Executive Summary

Setting the Framework for Benchmarks

The benchmarks in this report are a relatively simple expression of a complex quantity, airport capacity. They serve primarily as a reference point on the state of the airport system at a specific time. They can be updated in the future to mark progress. They can also be used to identify and compare specific types of airports, for instance to determine which airports are most severely affected by adverse weather or to compare the prospects for airports that plan to build new runways to those that do not. The benchmarks also provide a starting point for public policy discussions, because they give a succinct report on the current and future state of major airport capacity.

Benchmarks are useful data that help frame discussions. However, they are not a substitute for the more detailed analysis that should precede major investment and policy decisions. In this sense they might be compared to a vital sign of human health, such as blood pressure. That simple indicator might be the starting point for a diagnosis, but more information would be wanted before recommending surgery. Similarly, capacity benchmarks help identify problem areas but are not, in themselves, an adequate basis for selecting remedies.

This issue is apparent in the case of Atlanta Hartsfield International Airport. The scheduled operations exceed the benchmarks several times daily in optimum weather and frequently under reduced rate conditions. The simple comparison of schedule to benchmarks suggests that some action is needed to curtail the schedule. However, air traffic controllers, airlines, and the airport operator have indicated in discussions that they are relatively comfortable with the current schedule and believe that it makes efficient use of the airport. Their judgment is based on vast experience and a broad understanding of air transportation. Some of the considerations are specific to Atlanta (favorable runway configuration, weather patterns, and airspace structure), some are applicable to transfer hub airports in general (the concentration of traffic into schedule peaks to allow passengers to make convenient transfer between flights, the ability to catch up with traffic between peaks in the schedule, and the ability of hubbing carriers to cancel and consolidate some flights during reduced rate conditions), and some are applicable to all busy airports (the premise that some amount of congestion and delay is not inconsistent with efficient and affordable air transportation).

Purpose

- The FAA has developed capacity benchmarks for 31 of the nation’s busiest airports to understand the relationship between airline demand and airport runway capacity and what we in the aviation community can do about it.
- Capacity benchmarks are defined as the maximum number of flights an airport can routinely handle in an hour.
  - These benchmarks are estimates of a complex quantity that varies widely with weather conditions, runway configurations, and the mix of aircraft types. Capacity benchmarks assume there are no constraints in the en route system or the airport terminal area. They are useful for broad policy discussions and the development of long–term strategies.

Methodology

- Between October 2000 and April 2001, the FAA and MITRE/CAASD developed capacity benchmarks for 31 airports.
- There are two rates for each airport – an optimum rate based on good weather conditions and a reduced rate based on adverse weather conditions, which may include poor visibility, unfavorable winds, or heavy precipitation.

- The optimum rate is defined as the maximum number of aircraft that can be routinely handled using visual approaches during periods of unlimited ceiling and visibility.
- The reduced rate is defined as the maximum number of aircraft that can be routinely handled during reduced visibility conditions when radar is required to provide separation between aircraft. This rate was determined for the most commonly used runway configuration in adverse weather conditions.

- The benchmarks reflect the number of takeoffs and landings per hour for the given conditions. These benchmarks can be exceeded occasionally and lower rates can be expected under adverse conditions.
- The FAA confirmed capacity benchmark rates in three ways:
  - Benchmark rates for each airport were provided by the air traffic team at the facility and the airport operator and were based on their collective operational experience.
  - Benchmark rates provided by the air traffic teams were compared to historical arrival and departure data (Aviation System Performance Metrics) to confirm that they represent the best performance of the airport.
  - Using the FAA's widely accepted airfield capacity computer model, benchmark rates were also calculated based on a set of standard performance characteristics.
- The resulting capacity benchmarks were then compared to carrier schedule data from the Official Airline Guide. Scheduled carrier operations constitute a significant part, but not all, of an airport's traffic. Excluded are general aviation and military operations, non-scheduled flights and some cargo operations. These typically account for between 1 and 30% of the total traffic at the 31 airports studied.
- Human factors play a critical role in the benchmark rates reported by the air traffic facility. Benchmarks are strongly affected by how busy the airport is and how aggressively the management team sets target rates.
- Six airports were selected for on-site visits to validate the methodology: Atlanta, Chicago, Dallas-Fort Worth, St. Louis, Memphis, and Detroit. These on-site visits included discussions with local air traffic personnel, airport authorities, and air carriers serving the airport. For the other airports, discussions were conducted with managers at the local air traffic facility.
- The individual benchmark summaries compare projected growth in capacity with projected growth in demand to understand the relationship between future airline demand and airport capacity. Demand is based on the Terminal Area Forecast, the FAA's projection of aviation activity at select U.S. airports, and is revised annually to reflect current and anticipated economic and social conditions.
- Historically, there are several measures of delay commonly used. (See appendix) The measure used herein to identify the most delayed airports is the percent of aircraft delayed more than 15 minutes from the FAA's Operations Network (OPSNET).

Assumptions

- The improvements that were considered as part of the study included new runways for which plans are sufficiently advanced, and the following technologies and procedures, where they were appropriate to the specific airport:
  - Automatic Dependent Surveillance-Broadcast/Cockpit Display of Traffic Information with Local Area Augmentation System (ADS-B/CDTI with LAAS) – provides a cockpit display of the location of other aircraft and will help the pilot maintain the desired separation more precisely.
  - Flight Management System/Area Navigation (FMS/RNAV) Routes – allow a more consistent flow of aircraft to the runway.

- Passive Final Approach Spacing Tool (pFAST) – assists the controller with runway assignment and sequencing for aircraft and better flow of traffic into the terminal area.
- Simultaneous instrument approaches – allow full independent use of two or more runways for landings in adverse weather conditions.
- Precision Runway Monitor (PRM) – a high update radar system that allows simultaneous instrument approaches to parallel runways as close as 3000 feet apart. Also helps in procedural applications such as Simultaneous Offset Instrument Approaches (SOIA) where applicable.
- Land and Hold Short Operations (LAHSO) – allows independent arrivals for specific aircraft types on intersecting runways, where runway geometries permit.

- Benefits from planned improvements assume that all required infrastructure and regulatory approvals will be in place including aircraft equipment, airspace design, environmental reviews, radio frequencies, training, etc. as needed.
- In general, the benchmarks do not consider any limitation on airport traffic flow that may be caused by non-runway constraints at the airport or elsewhere in the National Airspace System. Such constraints may include:
  - Taxiway and gate congestion, runway crossings, slot controls, construction activity;
  - Terminal airspace, especially limited departure headings;
  - Traffic flow restrictions caused by en route miles-in-trail restrictions, weather, or congestion problems at other airports; and
  - Seasonal limitations due to high temperatures that restrict aircraft climb rates.

Observations across all 31 Airports

- The nature and extent of the problem and discussions of potential solutions are site-specific and different for each of the airports. However, there is a general pattern that as the airport traffic volume approaches capacity, delays increase. Thus, airports can achieve maximum capacity only at a reduced quality of service.
- Today there are eight airports that experience significant passenger delays – where three percent or more of the operations experience delays in excess of 15 minutes:
  - New York LaGuardia
  - Newark
  - New York Kennedy
  - Chicago O'Hare
  - San Francisco
  - Philadelphia
  - Atlanta
  - Boston
- The benchmark study predicts that, in 10 years, the first 6 of the 8 airports above plus Los Angeles will still have significant passenger delays. New runways at Atlanta and Boston should alleviate delays at those two airports.
- Table 1 shows the capacity benchmarks for the 31 airports studied.
- The capacity of airports decreases in adverse weather conditions, which may include poor visibility, unfavorable winds, or heavy precipitation. The reduced rate reflects the capacity benchmark for the

most commonly used configuration in adverse weather. Under very low ceiling/visibility in Instrument Meteorological Conditions (IMC), capacity is even lower.

- Extent of capacity loss during operations at reduced rates (as compared to the optimum) varies widely across the 31 airports, e.g.,
  - At Cincinnati and Minneapolis-St. Paul, it is minimal (2 percent)
  - At some airports like Detroit, Washington Dulles, and Houston, it is relatively small (10 percent or less)
  - At other airports like St. Louis and San Francisco it is very high (about 40 percent)

  These differences are due to different runway configurations and operational procedures in adverse weather at each airport.
- Most airports are able to handle demand under good weather conditions (i.e., optimum capacity). New York LaGuardia is an exception and is the highest ranked airport for delay rates in the year 2000. Looking at the number of aircraft delayed significantly (i.e., greater than 15 minutes), LaGuardia had 156 delays per 1,000 aircraft operations and Newark was a distant second at 81 delays per 1,000 aircraft operations (Table 2).
- During good weather, delays are generally small and manageable.
- During bad weather, capacity is lower and results in even more delays. Overall, LaGuardia, Newark, Chicago O'Hare, and San Francisco have the highest delay rates (57 to 156 delays per 1,000 aircraft operations). Several airports such as Las Vegas, Baltimore-Washington, Denver, and Salt Lake City do not have any significant delay problems (less than 10 delays per 1,000 aircraft operations).
- New runways planned for 14 airports provide significant capacity increases but the amount of the increase varies from site to site.
  - Detailed plans for new runways in the next 10 years were available for Atlanta, Houston, Dallas/Fort Worth, Phoenix, Washington Dulles, St. Louis, Detroit, Cincinnati, Minneapolis-St. Paul, Miami, Seattle-Tacoma, Orlando, Charlotte, and Denver. Additional airport operators are considering new runways, but their plans are not advanced to the point where the impact can be estimated.
  - Nominal increases are in the range of 30 to 60 percent at Atlanta, Houston, Phoenix, Washington Dulles, Seattle-Tacoma, and Minneapolis-St. Paul.
  - Some airports with high capacity configurations at their disposal today have a lower percentage of capacity increase from new runways (e.g., Denver).
- Technology improvements also provide capacity increases – most are in the 3 to 8 percent range.
- Procedural enhancements also hold promise. Depending on the airport, the enhancements could account for an additional 5 to 10 percent improvement in operations.
- For those airports operating close to capacity, technology and procedural changes could have a significant impact in improving capacity.
- Projected demand growth to 2010 at these 31 airports varies from 4 percent at Washington National Airport to 42 percent at Orlando.

Table 1
Capacity Benchmarks for Today's Operations at 31 Airports

Airport		Optimum	Reduced
ATL	Atlanta Hartsfield International	185–200	167-174
BOS	Boston Logan International	118–126	78–88
BWI	Baltimore-Washington International	111–120	72–75
CLT	Charlotte/Douglas International	130–140	108–116
CVG	Cincinnati-Northern Kentucky	123–125	121–125
DCA	Washington Reagan National	76–80	62–66
DEN	Denver International	204–218	160–196
DFW	Dallas-Fort Worth International	261-270	183-185
DTW	Detroit Metro Wayne County	143–146	136–138
EWR	Newark International	92–108	74–78
HNL	Honolulu International	120–126	60–60
IAD	Washington Dulles International	120–121	105–117
IAH	Houston Bush Intercontinental	120–123	112–113
JFK	New York Kennedy International	88–98	71–71
LAS	Las Vegas McCarran International	84–85	52–57
LAX	Los Angeles International	148–150	127–128
LGA	New York LaGuardia	80–81	62–64
MCO	Orlando International	144–145	104–112
MEM	Memphis International	150–152	112–120
MIA	Miami International	124–134	95–108
MSP	Minneapolis-St. Paul International	115–120	112–112
ORD	Chicago O'Hare International	200–202	157–160
PHL	Philadelphia International	100–110	91–96
PHX	Phoenix Sky Harbor International	101–110	60–65
PIT	Greater Pittsburgh International	140–160	110–131
SAN	San Diego Lindbergh Field	43–57	38–49
SEA	Seattle-Tacoma International	90–91	78–81
SFO	San Francisco International	95-99	67–72
SLC	Salt Lake City International	130–132	95–105
STL	Lambert St. Louis International	104–112	64–65
TPA	Tampa International	110–119	80–87

Table 2
Capacity Benchmark Summary

Airport (ranked by delay in 2000)	Capacity Improvement (percent)						Projected Growth to 2010 (percent)	Delays per 1000 operations (2000)
	New Runway (if planned)		New Technology*		New Runway Plus New Technology**			
	Optimum	Reduced	Optimum	Reduced	Optimum	Reduced		
LGA	—	—	10	3	10	3	17	155.9
EWR	—	—	10	7	10	7	20	81.2
ORD	—	—	6	12	6	12	18	63.3
SFO	—	—	0	3	0	3	18	56.8
BOS	0	0	4	4	4	4	6	47.5
PHL	—	—	17	11	17	11	23	44.5
JFK	—	—	2	3	2	3	18	38.8
ATL	31	27	5	6	37	34	28	30.9
IAH	35	37	5	3	42	41	34	28.1
DFW	3	17	1	3	4	21	21	23.8
PHX	36	60	3	0	40	60	31	22.0
LAX	—	—	11	4	11	4	25	21.9
IAD	46	54	2	4	49	60	20	19.5
STL	14	84	11	3	27	89	30	18.2
DTW	25	17	5	6	31	24	31	17.6
CVG	26	26	2	1	28	27	40	15.4
MSP	29	26	4	4	34	31	32	12.7
MIA	10	20	12	6	24	27	23	11.3
SEA	52	46	3	4	57	51	17	10.4
LAS	—	—	0	12	0	12	30	8.0
DCA	—	—	4	8	4	8	4	8.0
BWI	—	—	0	0	0	0	27	6.9
MCO	23	34	5	3	28	38	42	6.3
CLT	25	15	4	8	30	24	15	6.0
PIT	—	—	3	1	3	1	15	3.8
SAN	—	—	2	3	2	3	33	2.5
DEN	18	4	6	13	25	17	23	2.2
SLC	—	—	5	4	5	4	34	2.0
TPA	—	—	0	19	0	19	18	1.6
MEM	—	—	3	4	3	4	30	0.4
HNL	—	—	2	7	2	7	25	0.0

* Estimates assume that new runways (where applicable) are in place
** Numbers include compounding effects of new runways and new technologies and are not strictly additive