EXTENT AND IMPACT OF FUTURE NAS CAPACITY SHORTFALLS IN THE UNITED STATES: A SOCIO-ECONOMIC DEMAND STUDY

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Abstract

The U.S. aeronautics industry remains one of the undisputed success stories in global competitiveness throughout the latter half of the past century and is currently one of the largest positive industrial contributors to the U.S. balance of trade. Yet experts agree that demand for air transportation will soon outpace National Airspace System (NAS) capacity, and that such capacity shortfalls will impose significant, tangible costs to the nation. Long-term strategic planning is therefore essential to safeguard America's economic prosperity, national security, and quality of life. Such planning requires a broad-based national perspective that considers the needs of the aviation industry and its customers and equips policy makers and planners with the information necessary to effect beneficial change.

In response to those requirements, the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration (FAA) with GRA, Inc., LMI, and the Volpe National Transportation Systems Center undertook a year-long study to assess the potential benefits of transforming the air transportation system to meet future demand. Our research quantified the projected economic loss to the United States over the period 2015-2025 should NAS capacity fail to keep pace with the anticipated growth in demand. The study estimated that the anticipated shortfall in NAS capacity could have significant costs for the nation, ranging between a cumulative $91.6 billion and $229.4 billion from 2015-2025. Our research thus establishes a firm foundation for what must follow—a complete cost-benefit analysis of potential federal investment in a new national initiative to transform the air transportation system.

Introduction

The United States Congress established the Commission on the Future of the United States Aerospace Industry in 2001 to study the U.S. aerospace industry and to assess its importance to the U.S. economy and national security. In its report to Congress one year later, the Commission issued a stern warning that the nation "stands dangerously close to squandering the advantage bequeathed us by prior generations of aerospace leaders." It also issued nine recommendations deemed essential to preserving U.S. global aerospace leadership in the 21st century. Key among them was a call for "transformation of the U.S. air transportation system as a national priority [1]."

In response to this pressing need, the Joint Planning and Development Office (JPDO) was created by the U.S. Congress in 2003 in the *Vision 100–Century of Aviation Reauthorization Act*. The JPDO is led by the Federal Aviation Administration (FAA) and coordinates long-term aviation planning by the FAA, NASA, Department of Homeland Security, Department of Defense, and Department of Commerce. The first step was to build an advocacy package, i.e., a "compelling case".

The purpose of the socio-economic demand forecast (SEDF) study was to improve understanding among policymakers and planners, segments of the aviation industry, and the public concerning the economic, safety, security, and quality-of-life impacts of the U.S. air transportation system on the nation. One objective of the SEDF study focused on assessing future levels of demand for air transportation services relative to system capacity in order to quantify the potential resultant losses, both in terms of disrupted air transportation activity and economic losses. Our study provides evidence that the air transportation system will fail to meet future demand without significant new investment in capacity and efficiency improvements that go beyond those called for in the Operational Evolution Plan (OEP), the FAA framework for improvements through 2015.

Of course, the transformation of the air transportation system that could prevent these losses arising from a shortfall between NAS capacity and demand will not be without cost. A complete cost benefit assessment of the transformation should compare the costs associated with specific plans and systems that would achieve this transformation with the value to the national economy of avoiding the losses arising from a capacity shortfall.

Providing these assessments is the role of the Evaluation and Analysis Office (E&AO), an element of the JPDO. The E&AO will assess strategies for transforming the NAS to meet the high level national goals and will provide the JPDO principals with the knowledge necessary to prioritize investments and make tradeoffs.

Background

As noted by Hustache, Gibellini, and De Matos at the 4th USA/Europe Air Traffic Management R&D Seminar: "The scope of studies concerning economic analysis of ATM is still quite limited, and the first attempts, despite showing promising results, are often constrained by lack of appropriate data [2]." To enable economic analyses that take into account links among the various components of air traffic services, Eurocontrol developed a model called PAMELA. The authors note that while PAMELA models en-route capacity, it does not address airport capacity, and this is considered an area for further development.

Peter Kostiuk asserted at the same seminar that: "Delay metrics do not capture the true economic benefits of ATM investments, which are to enable growth in air travel. Until the ATM community expands its metrics and focuses on benefits that can justify the required investments, it will continue to experience difficulty acquiring funding for system improvements [3]."

New technologies, procedural changes, and policy changes which aim to increase NAS capacity have traditionally been expected to reduce flight delay. While delay would indeed be reduced, we believe the primary benefit of NAS capacity improvement is in increasing the system throughput; i.e., allowing more flights to be scheduled and flown without having delays rise to untenable levels.

In our present study, we consider the problem that potential air traffic growth may not be sufficiently supported by the NAS infrastructure. Instead of unrealistic average flight delays which would result if all forecasted demand were to be accommodated, we postulate that some of the flights needed to fulfill the demand for air transportation will not materialize. Since airlines must provide a service with reliable schedule integrity, capacity constraints will dictate the elimination of some of the future flights to ensure that delays do not grow beyond reasonable limits.

Our study quantifies the cost to the U.S. economy if NAS capacity fails to keep pace with "unconstrained" demand growth in the future. Unconstrained demand growth reflects the projected level of aviation activity that would occur given anticipated economic growth and trends in airline industry pricing, irrespective of system capacity. We define constrained demand, on the other hand, as the level of demand that can be accommodated in a system where performance (in terms of congestion and delay) is no worse than that observed in 2000, a year when the capacity of the air transportation system was seriously strained.

We looked at the differences between constrained and unconstrained demand and estimated the cost to the economy in terms of the following measures:

- Increased delay cost to passengers and airlines
- Increased cost of transportation (fares) for passengers
- Reduced number of passenger trips due to insufficient NAS capacity

SEDF Study Approach

We began by quantifying the national value of air transportation in terms of its role in the economy as well as how it influences the nation's quality of life. The next step focused on projecting the anticipated growth in air transportation demand to 2015 and 2025 based on the FAA long-range aviation forecast. In addition, we analyzed enablers and constraints that could affect the growth and the patterns of future air transportation demand. We reviewed possible futures for air transportation demand based on the interactions of economic growth and socio-economic constraints and enablers.

Finally, we assessed future capacity levels in relation to anticipated demand. This was done by first estimating future demand for passenger air transportation services, assuming that there would be no constraints on the ability to satisfy demand. Then we estimated the level of demand that the system would be able to handle if no further system improvements were undertaken after 2015. Comparison of these estimates reveals that there is a considerable shortfall in capacity, which grows year-by-year from 2015 to 2025. Figure 1 illustrates the SEDF study approach.

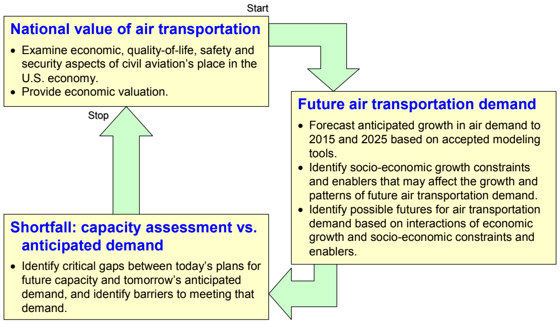

Figure 1. SEDF Study Approach

Capacity Shortfall Analysis

The cornerstone of our analytic approach to estimating the future shortfall of capacity involves comparing the forecasted demand for air travel with a forecast of feasible air travel service that explicitly accounts for the impact of airport and airspace capacity constraints on flight schedule planning. Figure 2 shows an overview of the process we follow.

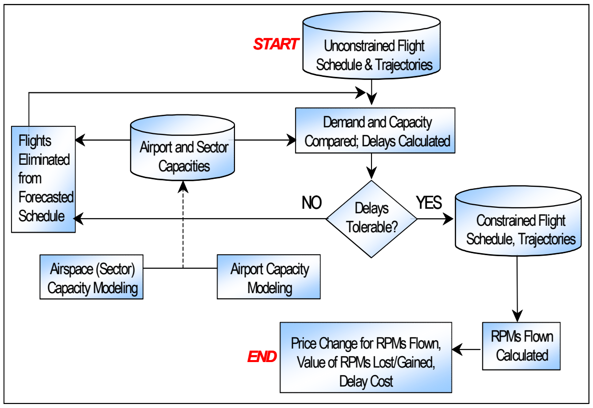

Figure 2. Shortfall Assessment Methodology

Our capacity shortfall analysis begins by forecasting a future flight schedule, for nominal day-to-day operations (year 2015 and year 2025), including each flight's origin and destination (O&D), departure and arrival times, and aircraft type. The flight schedule is generated incorporating both commercial (domestic and international) and GA air traffic. For each flight, we also generate a four-dimensional trajectory; i.e., the flight path. The schedule embodies the demand at airports while the associated trajectories embody the demand on the airspace, without consideration of capacity limitations.

The process continues by comparing the demand to capacities of the airports and airspace. The airport capacities are calculated based on the number of runways and the configuration being used depending on the meteorological conditions. For the airspace, the en route sector capacities are specified as the maximum number of allowable aircraft within each sector per unit time. The predicted imbalance between demand and capacity would result in unacceptable levels of chronic congestion and delays.

Flights are eliminated until delays do not exceed tolerable limits to produce a tenable flight schedule. Calculating the number of flights that would be eliminated to produce the constrained schedule is fundamental to the shortfall assessment because it allows us to estimate the limits to growth in the NAS and the associated lost value to the nation. To perform the economic valuation, we convert the lost flights to foregone revenue passenger miles (RPMs) for which we then estimate an economic value in terms of lost consumer surplus. We also estimate the impact of sufficient capacity on airline and passenger delay costs.

Baseline Demand Forecast

The FAA's long-range forecast for U.S. air transportation demand served as the baseline demand forecast for the SEDF study. The FAA uses the forecasts of RPMs and enplanements to provide the basis for forecasts of air transportation activity which are in turn, used to determine staffing levels and capital expenditures required to accommodate the growth of air transportation activity while maintaining a safe, secure, and efficient air transportation system. The forecasts are not capacity constrained, and assume that the FAA and the airlines will develop cost efficient solutions to mitigate any congestion and delay problems.

In general, the model used for developing the FAA domestic large air carrier forecast of traffic and yield relies upon a system of statistical and deterministic equations. The pivotal equations of the system relate RPMs and enplanements to three primary variables: real U.S. GDP, real U.S. personal consumption expenditures (PCE), and real yield (incorporating aviation user taxes and fees such as passenger facility charges). This analytical framework ties the domestic forecast model closer to projected changes in economic activity and reduces the number of subjective inputs. The general functional forms of the equations as follows:

RPMs = f (PCE, Yield)

Yield = f (RPMs, Sept 11)

Enplanements = f (GDP or PCE, Yield, Sept 11)

In the system of equations, there are a number of exogenous shift variables. The majority of these dummy variables are temporary in nature, attempting to account for short-run disruptions to the long-run relationships. The Sept 11 dummy variable is an example of such a shift variable.

Air carrier demand, as measured by domestic RPMs, is projected to continue to grow faster than the general economy. For the period 2002 to 2014, domestic RPMs are forecast to increase at an average annual rate of 3.9% compared to a 3.2% annual growth rate in real GDP. Over the extended forecast period (2014-2025), domestic RPMs are projected to increase at an average annual rate of 3.6% compared to real GDP growth of 3.1% annually.

International RPMs have historically grown at faster rates than domestic RPMs. The baseline demand forecast reflects a continuation of this trend. International RPMs are projected to increase at an average annual rate of 4.9% during 2002 to 2014. Over the extended forecast period (2014-2025), international RPMs are forecast to increase at an average annual rate of 4.3%. Tables 1 and 2 summarize the baseline demand forecast results.

Table 1. Baseline U.S. Domestic Demand

Year	RPMs (Billions)	Real Yield (2002 $)
2000	512.3	$ 0.1470
2015	780.8	$ 0.1084
2025	1,116.3	$ 0.0964

Table 2. Baseline U.S. International Demand

Year	RPMs (Billions)	Real Yield (2002 $)
2000	181.8	$ 0.1095
2015	293.3	$ 0.0909
2025	446.6	$ 0.0882

Unconstrained Flight Schedule Generation

The term "air traffic demand" is a loosely defined concept that can mean anything from aircraft operations, to passenger enplanements, to the number of RPMs at different aggregation levels. We are interested primarily in the *schedule* of aircraft flights because that is the variable that determines air traffic demand at both airports and air traffic control sectors.

A schedule is a set of flights departing from various origin airports and arriving at various destination airports, leaving at certain times and arriving at certain times, and operated by various air carriers using a particular aircraft with an associated passenger/load capability. The unconstrained schedule forecast generation method uses different approaches for the air carrier traffic component and the general aviation (GA) traffic component.

Our approach for forecasting the unconstrained air carrier schedule [4] includes the following assumptions:

- We seek to construct an industry-wide model instead of one that integrates carrier-specific models. By taking the industry as a whole, while still assuming the existence of competition among the carriers, we avoid attempting to predict winners and losers in the competition.
- The traffic growth rate between two cities must be proportional to the traffic growth rates in both cities, respectively, if the terminal growth rates in other cities are unchanged.
- Current air carriers' operational practices will be unchanged in the future. Our schedule reflects the current mix of hub-and-spoke and point-to-point operations. This may, of course, be different in the future but we made this assumption to avoid having to prognosticate.

While the commercial air transportation market largely operates on published flight schedules, GA is characterized by itinerant and local operations for which there is no analogue to the commercial schedule. Generating a future unconstrained GA air traffic schedule forecast therefore requires a significantly different process than that for commercial air traffic [5]. Though we talk of generating a "GA schedule", this does not mean that the future GA operations will be scheduled; rather, it is simply an expression of the forecasted GA flights in terms of origin and destination as well as time of day.

In our GA schedule generation process, the forecast of aircraft based at various airports across the continental U.S., and the forecast of GA itinerant operations for each of these airports come from the output of the top-down model of the Integrated Air Transportation System Evaluation Tool (IATSET) [6]. The tool allows us to forecast the future distribution of GA aircraft and GA itinerant operations, the size of the GA fleet, fleet productivity, and transported passenger miles (TPMs).[1]

Airport and Airspace Capacity and Delay Analysis

LMINET was originally developed in the 1990s by LMI as part of NASA's Aviation System Analysis Capability (ASAC) and subsequently refined further in support of NASA's Advanced Air Transportation Technologies (AATT) project. In general terms, LMINET models flights among a set of airports by linking queuing network models of the airports with a sector loading model of en route, Terminal Radar Approach Control (TRACON), and Air Route Traffic Control Center (ARTCC) sectors. All flights in the U.S. are considered, both commercial and general aviation, including international flights that originate or terminate in the U.S. The arrival and departure delays are computed for the top 102 airports; these airports comprise roughly 95% of all enplanements in the U.S.

Airport arrival and departure capacities can either be accepted as inputs or generated internally, in which case runway configuration, ceiling, visibility, and wind speed and direction are considered, and arrival and departure capacities are dynamically traded off based on demand. We specify the sequences of sectors to represent various operating modes for the NAS. In this study, the sequences correspond to the trajectories as flown on a specific day as determined from actual flight data.

Modeling OEP Capacity Improvements

Although the focus of our study is on assessing the NAS performance shortfall if nothing is done to address the forecasted demand for air travel, we recognize that plans to enhance NAS capacity do exist, at least in the near term. Among these plans, the most prominent is the OEP.[2]

There are several enhancements listed in the OEP that, if implemented, should improve runway capacity at airports. The SEDF study models the following improvements:

- Runway additions and improvements
- Filling gaps in arrival and departure streams
- Coordinating efficient surface movement

Based on the data provided in the OEP, the new airport plates, and results from the LMINET Capacity Model, we were able to estimate the new FAA-style Pareto curves of maximum capacity for these airports. It is important to note that in some cases the airport capacity may only increase under certain weather conditions. Therefore, under the good weather assumption in this study, some of these airports may not have a higher capacity in the future scenario years. The study also assumes there are no additional runway improvements after 2015 (i.e., the runway capacities in 2025 are identical to those in 2015).

Decision support tools can improve controllers' ability to improve sequencing plans and optimize runway balancing. The implementation of the Traffic Management Advisor (TMA) and the passive Final Approach Spacing Tool (pFAST) will provide an increased arrival capacity by optimizing the sequencing of aircraft types into an airport. For the SEDF analysis, we assume that TMA and pFAST are deployed and in effect at all 102 LMINET airports by 2015. The FAA estimates that the implementation of these technologies will improve an airport's arrival capacity by 5%. The results we obtain from modeling these tools using the LMINET Capacity Model are very similar. We note that the OEP only identifies deployment of TMA at select airports and pFAST is not identified for deployment. We chose our stated modeling of TMA and pFAST to compensate for our inability to capture all the technological and procedural improvements indicated in the OEP.

Efficient movements at the airport surface could significantly increase taxiing and runway capacity. Improved communication and surveillance can reduce taxiing times and improve departure streams. The study team assumed the fusion of Automatic Dependent Surveillance Broadcast (ADS-B) with Airport Surface Detection Equipment (ASDE) for the 2015 and 2025 analyses. Furthermore, we assume an improved Surface Management System (SMS) will improve taxiing procedures.

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[1] A transported passenger mile is one passenger transported one statute mile in a GA aircraft. The concept is analogous to the revenue passenger mile used for measuring the output of U.S. commercial air carriers.

[2] http://www.faa.gov/programs/oep/

The study models these technologies in two ways. First, we assume that departures are conducted more efficiently by utilizing these tools. Specifically, we run the model such that small, large, and heavy aircraft are sequenced and depart in an optimized manner, much like how TMA functions on the arrival side. Secondly, we assume that any increase in runway capacity, whether by technologies or increased or improved runways, will result in a proportional increase in taxiing capacity. That is, if the total maximum number of operations in an hour for a given airport increases from 100 to 120, then we model the taxi capacity also to increase 20% at that airport.

For improving the en-route congestion, the OEP considers several potential concepts for reducing the strain on the system. We consider the two that we believe are both likely to occur and have the most dramatic effect when implemented.

The reliance on voice communications between pilots and controllers can cause some inefficiency through a variety of imperfect human actions and responses. A voice system that is supplemented by the Controller-Pilot Data Link Communications (CPDLC) would provide much of the necessary information in a reduced amount of time, thereby making en-route capacity higher. We assume implementation of CPDLC Build 1A by 2015. We note that CPDLC no longer appears in the most current version of the OEP. However, the FAA and industry stakeholders still consider the program to be vital and are pushing to secure the necessary funding.

The implementation of Reduced Vertical Separation Minimum (RVSM) will add six more flight levels at high altitudes. The increase in flight levels will help Air Traffic Control and reduce delays, thereby increasing fuel savings. There are currently seven flight levels between 29,000 and 41,000 feet. We model the addition of these six, making a flight level at every 1000 feet and assume that all aircraft that fly above 29,000 feet will be RVSM compliant by that time. In fact, RVSM has begun to be implemented in 2005.

We translate the improvement due to CPDLC and RVSM into an increase in en route sector capacity of 30%. This number was based on results of prior studies which modeled the decrease in en route controller workload to derive an estimate of sector capacity increase [7].

Imposing NAS Constraints in LMINET

Our thesis rests on the idea that it is unrealistic to generate a future schedule in which the level of demand creates delays—under optimal weather conditions—that are excessive [8]. To generate a more realistic (i.e., “constrained”) forecast, we impose a maximum delay per flight at each airport. Once the delay per 15 minute epoch reaches that maximum, no increase in flights is allowed during that period. In other words, when the departure and arrival queues become too large, the number of flights forecast for the future schedule must be reduced.

The delay tolerance, at each airport, is the greater of either the peak quarter-hourly delay experienced at that airport, during good weather conditions in 2000, or the same figure averaged for the 31 large hub airports. By using this scheme, we allow the delay levels of today’s less congested airports to grow as they experience more demand but still impose a reasonable overall constraint on airport delay.

We use the peak delays (due strictly to demand, not weather) from 2000 because that year was characterized by very high levels of delay. Our interpretation is that while the NAS was experiencing high demand and was close to its capacity limits, the level of delay was still tolerable, at least from the airlines’ perspective.

Using these airport-specific delay tolerances, the model estimates the excess arrivals and departures which must be eliminated. Several policies could result in such an outcome: self-imposed airline restrictions and airport demand management rules, for example. The objective in enforcing this delay tolerance is to apply plausible limits on the growth in delay or block times, and thereby estimate limits to growth in the NAS.

In our study, consistent with the FAA’s practice, we define sector flight demand as the maximum number of flights simultaneously in the sector in every 15-minute interval. If the sector demand exceeds its Monitor Alert Parameter (MAP), then some action will be taken (e.g., delaying the departure time, rerouting) to some flights to make the demand below the MAP. MAP is thus the sector capacity, which is determined by the volume and complexity of the traffic, the sector definition, and the radar coverage. MAP is typically 18 for most of the enroute sectors in the current system.

There is a remaining important problem of selecting which flights to eliminate from the future schedule; merely identifying a number of flights to eliminate is insufficient. Additionally, identifying flights to constrain based on a set of criteria allows flights of greater "value" to remain. We choose to optimize the number of operations. This is a conservative decision because it assumes that the NAS will continue to be operated as it is today; i.e., "first come, first served." In other words, all flights are treated equally. It does not matter how many passengers are carried, whether commercial or GA; what matters is the NAS resources used (long flights traversing many congested sectors are penalized as are flights departing from and/or arriving at congested airports). For a set of flights with the same flight elimination score, we choose to eliminate the one with the fewest RPMs.

Economic Valuation

There is inherent uncertainty about how a capacity constrained air transportation system will evolve over the next 20 years. However, reliable estimates of the economic cost of a future air transportation system that lacks sufficient capacity to meet demand can help policy makers and planners understand the importance of acting now to prevent a significant shortfall. If the air transportation system is unable to meet future demand, embedded delays and other inefficiencies in the system are also likely to grow. Some travelers will encounter delays, some will encounter increased airfares, and some will be priced out of the air travel market completely.

Loss of Consumer Surplus

In the marketplace, the interaction of buyers and sellers determines the market-clearing price. The demand curve for a good or service represents the marginal benefit received by the purchaser of each additional unit of the good or service, as measured by the amount a buyer is willing to pay for it.

Buyers who pay the market clearing price for a particular good or service—but who would be willing to pay more, if necessary (inframarginal buyers)—in effect enjoy a bonus, since they acquire the good or service for less than they were willing to pay. This bonus, aggregated over all consumers able to purchase at a price lower than what they are willing to pay is termed "consumer surplus." It measures the total value received by buyers from obtaining and consuming a good or service that is in excess of the total amount of money spent by the buyers to obtain the good or service.

The economic concept of consumer surplus is an important conceptual tool for valuing the loss to air travelers from a future NAS capacity shortfall.[3] In the context of our analysis, the *change* in consumer surplus represents the total lost value of the foregone demanded RPMs that cannot be delivered coupled with the resultant higher price of travel to the flying public because of the capacity shortfall.

In the domestic arena for 2015, we estimate that air system capacity constraints will lead to a 6.3% reduction in total flights and a 4.9% reduction in RPMs. In the same year, international flights are reduced 1.1% and RPMs are reduced nearly 1%, while GA flights are reduced 4.6% and GA RPMs are reduced 3%. Without additional capacity, domestic flights in 2025 are reduced nearly 16% from the baseline level of unconstrained demand, and RPMs are reduced nearly 15%. International flights are reduced nearly 4% in 2025, and international RPMs are reduced 1.6%, while GA flights and RPMs are reduced 9.1% and 6.2%, respectively.

For the domestic and international market segments, the consumer surplus calculations are fairly straight-forward. Because we do not have a demand curve for the GA market, we approximated the loss by multiplying the reduction in GA passenger miles times the domestic yield in each of the two years of interest.

Cost of Delay

The LMINET queuing model provides statistics that help generate the constrained schedule. The unconstrained demand is fed into the model, and the airport queues are computed. Recall that we generate the constrained demand based on the concept of delay tolerance. Specifically, we assume that for the major airports, delays can grow no larger than those experienced at the peak demands for a 2000 schedule under universally good weather—i.e., those peak delays, strictly due to demand and not weather, are the largest allowable tolerance in a future year. For those airports whose delays are less significant (typically smaller, less congested airports), we stipulate that their delays cannot grow larger than the average delay experienced in 2000 at the 31 large hub airports.

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[3] Consumer surplus is the economic measure recommended by the U.S. Office of Management and Budget for use in benefit-cost analyses of federal programs.

Thus, while the SEDF method caps delay by eliminating flights, average delay will still rise significantly in the 2015 and 2025 scenarios. In particular, delay during the off-peak hours will grow from their minimal 2000 levels until they reach the maximum delay allowed. However, for peak hours at the major airports, delays will increase relatively little as they are already very close to capacity and the imposed delay tolerance. We stress that a significant portion of the demand is shed in the constrained schedule and that is the major source of economic loss. The residual delay imposes an additional cost on airlines and passengers via the increased variable operating costs incurred and the value of lost passenger time.

To estimate the economic cost of flight delay, we multiply incremental hours of delay by aircraft variable operating costs (VOC) and the value of passenger time, both expressed on an hourly basis. Using these data and the incremental annual arrival and departure delays previously discussed as performance results, we can estimate an annual economic loss associated with the increase in delays as capacity constraints begin to bind at more and more airports.

Aggregate Results

Table 3 reports consumer surplus losses and passenger delay costs due to the NAS capacity shortfalls in 2015 and 2025 under the baseline demand forecast. It is assumed that incremental airline delay costs will be passed to passengers as part of higher fares, and that these costs are therefore already counted in the passenger consumer surplus loss values. Aggregate losses and costs to passengers range from $6.53 billion in 2015 to $19.6 billion in 2025 measured in constant, undiscounted 2002 dollars. The area of largest impact is the loss of consumer surplus in the domestic air transportation market.

Table 3. Summary of Baseline Annual Results

Future NAS Performance And Shortfall Metrics	2015	2025
Lost Value From Foregone Flights For Domestic Air Travel (Domestic Consumer Surplus)	$3.30	$13.14
Lost Value From Foregone Flights For International Air Travel (International Consumer Surplus)	$0.25	$0.80
Lost Value From Foregone Flights For General Aviation	$0.07	$0.18
Additional Cost To Passengers Due To Increased Delays	$2.91	$5.52
Total Annual Loss	$6.53 Billion	$19.6 Billion

Sensitivity Analysis

We also conducted a sensitivity analysis, based on a range of possible future demand levels around the baseline FAA-based forecast. The team estimated the high and low demand numbers by varying the assumed future growth rate for the nation's GDP and the rate of change in air carrier yield (i.e., fare revenue per passenger seat mile flown).

Means and standard deviations for, and the correlation between, GDP and air carrier yield were calculated from historical data as measures of variability in real GDP and air carrier yield. Monte Carlo simulation was then used to obtain a range of possible revenue passenger mile projections for 2015 and 2025. The 10 percentile and 90 percentile values of revenue passenger mile projections were used as inputs to calculate the foregone flights and increased delays for future demand levels at these 10 percentile and 90 percentile values.

When we ran the sensitivity analysis, the largest source of variation in impacts arose from consumer surplus losses associated with foregone trips and higher airfares in the domestic air travel market. The aggregate impacts on U.S. consumers range from $3.69 billion to $8.44 billion in 2015 and from $12.7 billion to $26.2 billion in 2025.

Summary of Cumulative Results (2015 to 2025)

The baseline analysis indicates that failure to expand NAS capacity to meet future demand could cost U.S. consumers $19.6 billion in 2025, up from an estimated $6.5 billion in 2015. Losses would increase progressively over the years, with an estimated cumulative impact of $143.6 billion over the period 2015-2025, when measured in constant, undiscounted 2002 dollars.

If demand follows the high-end alternative forecast, failure to expand NAS capacity to meet future demand could cost $26.2 billion in 2025, up from an estimated $8.4 billion in 2015. The high-end demand forecast indicates that a NAS capacity shortfall could cost the nation $229.4 billion over the period 2015-2025.

If demand follows the low-end alternative forecast, failure to expand NAS capacity to meet future demand could cost $12.7 billion in 2025, up from an estimated $3.7 billion in 2015. The low-end demand forecast indicates a NAS capacity shortfall could cost the nation $91.6 billion over the period 2015-2025.

Conclusions

Future U.S. economic prosperity and quality of life depend on an air transportation system that can accommodate future demand. Implementing the OEP will not be enough. In the absence of investment to continue improving the air transportation system after completion of the OEP, accommodating continued growth in demand after 2015 will become increasingly problematic. The system will become saturated, which may mean that additional flights would be unable to gain access to the system because they would unacceptably compromise the reliability of the air transportation system for its users. Some passengers and air cargo will be unable to fly at preferred times or may find it unaffordable to fly.

Now is the time to begin designing the air transportation system of the future, which will require nothing less than complete transformation. Such an ambitious undertaking will require focused research and technology development and new public policy changes that systematically coordinate airport, aircraft, and air traffic control system technologies and procedures.

The SEDF study lays the foundation for transformation by quantifying the national economic cost of "business as usual." The study thus provides the foundation for additional studies that will consider both benefits and costs associated with a 21st century air transportation system as the national plan develops and additional information emerges.

Government must encourage industry, labor, and academic institutions to work together to support transformation of the air transportation system and reward them for collaborative efforts in research, product development, and engineering, and in delivering products and services that harness their unique strengths and skills. The JPDO hopes to act as a catalyst for such an effort.

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Key Words

ATC | capacity | demand | delay | JPDO | LMINET | metrics | SEDF | simulation | validation |

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