to recognize significant departure delays at an airport. The original FACT study focused on arrival delays, leaving open the possibility that an airport that experiences significant departure delays but not arrival delays would not be identified as needing additional capacity. With this additional criterion, departure delays are captured as an indication of capacity shortfalls.

In the original study, another criterion called ***Extrapolated Delay*** was incorporated into the analysis. In discussions with the aviation community following the release of the original report, it was suggested the assumptions used by this criterion were too conservative and that it did not accurately reflect what could reasonably be expected given changes in future demand and capacity. Based on this feedback, the Extrapolated Delay criterion was removed from the FACT analysis.

Another important difference from the original study should be noted. In the first FACT report, a simplified approach was used for non-OEP airports because ASV estimates did not exist for most of these other airports at the time and detailed capacity modeling was not complete. However, following the release of the original report, more detailed analyses were performed for the smaller airports. Because these results are now available for all airports, this analysis of future capacity needs now uses the same detailed criteria for all airports.

Validation of Results

Additional capacity related information was gathered though a validation process involving many of the airports included in this study. The FACT team provided airport operators with the input assumptions and preliminary output data for their individual facilities. The purpose of the validation was to ensure the operational data was accurate and the assumptions made were reasonable and consistent with observed current conditions. In some instances, these queries were augmented by discussions with airport management and FAA air traffic control personnel at the airports being evaluated. In total, these discussions served as an opportunity for coordination and validation of the results.

Evaluating Capacity Needs in Metropolitan Areas

A separate analysis was performed to evaluate the possible use of secondary airports in a metropolitan area to alleviate congestion at the primary airport(s). As part of this analysis, the total annual demand for commercial airports in a metropolitan area was compared to a measure of the total annualized capacity for those same airports.

Defining the Metropolitan Area

The geographical boundaries for the FACT 2 metropolitan areas are based on the Metropolitan Statistical Areas (MSAs) established by the Office of Management and Budget (OMB)[28]. An MSA includes a central county or counties that have an urban area with a population of at least 50,000, plus adjacent counties that have a high degree of social and economic integration with the central county/counties as measured by commuting ties. For the purpose of the FACT study, the analysis focused on MSAs that contained at least one commercial service airport.

[28] *Federal Register*, Office of Management and Budget (2000), "Standards for Defining Metropolitan and Micropolitan Statistical Areas". See http://www.census.gov/population/www/estimates/00-32997.pdf.

Most metropolitan areas consist of a single MSA, but sometimes the catchment area for large airports may extend beyond the MSA boundary. Some passengers may be willing to travel across MSA boundaries to fly out of an airport that offers a wider selection of flights and/or lower fares. In these cases, MSAs were combined to form a metropolitan area that captured the dynamics of the regional passenger demand and its airport system. For example, to accurately reflect the Boston regional airport system in FACT 2, the Boston-Cambridge-Quincy, MA-NH MSA (which is Boston's central MSA containing BOS) was combined with the Manchester-Nashua, NH MSA (containing MHT) and the Providence-New Bedford-Fall River, RI-MA MSA (containing PVD) to form the Boston Metropolitan Area.

For MSAs containing a major airport, which has been defined in this study as an OEP airport, the following criteria were used to determine whether other MSAs should be combined with the MSA containing the OEP airport:

- If there is a commercial service airport in a nearby MSA that is within an hour's drive (or approximately 60 miles) of an OEP airport, the nearby MSA was combined with the OEP MSA.

- If there is an adjacent MSA with no commercial service airports but that is sufficiently close to an OEP airport to contribute to the O&D traffic demand, then the adjacent MSA was added to the OEP MSA.

Depending on the local dynamics of a metropolitan area and the observed commuting behavior within the airport catchment area, it was sometimes necessary to add secondary airports and their associated MSAs to a metropolitan area even though the above criteria were not satisfied. An example is the addition of MKE to the Chicago Metropolitan Area. Even though MKE is outside of the Chicago Metropolitan Area, it serves O&D passengers living in Northeastern Illinois, which overlaps with the Chicago Metropolitan Area.

Secondary Airports Considered in the Metropolitan Area

A more stringent criterion was used in FACT 2 to determine which additional airports should be included in the local "system" of commercial airports for a metropolitan area together with the capacity-constrained airport(s). Only secondary airports that have a significant share of the local passenger traffic and are essentially substitutes for the capacity-constrained airport(s) were considered in this analysis. The significant share criterion specifies that the secondary airport must account for at least 5 percent or more of the local originating traffic for the metropolitan area or have a minimum of 500,000 annual local originating passengers. The criterion was expanded for the Chicago Metropolitan Area. GYY and RFD were included in the Chicago Metropolitan Area for consistency with the definition used in the Environmental Impact Statement for the O'Hare Modernization Program.

Criteria for Identifying Capacity-Constrained Metropolitan Areas

The candidate list of metropolitan areas was limited to those containing at least one large or medium hub, or at least two small hub airports identified as capacity-constrained in the FACT 2 analysis. From this candidate list, a metropolitan area was identified as capacity-constrained if it met one of the following three criteria:

- The total annual demand of the capacity-constrained airport(s) and the secondary commercial service airports exceeded 80 percent of the total annualized capacity of these same airports, using either the TAF or FATE demand projections, or

- No other secondary commercial service airports were located within the same metropolitan area as the capacity-constrained airport(s), or

- There were at least two large hub airports identified as capacity-constrained within the same metropolitan area.

The total annual demand is the sum of the forecasts of total operations (arrivals and departures) for the individual airports in the metropolitan area. The total annualized capacity is the sum of the annualized capacities for the individual airports in the metropolitan area. The annualized capacity is determined by multiplying the hourly benchmark capacities for VMC and IFR conditions, weighted by the annual percentages of VMC and IFR weather, and then multiplying by the number of operating hours per day and by 365 days per year.

In a multi-airport metropolitan area, if the total metropolitan area demand was determined to be at least 80 percent of the total metropolitan area (for either the TAF or FATE demand projections), then it was identified as capacity-constrained. This percentage is a recognition that demand is not perfectly transferable from one airport to another: passengers who are far away from an airport are less likely to use it rather than a closer airport, even if the closer airport does have delay problems.

If there was only a single commercial service airport in the metropolitan area and it was capacity-constrained, this would indicate the need for additional capacity in that metropolitan area. If the capacity cannot be easily added to the existing airport, it might be necessary to develop other commercial service airports in the area. Similarly, if there are two large hub airports in the metropolitan area and both are capacity-constrained, this is a good indicator that additional service to secondary airports should be considered to help reduce the congestion at the primary airports.

In Closing

A system-wide analysis such as this, including a large number of airports and forecasting well into the future, inherently contains a number of variabilities and uncertainties. Consequently the methodology was structured in a conservative manner, to identify only those airports where multiple studies agreed that future delays would be excessive. Such an analysis cannot substitute for the more detailed modeling and analysis performed at the local level, with greater depth and greater attention to local factors. However, this evaluation of future needs can help the FAA identify airports needing additional attention now, possibly to include more detailed analysis and planning, in order to avoid a larger problem later.

APPENDIX E: COMPARING THE FACT 1 AND FACT 2 FINDINGS

Comparison of FACT 1 (2003) and FACT 2 (2007) Results after Planned Improvements

Figure E1

FACT 1 (2003) Results after Planned Improvements

- 5 airports that need additional capacity in 2003
- 1 metro area that needs additional capacity in 2003

Figure E2

Comparison of FACT 1 (2003) and FACT 2 (2007) Results after Planned Improvements

- 3 airports identified in both FACT 1 and FACT 2
- 0 metro areas identified in both FACT 1 and FACT 2
- 0 airports newly identified in FACT 2
- 1 metro area newly identified in FACT 2
- 2 airports no longer meeting FACT criteria
- 1 metro area no longer meeting FACT criteria

Table E1

Comparison of FACT 1 (2003) and FACT 2 (2007) Results after Planned Improvements

● Continues to need additional capacity based on the results of both studies

⊕ Identified with the new FACT 2 criteria

⊗ No longer needing additional capacity assuming planned improvements are completed

Airports Needing Additional Capacity	2003 (FACT 1)	2007 (FACT 2)
● LaGuardia (LGA)	✓	✓
● Newark Liberty International (EWR)	✓	✓
● O'Hare International (ORD)	✓	✓
⊕ Fort Lauderdale-Hollywood International (FLL)		✓
⊗ Hartsfield-Jackson Atlanta International (ATL)	✓	
⊗ Philadelphia International (PHL)	✓	
Total	**5**	**4**

Metropolitan Areas Needing Additional Capacity	2003 (FACT 1)	2007 (FACT 2)
⊕ New York		✓
⊗ Atlanta	✓	
Total	**1**	**1**

Comparison of FACT 1 (2013) and FACT 2 (2055) Results after Planned Improvements

Figure E3

FACT 1 (2013) Results after Planned Improvements

- 15 airports that need additional capacity in 2013
- 7 metro areas that need additional capacity in 2013

Figure E4

Comparison of FACT 1 (2013) and FACT 2 (2015) Results after Planned Improvements

- 6 airports identified in both FACT 1 and FACT 2
- 3 metro areas identified in both FACT 1 and FACT 2
- 0 airports newly identified in FACT 2
- 1 metro area newly identified in FACT 2
- 9 airports no longer meeting FACT criteria
- 4 metro area no longer meeting FACT criteria

Table E2

Comparison to FACT 1 Results for 2013 after Planned Improvements

● Continues to need additional capacity based on the results of both studies

⊕ Identified with the new FACT 2 criteria

⊗ No longer needing additional capacity assuming planned improvements are completed

Airports Needing Additional Capacity	2013 (FACT 1)	2015 (FACT 2)
● John Wayne-Orange County (SNA)	✓	✓
● LaGuardia (LGA)	✓	✓
● Long Beach-Daugherty Field (LGB)	✓	✓
● Metropolitan Oakland International (OAK)	✓	✓
● Newark Liberty International (EWR)	✓	✓
● Philadelphia International (PHL)	✓	✓
⊗ Albuquerque International Sunport (ABQ)	✓	
⊗ Bob Hope (BUR)	✓	
⊗ Fort Lauderdale-Hollywood International (FLL)	✓	
⊗ John F. Kennedy International (JFK)	✓	
⊗ O'Hare International (ORD)	✓	
⊗ Palm Beach International (PBI)	✓	
⊗ San Antonio International (SAT)	✓	
⊗ Tucson International (TUS)	✓	
⊗ William P. Hobby (HOU)	✓	
Total	**15**	**6**

Metropolitan Areas Needing Additional Capacity	2013 (FACT 1)	2015 (FACT 2)
● Los Angeles	✓	✓
● New York	✓	✓
● San Francisco	✓	✓
⊕ Philadelphia		✓
⊗ Austin-San Antonio	✓	
⊗ Chicago	✓	
⊗ South Florida	✓	
⊗ Tucson	✓	
Total	**7**	**4**

Comparison of FACT 1 (2020) and FACT 2 (2025) Results after Planned Improvements

Figure E5

FACT 1 (2020) Results after Planned Improvements

- 18 airports that need additional capacity in 2020
- 8 metro areas that need additional capacity in 2020

Figure E6

Comparison of FACT 1 (2020) and FACT 2 (2025) Results after Planned Improvements

- 8 airports identified in both FACT 1 and FACT 2
- 5 metro areas identified in both FACT 1 and FACT 2
- 6 airports newly identified in FACT 2
- 3 metro areas newly identified in FACT 2
- 10 airports no longer meeting FACT criteria
- 3 metro area no longer meeting FACT criteria

Table E3

Comparison of FACT 1 (2020) and FACT 2 (2025) Results after Planned Improvements

● Continues to need additional capacity based on the results of both studies

⊕ Identified with the new FACT 2 criteria

⊗ No longer needing additional capacity assuming planned improvements are completed

Airports Needing Additional Capacity	2020 (FACT 1)	2025 (FACT 2)
● Hartsfield-Jackson Atlanta International (ATL)	✓	✓
● John Wayne-Orange County (SNA)	✓	✓
● LaGuardia (LGA)	✓	✓
● Long Beach-Daugherty Field (LGB)	✓	✓
● McCarran International (LAS)	✓	✓
● Metropolitan Oakland International (OAK)	✓	✓
● Midway Airport (MDW)	✓	✓
● Newark Liberty International (EWR)	✓	✓
⊕ Fort Lauderdale-Hollywood International (FLL)		✓
⊕ John F. Kennedy International (JFK)		✓
⊕ Philadelphia International (PHL)		✓
⊕ Phoenix Sky Harbor International (PHX)		✓
⊕ San Diego International (SAN)		✓
⊕ San Francisco International (SFO)		✓
⊗ Albuquerque International Sunport (ABQ)	✓	
⊗ Birmingham International (BHM)	✓	
⊗ Bob Hope (BUR)	✓	
⊗ Bradley International (BDL)	✓	
⊗ Long Island MacArthur International (ISP)	✓	
⊗ Ontario International (ONT)	✓	
⊗ San Antonio International (SAT)	✓	
⊗ T.F. Green (PVD)	✓	
⊗ Tucson International (TUS)	✓	
⊗ William P. Hobby (HOU)	✓	
Total	**18**	**14**

Metropolitan Areas Needing Additional Capacity	2020 (FACT 1)	2025 (FACT 2)
● Atlanta	✓	✓
● Las Vegas	✓	✓
● Los Angeles	✓	✓
● New York	✓	✓
● San Francisco	✓	✓
⊕ Philadelphia		✓
⊕ Phoenix		✓
⊕ San Diego		✓
⊗ Austin-San Antonio	✓	
⊗ Birmingham	✓	
⊗ Tucson	✓	
Total	**8**	**8**