APPENDIX A: STUDY AIRPORTS

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

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

APPENDIX B: METROPOLITAN AREAS AND ASSOCIATED AIRPORTS

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

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

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

APPENDIX C: PLANNED IMPROVEMENTS

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

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

▲	Included in 2006 capacity	x*	Visual separations applied in VMC and MMC (2025)
◊	2015 capacity improvement	◊*	Visual separations applied in VMC (2015)
x	2025 capacity improvement		

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

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

◊	2015 capacity improvement
x	2025 capacity improvement

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

APPENDIX D: METHODOLOGY

Introduction

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

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

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

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

Modeling Future Airport Demand

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

Terminal Area Forecast

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

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

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

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

Future Air Traffic Estimator

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

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

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

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

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

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

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

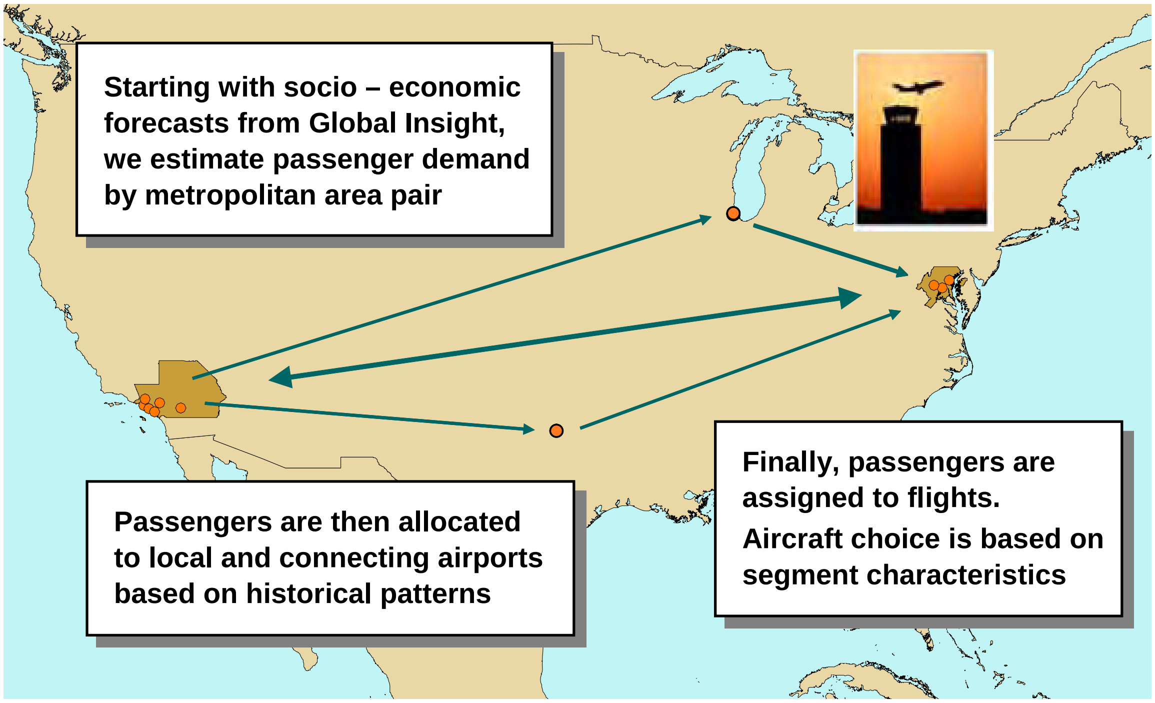

Figure D1 – Future Air Traffic Estimator (FATE) Model

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

Modeling Current and Future Airport Capacity

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

Modeling Current Capacity

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

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

[16] *Airport Capacity Benchmark Report 2004,* U.S. Department of Transportation, Federal Aviation Administration, The MITRE Corporation Center for Advanced Aviation System Development, October 2004. See http://www.faa.gov/events/benchmarks/2004download.htm.
[17] ABQ, AUS, BDL, BHM, BUR, GYY, HPN, HOU, ISP, LGB, MKE, OAK, ONT, PBI, PVD, RFD, SAT, SJC, SNA, SWF, and TUS.

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

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

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

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

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

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

Modeling Future Capacity

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

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

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

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

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

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

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

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

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

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

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

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

Incorporating Operational Constraints

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

Identifying Airports Needing Additional Capacity

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

Estimating Future Performance at Individual Airports

Annual Service Volume

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

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

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

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

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

NAS-Wide Simulation Model

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

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

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

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

Criteria for Identifying Capacity-Constrained Airports

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

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

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

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

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

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

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

Refined Identification Criteria

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

- **Annual Service Volume Ratio** was estimated at 0.8 or above (annual demand at least 80 percent of ASV based on 7 minutes average delay)

- **Scheduled Arrival Delay** was estimated at 12 minutes per flight or above, on an annual basis, *and either*

    - **Local Scheduled Arrival Delay** was estimated at 50 percent or more of the total Scheduled Arrival Delay in good or bad weather conditions, *or*

    - **Arrival Queue Delay** (delay waiting to land after arriving at an airport) was estimated at 12 minutes per flight or above in good or bad weather conditions

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

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

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

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

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

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

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

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

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

Validation of Results

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

Evaluating Capacity Needs in Metropolitan Areas

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

Defining the Metropolitan Area

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

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

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

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

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

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

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

Secondary Airports Considered in the Metropolitan Area

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

Criteria for Identifying Capacity-Constrained Metropolitan Areas

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

- The total annual demand of the capacity-constrained airport(s) and the secondary commercial service airports exceeded 80 percent of the total annualized capacity of these same airports, using either the TAF or FATE demand projections, or
- No other secondary commercial service airports were located within the same metropolitan area as the capacity-constrained airport(s), or
- There were at least two large hub airports identified as capacity-constrained within the same metropolitan area.

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

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

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

In Closing

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

APPENDIX E: COMPARING THE FACT 1 AND FACT 2 FINDINGS

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

Figure E1

FACT 1 (2003) Results after Planned Improvements

5 airports that need additional capacity in 2003

1 metro area that needs additional capacity in 2003

Figure E2

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

3 airports identified in both FACT 1 and FACT 2

0 metro areas identified in both FACT 1 and FACT 2

0 airports newly identified in FACT 2

1 metro area newly identified in FACT 2

2 airports no longer meeting FACT criteria

1 metro area no longer meeting FACT criteria

Table E1

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

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

⊕ Identified with the new FACT 2 criteria

⊗ No longer needing additional capacity assuming planned improvements are completed

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

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

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

Figure E3

FACT 1 (2013) Results after Planned Improvements

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

Figure E4

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

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

Table E2

Comparison to FACT 1 Results for 2013 after Planned Improvements

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

⊕ Identified with the new FACT 2 criteria

⊗ No longer needing additional capacity assuming planned improvements are completed

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

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

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

Figure E5

FACT 1 (2020) Results after Planned Improvements

18 airports that need additional capacity in 2020

8 metro areas that need additional capacity in 2020

Figure E6

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

8 airports identified in both FACT 1 and FACT 2

5 metro areas identified in both FACT 1 and FACT 2

6 airports newly identified in FACT 2

3 metro areas newly identified in FACT 2

10 airports no longer meeting FACT criteria

3 metro area no longer meeting FACT criteria

Table E3

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

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

⊕ Identified with the new FACT 2 criteria

⊗ No longer needing additional capacity assuming planned improvements are completed

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

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