

# Fewer air traffic delays in the summer of 2001

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The FAA worries a lot about summer. Not only is summer the time when many people want to travel, it is also the peak of the convective weather season—a time when thunderstorms can and do pop up unexpectedly in the middle of some of the nation's busiest airspace. During the summers of 1999 and 2000, these thunderstorms collided with a bumper crop of passengers from a booming economy, breaking all records for delays and cancellations.

The drop in air travel since September 11 should give passengers some relief from delays in 2002, but it's inevitable that traffic will return and eventually surpass previous levels. The FAA estimates that the current slump in air travel will last just a year or two. Over the long term, it expects airline passenger traffic to increase 30% over the next ten years. With this in mind, it is worthwhile for us to review the performance of the National Airspace System (NAS) during the most recent summer—the summer of 2001. That summer, there were fewer delays nationwide than the summer before, although the complexity of the NAS makes it hard to pinpoint the reason for the drop in delays.

The difference might be due to greater collaboration between FAA traffic managers and airspace users. Following the summer of 1999, the FAA—together with the airlines and other aviation stakeholders—put together a set of initiatives, called Spring/Summer 2000 (S2000), for coping with the effects of severe weather.

A big part of S2000 was setting up a teleconference, held every two hours from the FAA command center, during which the stakeholders create a strategic plan of operations—basically an agreed-upon plan for routing air traffic around expected bad weather. Spring/Summer 2000 also opened up airspace over Canada for reroutes as well as military airspace along the Atlantic Coast.

## **Commercial flights displace GA at major airports**

We'll begin our review by looking at the change in the number of operations (arrivals plus departures) nationwide. The FAA identifies four classes of air traffic: air carrier, air taxi, general aviation, and military. During the summer of 2001—here taken simply to be the months of June, July, and August—there was a slight drop, 0.7%, in operations at the country's 55 busiest commercial airports from the summer before, due mainly to a growing tendency among private pilots to use smaller airports. Carrier flights remained close to the previous summer's all-time high, and air taxi flights—commercial flights carrying fewer than 60 people—rose, as they have for the past five years (See figures 1 and 2).

Figure 1. Total operations, Jun-Aug, 55 airports (OPSNET)

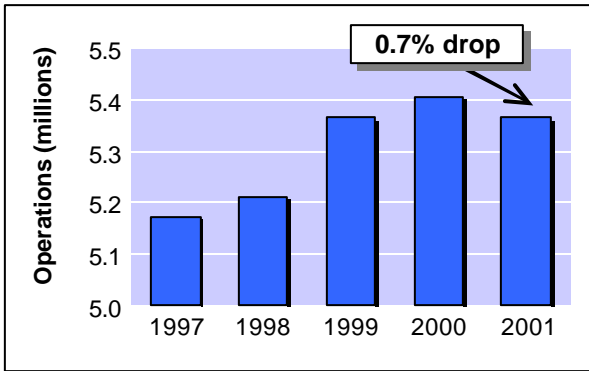
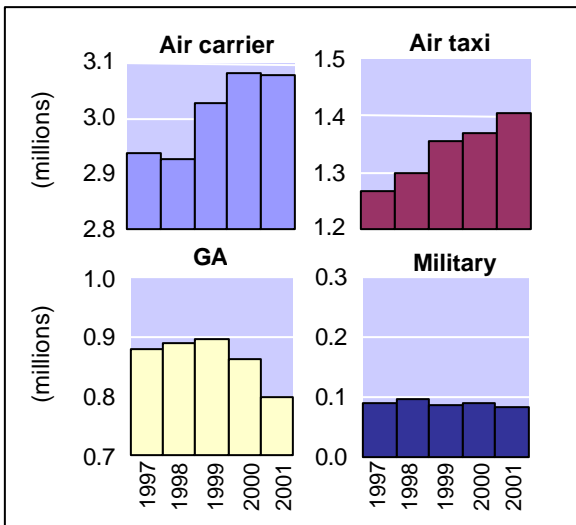


Figure 2. Operations by aircraft type, Jun-Aug, 55 airports



## Two systems for tracking delays

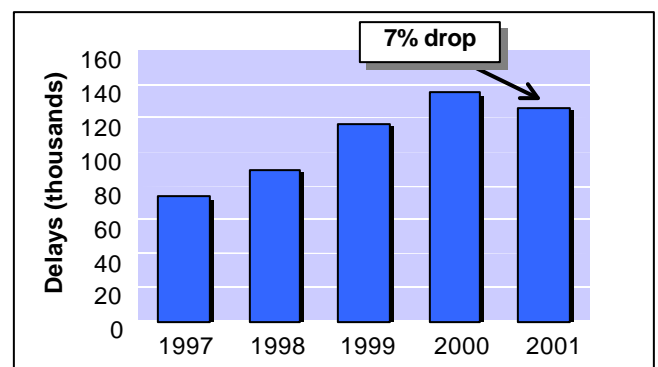
Before we discuss how delays have changed, we should clarify what we mean by a “delay.” The FAA actually has two systems for tracking delays: ASPM (Aviation System Performance Metrics) and OPSNET (Operations Network). ASPM credits an airport with a delay every time a flight arrives or departs more than fifteen minutes later than scheduled. Many people like ASPM for its straightforward definition of delay, a definition that reflects the amount of inconvenience experienced by air travelers. On the down side, ASPM doesn’t record why a flight was delayed; nor does it say which airport caused the delay. ASPM will credit an airport with an

arrival delay even if the arriving aircraft was held up an hour or more by runway congestion at its airport of origin. Likewise, a departure delay will be given to an airport that is forced to hold a flight because its destination airport is in ground stop or ground delay. In neither case are the delays attributed to the airport that caused them.

OPSNET, on the other hand, is designed to track delays associated with the traffic management system. Under OPSNET’s rules, an airport picks up a delay every time a flight is held up fifteen minutes or longer due to such things as runway congestion, airport weather, airborne holding, or traffic flow restrictions, imposed either nationally or locally. OPSNET would not record a delay for a flight delayed several hours due to mechanical failure, unless the failure involved FAA or airport equipment. Nor does OPSNET capture delays that occur because of delay propagation—the way a late-departing aircraft arrives late at its destination and, in turn, departs late for its next destination. And if an aircraft is unable to depart because its destination airport is in ground stop or ground delay, OPSNET attributes the delay to the destination airport, not the originating airport.

Overall, OPSNET delays fell 7% in summer 2001, reversing the steady rise in delays of the previous four summers (See figure 3). To see how the distribution of delays changed from summer 2000 to 2001, we constructed a quantile-quantile (Q-Q) plot (See figure 4). The number of delays each day for the two summers

Figure 3. OPSNET delays, Jun-Aug, 55 airports



is sorted and then plotted as X-Y pairs. The day with the fewest delays in 2001 is paired with the day with the fewest delays in 2000, and so on. The Q-Q plot shows a downward shift in the number of delays per day in summer 2001 from the year before, the exception being the handful of days with largest number of delays—the five worst days in 2001 had more delays than the five worst days of 2000. The difference between the two summers stands out more clearly if we tilt the Q-Q plot forty-five degrees (See figure 5). Low delay days in summer 2001 had about 90 fewer delays than the summer before, medium delay days had 100-400 fewer delays, and the highest delay days again had more delays in summer 2001. The drop in overall delays between the two summers appears therefore to be systematic and not the result of one or two fewer storms.

**Delays down with respect to weather**

Most air traffic delays are caused by bad weather. And no two days, weeks, or months have the same weather. So to see if NAS performance really did improve in summer 2001 from the summer before, we used least-squares regression analysis to factor out differences in weather and the number of flights. The dependent variable in our regression model—the variable we want to “explain”—is the number of OPSNET delays at the 55 busiest commercial airports. Our first independent variable, “Operations,” is the total number of arrivals and departures each day at these airports. Operations varied between 59,000 on a typical Sunday to 65,000 on a typical Thursday (there are fewer flights on weekends than on weekdays).

Figure 4. Comparison of daily OPSNET delays, Jun -Aug

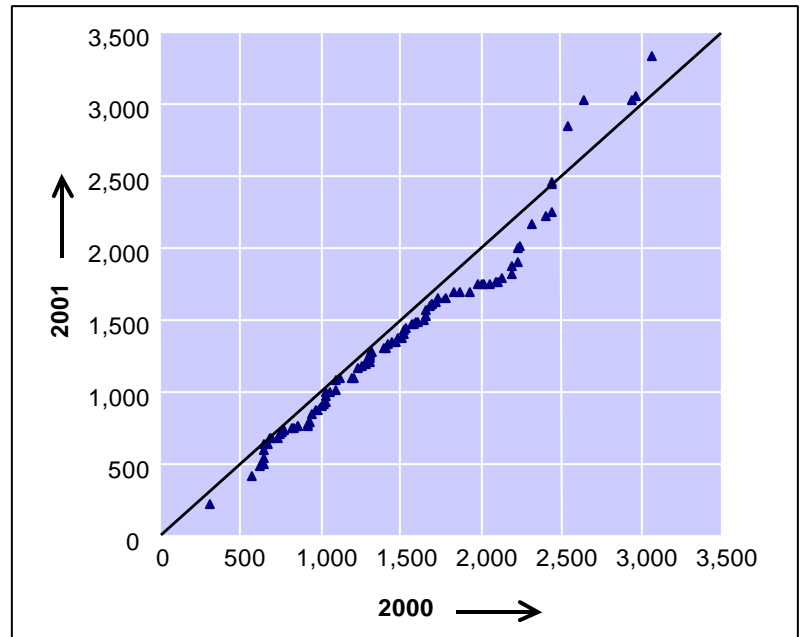
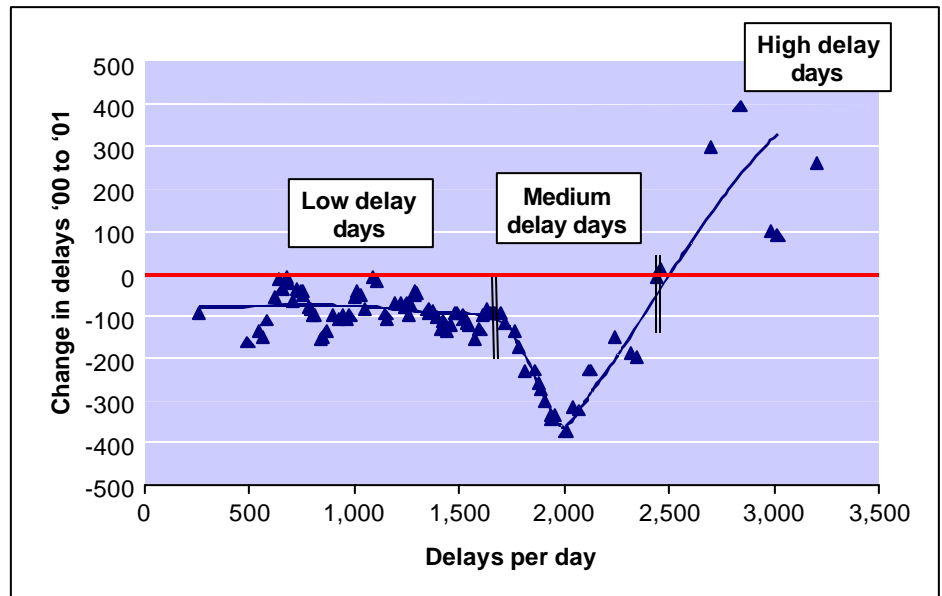


Figure 5. Comparison of daily OPSNET delays, Jun-Aug



Data for our second independent variable, “Convective coverage,” came from a web site run by the Forecast Systems Laboratory of the National Oceanic and Atmospheric Administration, [www-ad.fsl.noaa.gov/fvb/index.html](http://www-ad.fsl.noaa.gov/fvb/index.html). Using information from this site we computed the percentage of the continental United States that was covered by convective weather

(thunderstorms) at four times: 12 p.m., 2 p.m., 4 p.m., and 6 p.m. (EDT). Averaging these percentages gives an aggregate percent coverage for each day, which varies between 2% and 10%. Days with more convective coverage generally have more delays, although there are exceptions: A small storm sitting between Chicago and New York will disrupt more flights than a larger storm over the Midwest.

Combining the three variables “Delays”, “Operations” and “Coverage” into a single model gives the following regression equation:

$$\text{Delays} = 202.2 \text{ Coverage} + 0.0385 \text{ Ops} - 21.5 \text{ Coverage} * \text{Year} - 1832$$

Here Coverage\*Year is the product of “Coverage” and the categorical variable “Year” (=1 if 2001; =0 otherwise). This equation says that a one-percent increase in convective coverage causes about 200 additional delays, and an increase in operations of 1000 flights leads to about 39 additional delays. Also, when differences in weather and the number of flights are factored out, summer 2001 still had fewer delays than the summer before. The difference between the summers increases as weather gets worse: days with 2% convective coverage had 43 fewer delays in 2001 than in 2000; days with 8% convective coverage had 172 fewer delays.

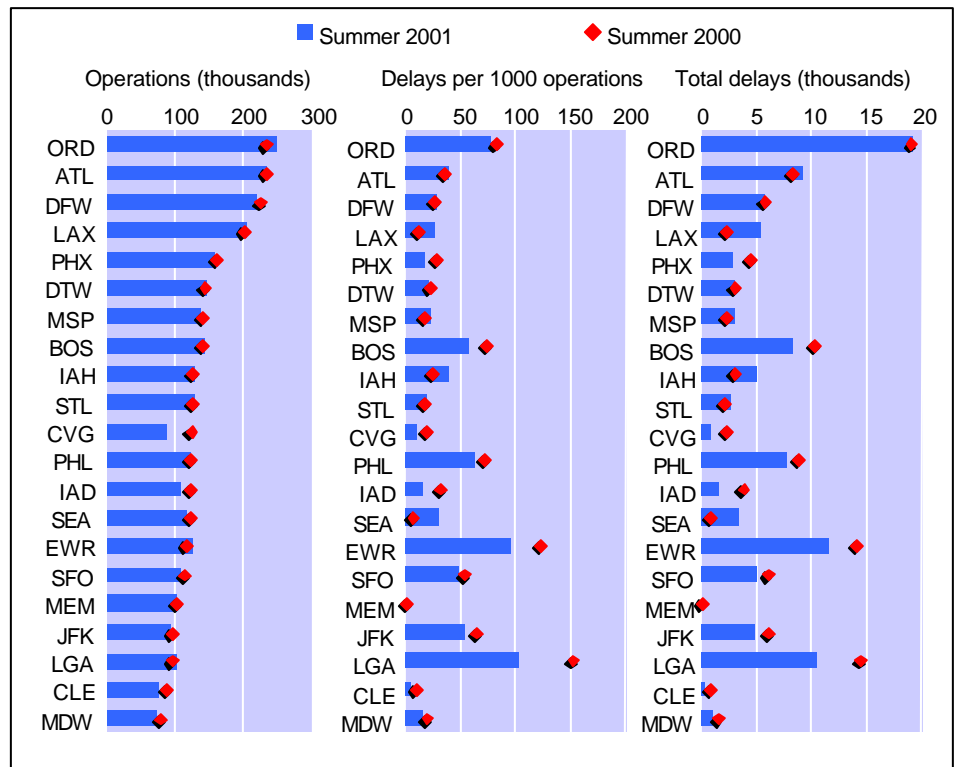
One drawback of least squares is that it tends to overemphasize extreme data — for example, days with many delays but little convective coverage. A different statistical model—one based on the median number of

delays per day—suggests an even greater difference between the two summers, on the order of 250-400 delays per day on days with medium to bad weather.

### Change in delays varies by airport

Delay counts for the entire country change by at most five to ten percent per year; delay counts at individual airports, on the other hand, can experience much more dramatic swings. Figure 6 shows operations and delays at the country’s 21 busiest airports for summer 2000 and 2001. Ordering the airports vertically by the number of operations highlights airports that have many delays relative to their size. The largest proportion of delayed flights both summers belongs to one of the smaller airports, New York’s LaGuardia Airport (LGA). Also, an airline strike at Cincinnati International Airport (CVG) explains the substantial drop in operations there from the year before.

Figure 6. OPSNET delays and operations at 21 major airports



OPSNET delays decreased at all major Northeastern airports in summer 2001, including New York LaGuardia (-27%), Newark International (-17%), Washington Dulles (-60%), Boston Logan (-20%), John F. Kennedy (-21%), and Philadelphia (-11%) (See table 1). Overall NAS performance is strongly tied to congestion in the busy and constrained airspace of the Northeast. And fewer planes delayed in the Northeast means that more planes will arrive on time at their destination airports throughout the country.

Table 1. Change in OPSNET delays by major airport

Airport	Change	Airport	Change
LGA	-27%	LAX	+124%
EWR	-17%	SEA	+268%
IAD	-60%	IAH	+64%
BOS	-20%	ATL	+12%
PHX	-38%	MSP	+36%
CVG	-64%	STL	+17%
JFK	-21%		
PHL	-11%		

Figure 7. Percent on-time gate arrivals rose in summer 2001

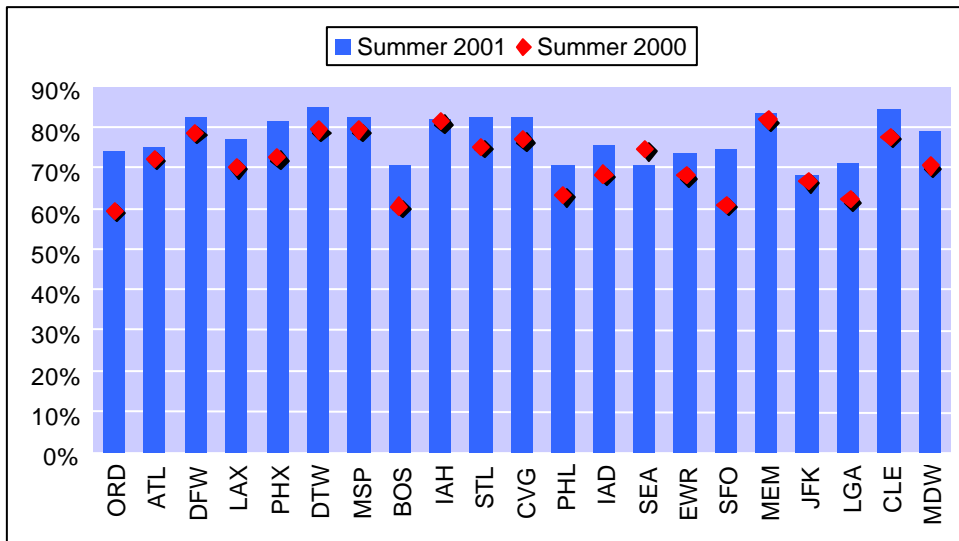
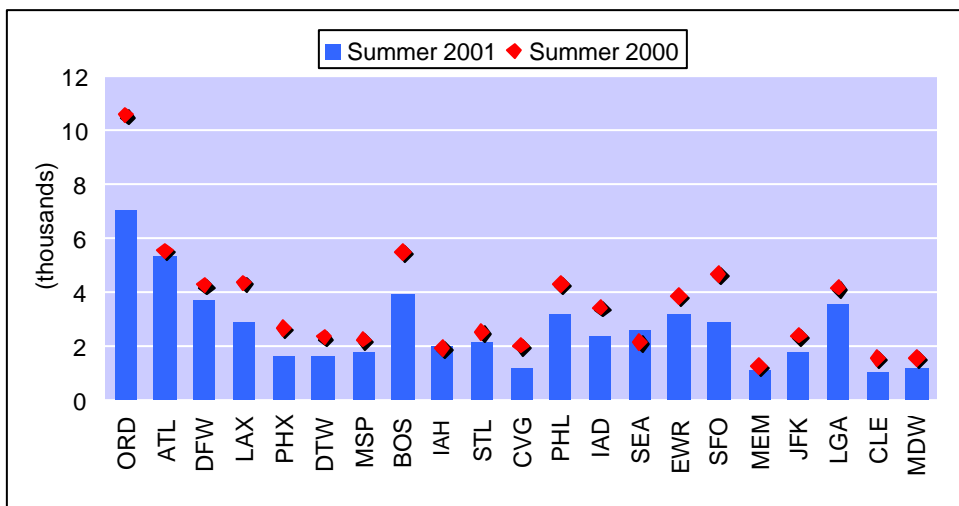


Figure 8. Departures delayed more than an hour fell in summer 2001 (ASPM)



In summer 2001, on-time performance improved at 20 of the 21 busiest U.S. airports (See figure 7). Also, the number of flights that departed more than one hour late fell at these same airports (See figure 8). The exception in both cases was Seattle Tacoma International Airport (SEA).

### Capacity shortfalls at SEA and LAX

So why the big increase in OPSNET delays at Seattle and Los Angeles? To answer this question we need to introduce the idea of airport capacity and airport capacity shortfalls. Capacity is a measure of an airport's ability to throughput aircraft. Airports lose capacity when, for example, poor visibility makes it necessary for them to increase aircraft separation, lowering the rate at which they can launch and land aircraft. For the past few years, major airports have been reporting in real-time the maximum arrival and

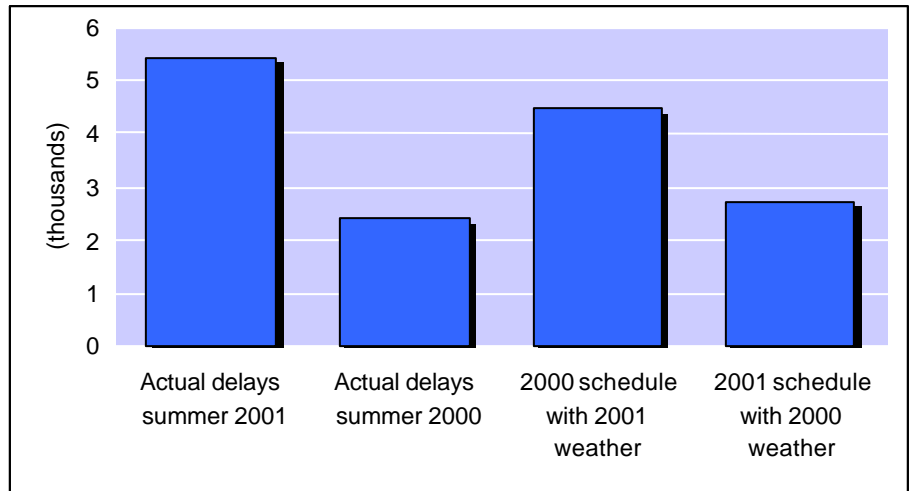
departure rates they can deliver. They adjust these rates throughout the day in response to changes in visibility, ceilings, runway configuration, and airport construction.

Hourly capacity shortfall is defined as the difference between an airport's reported arrival rate—the rate it says it can deliver—and the number of aircraft scheduled to arrive there at a particular hour. If the number of flights scheduled to land is less than the reported rate then there is no shortfall. If the number of scheduled arrivals exceeds the reported rate then we expect some arrivals to be delayed. A shortfall in arrival capacity can also disrupt departures since arrivals and departures often share the same airspace and runways.

At many airports, daily OPSNET delays track well with daily totals of arrival capacity shortfall. Empirical data for Los Angeles International Airport shows that a capacity shortfall of one flight per hour causes, on average, about three-and-a-half delays; at Seattle and St. Louis, the ratio is closer to one-to-two. The relationship between shortfalls and delays is approximate, and likely relates to the size, location, and the physical layout of an airport. For a severe loss of capacity, we would need to account for cancellations as well as delays. If an airport were to temporarily lose a runway, for example, it could offset the expected capacity shortfall by canceling some flights and delaying others.

The relationship between OPSNET delays and capacity shortfalls gives us a way to estimate how delay counts at an airport will be affected by changes in weather and schedule, as well as by potential enhancements in airport capacity due to new runways or new procedures. For the case of Los Angeles and Seattle it allows us to estimate how much of the increase in delays from summer 2000 to 2001 was due to worse weather, and how much was due to a heavier schedule. We do this by combining

Figure 9. Delay totals for LAX, Jun-Aug: actual and hypothetical



LAX's reported weather in summer 2001—represented by LAX's reported arrival rate—with its summer 2000 schedule. Delay totals are inferred from the resulting capacity shortfall. Similarly we can combine LAX's summer 2001 schedule with its reported weather in summer 2000. Our results attribute about 85% of the increase in delays at Los Angeles to an increase in scheduled operations there, particularly between 11:00 am and noon. Only about 15% of the increase came from worse weather at LAX in 2001. The same analysis was also done for Seattle, where OPSNET delays increased almost two-and-a-half times from the year before. Unlike at Los Angeles, where a heavier schedule caused most of the increase in delays, at Seattle the increase was almost entirely due to worse weather: Seattle airport was hit by about six major storms in summer 2001, up from just two storms the summer before.

## Outlook

The public outcry caused by record delays and cancellations in the summers of 1999 and 2000 compelled the FAA and the user community to rethink how they manage traffic on a national scale. Collaboration between the FAA and airspace users is now seen as key to mitigating the effects of severe summer weather. This change in philosophy may be

responsible for the increase in NAS efficiency that took place between the summers of 2000 and 2001, when more passengers flew but delays decreased. More needs to be done, however—such as building airport capacity,

redesigning airspace, and keeping an eye on airport schedules—to ensure that improvements in system performance keep pace with the inevitable growth in demand for air travel.

