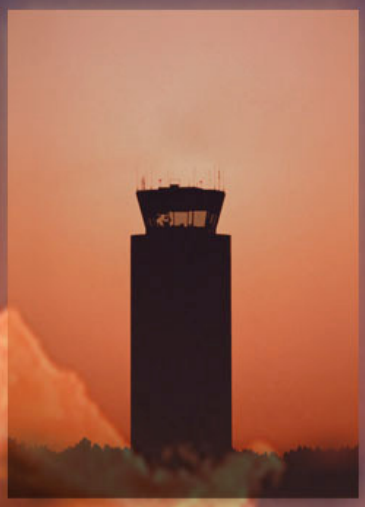
Capacity Needs in the National Airspace System

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



U.S. Department of Transportation
Federal Aviation Administration
The MITRE Corporation
Center for Advanced Aviation System Development

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U.S. Department
of Transportation
Federal Aviation Administration

Office of the Administrator

800 Independence Ave., SW.
Washington, DC 20591

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You are about to read a study that takes a new approach to assessing our country's future needs for airport capacity. This study looks at population trends, economic and societal shifts, and the changing dynamics of the airline industry. It compares that data with planned infrastructure improvements at our airports and projects where future capacity constraints will occur.

The time is right to do this. The aviation industry is going through a difficult period. The blows that hit the U.S. economy so hard after 9-11 landed squarely on the back of the aviation industry. But more passengers are returning to the air. Nine of our 35 major airports are operating above 9-11 levels. And by the end of 2004, we expect a return to pre-9-11 operating levels at 15 major airports, including seven of the top ten.

So, what does the future hold? The changes are clear and profound. Starting before 9-11, and accelerating since then, business travelers are revisiting their travel needs and choices. Demand for low-fare service is strong and growing stronger. The internet has led to price transparency that today allows consumers to "shop around" and compare prices for competing carriers in minutes. Fractional ownership is also offering business travelers new options. And smaller aircraft are promising travelers greater schedule and destination choices.

Our data indicate that many existing airports will need to be expanded to meet future demand, and in a few instances, new airports will need to be pursued to meet growth challenges. The metropolitan areas that have traditionally driven aviation demand will continue to do so, but new metropolitan areas in the South and Southwest are emerging as needing critical capacity as well. And unfortunately, we have metropolitan areas on both coasts where demand will outstrip capacity without adequate solutions in sight.

The Government's most significant and challenging role in this dynamic environment is to examine where the requirements are and to work for the development of the infrastructure and capacity to accommodate whatever level and type of demand the market may bring. Since the summer of 2000, when congestion choked the system, airport owners have poured a lot of concrete,

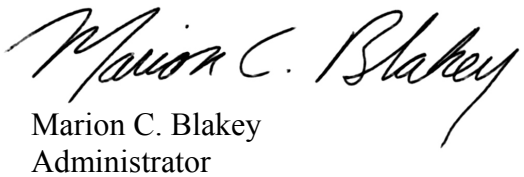
added new runways, and made solid progress in expanding this Nation's physical infrastructure. Our program of strategic investments under the Operational Evolution Plan (OEP) is intended to keep pace with demand over the next decade. The OEP is a 10-year plan to increase the capacity and efficiency of the National Airspace System. It focuses on infrastructure -- primarily new runways -- and technological and procedural initiatives at the top 35 airports.

The Department of Transportation, under the leadership of Secretary Mineta, wants to ensure that the long-term capacity of the aviation system matches forecasts of demand. This study asks:

- Which of the 35 OEP airports will be able to meet future demand and which will not and why?

- Besides the 35 OEP airports, will there be other geographic areas of the country unable to accommodate demand for air transportation?

Our study looks further into the future and takes a different approach than we have before by comparing demand and capacity levels not only at airports, but in metropolitan areas as well to determine where future capacity constraints may emerge. This will underscore the importance of continuing the investment plans now in place in order to be ready for future airport capacity demands. We do this with the conviction that if we provide accurate data and credible forecasts, communities around the country will step up to the plate. They need to help make sure they have a dynamic place in our aviation system -- one that provides such vital support for our Nation's economy and social fabric.



Marion C. Blakey
Administrator

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Purpose

This study was undertaken because the Federal Aviation Administration wanted to assure that the long-term capacity of the aviation system matched forecasts of demand. It is important to look not only at individual airports in the longer term, but also at the infrastructure of the airport network to ensure sufficient capacity to meet that demand. To that end, two basic questions were asked by the FAA:

- Which of the 35 Operational Evolution Plan (OEP) airports will be able to meet future demand and which will not and why?
- Besides the 35 OEP airports, will there be other geographic areas of the country unable to accommodate demand for air transportation?

The OEP is a 10-year plan to increase the capacity and efficiency of the National Airspace System. It focuses on infrastructure - - primarily new runways - - and technological and procedural initiatives. The first OEP report was issued in December of 2001. It is published annually. It focuses on 35 of the busiest US airports (the 31 large hubs plus MEM, CLE, DCA, and PDX). It is divided into four core problem areas: airport weather condition, en route severe weather, en route congestion, and arrival/departure rate. FAA's Airports organization determines when a proposed runway is ready for inclusion in the OEP and monitors its progress with support from the Air Traffic, System Capacity, and Region and Center Operations organizations in the FAA. A new runway at an OEP airport is added when we are reasonably certain of its alignment, schedule, configuration, and planned use.

In March 2003, a team was assembled to develop answers to these questions. The team, led by the Airports organization (ARP), and including representatives of the Air Traffic Organization (ATO) and the MITRE Corporation's Center for Advanced Aviation System Development (CAASD), began the Future Airport Capacity Task (FACT), an assessment of the future capacity of the nation's airports and metropolitan areas.

Overview of Methodology

There have been several well-documented studies to evaluate airfield capacity at the busiest 35 airports. The purpose of the FACT effort is to bring these studies together in order to develop a common list of airports (or associated metropolitan areas) that may need additional capacity. Bringing these studies together required extensive amounts of information to ensure consistency among them, including information on:

- current operations
- current capacity at individual airports
- how operations may change in the future
- how new technologies and runways will contribute to increasing airport capacity

- what demand levels are likely to exist in the future
- where that demand is most likely to occur.

Once this information was gathered it was possible to perform the necessary analyses to identify where additional capacity may be necessary.

Top 35 airports

The initial focus of this effort concentrated on the 35 airports currently tracked as part of the OEP. To be identified on the common list of airports it was necessary for these airports to satisfy the criteria of each individual study, under two different future traffic level assumptions: one using the 2002 Terminal Area Forecast (TAF) and the other using demand estimates produced by CAASD's experimental model of origin and destination (O&D) traffic (a total of six criteria). If any of the criteria was not met in either future demand scenario, then an airport was not included on the common list. Because the requirement for commonality was so strict, the results of this assessment should be viewed as a minimal list of airports needing additional future capacity. The specific criteria used for each individual study are described below:

- **Annual Service Volume (ASV):** The annual level of traffic that results in a given level of average delay, known as ASV, was calculated as part of the capacity assessment used in this analysis. ASV considers multiple runway configurations and utilizes an annual estimation of weather conditions for each configuration in its calculation. A ratio of annual demand to ASV estimated at 0.8 or above (demand at least 80% of capacity) was an indication that an airport may need additional capacity.
- **NAS-wide simulation of airport arrival delay:** Another way of estimating the future performance of airports is by using a simulation model to estimate future levels of delay. Capacity information is combined with traffic information and used as inputs to a simulation model. The model then calculates average delay for individual airports. High levels of delay indicate a potential need for additional capacity while lower levels of delay could indicate adequate capacity to meet demand expectations. For the purpose of this analysis, average arrival delay estimated at 12 minutes per flight or above was an indication that an airport may need additional capacity.
- **Extrapolation of historical data:** A third way to estimate future performance is to use historical data to extrapolate potential changes in performance while accounting for changing levels of demand and capacity. Using the FAA's Aviation System Performance Metrics (ASPM) database, "Airborne Delay" was used as an estimate of the arrival delay due to capacity at the airport, and "Taxi Out Delay" was used as a measure of airport-related departure delay. Also calculated was the ratio of annual traffic to an annualized capacity at each airport (based upon hourly airport capacities in VMC, MMC, and IMC). If the extrapolated delay was estimated to exceed 4.5 minutes per flight or the demand/capacity ratio was 0.95 or above, that was an indication that an airport may need additional capacity.

Recall that each of these criteria needed to be satisfied under each traffic level assumption. Requiring the criteria to be met using the two different traffic levels provided some level of sensitivity analyses around the results.

Other airports

This analysis was later expanded to include 291 commercial service airports across the country, including an analysis of capacity in 223 metropolitan areas. The reason for expanding the list beyond the top 35 airports was to approach the question of which airports and metropolitan areas may need additional capacity in the future. The information available about, and the knowledge of, the top 35 airports was much more extensive than the information about these other airports. Because of this, the criteria used in this assessment for the top 35 airports were much more stringent than the criteria for the other airports. For airports beyond the top 35, a simple analysis of annual demand versus annualized capacity was performed. If the predicted demand was expected to be at least 90% of the available capacity, that was an indication that an airport may need additional capacity. As more detailed modeling is done in the future, a set of criteria similar to that used for the top 35 airports will be utilized.

Socio-economic demand modeling

The principal forecast of future operations was the 2002 TAF. For the OEP 35 airports, the TAF makes projections of future enplanements and operations on an airport-by-airport basis based upon the economic and demographic characteristics of the airport metropolitan area. As a secondary source of information, this analysis also considered demand estimates produced by CAASD's experimental model of origin and destination (O&D) traffic. Similar to the TAF, this model produces forecasts of demand based upon the economic and demographic trends. Unlike the TAF though, the 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 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 fleet necessary to handle the passenger traffic. This additional estimate of future traffic levels was then utilized as part of the demand/capacity analysis.

Capacity modeling

Three years were selected for analysis: 2003 was used as the present-day baseline; 2013 was chosen because it is the last year covered by version 5 of the OEP; and 2020, because it was the time horizon of the 2002 TAF. The 2013 evaluation assumed that all new runways and procedural improvements outlined in the FAA's Operational Evolution Plan (OEP), version 5.0 would be implemented at the top 35 airports. For the 2020 capacity assessment, all active plans for additional runways and airport reconfigurations were taken into account. Also included were optimistic assumptions about future technology and procedures at the top 35 airports. These assumptions were based on various research

proposals and extrapolations from the latest OEP because there is no similar report that would indicate likely capacity improvements by 2020.

Findings in Brief

General

- As air traffic levels continue to grow over time, it is well known that the additional demands placed upon the NAS will strain the system's capacity. However, the FACT analysis shows that even today there are areas in the NAS where additional capacity is needed, and these needs will grow even stronger as traffic levels continue to increase. Based upon this study, it is expected that approximately 5 percent of the nearly 300 airports analyzed will require additional capacity by either 2013 or 2020.
- This study indicates that airports other than the top 35 tracked by the FAA's current OEP will potentially need additional capacity in the future. As more detailed studies are performed at those airports, it may be shown that they warrant inclusion in the OEP to better track planned improvements over time.
- Growth trends will continue to affect many of the same metropolitan areas that historically have had a need for additional capacity. This study indicates that the predominant trend over the next two decades largely will be the expansion of existing airports to meet forecast demand. At the same time, new metropolitan areas have emerged as needing additional capacity in the future. These metropolitan areas are mostly in the south and southwest. Increases in air traffic congestion in some metropolitan areas, however, may lead to the establishment of new supplemental airports such as the proposed Ivanpah airport near Las Vegas, NV and the proposed South Suburban Airport near Chicago, IL. (A replacement airport at San Diego, CA may also be a possibility.)

Capacity needs in 2003

The FACT analysis identified five airports where additional capacity is necessary today (see Figure ES-1):

- Hartsfield-Jackson Atlanta International (ATL)
- Newark Liberty International (EWR)
- New York LaGuardia (LGA)
- Chicago O'Hare International (ORD)
- Philadelphia International (PHL).

In addition to these airports, the Atlanta metropolitan area was also identified as needing additional capacity. The Atlanta metropolitan area was identified because ATL is the only commercial service airport in the Atlanta metropolitan area, which leaves no opportunity for relief of the congestion occurring there.

Figure ES - 1. Airports and Metro Areas that Need Additional Capacity in 2003

Capacity needs in 2013

Future capacity for 2013 was based on planned improvements contained in the OEP version 5.0. Even assuming those improvements, 15 airports are identified as needing additional capacity (see Figure ES-2):

- Metropolitan Oakland International (OAK)
- Bob Hope (Burbank, CA) (BUR)
- Long Beach (LGB)
- John Wayne-Orange County (SNA)
- Tucson International (TUS)
- Albuquerque International Sunport (ABQ)
- San Antonio International (SAT)
- Houston Hobby (HOU)
- Chicago O'Hare International (ORD)[1]
- New York LaGuardia (LGA)
- New York Kennedy International (JFK)

[1] Note that OEP v.5.0 did not include the O'Hare Modernization Plan (OMP), which will reconfigure the runways at ORD for additional capacity. However, the effects of the OMP are included in the 2020 analysis.

- Newark Liberty International (EWR)
- Philadelphia International (PHL)
- Palm Beach International (PBI)
- Fort Lauderdale-Hollywood International (FLL).

Seven metropolitan areas are also identified as needing additional capacity by 2013: San Francisco Bay, Los Angeles Basin, Tucson, Austin-San Antonio, Chicago, New York Metro, and South Florida.

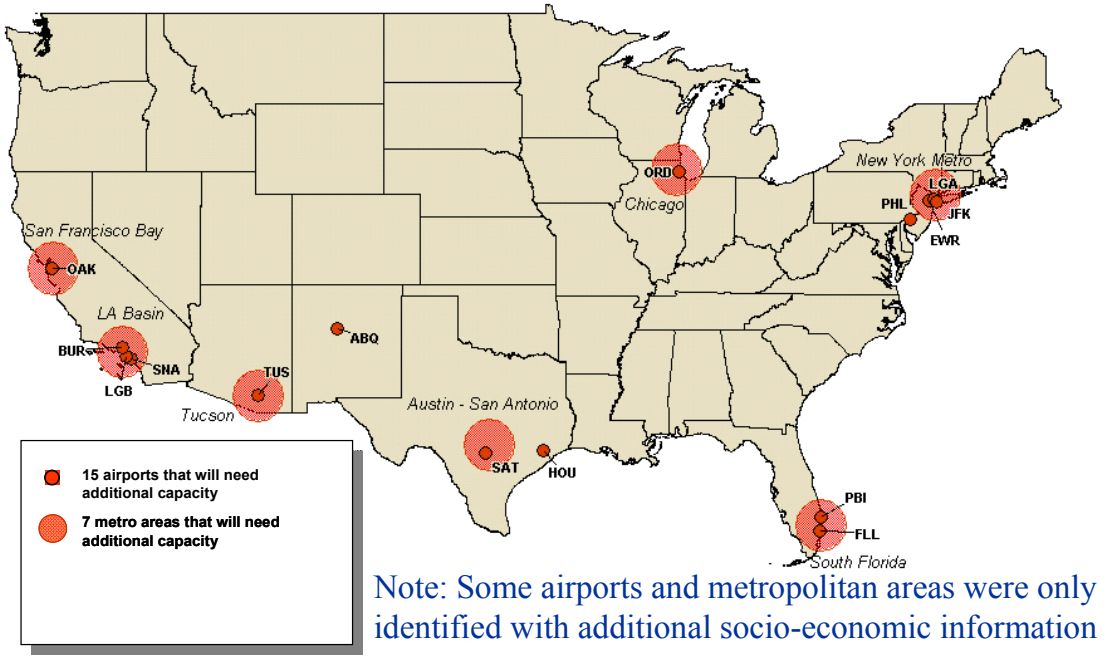


Figure ES - 2. Airport and Metro Areas that Need Additional Capacity in 2013 (After Assumed Improvements)

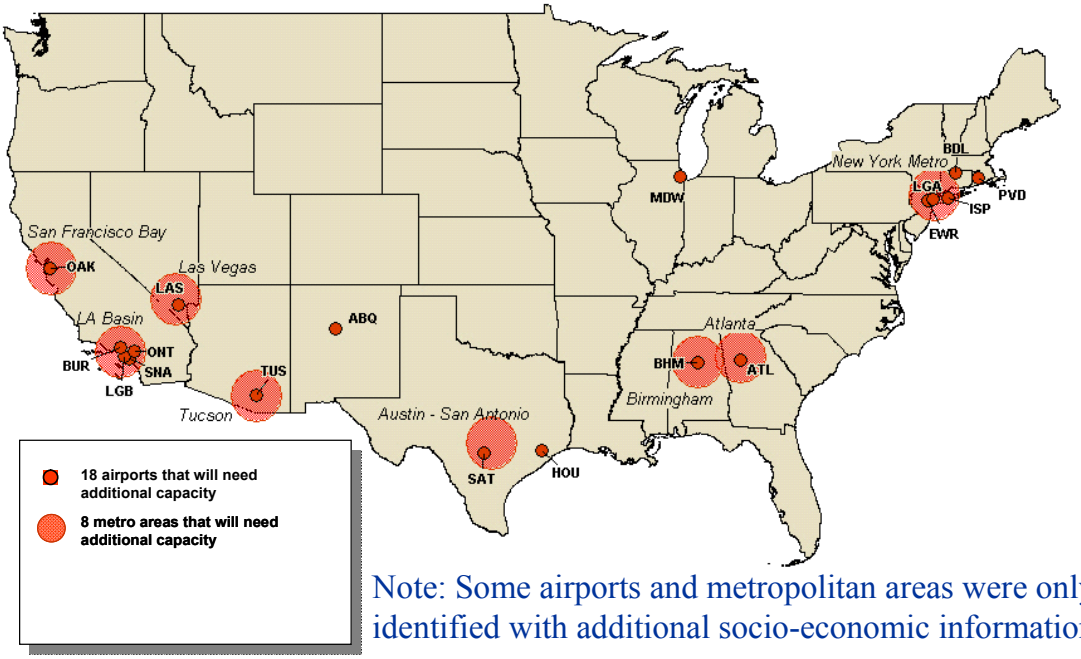
Most of these airports and metropolitan areas are located in the southern part of the country where shifts in population and the industrial base are occurring. Furthermore, if the improvements proposed in the OEP do not take place, the number of airports with capacity problems in 2013 jumps from 15 to 26.

Capacity needs in 2020

For the year 2020, future capacity was based on assumed improvements in technology and procedures, as well as the implementation of runway construction projects not listed in the OEP. Even with those assumed improvements, 18 airports are identified as likely needing additional capacity (see Figure ES-3):

- Metropolitan Oakland International (OAK)
- Bob Hope (Burbank, CA) (BUR)

- Long Beach (LGB)
- John Wayne-Orange County (SNA)
- Ontario International (ONT)
- Las Vegas McCarran International (LAS)
- Tucson International (TUS)
- Albuquerque International Sunport (ABQ)
- San Antonio International (SAT)
- Houston Hobby (HOU)
- Chicago Midway International (MDW)
- Birmingham International (BHM)
- Hartsfield-Jackson Atlanta International (ATL)
- Bradley International (BDL: Windsor Locks, CT)
- T.F. Green (PVD: Providence, RI)
- Long Island MacArthur (ISP)
- New York LaGuardia (LGA)
- Newark Liberty International (EWR).



Note: Some airports and metropolitan areas were only identified with additional socio-economic information

Figure ES - 3. Airport and Metro Areas that Need Additional Capacity in 2020 (After Assumed Improvements)

Eight metropolitan areas are identified as likely needing additional capacity by 2020: San Francisco Bay, Los Angeles Basin, Las Vegas, Tucson, Austin-San Antonio, Birmingham, Atlanta, and New York Metro. As is true in 2013, most of these airports and metropolitan areas are occurring in the southern part of the country where shifts in population and the industrial base are occurring.

Again, however, if no improvements over today's level of capacity take place, the number of capacity-constrained airports rises from 18 to 41.

Other Airports with Capacity or Delay Constraints that Warrant Further Action

The FAA believes that the criteria used in this study has produced results that accurately reflect where our efforts at capacity enhancement should be directed. However, any study that attempts to identify the most significant areas where capacity constraints are likely to occur may not capture all of the dynamics associated with growth in demand and resultant delay. This is a constantly changing, very fluid environment. While the criteria developed and applied in this study proved to be a useful filter for determining significant capacity needs, it must be recognized that a number of airports not meeting the highly selective criteria used in this study, may need to capitalize on local capacity enhancement opportunities. Such airports as Dulles International (IAD), San Diego International (SAN), and San Francisco International (SFO) certainly fall within this group and further examination of these locations among others may be necessary:

- At IAD, the likelihood that new carriers (e.g., Independence Air and TED) will shortly add flights at this airport, adds to concerns about adequate capacity. Much more rapid growth may be experienced at this location than is suggested by recent forecasts.
- SAN is the only large-hub airport in the U.S. with a single, range-limited air carrier runway. The airport has geographic and terrain issues that constrain its ability to adequately handle future growth. The airfield is constrained by displaced thresholds and numerous modifications to standards. Furthermore, due to these issues and the type of activity at this facility, SAN may not be able to realize the capacity benefits of future technology assumed in this study. The FAA is aware of the studies completed by the airport sponsor that support the need for additional capacity within the 2020 timeframe. As a result of these unique issues, further study of SAN is indicated.
- Because of the increasing traffic levels at SFO and higher levels of forecast demand, a separate sensitivity analysis based on the 2003 TAF was conducted. This analysis indicates that SFO could be in need of additional capacity as early as 2015.

The stated purpose of this study is to identify airports and metropolitan areas with present or future capacity problems. However, a number of airports are dealing with important issues associated more with delay reduction than with increase in capacity and are as deserving of attention. Such airports as Boston Logan International and Seattle-Tacoma

International should be included in this category. The new runways at each of these airports are will help better manage the peak levels of delay that each currently experiences.

A System in Transition

These results are based upon forecasts of an unknown future. Changes in future demand and capacity projections are likely as the underlying assumptions are updated. The difference between the 2002 TAF and the recently released 2003 TAF is one example of this. (See Appendix D for a discussion of the sensitivity analysis performed using the FY 2003 TAF.) As different forecasts are developed and system enhancement plans mature over time, the results of a study such as this will likely change as well. In addition, major changes that occur locally, such as the introduction of a new air carrier expected at Washington Dulles International (IAD) in the summer of 2004, can drastically alter future demand predictions. These alterations can suddenly change the situation at an airport from having adequate capacity to needing more capacity for the new levels of demand. For these reasons it is important to track changes in assumptions over time and then update analytic results accordingly.

Conclusions

- The predominant trend over the next two decades largely will be the expansion of existing airports to meet forecast demand. Because of the long lead times necessary to bring large complex runway projects on line, current improvement plans must move forward to keep pace with demand forecast for 2013. If the planned improvements do not occur for any reason, the number of airports experiencing capacity shortages will grow sharply.
- The long lead times also necessary to move research out of the lab and into the field, to equip aircraft with the latest technologies, and to implement procedural changes require that this vital work move forward to address future demand/capacity mismatches in 2013 and 2020.
- This study focused on three distinct time periods: 2003, 2013 and 2020. Although some airports do not meet the criteria for needing additional capacity in the time periods studied, it is possible that they would meet the criteria in intermediate years (prior to the implementation of the improvements considered in this report). In other words, some airports not meeting these criteria until 2020 may actually reach that state as early as 2014. This highlights the need to press ahead with development plans.
- Even planned improvements will not be sufficient at some locations. Therefore, plans for capacity enhancements, including new runways and, in limited cases, new airports must continue and more new runways must be planned.
- Ambitious assumptions were made for improvements projected for 2020; some of these improvements may not materialize and even these assumed improvements will not be sufficient at some locations. Most importantly, the majority of the assumed improvements in 2020 do not have formal plans associated with them.

This makes it ever more important to begin to formalize capacity improvement plans for the 2020 timeframe.

- Additional analyses are necessary to develop possible solutions for the identified airports; this is particularly true for the non-OEP airports in order to gain a better understanding of their capabilities, operations, and local regulations.
- For all the airports, detailed feedback and information obtained through discussions with them will need to be incorporated into future iterations of this study. Solutions beyond those considered here, including policy options, need to be explored.
- In addition to new runways and airports, procedures, technologies, and policy options should be explored.
- The FAA must manage its budget and programs responsibly to ensure that the development of new technological improvements remains on track.

Capacity Needs in the National Airspace System Report

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

Purpose

This study was undertaken because the Federal Aviation Administration wanted to assure that the long-term capacity of the aviation system matched forecasts of demand. It is important to look not only at individual airports in the longer term, but also at the infrastructure of the airport network to ensure sufficient capacity to meet that demand. To that end, two basic questions were asked by the FAA:

- Which of the 35 Operational Evolution Plan (OEP) airports will be able to meet future demand and which will not and why?
- Besides the 35 OEP airports, will there be other geographic areas of the country unable to accommodate demand for air transportation?

In March 2003, a team was assembled to develop answers to these questions. The team, led by the Airports organization (ARP), and including representatives of the Air Traffic Organization (ATO) and the MITRE Corporation's Center for Advanced Aviation System Development (CAASD), began the Future Airport Capacity Task (FACT), an assessment of the future capacity of the nation's airports and metropolitan areas. The goal of the Future Airport Capacity Task was to determine which airports may need additional capacity in the future and why. In addition to identifying the airports, any constraints and limitations to enhancing their capacity were also examined.

The OEP is a 10-year plan to increase the capacity and efficiency of the National Airspace System. It focuses on infrastructure - - primarily new runways - - and technological and procedural initiatives. The first OEP report was issued in December of 2001. It is published annually. It focuses on 35 of the busiest US airports (the 31 large hubs plus MEM, CLE, DCA, and PDX). It is divided into four core problem areas: airport weather condition, en route severe weather, en route congestion, and arrival/departure rate. FAA's Airports organization determines when a proposed runway is ready for inclusion in the OEP and monitors its progress with support from the Air Traffic, System Capacity, and Region and Center Operations organizations in the FAA. A new runway at an OEP airport is added when we are reasonable certain of its alignment, schedule, configuration, and planned use.

There have been several well-documented studies to evaluate airport capacity at the busiest 35 airports. Annual Service Volume[2] (ASV), Airport Capacity Benchmarks, and

[2] FAA Advisory Circular 150/5060-6 *Airport Capacity and Delay,* Date 9/23/83, Chapter 1. Airport Capacity and Aircraft Delay, Section 1-3. Capacity Terms, b. Annual Service Volume (ASV)

the OEP System Performance Assessment[3] are three of these studies. The focus of the FACT effort was to bring these studies together in order to develop a very selective criteria set highlighting airports (or associated metropolitan areas) that have the most significant capacity needs. If an airport failed to meet the criteria of any individual study, then it was not identified by the FACT study as a member of the common list of airports needing additional capacity. Airports not identified in this analysis may have been identified in one or more of the studies, but not in all of them. Because the requirement for commonality was so strict, the results of this assessment should be viewed as a list of airports in the greatest need of additional future capacity among a larger group of airports facing significant capacity constraints.

The initial focus of this effort concentrated on the 35 airports currently tracked as part of the FAA's Operational Evolution Plan (OEP), version 5.0. This analysis was later expanded to include 291 commercial service airports in 223 metropolitan areas across the country. The idea of expanding the list beyond the top 35 airports was to approach the question of which airports and metropolitan areas of the country may be unable to accommodate demand for air transportation in 2020. For airports other than the top 35, a future demand predicted to be at least 90 percent of available capacity was used to indicate a need for additional capacity. As more detailed modeling is done in the future, a similar set of criteria to that used for the top 35 airports will be utilized.

Due to data limitations, a simplified approach was taken for airports beyond the top 35. Although more detailed assessments were performed whenever possible, the results for these airports should still be regarded as preliminary until more detailed analyses can be completed. This study is intended to complement detailed local airport planning activities, not as a substitute for such efforts. Where more detailed studies are available at individual locations, the results of those studies should be carefully considered in planning future capacity improvements and airport development.

By using multiple methodologies and criteria, this study has identified those airports with the most obvious need for additional capacity in the future. But clearly, other airports not identified by this study are in need capacity improvements. One should not assume that these airports will have adequate capacity. Many airports not identified in this analysis must continue to plan for future capacity improvements. The purpose of this analysis was to look across the NAS to highlight the most obvious capacity shortcomings, in order to help guide future analysis and planning; not to be the sole determinant of where capacity improvements will be necessary.

At some airports, projects are currently underway to address problems other than capacity such as delay reduction. As the FACT is focused on increasing capacity, these airports and their need for such improvements may not have been identified on the common list. However, it is important that these projects continue to move forward.

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[3] Solomos et al., *Modeling NAS Performance Assessment Results of OEP 5.0*, 8 December 2003, The MITRE Corporation, McLean, VA

Coordination With Affected Airports

In January and February 2004 the FACT analysis was coordinated with each of the airports identified as needing additional capacity in the future, some 24 airport sponsors in total. We wanted to provide each facility with the assumptions we used regarding fleet mix, runway configuration and any constraints or limitations to the operational flexibility of the airport. In most cases, the airports agreed with our assumptions, while others thought we were overly aggressive particularly with the longer-term enhancements. In those cases, we adjusted our assumptions to be more in line with those of the airport.

Although each coordination meeting with the airports was different, there were several common issues that were repeated from airport to airport. While these will not be specifically discussed here, a summary of these commonalities follows:

- Airfield is not necessarily the limiting factor. Terminal Buildings limit the number of annual passengers, which in turn limits the number of operations. If terminals could be expanded, operations may increase placing an additional burden on the airfield.
- General Aviation. Many of the airports that we visited had a significant general aviation (GA) operation. In many cases these are "high end" GA, business jet type aircraft that typically use the main air carrier runway rather than a shorter GA runway. A fast growing segment of the GA community is the fractional ownership of aircraft. Since there may be several owners of such an aircraft the number of operations may increase at a much greater rate than based aircraft. These fractional ownership aircraft are also high end GA, and may be as large as the Boeing 737 Business Jet.
- Airspace limitations. The ability of the airspace around many of the airports to accommodate more arrivals and departures may be limited, especially where several major airports are in the same area (Southern California, Northern California, 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.
- Roadway limitations. As airports are gaining additional passengers and traffic, particularly the smaller commercial service airports, a limiting factor is the off-airport roadway network. The roads leading into the airports are not able to accommodate this increase in surface traffic without congestion. At some airports the curb frontage and adjacent through lanes are not adequate for passenger drop-off and pick-up. New TSA regulations have also limited the curb frontage at many of the smaller airports.

Findings of the Study

- As air traffic levels continue to grow over time, it is well known that the additional demands placed upon the NAS will strain the system's capacity.

However, the FACT analysis shows that even today there are areas in the NAS where additional capacity is needed, and these needs will grow even stronger as traffic levels continue to increase. Based upon this study, it is expected that approximately 5 percent of the nearly 300 airports analyzed will require additional capacity by either 2013 or 2020.

- This study indicates that airports other than the top 35 tracked by the FAA's current OEP will potentially need additional capacity in the future. As more detailed studies are performed at those airports, it may be shown that they warrant inclusion in the OEP to better track planned improvements over time.
- Growth trends will continue to affect many of the same metropolitan areas that historically have had a need for additional capacity. This study indicates that the predominant trend over the next two decades largely will be the expansion of existing airports to meet the forecast. At the same time, new metropolitan areas have emerged as needing additional capacity in the future. These metropolitan areas are mostly in the south and southwest. Increases in air traffic congestion in some metropolitan areas, however, may lead to the establishment of new supplemental airports such as the proposed Ivanpah Airport near Las Vegas, NV and the proposed South Suburban Airport near Chicago, IL. (A replacement airport at San Diego, CA may also be a possibility.)

The findings of the analysis done for each of these three years are discussed below. Appendix B contains a list of the airports considered as part of the metropolitan areas described below:

Capacity Needs in 2003

Using the demand and capacity measures described later in the section on scope and methodology, the FACT analysis has identified five airports where additional capacity is already necessary today. (See Figure 1). Airfield configuration, airspace limitations and the volume of activity contribute to the capacity needs of the following five airports:

- Hartsfield-Jackson Atlanta International (ATL)
- Newark Liberty International (EWR)
- New York LaGuardia (LGA)
- Chicago O'Hare International (ORD)
- Philadelphia International (PHL).

Improvements to address the capacity needs of these airports, such as a new runway at ATL and airspace redesign in New York, are already underway or in the works. The rapid growth in operations at some airports has also triggered policy change related to acceptable traffic levels, such as that which occurred at ORD this past year.

Figure 1. Airports and Metro Areas that Need Additional Capacity in 2003

In addition to these airports, the Atlanta metropolitan area has also been identified as needing additional capacity. The Atlanta metropolitan area was identified because ATL is the only commercial service airport in the Atlanta metropolitan area, which leaves no opportunity for relief of the congestion occurring there. Other metropolitan areas, such as Chicago and New York, potentially have adequate capacity available to them due to the existence of multiple commercial service airports with excess capacity. Individual airports within these metro areas, such as ORD, EWR and LGA, do need additional capacity today. However, it may be difficult to shift traffic demand from one airport to another within a metropolitan area.

Capacity Needs in 2013

By 2013 the need for additional capacity becomes much larger. Plans identified as part of the OEP v5.0 are not enough to keep up with the projected levels of demand at the following 15 airports even after assumed improvements have been incorporated. (see Figure 2):

- Metropolitan Oakland International (OAK)
- Bob Hope (Burbank, CA) (BUR)
- Long Beach (LGB)
- John Wayne-Orange County (SNA)
- Tucson International (TUS)
- Albuquerque International Sunport (ABQ)

- San Antonio International (SAT)
- Houston Hobby (HOU)
- Chicago O'Hare International (ORD)
- New York LaGuardia (LGA)
- New York Kennedy International (JFK)
- Newark Liberty International (EWR)
- Philadelphia International (PHL)
- Palm Beach International (PBI)
- Fort Lauderdale-Hollywood International (FLL).

Seven metropolitan areas are also identified as needing additional capacity by 2013: San Francisco Bay, Los Angeles Basin, Tucson, Austin-San Antonio, Chicago, New York Metro, and South Florida.

Two of the 15 airports (BUR and PBI), as well as two of the metropolitan areas (Chicago and South Florida), were only identified using the socio-economic demand model. Figure 2 shows the locations of airports and metropolitan areas needing additional capacity.

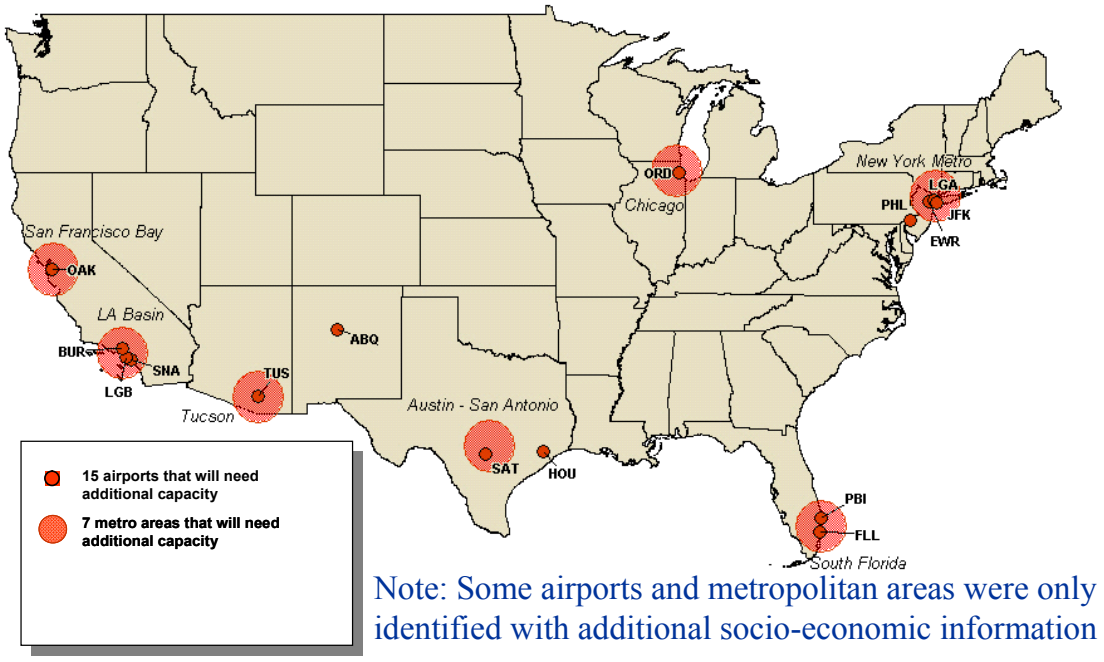

Figure 2. Airport and Metro Areas that Need Additional Capacity in 2013 (After Assumed Improvements)

Airfield configuration, airspace limitations and the volume of activity continue to limit the capacity of EWR, LGA, ORD and PHL. These factors also contribute to the need for additional capacity at FLL and JFK. Airfield redevelopment plans at ORD and PHL have not been finalized, so they were not included in this analysis until 2020. The construction of a new runway at ATL prior to 2013 results in the airport dropping off the list, at least for that year.

Airports such as ABQ, BUR, HOU, LGB, OAK, PBI, SAT, SNA, and TUS are also expected to experience a need for additional capacity. It is interesting to note that these airports are located across the entire southern part of the country from coast to coast. Growth in population and income in the surrounding metropolitan areas are a major cause of anticipated future demand.

Significant growth in the Chicago, LA Basin, New York and San Francisco Bay metropolitan areas indicate a possible need for additional capacity. In addition, expected growth in the Austin-San Antonio, South Florida, and Tucson metropolitan areas indicate a need for additional capacity. Tucson is similar to Atlanta in that it has only one commercial service airport considered in the metropolitan area.

The Atlanta metropolitan area is expected to have adequate capacity by the 2013 time frame. The construction of the new runway at ATL increases the available capacity at the airport, thus affecting the entire metropolitan area.

If for any reason the planned improvements assumed at each of the airports in this analysis do not occur by 2013, the number of airports needing additional capacity may climb to as high as 26 airports: the 15 previously discussed as well as 11 additional airports (see Figure 3).

As already stated, the assumed improvements are aggressive in some cases and uncertain in others. The OEP, used as a basis for our capacity assumptions in 2013, is a 'rolling' 10-year plan and is updated annually. These updates included additional improvements, removal of some plans, and a retiming of others (either earlier or later than originally planned). Therefore, it is possible that some or all of these additional airports would experience a need for additional capacity by 2013. Furthermore, assuming that all planned improvements are implemented by 2013, it is still possible that at some time between 2003 and the incorporation of the planned improvements, the airport(s) may experience a capacity shortage. This illustrates the importance of following through on planned improvements as well as the need for additional plans to be put in place for handling the expected capacity needs.

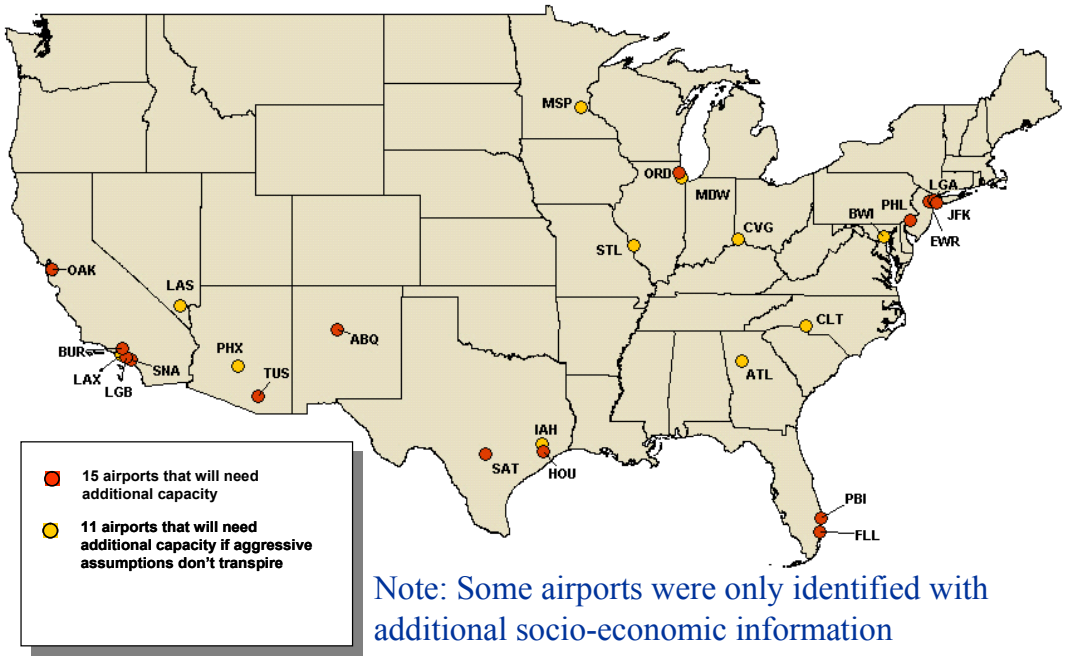

Figure 3. Airports that Need Additional Capacity in 2013
(If Planned Improvements Do Not Occur)

Capacity Needs in 2020

For the year 2020, future capacity was based on assumed improvements in technology and procedures, as well as the implementation of runway construction projects not listed in the OEP. Even with those assumed improvements, 18 airports are identified as likely needing additional capacity (see Figure 4):

- Metropolitan Oakland International (OAK)
- Bob Hope (Burbank, CA) (BUR)
- Long Beach (LGB)
- John Wayne-Orange County (SNA)
- Ontario International (ONT)
- Las Vegas McCarran International (LAS)
- Tucson International (TUS)
- Albuquerque International Sunport (ABQ)
- San Antonio International (SAT)
- Houston Hobby (HOU)
- Chicago Midway International (MDW)
- Birmingham International (BHM)

- Hartsfield-Jackson Atlanta International (ATL)
- Bradley International (BDL: Windsor Locks, CT)
- T.F. Green (PVD: Providence, RI)
- Long Island MacArthur (ISP)
- New York LaGuardia (LGA)
- Newark Liberty International (EWR).

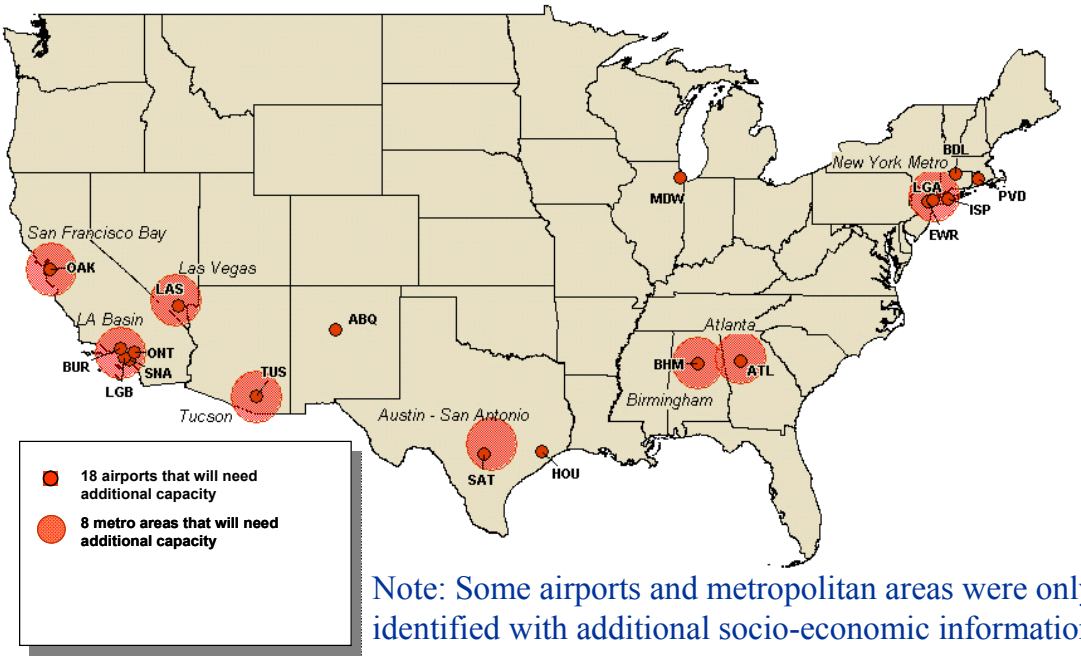

Figure 4. Airport and Metro Areas that Need Additional Capacity in 2020 (After Assumed Improvements)

Eight metropolitan areas are identified as likely needing additional capacity by 2020: San Francisco Bay, Los Angeles Basin, Las Vegas, Tucson, Austin-San Antonio, Birmingham, Atlanta, and New York Metro. As is true in 2013, most of these airports and metropolitan areas are occurring in the southern part of the country where shifts in population and the industrial base are occurring.

Five of the 18 airports (BDL, BHM, BUR, ONT and PVD), as well as one of the eight metropolitan areas (Birmingham) identified as needing additional capacity, were only identified using the socio-economic demand model. Figure 4 illustrates where all of the airport and metropolitan areas are located.

Airfield configuration, airspace limitations and the volume of activity continue to limit the capacity of EWR and LGA. These factors also contribute to the need for more capacity at MDW and LAS. The growth in traffic at ATL between 2013 and 2020 is expected to result once again in the airport having an increased capacity need.

The airports identified in the 2013 analysis (ABQ, BUR, HOU, LGB, OAK, SAT, SNA, and TUS) continue to need additional capacity. Additional airports (BHM, BDL, ISP, ONT, and PVD) also appear as capacity constrained by 2020. While the southern part of the country will continue to need more capacity, traffic growth is affecting the northeast corridor as well by this time period.

Several airports identified as needing additional capacity in 2013 no longer appear capacity constrained by 2020. If the construction of a new runway extension at FLL takes place, then the airport will be able to accommodate demand and the additional capacity need identified in the 2013 time period will be satisfied. Technology and airspace improvements should provide relief at JFK. Aggressive assumptions for the airfield reconfigurations at ORD and PHL were used in the 2020 analysis. Using these assumptions the airports are expected to have sufficient capacity to meet demand growth. PBI is expected to open a new runway by 2020 alleviating its need for additional capacity.

Five of the metropolitan areas identified in 2020 were also noted in the 2013 analysis. Continued growth in the Austin-San Antonio, LA Basin, New York, San Francisco Bay and Tucson metropolitan areas continue to drive a need for additional capacity. Although by 2013 Atlanta metropolitan area is expected to have sufficient capacity to meet demand projections, the continued growth in the region places Atlanta into a situation potentially requiring additional capacity by 2020. The Birmingham and Las Vegas metropolitan areas (which contain only one commercial service airport each in this study) were also identified as needing additional capacity. The reconfiguration of ORD and the construction of a new runway at PBI will add sufficient capacity to satisfy expected demand levels in the Chicago and South Florida metropolitan areas.

As was shown in the 2013 analysis, if for any reason the planned improvements assumed at each of the airports in this analysis do not occur by 2020, the number of airports needing additional capacity may climb to as high as 41 airports: the 18 previously discussed as well as 23 additional airports (see Figure 5). Once again it is possible that some or all of these additional airports would experience a need for additional capacity by 2020. Furthermore, as was true in the 2013 analysis the exact timing of these improvements is not illustrated. It is possible that at some time between 2013 and the incorporation of the improvements the airport(s) may experience a capacity shortage. This illustrates the importance of following through on planned improvements as well as the need for additional plans to be put in place for handling the expected capacity needs.

Again, however, if no improvements over today's level of capacity take place, the number of capacity-constrained airports rises from 18 to 41.

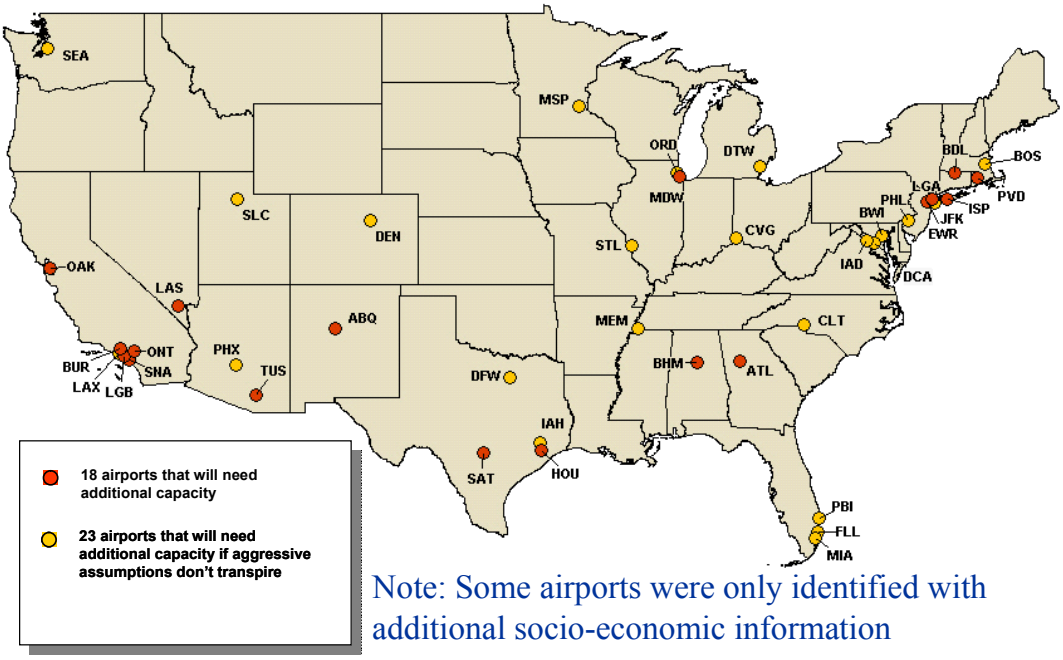

Figure 5. Airports that Need Additional Capacity in 2020 (If Planned Improvements Do Not Occur)

Other Airports with Capacity or Delay Constraints that Warrant Further Action

The FAA believes that the criteria used in this study has produced results that accurately reflect where our efforts at capacity enhancement should be directed. However, any study that attempts to identify the most significant areas where capacity constraints arelikely to occur may not capture all of the dynamics associated with growth in demand and resultant delay. This is a constantly changing, very fluid environment. While the criteria developed and applied in this study proved to be a useful filter for determining significant capacity needs, it must be recognized that a number of airports not meeting the highly selective criteria used in this study, may need to capitalize on local capacity enhancement opportunities. Such airports as Dulles International (IAD), San Diego International (SAN), and San Francisco International (SFO) certainly fall within this group and further examination of these locations among others may be necessary:

- At IAD, the likelihood that new carriers (e.g., Independence Air and TED) will shortly add flights at this airport, adds to concerns about adequate capacity. Much more rapid growth may be experienced at this location than is suggested by recent forecasts.
- SAN is the only large-hub airport in the U.S. with a single, range-limited air carrier runway. The airport has geographic and terrain issues that constrain its ability to adequately handle future growth. The airfield is constrained by displaced thresholds and numerous modifications to standards. Furthermore, due

to these issues and the type of activity at this facility, SAN may not be able to realize the capacity benefits of future technology assumed in this study. The FAA is aware of the studies completed by the airport sponsor that support the need for additional capacity within the 2020 timeframe. As a result of these unique issues, further study of SAN is indicated.

- Because of the increasing traffic levels at SFO and higher levels of forecast demand, a separate sensitivity analysis based on the 2003 TAF was conducted. This analysis indicates that SFO could be in need of additional capacity as early as 2015.

The stated purpose of this study is to identify airports and metropolitan areas with present or future capacity problems. However, a number of airports are dealing with important issues associated more with delay reduction than with increase in capacity and are as deserving of attention. Such airports as Boston Logan International and Seattle-Tacoma International should be included in this category. The new runways at each of these airports are will help better manage the peak levels of delay that each currently experiences.

A System in Transition

These results are based upon forecasts of an unknown future. Changes in future demand and capacity projections are likely as the underlying assumptions are updated. The difference between the 2002 TAF and the recently released 2003 TAF is one example of this. (See Appendix D for a discussion of the sensitivity analysis performed using the FY 2003 TAF.) As different forecasts are developed and system enhancement plans mature over time, the results of a study such as this will likely change as well. In addition, major changes that occur locally, such as the introduction of a new air carrier expected at Washington Dulles International (IAD) in the summer of 2004, can drastically alter future demand predictions. These alterations can suddenly change the situation at an airport from having adequate capacity to needing more capacity for the new levels of demand. For these reasons it is important to track changes in assumptions over time and then update analytic results accordingly.

Scope and Methodology

There have been several well-documented studies to evaluate airfield capacity at the busiest 35 airports. The purpose of the FACT effort was to bring these studies together in order to develop a very selective criteria set highlighting airports (or associated metropolitan areas) that have the most significant capacity needs. If an airport failed to meet the criteria of any individual study, then it was not identified by the FACT study as a member of the common list of airports needing additional capacity. Airports not identified in this analysis may have been identified in one or more of the studies, but not in all of them. Because the requirement for commonality was so strict, the results of this assessment should be viewed as a list of airports in the greatest need of additional future capacity among a larger group of airports facing significant capacity constraints.

Bringing these studies together required extensive amounts of information to ensure consistency among them, including information on:

- current operations
- current capacity at individual airports
- how operations may change in the future
- how new technologies and runways will contribute to increasing airport capacity
- what demand levels are likely to exist in the future
- where that demand is most likely to occur.

Once this information was gathered it was possible to perform the necessary analyses to identify where additional capacity may be necessary. An understanding of current day operations as well as the amount of capacity provided at individual airports today was necessary. How operations may change in the future as well as how new technologies and runways will contribute to increasing airport capacity needed to be determined. Demand levels that would likely exist in the future and where that demand was most likely to occur needed to be taken into account. Appendix C contains a more detailed discussion of the scope and methodology.

Top 35 airports

The initial focus of this effort concentrated on the 35 airports currently tracked as part of the OEP. To be identified on the common list of airports it was necessary for these airports to satisfy the criteria of each individual study, under two different future traffic level assumptions: one using the 2002 Terminal Area Forecast (TAF) and the other using demand estimates produced by CAASD's experimental model of origin and destination (O&D) traffic (a total of six criteria). If any of the criteria was not met in either future demand scenario, then an airport was not included on the common list. Because the requirement for commonality was so strict, the results of this assessment should be viewed as a minimal list of airports needing additional future capacity. The specific criteria used for each individual study are described below:

- **Annual Service Volume (ASV):** The annual level of traffic that results in a given level of average delay, known as ASV, was calculated as part of the capacity assessment used in this analysis. ASV considers multiple runway configurations and utilizes an annual estimation of weather conditions for each configuration in its calculation. A ratio of annual demand to ASV estimated at 0.8 or above (demand at least 80% of capacity) was an indication that an airport may need additional capacity.
- **NAS-wide simulation of airport arrival delay:** Another way of estimating the future performance of airports is by using a simulation model to estimate future levels of delay. Capacity information is combined with traffic information and used as inputs to a simulation model. The model then calculates average delay for individual airports. High levels of delay indicate a potential need for additional capacity while lower levels of delay could indicate adequate capacity to meet

demand expectations. For the purpose of this analysis, average arrival delay estimated at 12 minutes per flight or above was an indication that an airport may need additional capacity.

- **Extrapolation of historical data:** A third way to estimate future performance is to use historical data to extrapolate potential changes in performance while accounting for changing levels of demand and capacity. Using the FAA's Aviation System Performance Metrics (ASPM) database, "Airborne Delay" was used as an estimate of the arrival delay due to capacity at the airport, and "Taxi Out Delay" was used as a measure of airport-related departure delay. Also calculated was the ratio of annual traffic to an annualized capacity at each airport (based upon hourly airport capacities in VMC, MMC, and IMC). If the extrapolated delay was estimated to exceed 4.5 minutes per flight or the demand/capacity ratio was 0.95 or above, that was an indication that an airport may need additional capacity.

Recall that each of these criteria needed to be satisfied under each traffic level assumption. Requiring the criteria to be met using the two different traffic levels provided some level of sensitivity analyses around the results.

Other airports

This analysis was later expanded to include nearly 300 commercial service airports across the country, including an analysis of metropolitan area capacity. The reason for expanding the list beyond the top 35 airports was to approach the question of which airports and metropolitan areas may need additional capacity in the future. The information available about, and the knowledge of, the top 35 airports was much more extensive than the information about these other airports. Because of this, the criteria used in this assessment for the top 35 airports were much more stringent than the criteria for the other airports. For airports beyond the top 35, a simple analysis of annual demand versus annualized capacity was performed. If the predicted demand was expected to be at least 90% of the available capacity, that was an indication that an airport may need additional capacity. As more detailed modeling is done in the future, a set of criteria similar to that used for the top 35 airports will be utilized.

Socio-economic demand modeling

The principal forecast of future operations was the 2002 TAF. For the OEP 35 airports, the TAF makes projections of future enplanements and operations on an airport-by-airport basis based upon the economic and demographic characteristics of the airport metropolitan area. As a secondary source of information, this analysis also considered demand estimates produced by CAASD's experimental model of origin and destination (O&D) traffic. Similar to the TAF, this model produces forecasts of demand based upon the economic and demographic trends. Unlike the TAF though, the 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 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 fleet necessary to handle the passenger traffic. This additional estimate of future traffic levels was then utilized as part of the demand/capacity analysis.

Capacity modeling

Three years were selected for analysis: 2003 was used as the present-day baseline; 2013 was chosen because it is the last year covered by version 5 of the OEP; and 2020, because it was the time horizon of the 2002 TAF. The 2013 evaluation assumed that all new runways and procedural improvements outlined in the FAA's *Operational Evolution Plan* (OEP), version 5.0 would be implemented at the top 35 airports. For the 2020 capacity assessment, all active plans for additional runways and airport reconfigurations were taken into account. Also included were optimistic assumptions about future technology and procedures at the top 35 airports. These assumptions were based on various research proposals and extrapolations from the latest OEP because there is no similar report that would indicate likely capacity improvements by 2020.

Conclusions

- Because of the long lead times necessary to bring large complex runway projects on line, current improvement plans must move forward to keep pace with demand forecast for 2013. Such projects are not subject to small perturbations in demand of only a few years duration. If the planned improvements do not occur for any reason, the number of airports experiencing capacity shortages will grow sharply.
- The long lead times also necessary to move research out of the lab and into the field, to equip aircraft with the latest technologies, and to implement procedural changes require that this vital work move forward to keep pace with demand forecasts for 2013 and 2020.
- This study focused on three distinct time periods: 2003, 2013 and 2020. Although some airports do not meet the criteria for needing additional capacity in the time periods studied, it is possible that they would meet the criteria in intermediate years (prior to the implementation of the improvements considered in this report). In other words, some airports not meeting these criteria until 2020 may actually reach that state as early as 2014. This highlights the need to press ahead with development plans.
- Even planned improvements will not be sufficient at some locations. Therefore, plans for new airports and new runways must continue and more new runways must be planned.
- Ambitious assumptions were made for improvements projected for 2020; some of these improvements may not materialize and even these assumed improvements will not be sufficient at some locations. Most importantly, the majority of the assumed improvements in 2020 do not have formal plans associated with them. This makes it ever more important to begin to formalize capacity improvement plans for the 2020 timeframe.

- Additional analyses are necessary to develop possible solutions for the identified airports; this is particularly true for the non-OEP airports in order to gain a better understanding of their capabilities, operations, and local regulations.
- For all the airports, detailed feedback and information obtained through discussions with them will need to be incorporated into future iterations of this study. Solutions beyond those considered here, including policy options, need to be explored.
- The sensitivity analysis performed using the newly released 2003 *Terminal Area Forecast* did not cause the FAA to alter the findings of this study. The analysis did determine that there may be a small number of locations that may be added to or deleted from this list in a future detailed analysis. See Appendix D for a discussion of the sensitivity analysis.
- In addition to new runways and airports, procedures, technologies, and policy options should be explored.
- The FAA must manage its budget and programs responsibly to ensure that the development of new technological improvements remains on track.

Appendix A: Location Identifiers

The following is a listing of the airports referenced in this paper.

ABQ	***ALBUQUERQUE INTERNATIONAL SUNPORT***
ATL	***HARTSFIELD - JACKSON ATLANTA INTERNATIONAL***
BDL	***BRADLEY INTERNATIONAL***
BHM	***BIRMINGHAM INTERNATIONAL***
BOS	***BOSTON LOGAN INTERNATIONAL***
BUR	***BOB HOPE (BURBANK, CA)***
BWI	***BALTIMORE-WASHINGTON INTERNATIONAL***
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***
EWR	***NEWARK LIBERTY INTERNATIONAL***
FLL	***FORT LAUDERDALE-HOLLYWOOD INTERNATIONAL***
HNL	***HONOLULU INTERNATIONAL***
HOU	***HOUSTON WILLIAM P HOBBY***
IAD	***WASHINGTON DULLES INTERNATIONAL***
IAH	***GEORGE BUSH INTERCONTINENTAL/HOUSTON***
ISP	***LONG ISLAND MACARTHUR***
JFK	***JOHN F KENNEDY INTERNATIONAL***
LAS	***LAS VEGAS MCCARRAN INTERNATIONAL***
LAX	***LOS ANGELES INTERNATIONAL***
LGA	***LAGUARDIA***
LGB	***LONG BEACH***
MCO	***ORLANDO INTERNATIONAL***
MDW	***CHICAGO MIDWAY INTERNATIONAL***
MEM	***MEMPHIS INTERNATIONAL***
MIA	***MIAMI INTERNATIONAL***
MSP	***MINNEAPOLIS-ST PAUL INTERNATIONAL***
OAK	***METROPOLITAN OAKLAND INTERNATIONAL***
ONT	***ONTARIO INTERNATIONAL***

ORD	***CHICAGO O'HARE INTERNATIONAL***
OXR	***OXNARD***
PBI	***PALM BEACH INTERNATIONAL***
PDX	***PORTLAND INTERNATIONAL***
PHL	***PHILADELPHIA INTERNATIONAL***
PHX	***PHOENIX SKY HARBOR INTERNATIONAL***
PIT	***PITTSBURGH INTERNATIONAL***
PVD	***THEODORE FRANCIS GREEN STATE***
SAN	***SAN DIEGO INTERNATIONAL***
SAT	***SAN ANTONIO INTERNATIONAL***
SEA	***SEATTLE-TACOMA INTERNATIONAL***
SFO	***SAN FRANCISCO INTERNATIONAL***
SLC	***SALT LAKE CITY INTERNATIONAL***
SNA	***JOHN WAYNE-ORANGE COUNTY***
STL	***LAMBERT-ST LOUIS INTERNATIONAL***
TPA	***TAMPA INTERNATIONAL***
TUS	***TUCSON INTERNATIONAL***

Appendix B: Metropolitan Areas and Associated Airports

The following is a list of the metropolitan areas and the airports that were studied in this analysis.

Albuquerque	**ABQ**	***ALBUQUERQUE INTERNATIONAL SUNPORT***
	SAF	***SANTA FE MUNICIPAL***
Atlanta	**ATL**	***HARTSFIELD- JACKSON ATLANTA INTERNATIONAL***
Austin-San Antonio	**AUS**	***AUSTIN BERGSTROM INTERNATIONAL***
	SAT	***SAN ANTONIO INTERNATIONAL***
Birmingham	**BHM**	***BIRMINGHAM INTERNATIONAL***
Boston	**BDL**	***BRADLEY INTERNATIONAL***
	BOS	***BOSTON LOGAN INTERNATIONAL***
	MHT	***MANCHESTER***
	ORH	***WORCESTER REGIONAL***
	PVD	***THEODORE FRANCIS GREEN STATE***
Chicago	**GYY**	***GARY/CHICAGO INTERNATIONAL***
	MDW	***CHICAGO MIDWAY INTERNATIONAL***
	MKE	***GENERAL MITCHELL INTERNATIONAL***
	ORD	***CHICAGO O'HARE INTERNATIONAL***
	RFD	***NORTHWEST CHICAGOLAND REGIONAL AT ROCKFORD***
Houston	**HOU**	***HOUSTON WILLIAM P HOBBY***
	IAH	***GEORGE BUSH INTERCONTINENTAL/HOUSTON***
LA Basin	**BUR**	***BURBANK GLENDALE PASADENA***
	LAX	***LOS ANGELES INTERNATIONAL***
	LGB	***LONG BEACH***
	ONT	***ONTARIO INTERNATIONAL***
	OXR	***OXNARD***
	SNA	***JOHN WAYNE-ORANGE COUNTY***
Las Vegas	**LAS**	***LAS VEGAS MCCARRAN INTERNATIONAL***
New York Metro	**EWR**	***NEWARK LIBERTY INTERNATIONAL***
	HPN	***WESTCHESTER COUNTY***
	ISP	***LONG ISLAND MACARTHUR***
	JFK	***JOHN F KENNEDY INTERNATIONAL***
	LGA	***LAGUARDIA***
	SWF	***STEWART INTERNATIONAL***

Philadelphia	**ABE**	***LEHIGH VALLEY INTERNATIONAL***
	ACY	***ATLANTIC CITY INTERNATIONAL***
	PHL	***PHILADELPHIA INTERNATIONAL***
San Francisco Bay	**OAK**	***METROPOLITAN OAKLAND INTERNATIONAL***
	SFO	***SAN FRANCISCO INTERNATIONAL***
	SJC	***MINETA SAN JOSE INTERNATIONAL***
South Florida	**FLL**	***FORT LAUDERDALE-HOLLYWOOD INTERNATIONAL***
	MIA	***MIAMI INTERNATIONAL***
	PBI	***PALM BEACH INTERNATIONAL***
Tucson	**TUS**	***TUCSON INTERNATIONAL***
Washington/Baltimore	**BWI**	***BALTIMORE-WASHINGTON INTERNATIONAL***
	DCA	***RONALD REAGAN WASHINGTON NATIONAL***
	IAD	***WASHINGTON DULLES INTERNATIONAL***

Note: The metropolitan areas used for this study were defined by the FACT team for the task of jointly evaluating airports that potentially serve the same urban areas. The names and definitions of these metropolitan areas do not necessarily correspond to those of the federally defined Metropolitan Statistical Areas (MSAs)

Appendix C: Scope and Methodology

The completion of this study required extensive amounts of information. An understanding of current day operations as well as the amount of capacity provided at individual airports today was necessary. How operations may change in the future as well as how new technologies and runways will contribute to increasing airport capacity needed to be determined. Demand levels that would likely exist in the future and where that demand was most likely to occur needed to be accounted for. This section will focus on the scope of information utilized by this analysis as well as the methodology incorporated. In addition to documenting the approach used in both demand and capacity modeling, this section will describe the processes applied in the identification of airport and metropolitan areas as needing additional capacity.

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 impacting capacity are expected to change over time. One methodology for doing this is found in the *Airport Capacity Benchmark Report*. The capacities documented in that report, which have been updated as a part of the FACT work, provide 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 under given assumptions. These measures of future airport performance will be discussed later in this section.

Modeling Current Capacity

The original *Airport Capacity Benchmark Report* was released by the FAA in April 2001. As part of the FACT analysis, the benchmarks reported in the 2001 document have been updated and enhanced in the following ways:

- The original report estimated capacity at 31 of the busiest airports. The update increased this number to 35.
- The original report estimated capacity at each airport under two weather conditions: Optimal and Reduced. With this update, capacity estimates were completed for three weather conditions, with standardized definitions:
    - Visual Meteorological Conditions (VMC) – Above visual approach minima
    - Marginal Meteorological Conditions (MMC) – Below visual approach minima but ceiling of 1000 ft or more and visibility of 3 miles or more
    - Instrument Meteorological Conditions (IMC). – Below 1000 ft ceiling or 3 miles visibility

- The original report was based upon how operations were performed in 2000. The current benchmarks were updated to include recent capacity improvements and changes to operations in 2003.
- The original report estimated future capacity at each airport based upon the FAA's capacity plans known at that time. The updated capacity estimates are based upon the FAA's *Operational Evolution Plan (OEP)* version 5.0.

To produce the capacity estimates necessary for the FACT analysis the team utilized the Enhanced Airfield Capacity Model (E-ACM). The E-ACM is a MITRE-developed update of the widely used FAA Airfield Capacity Model[4]. The E-ACM analytically calculates the average number of arrivals and departures that can be expected during busy periods at an airport, based on the probabilistic characteristics of aircraft performance.

The capacity of an airport is strongly influenced by the fleet mix using it. For the purpose of running the E-ACM, the fleet mix experienced today was assumed to continue in the future. That is, no fleet mix changes were estimated as part of the *capacity* analysis. However, both of the operational demand analyses used as inputs by this report allowed fleet mix changes to occur in their estimates of future traffic levels.

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

Finally, model output was compared with historical data and with feedback from the individual facilities.

Modeling Future Capacity

With 2003 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. In its examination of future capacity requirements, the FACT analysis focused on the years 2013 and 2020.

The 2013 evaluation assumed that all new runways and procedural improvements outlined in the FAA's *Operational Evolution Plan* (OEP), version 5.0 would be implemented at the top 35 airports, and would provide the expected benefits. New runways were included at 12 of these airports. It is important to note that not every proposed runway project was included in the OEP. For example, OEP v5.0 did not include new runways at ORD or a runway extension at FLL, since these have not yet received final FAA approval. Technical improvements included in OEP v5.0, such as

[4] 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

Simultaneous Offset Instrument Approaches (SOIA) at SFO, and visual separation between arrivals in marginal weather conditions using cockpit display aids, were also assumed to increase capacity at several airports. For airports other than the top 35, only planned new runways were considered, but not technological or procedural enhancements.

For the 2020 capacity assessment, all active plans for additional runways and airport reconfigurations were taken into account. Analysis of the top 35 airports also included optimistic assumptions about future technology and procedures. There is no report similar to the OEP that would indicate likely capacity improvements by 2020. Instead, the FACT analysis made assumptions based on various research proposals and extrapolations from the latest OEP. For example, if a technology was assumed to provide visual separations in MMC by 2013, it was assumed that the same technology would be able to provide reduced separations under IMC by 2020. Capacity improvements assumed for 2020 included some that were applied to all airports, 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 airports other than the top 35, only planned new runways were considered, but not technological or procedural enhancements.

Some of these assumptions could be regarded as overly aggressive given the timeframe of interest. However, these assumptions were *intended* to be optimistic. If an airport is forecast to be capacity constrained in 2020 despite our optimistic capacity estimates, it is an indicator that additional measures will be needed to accommodate the expected traffic, such as new runways or changes in demand policy.

Also, while the assumed improvements would hopefully be implemented in time to accommodate the forecast 2020 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

Constraints on how operations are currently performed at each airport were taken into consideration in the assessment of current and future capacity. Constraints placed upon operations for noise, airspace, and arrival and departure procedures were all evaluated. Noise mitigation constraints were assumed to continue in the future years. It was assumed that some airspace limitations (such as those not caused by terrain) could be alleviated with improvements in the future, as could some arrival and departure restrictions.

Modeling Future Airport Demand

Simply forecasting airport capacity is not sufficient to identify a future capacity shortfall. Forecasts must also be made of future airport *demand*. Estimated future operations can then be compared with estimated future capacity to assess the ability of an airport to handle the demands placed upon it. For the FACT study, two different estimates of future operations were used.

The principal forecast of future operations was the FAA's *Terminal Area Forecast*, or TAF. 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.

The TAF numbers were used by the FACT study in two ways. First, the annual future demand estimates were compared directly with future estimates of annualized airport capacity to produce a ratio of demand-to-capacity. Second, an algorithm was run to develop a forecast traffic scenario based on the TAF. This scenario, which is basically a "schedule" for all flights in the NAS, could then be used as an input into a NAS-wide simulation model. This model will be discussed later in this section.

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[5]. This socio-economic model, known as the Future Aviation Timetable Estimator, or FATE, is based upon 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. Figure C-1 illustrates where the largest growth is in the United States regarding income and population. Also shown are the locations where low fare carriers had at least 15 percent of the market share at the start of this analysis (which is rapidly changing). Inputs to the model include socio-economic forecasts from the consultancy Global Insight,[6] as well as historical data on origin-destination traffic from the Department of Transportation.[7]

[5] Bhadra, D., *Demand for Air Travel in the United States: Bottom-Up Econometric Estimation and Implications for Forecasts by O&D Pairs*, Journal of Air Transportation, Volume 8, number 2, pp 19-56, September, 2003

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

[7] For more information see: www.transtats.gov

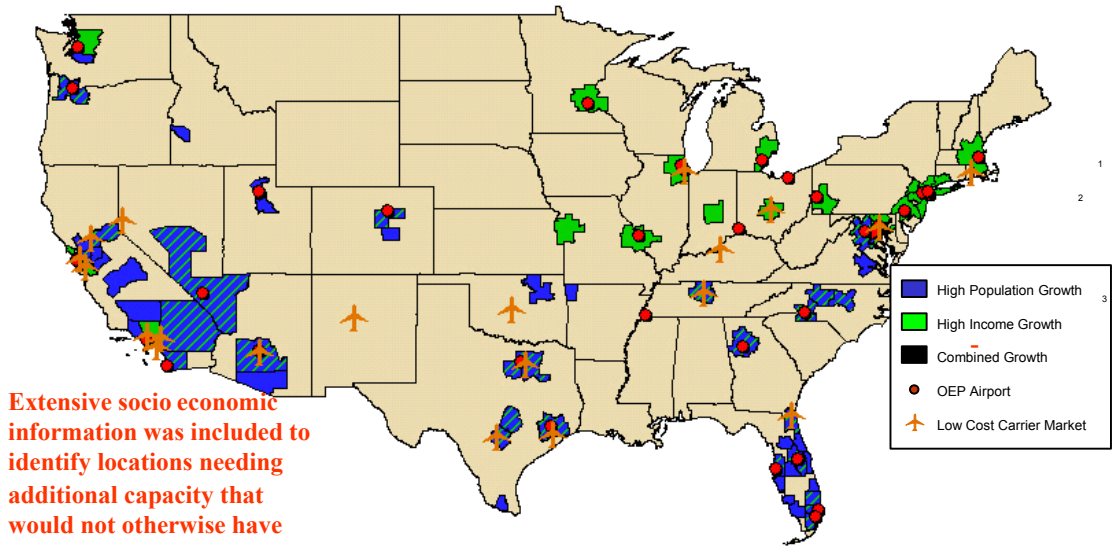

Figure C-1. Socio-Economic Information

As shown in Figure C-2, 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 "route choice" process. This process is then repeated for all O&D pairs in the contiguous continental U.S.

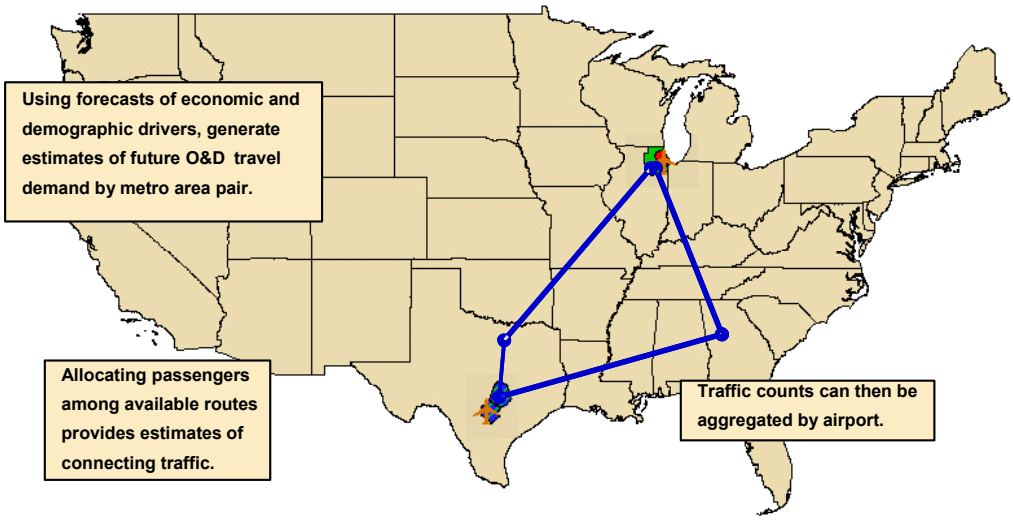

Figure C-2. Forecasting Origin and Destination Passengers

At this point there is an estimate of future passenger demand between individual airport pairs, including those passengers connecting through hubs. In order to translate this into operations, aircraft must be assigned to each airport pair. The size of the aircraft assigned depends upon the distance to be flown and the total number of passengers. Adjustments are also made to include charter, general aviation, 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 contiguous continental U.S.

In this study the FATE socio-economic forecasts were used in essentially the same way as the Terminal Area Forecast. The socio-economic model generated annual counts of airport operations in 2013 and 2020, which were then compared to capacity in those years at the individual airports and metropolitan areas. The socio-economic forecasts were helpful in validating the results obtained with the TAF.

Process of Identifying Airports Needing Additional Capacity

Once the forecasting of future demand, as well as the forecasting of future capacity was complete it was possible to perform the necessary analyses to identify where additional capacity may be necessary. The following will describe the methods used to combine the two and arrive at a set of well-defined measures of future operational performance.

Estimating Future Performance

The following will describe the approaches used to estimate future performance at the individual airports:

Annual Service Volume: The annual level of traffic that results in a given level of average delay, known as *Annual Service Volume* (ASV), was calculated as part of the capacity assessment used in this analysis. The level of delay chosen by this analysis as appropriate for a given airport was dependent upon that airport's historical levels of delay. A quick analysis of historical delay at the top 35 airports showed the average delay per flight on the best delay days was around seven minutes. For airports currently experiencing seven minutes of delay per flight or less under the best conditions, the target delay level for calculating ASV was set at seven minutes. But for airports currently experiencing average levels of delay above seven minutes, even under the best conditions, then this higher level was utilized for ASV purposes. This is an important point, because the higher the "allowable" delay limit is set at an airport, the higher the level of traffic it can handle, as measured by the ASV.

Note that ASV considers multiple runway configurations and utilizes an annual estimation of weather conditions for each configuration in its calculation. Future levels of ASV (2013 and 2020) incorporate planned runway improvements/additions, but not technological or procedural improvements.

NAS-Wide Simulation of Airport Arrival Delay: A more rigorous way of estimating the future performance of airports is by using a simulation model to estimate future levels of delay. Here, capacity information is taken from the updated airport capacity

benchmarks and used as an input to the simulation model. The model is run, and average delay is 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. In some ways, this is the opposite of the ASV, where delay level was fixed and the traffic level was variable.

The simulation model used by the FACT analysis is a network queuing model of the NAS. This model takes demand, capacity, adaptation 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 impacts 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 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 the 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 by the FACT task 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[8] and estimates of general aviation, cargo, and commuter traffic based upon 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 2002 TAF.

Capacity estimates come from detailed modeling performed in other tools such as the E-ACM. It is important that in the use of such tools the interaction between improvements be properly accounted for. At times various enhancements may provide similar benefits under like conditions. If these interactions are not accounted for capacity estimates may be too high. By using a network model, such as the one incorporated into this study, additional interaction between demand and capacity at a single airport, as well as across airports can also be taken into account.

Capacity-Related Delay Estimates: The benchmark capacities were also used to perform a simple estimate of future delay levels. First, historical delay data was obtained from the FAA's Aviation System Performance Metrics[9] (ASPM) database for the top 35 airports. "Airborne Delay" was used as an estimate of the arrival delay due to capacity at the airport, and "Taxi Out Delay" was used as a measure of airport-related departure delay. Also calculated was the ratio of annual traffic to an annualized capacity at each airport. For future delay estimates, it was assumed that the average delay was proportional to this demand/capacity ratio (which simplifies the known exponential relationship between capacity and delay). Thus, if the demand/capacity ratio at an airport increased by ten percent, future airport-related delay at that airport was also estimated to rise by ten percent.

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[8] *Official Airline Guide* - Source of flight schedule information. See http://www.oag.com
[9] For more information see: http://www.apo.data.faa.gov

Demand-to-Capacity Ratio for Airports Other Than The Top 35: A simplified approach was used for airports other than the top 35. Because ASV estimates did not exist for most other airports, and detailed delay modeling was not complete, the approach was to compare annualized demand to annualized capacity. In the absence of detailed information about these airports, conservative assumptions about fleet mix and operating procedures were made, in order to avoid overlooking airports with potential capacity problems. The resulting hourly capacities from the E-ACM were annualized based on an analysis of weather conditions and an assumed operating day of 12 hours. As additional information is obtained through coordination with the individual airports it will be possible to update this analysis by using a similar approach to that used for the top 35 airports.

Selection Criteria for Identifying Capacity Constrained Airports

As discussed earlier the FAA began this task to look across multiple studies and determine a *common set of airports* that each study could agree upon as needing additional capacity. Because of the strict commonality requirement, the results of this assessment should be viewed as a *minimal* list of airports needing additional future capacity.

Because of the differences in approach and assumptions made in each study used by this report, each study had a different set of criteria that it used to indicate an airport may need additional capacity. It was only when all the criteria were met that an airport was included in the list of common airports. The criteria used by each study are described below.

Top 35 airports

The information available about, and the knowledge of, the top 35 airports was much more extensive than the information about the other airports. Because of this, the criteria used for the top 35 airports was much more stringent in this assessment than the criteria for the other airports. The need for additional capacity was indicated by:

- Ratio of annual demand to Annual Service Volume estimated at 0.8 or above (demand at least 80 percent of capacity).
- Arrival delay estimated at 12 minutes per flight or above, on an annual basis.
- Capacity related delay estimated to exceed 4.5 minutes per flight, or a demand/capacity ratio of 0.95 or above (using an annualized capacity based upon hourly benchmark capacities in VMC, MMC, and IMC).

To be identified on the common list of airports it was necessary to satisfy *each* of the three criteria described above, under *two* different future traffic level assumptions: one using the 2002 TAF and the other using the socio-economic information described earlier in this section (a total of six criteria). If any of the criteria was not met in either future demand scenario, then an airport was not included on the common list. Requiring the

criteria to be met using the two different traffic levels provided some level of sensitivity analyses around the results.

Other Airports

For airports other than the top 35, a Demand-to-Capacity Ratio was approximated using annualized hourly capacity estimates obtained from the E-ACM. Future demand predicted to be at least 90 percent of available capacity was used to indicate a need for additional capacity. As more detailed modeling is done in the future, a similar set of criteria to that used for the top 35 airports will be utilized.

Because a more simplified approach was used for these airports the strict requirement that the criteria must be met for both TAF derived demand projections as well as socio-economic demand projections was not used here. Several of the airports earlier identified in this report as needing additional capacity were only identified using the experimental model based upon the socio-economic information. On the other hand, all airports identified with the TAF demand were also identified using the socio-economic information.

The purpose of the FACT effort is to bring all these studies together in order to develop a *common list* of airports (or associated metropolitan areas) that may need additional capacity. If an airport failed to meet any of the individual study's criteria, then it was not identified by the FACT study as a member of the common list of airports needing additional capacity. Airports not identified in this analysis may have been identified in one or more of the studies, but not in all of them. Because the requirement for commonality was so strict, the results of this assessment should be viewed as a *minimal* list of airports needing additional future capacity. Simply because an airport was not identified in this analysis as needing additional capacity does not mean it should stop planning for future capacity improvements. One should not assume that these airports will have adequate capacity.

Process of Identifying Metropolitan Areas Needing Additional Capacity

As traffic demand continues to grow in the future and airspace congestion is magnified, it will become ever more important to look at regional strategies and solutions to solve capacity shortfalls. Already today major metropolitan areas with multiple airports in close proximity to each other are showing signs of strain on airspace and surface congestion. One part of this analysis was to look at metropolitan areas and to determine, at a high level, if additional capacity would be necessary in the future.

Estimating Future Performance

To accomplish an analysis of metropolitan areas, commercial service airports within approximately 60 miles of the major population concentrations were identified. Figure C-3 provides an example for the Los Angeles Basin. In this example six airports were considered in the metropolitan analysis for the Los Angeles Basin: BUR, LAX, LGB, ONT, OXR, and SNA. Using a high-level approach, for each metropolitan area the sum

total of demand at each airport considered was compared to the sum total of the individual capacities of each airport. For the Los Angeles Basin example, that means summing up the demand at each of the six identified airports and comparing that demand to the sum of capacity at each of the six airports.

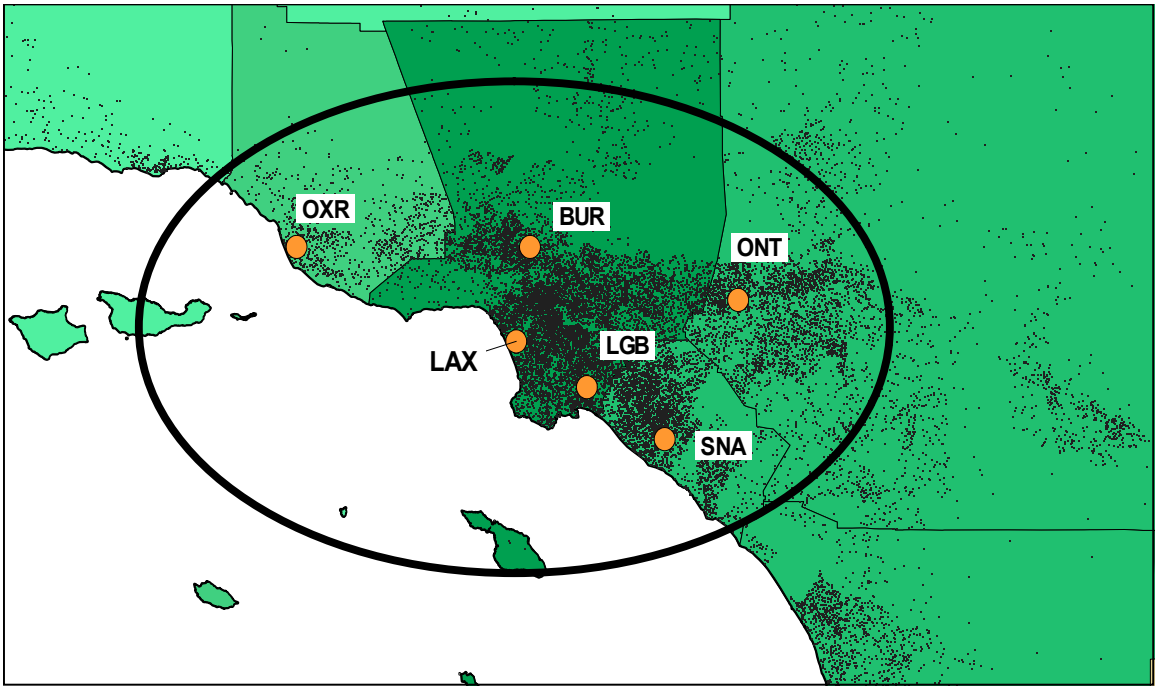

Figure C-3. LA Basin Metropolitan Analysis Example

This analysis did not attempt to reallocate traffic among airports within a metropolitan area and did not explore the feasibility of doing so. In discussions with individual airports on the results of this study, they did point out how some movement was possible but certain limitations existed. As a next step in this analysis, regional solutions such as the reallocation of traffic should be explored.

Selection Criteria for Identifying Capacity Constrained Metropolitan Areas

If total demand of commercial service airports in the metropolitan area was predicted to exceed 80 percent of the available capacity, this was an indication that additional capacity may be necessary. For metropolitan areas that consisted of only a single commercial airport, a threshold of 90 percent was used (same as the individual airport threshold). The lower threshold of 80 percent, being used for the metropolitan areas with multiple airports, recognizes that not all available capacity can be used due to increased airspace congestion and compensates for the simplified nature of the metropolitan analysis.

Appendix D: The Effect of the Sensitivity Analysis Using the FY 2003 Terminal Area Forecast

In the past several years the aviation industry has undergone a substantial amount of change. Changes to the industry that would typically take years to complete have been occurring over periods of months or even weeks. As traffic levels fell, older aircraft were retired or placed into storage. Fleet mixes at several major airports have changed and are continuing to evolve as airlines "right size" to current demand levels (both to smaller aircraft and to larger ones as well). Airlines have entered and exited bankruptcy, and restructured their operations along the way. Some airports have seen dramatic drops in operations as their dominant carriers have pulled out, while others have experienced sharp increases in operations. Many carriers have de-peaked their operations and transitioned to a "rolling-hub" type of operation. Changes of this type have a major impact on the risk of forecasting future traffic levels.

As changes in traffic predictions are occurring, specific capacity enhancing plans are also being revised. These plans are constantly updated in order to align them with current and predicted needs, as well as with anticipated funding levels. Changes in the underlying assumptions regarding which improvements will be in place, and by when, will impact the results of any study. Trying to evaluate the manner in which analytic results may change based upon moving targets such as these is difficult, but it is an important part of a study such as this one.

The purpose of this section is to evaluate how the results of this analysis could potentially change based upon updated forecasts contained in the newly released 2003 *Terminal Area Forecast*. The focus here will be strictly on the changing demand picture, but similar differences may be expected when accounting for changes in future capacity enhancement plans.

Forecasting the future, obviously, is always uncertain. In order truly to understand a forecast, it is helpful to understand potential sources of change; that is, things that were assumed as part of making the forecast, and how susceptible these assumptions are to change in the future. Three potential sources of so-called *forecast risk* are:

- the risk that forecasts of underlying explanatory variables may change
- the risk that a model was incorrectly specified due to inadequate data, and
- the risk of unanticipated structural shocks

As an example of the first risk, take the estimation of market power of existing carriers. This information is calculated using the concentration of dominant and non-dominant carriers in O&D markets. Market power plays an important role in determining O&D passenger flows, but it is not known how this factor will evolve in the future. A similar statement can be made regarding the presence of low-cost carriers in a market.

Forecast model risk is strongly influenced by assumptions about load factors and fleet mix. Recent examples of this can be seen when comparing traffic demand estimates in

the 2002 TAF and the 2003 TAF releases. For example at SFO, the 2002 TAF estimates 2013 traffic demand levels at 385,538 operations, while the 2003 TAF estimates 2013 traffic demand levels at 446,791 (a difference of approximately 16 percent more traffic). At MDW the 2002 TAF estimates 2020 traffic demand levels at 472,774 operations while the 2003 TAF estimates 2013 traffic demand levels at 358,528 (a decrease in traffic expectations of approximately 24 percent). The differences in these forecasts were caused by changing assumptions underlying the analysis. For example, the differences at SFO were caused by assuming a downsizing of aircraft size over time. This means more aircraft (and thus operations) are needed to serve the same number of passengers. At MDW it was a combination of assuming larger aircraft size and a shifting of the type of operations (air carrier, general aviation, and commuter) that would occur at the airport.

Finally, structural shocks to the system (e.g.; natural disasters, industrial accidents, national economic collapse, terrorist incidents) are another area that contributes to the uncertainty of a given forecast. For example, a catastrophic event may change the overall demand situation and invalidate a particular model of the system. As with most forecasts, the forecasts used by this analysis do not anticipate and incorporate structural shocks that may occur in the future, as they are by definition unpredictable.

When looking at total demand at the top 35 airports in 2013, the 2003 TAF differs little from the 2002 TAF. The 2002 TAF predicted a total of 19,338,535 operations to occur in 2013 at the top 35 airports. The 2003 TAF predicts traffic levels of 19,330,276 at the same airports; or 99.96 percent of the previous forecast. This difference is very small and inconsequential. The difference in 2020 predictions follows the same pattern, with the 2003 TAF predicting 99.95 percent of the operations forecast in the earlier TAF.

Although the differences in *total* operations at the top 35 airports between one TAF and the other is very minor, that is not the case when you look at individual airports. Specific airport differences can be significant (see Table D-1).

Table D-1. Summary of Forecast Differences: 2002 TAF and 2003 TAF

	2013	2020
At least 10 percent *higher* in 2003 TAF	**SFO - 16% ORD - 15% LAS - 10%**	**SFO - 19% ORD - 18% LAS - 12%**
At least 10 percent *lower* in 2003 TAF	**STL – 29% MDW – 14%**	**STL – 32% MDW – 24% CLE – 10% MIA - 11%**

With such dramatic changes between forecasts, one would expect the results of a study based upon these forecasts to differ. To understand better how the results of this study could potentially change, a series of sensitivity analyses was performed. Several of the

criteria used to indicate a need for additional capacity outlined in the section on scope and methodology reevaluated in light of the new forecast. No assessment was made to the magnitude of the individual difference; an evaluation was made simply to see if additional airports might be identified as needing additional capacity, or if airports currently identified may no longer indicate a need for additional capacity.
The specific approach used is as follows:

- First Step: a reevaluation of the ASV at each airport was performed to see if the ASV criterion outlined in the section on scope and methodology was met. If not, and the airport was previously identified as needing additional capacity, then it was noted as an airport that would no longer have such a need. If the criterion was met, step two was performed.
- Second Step: a reevaluation of the capacity related delay and annualized demand/capacity ratio criteria was performed (see section on scope and methodology). If neither criterion was met, the airport would not be identified as needing additional capacity and could potentially fall off the common list (if previously shown). If either one of these criteria were met then the third step was performed.
- Third Step: the change in forecast was compared to the arrival delay estimates previously calculated. Potential levels of delay given the new forecast were calculated by extrapolating changes in delay given changes in demand. This is only a rough order estimate as it only accounts for changes at the airport and not the system wide impact captured by the modeling effort. In addition, the larger the difference in forecast, the more inaccurate such an approach becomes. However, it provides one level of sensitivity analysis until further modeling can be performed. If the new estimated level of delay meets the criteria specified in the scope and methodology section, then the airport would be identified as needing additional capacity.

If all the criteria outlined above in all three steps are met by an airport, it is considered an airport that potentially needs additional capacity based upon the 2003 TAF. If any of the criteria is not met, then the airport is not considered to have a need for additional capacity. The results were then compared to the findings of this study based upon the detailed assessment using the 2002 TAF and the socio-economic information. The approach used here as a sensitivity study should provide insight into how the study results could potentially change. The results presented here are preliminary. Detailed modeling of operations at each airport, using the 2003 TAF, has not yet been completed. However, the preliminary differences between the results are discussed below.

Preliminary Evaluation of Changes to the 2013 Results

When performing an analysis that assumes the improvements outlined earlier in the document for 2013, the sensitivity study of the 2003 TAF indicates little change from the 2002 TAF findings (see Figure D-1). These results show that one additional airport (LAS) may be considered as needing additional capacity due to much faster growth expectations. At the same time, one airport previously identified as needing additional capacity (LGB) may no longer be included in the common list of airports.

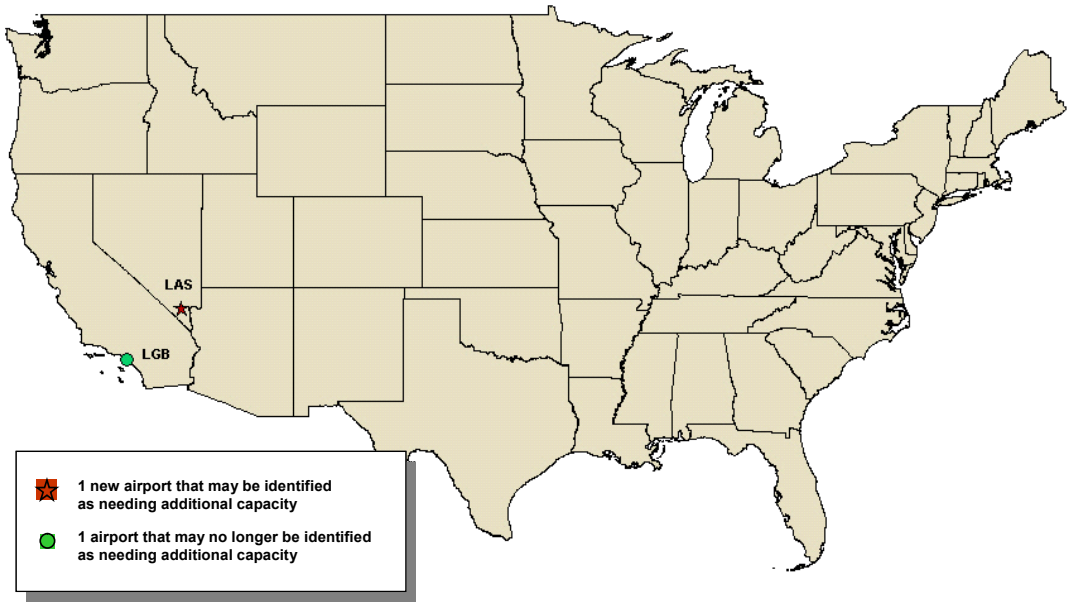

Figure D-1. 2013: Potential Change in Analysis Results Using 2003 TAF (After Assumed Improvements)

When performing an analysis that does not assume improvements to capacity above today's current levels, the sensitivity study of the 2003 TAF does not show any additional airports that need additional capacity in 2013. On the other hand, six airports (BWI, LAX, LGB, MDW, PHX and STL) would no longer meet the criteria for needing additional capacity (see Figure D-2). All of these airports are predicted to have fewer operations than predicted in the 2002 TAF. The change in MDW's forecast and the reason for such a change was discussed earlier in this section. The dramatic fall in operations at STL over the last year, as a major air carrier reorganized its operations, has been incorporated into the 2003 TAF. These results indicate a need to continually monitor changes to the forecasts and to periodically update associated analyses.

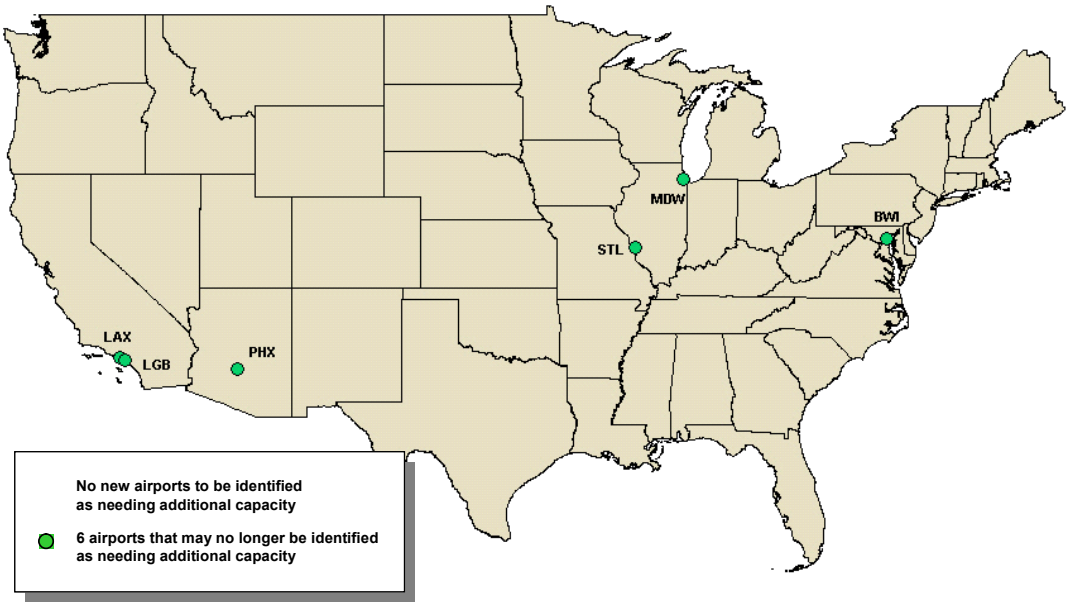

Figure D-2. 2013: Potential Change in Analysis Results Using 2003 TAF (If Planned Improvements Do Not Occur)

Summary of Potential Changes to 2013 Results

Table D-2 summarizes how the 2013 results of this study could potentially change based upon updated forecasts contained in the newly released 2003 *Terminal Area Forecast*.

Table D-2. Summary of Potential Changes to 2013 Results

	2013 Improvements	2013 No Improvements
New Airports Meeting Criteria for Needing Additional Capacity	**LAS**	**None**
Airports No Longer Meeting Criteria for Needing Additional Capacity	**LGB**	**BWI LAX LGB MDW PHX STL**

Preliminary Evaluation of Changes to the 2020 Results

When performing an analysis that assumes the improvements outlined earlier in the document for 2020, the sensitivity study of the 2003 TAF does not show any additional airports that need additional capacity in 2013. On the other hand, two airports (ISP and MDW) would no longer meet the criteria for needing additional capacity (see Figure D--3). Both of these airports are predicted to have fewer operations than predicted in the 2002 TAF. The change in MDW's forecast and the reason for such a change was discussed earlier in this section. ISP's forecast predicts 16% fewer operations in 2020 than the 2002 TAF prediction.

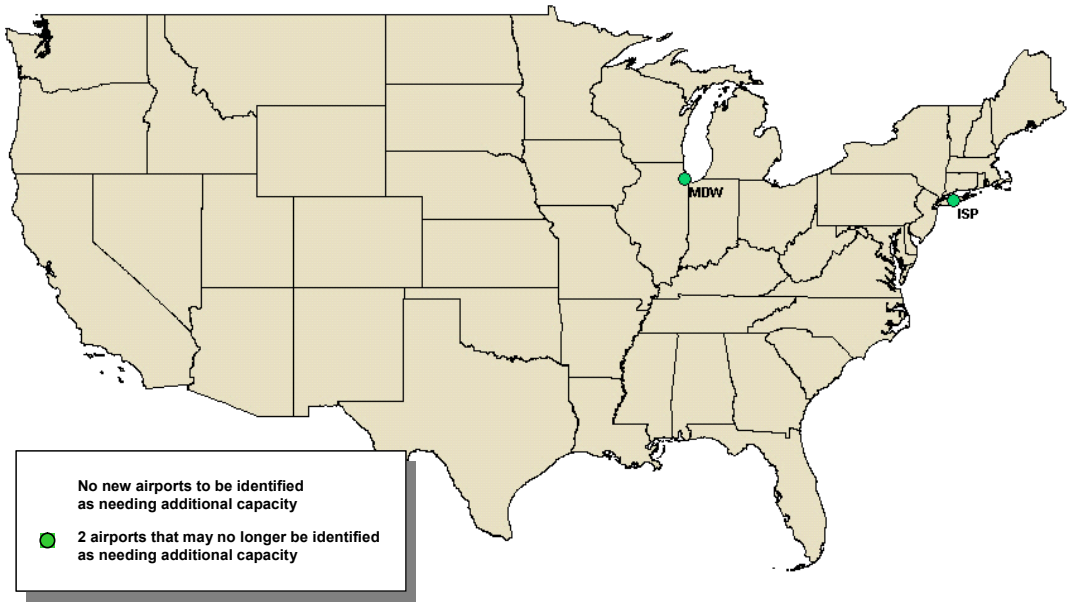

Figure D-3. 2020: Potential Change in Analysis Results Using 2003 TAF (After Assumed Improvements)

When performing an analysis that does not assume improvements to capacity above today's current levels, the sensitivity study of the 2003 TAF shows one additional airport would be considered as needing additional capacity in 2020 (SFO). At the same time, four airports (ISP, MDW, MIA and STL) would no longer be considered in need of additional capacity (see Figure D-4).

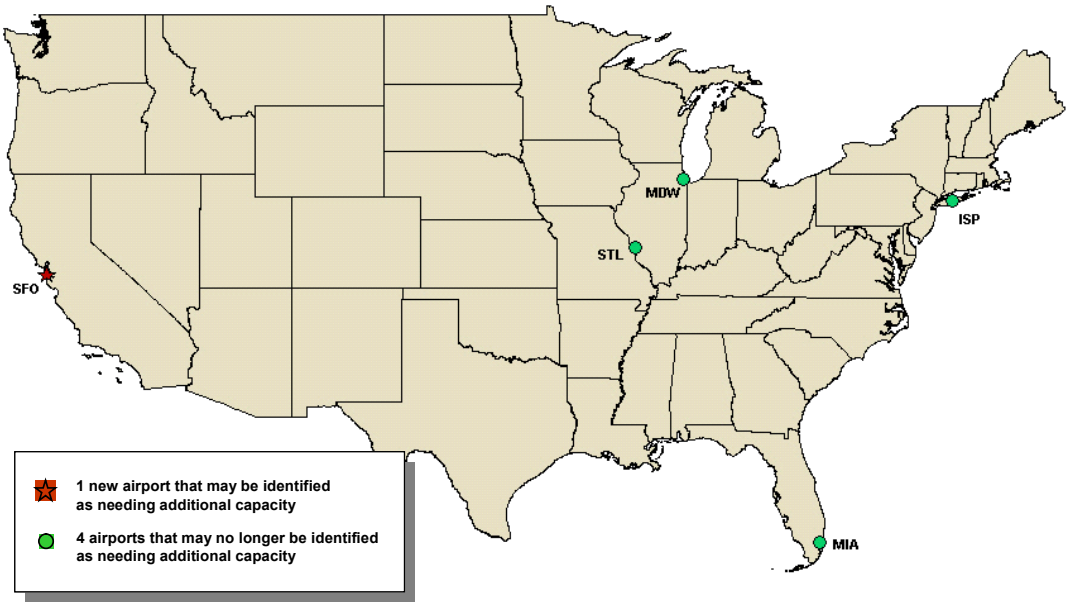

Figure D-4. 2020: Potential Change in Analysis Results Using 2003 TAF (If Planned Improvements Do Not Occur)

Summary of Potential Changes to 2020 Results

Table D-3 summarizes how the 2020 results of this study could potentially change based upon updated forecasts contained in the newly released 2003 *Terminal Area Forecast*.

Table D-3. Summary of Potential Changes to 2020 Results

	2020 Improvements	2020 No Improvements
New Airports Meeting Criteria for Needing Additional Capacity	**None**	**SFO**
Airports No Longer Meeting Criteria for Needing Additional Capacity	**LGB** **MDW**	**ISP** **MDW** **MIA** **STL**

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