Free Flight
Preserving Airline Opportunity

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Free Flight as an Investment

The early concepts of Free Flight emerged from ideas to gain greater efficiency by changing the present day Air Traffic Control (ATC) system so an aircraft could autonomously select the most efficient route and altitude. These initial efforts focused on several basic issues that could help reduce airline operating costs.

- Users wanted to self-optimize and select flight routings and altitudes.
- Users wanted to reduce Air Traffic Control restrictions to a minimum.
- User efficiencies within the current air traffic control system could be improved with better application of existing and new technologies.

In an unprecedented collaborative effort by leaders of both government and industry, Free Flight matured into a far more comprehensive concept, culminating with the Free Flight Action Plan in 1996. With oversight from a newly created and jointly led Government/Industry Free Flight Steering Committee, this plan included specific recommendations that broadly addressed the need to improve airspace efficiency and capacity in the near, medium, and far term. Although many of the near term recommendations are low-cost, intuitive improvements to the present day ATC systems, others are very complex, long term projects that will require very large capital investments by both the FAA and users of the system.

Clearly, the commercial airlines are major stakeholders in the Free Flight plan, since they are collectively expected to invest billions of dollars upgrading their aircraft and ground systems. To consider the challenges and solutions associated with this investment from an airline perspective, a basic understanding of the economics that support airline business decisions is needed.

The Economics of Commercial Aviation

An accurate perspective of the demands of the airline business requires a general understanding of its interdependence with the overall economic environment. In 1995, a national study[1] on the economic impact of civil aviation reported on the value of aviation to the U.S. economy. This study estimated that commercial aviation, general aviation, and aircraft manufacturing generated $771 billion in related economic activity and 8.8 million jobs, earning $230 billion in wages and salaries. Commercial aviation itself generated $723 billion in economic activity and 8.3 million jobs, earning $214 billion. Also, the study estimated that aviation contributed almost 6% ($376 billion) to the nation's Gross Domestic Product ($6,343 billion) in 1993. This value was considered conservative, since it did <u>not</u> include the benefits to U.S. businesses from the use of aviation.

At such levels of industry economic output, the commercial airlines are acutely aware of the intimate connection between corporate earnings growth and the health of the nation's economy. Airlines clearly recognize that their business success in meeting the public's need for air transportation services is an important factor in America's ability to retain economic leadership in the context of emerging global competition.

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[1] The Economic Impact of Civil Aviation on the U.S. Economy - Update '93, Wilbur Smith Associates, April 1995.

CNS/ATM - The Globalization of Free Flight

With the growing competitive pressures of a global economy, one important key to the airline business perspective is that the economics of Free Flight must be global. The U.S. Free Flight Action Plan is but one regional CNS/ATM[2] plan, and the airline business plan must incorporate the plans of other international aviation authorities, such as Europe's EATCHIP[3] and EATMS[4] programs. Global economic analysis must integrate the complexities of costs and benefits related to all of the new technologies, advanced operating concepts, and regulatory requirements being proposed.

In response to these emerging plans, airlines participate in many international government/industry cooperative activities to help define and identify key airline economic drivers. These groups are attempting to establish a common economic foundation for justifying and prioritizing airspace and ATC modernization plans now being proposed by the various civil aviation regional planning organizations. In the end, it is unlikely that global implementation and harmonization of ATC modernization can succeed without airline consensus on an acceptable business plan approach.

The Challenges of the Airline Business Case

With enthusiasm for change and promises of new technologies, Free Flight advocates have sometimes overstated the economic picture by adding benefits from various studies generated from overlapping operating assumptions. As a result, few studies to date have the necessary credibility for the demanding airline business case, where Return on Investment (ROI) is the core issue when competing for capital funds in a publicly owned corporation. With Free Flight, traditional ROI analysis is difficult because many of the advanced operating concepts are very complex and dependent on yet undefined or undeveloped technologies.

Quantifying economic benefits from the new operating efficiencies is nearly impossible when tied only to loosely defined operating assumptions. In fact, the Free Flight Action Plan itself lacks the detail required for rigorous financial analysis. Finally, the growing uncertainties in the FAA's ability to acquire the capital funds needed to upgrade the infrastructure makes large private capital commitments by airlines a risky venture, especially when such commitments are required before the FAA fields the new infrastructure. Where risks are high, the airline's ability to make an ROI case for such large capital commitments is threatened by higher discount rates and hurdles, which in turn can force pay-back periods to as little as 18 months.

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[2] CNS/ATM refers to future ATC and aircraft systems related to Communications, Navigation, and Surveillance/Air Traffic Management.

[3] EATCHIP is the European Air Traffic Control Harmonization and Integration Programme which incorporates regional air traffic control harmonization projects.

[4] EATMS is the European Air Traffic Management System which incorporates advanced medium to long term air traffic system modernization projects.

Although the ability to make the business case for Free Flight is difficult, it is not impossible. However, it will necessarily involve much more than the typical spreadsheet-based, deterministic analysis. For the purposes of this discussion, the airline business case generally fits into one of three basic categories.

1. Revenue Enhancement
2. Cost Avoidance
3. Competitive Position

All airline business cases, regardless of category, focus on increasing the margin of profitability, either by raising revenue, lowering costs, or both. Ultimately, the case for Free Flight will need to use one or more of these mechanisms to convince airline executives, banks, government, and industry that there are real and compelling economic reasons to invest in modernizing the ATC infrastructure.

Revenue Enhancement

This category is based on ROI from improving profitability margins by increasing revenue faster than costs. The capital required for more assets (facilities and/or aircraft) is justified by the revenue from penetrating new markets with existing infrastructure. Since airline operating assets tend to be centrally managed, the economies of scale from expansion can be used to lower overall unit costs for common requirements, such as administration and training.

One example is the borrowing of capital for new aircraft and/or facilities needed to open new routes and city pairs. Another example would be to purchase new aircraft in order to pursue new revenue by increasing frequency on existing routes. In both cases, success of the business case depends on the depth and credibility of the analysis, which in turn provides a high level of confidence that the new revenue can actually be realized.

Cost Avoidance

Cost avoidance business cases are based on the potential of preventing future costs. With today’s computer reservation systems, airlines operate in a virtually “perfect” competitive environment where air fares are instantly compared and matched. As a result, we vigorously compete on the basis of costs and are extremely sensitive to any cost inequities in the environment. Because of the focus on costs, the cost avoidance business case has become an important tool for justifying the capital needed for improving operating efficiencies.

In this type of justification, future operating assumptions must be well defined so that costs may be projected. Quantifying the cost savings is traditionally computed using these assumptions to build an operating model which deterministically predicts costs of operation. The underlying presumption is that the operating scenario is the probable outcome, since the realization of benefits is totally dependent on actualizing the new efficiencies. Ultimately, the credibility of the business case is driven by the detail of the assumptions in the supporting cost analysis.

One example that makes use of this type of justification is Europe’s requirement for new radio communications capability in 1999. Millions of capital dollars are needed to upgrade or replace current VHF radios so they are capable of tuning to 8.33 kHz channel separation instead of the current 25 kHz standard. Aircraft not capable of 8.33 kHz frequencies will be denied the more efficient higher altitudes, and thus be subject to significant operating cost penalties (i.e. fuel consumption and range). Avoiding this penalty meets the ROI hurdle for justifying the needed capital, although the scenario is “artificially” driven by European CAA regulatory mandate.

In the longer term and more complex scenarios of Free Flight, the probability of benefit actualization is much more challenging to quantify. In the more advanced concepts, consensus on the detail of operating assumptions has not yet been achieved. To succeed, this cost avoidance business case must find a way to raise the confidence in achieving the savings derived from the more efficient future operating scenarios.

Competitive Position

Business cases based on competitive position are generally less dependent on ROI spreadsheet analysis, and much more dependent on intelligence and analysis of one’s competitors. Airline capital justification for upgrading its products or services is based on protecting existing market share and without it, the potential negative impact on revenue. Once again, the main premise in the supporting analysis must focus on comparative costs among the airline competitors in producing the competitive product or service.

Recent examples of this type of justification include the millions of capital dollars that has been spent on upgrading cabin entertainment systems, increasing seat pitch, and installing satellite phones. To ensure marketing parity, this business case must produce an equivalent or superior service at the same or lower cost than its competitors.

The Business of Free Flight

Within these generalized business case definitions, airline financial justification of CNS/ATM must combine aspects of all three types. For major infrastructure changes, cost avoidance will be the primary justification mechanism. After the majority of airlines are equipped to participate, the cost avoidance case will eventually be replaced by competitive position as airspace “stratification” imposes penalties on aircraft with lesser capabilities. To a lesser extent, the revenue enhancement case could be used where new efficiencies potentially increase aircraft range and enable city pair combinations that are not possible with existing aircraft.

Long Term Investment Issues

In the long term cost avoidance business case, benefit value is largely driven by the cost of capital. Thus, improving confidence in the likelihood of the proposed future scenario is absolutely necessary to lower the discount and hurdle rates used in the analysis. Hence, the future scenario must be described using the minimum number of operating assumptions and interdependent operating concepts. In other words, the financial analysis that predicts lower operating costs using very complex combinations of interdependent operating scenarios and new technologies will significantly diminish confidence that real savings can be scheduled or even actualized. Although the long term case is challenging, however, it does present significant cost-saving opportunities by reducing aircraft out-of-service time when undertaking major fleet-wide upgrades.

In the long term scenarios, the competitive position business case can augment the cost avoidance case by estimating the potential revenue impact of the future operating scenario. Motivation to make large capital investments is proportional to the threat to the airline's ability to sustain revenue at a sufficient margin above its operating costs. Once again, the long term viability of the airline business is especially sensitive to the potential for differential costs among competitors. As airspace is "stratified" according to aircraft capability, some airlines could have significantly lower costs than their non-equipped competitors.

AA's National Airspace System Study

To understand the business aspects of Free Flight, American Airlines (AA) wanted to study the economic risk factors to our core product, the flight schedule. After reviewing the industry studies to date, AA was unable to find an easily quantifiable basis on which to justify the need, and therefore the capital, to commit to Free Flight. Thus, AA undertook a study of the National Airspace System (NAS), with the AMR SABRE Group, to answer its key concerns about moving towards Free Flight. The principal goals of the study were as follows.

- To understand its effects on the scheduled airline.
- To address the probability of the future scenario.
- To compare against other industry studies to date.

AA's NAS Study Objectives

The AA study looked to provide answers to key questions that would be essential to building a credible airline business case. Since airlines typically operate with expensive assets (i.e. aircraft) and narrow margins of profitability, the wasting of aircraft assets is one of our primary concerns. Furthermore, airline revenue opportunities are very sensitive to aircraft asset availability for providing our scheduled product.

Question 1: *How and when will the waste[5] become critical enough to justify a capital investment for improving efficiency?*

Question 2: *When does saturation become critical to our core product, the flight schedule[6]?*

Question 3: *How long will improvements last?*

Question 4: *Is this compatible with expected life-cycle of the new capital assets (aircraft and avionics)?*

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[5] Asset "waste" is defined here as the cost from operating delays and the revenue loss from reduced scheduling opportunities.

[6] Delay, a by-product of airspace congestion and air traffic control inefficiency, significantly impacts the airline's costs in operating a scheduled business.

Question 5: When would we have to start[7]?

Question 6: How long will NAS infrastructure changes take?

Question 7: Can we accommodate our normal aircraft down-time maintenance schedules to minimize the costs[8] of removing aircraft from service?

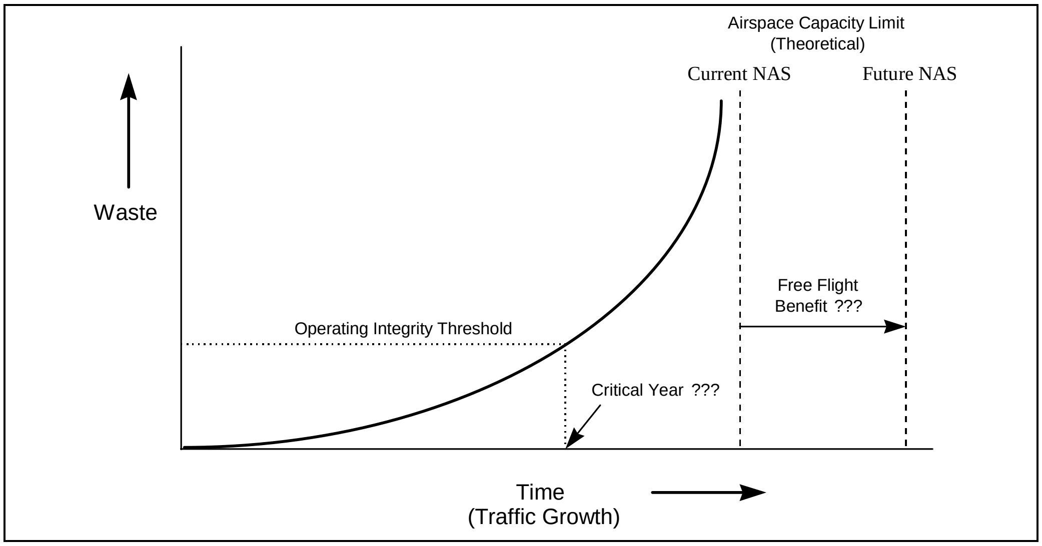

Figure 1. AA NAS Study: Notional Capacity Effects on Asset Waste

Figure 1 is a notional picture of the basic questions that the airline business case must answer. Specifically, at what future date will airline schedule integrity be threatened by capacity constraints? Investing in Free Flight will postpone the problem, but for how long and at what cost?

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[7] The value of long term efficiency improvements requiring large capital investments are very sensitive to the time between when the investment is made to the time benefits are realized.

[8] Acquisition and installation of new avionics into AA's fleet of over 600 aircraft will require many years to accomplish. It is not unusual that the high cost of removing aircraft from service for retrofit installations exceeds the actual purchase cost of the avionics.

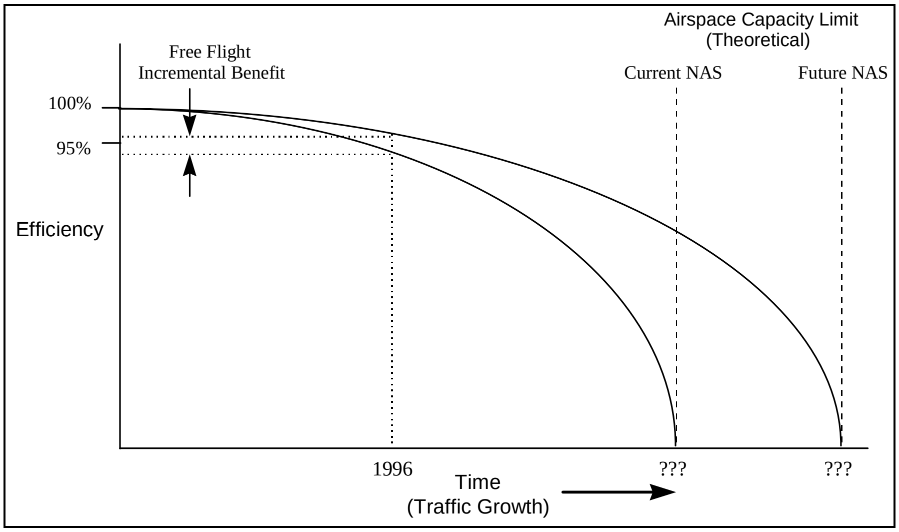

Figure 2. AA NAS Study: Notional Capacity Effects on Efficiency Benefits

Figure 2 illustrates the notional difficulty with cost avoidance business cases that try to justify long term improvements on efficiency benefits. Because scheduled airlines must already operate at high levels of efficiency, the greatest efficiency benefits are not available until the capacity limits are approached. This makes major infrastructure investments that require long lead times difficult to ROI justify in the near term.

AA NAS Study - Building a Credible Approach

To build a credible analysis suitable for a long term cost avoidance business case, the following were used as the basis for its development.

- Use an accepted fast-time simulation platform[9]
- Model is to be based on present ATC constraints
- Make minimal, conservative assumptions
- Validate and calibrate with actual data history
- Estimate future NAS by reducing separation

The basic assumptions used to base the simulation are as follows.

- 1996 OAG data used for baseline starting point (18,000+ flights per day)
- Used jet traffic only between the 50 busiest U.S. airports (4,000+ routes)
- Used annualized traffic growth of 2.3%. This represents over 4% growth in passenger enplanements, and is consistent with the FAA, Boeing, and NASA estimates for overall traffic growth.
- Used average observed horizontal separation standards in today's NAS (7 NM en route, 4 NM terminal, 1.9-4.5 NM wake turbulence matrix)
- The "Future NAS" is simply reduced horizontal separation standards (3 NM en route, 2 NM terminal, 1.5-2.5 NM wake turbulence matrix)

[9] SIMMOD was selected for the fast-time simulation, since it has an established empirical relationship to airline planning in broadly based airport capacity studies.

The reduced separation standards for predicting the potential of the Future NAS infrastructure were chosen only as a estimate, representing probable equivalence from combining more efficient operating concepts and separation standards possible with the application of new technologies. For instance, the application of RVSM in the U.S. domestic airspace would have a net equivalence of a “reduced horizontal separation” standard without RVSM in capacity/efficiency terms.

Fast-time Simulation Validation and Calibration

To calibrate the starting point of the model and validate its output, the following guidelines were used.

- Delay was calibrated to 1996 as the starting point. Historically, this modeling tool has been used to estimate different airport configuration capacities. Only good VFR weather days were simulated, since the airline builds its schedules to good VFR weather delay probabilities.
- The AA flights from the fast-time simulation were then validated against actual AA delay data from the same days, and a linear regression analysis was performed. For delays of five minutes or more, the correlation between the simulated and actual delay was virtually 100% (regression coefficient =1.0).

Figure 3 is a plot of the simulated AA delay results as compared with the actual historical AA delay data from the same time period.

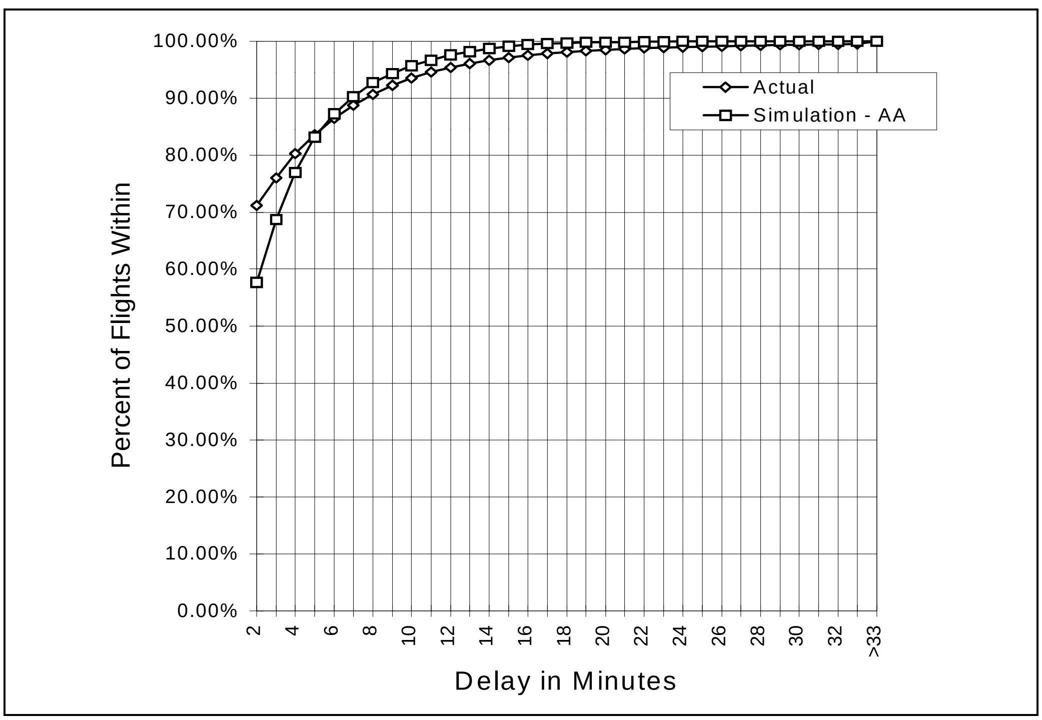

Figure 3. Fast-time Simulation Results vs. Actual AA Delay Data

Delay as a measure of inefficiency affects scheduled airlines in two different ways. The component of delay that is “predictable” results from inefficiencies that don’t change appreciably over time, such as using inefficient FAA-preferred routings or airport runway and taxiway configurations. The impact of predictable delay on the schedule can be reduced by using historical performance data to increase scheduled block time on the individual affected flights. All of the incremental waste (fuel, crew) from longer operating times and decreased revenue opportunities (aircraft scheduling) affects only these individual flights.

The effects of congestion is far more onerous, in that the “unpredictable” component becomes more significant. Unpredictable delay results in higher variances around the average delay, and is more difficult to apply to individual flights based on historical performance. Added to the effects of other “unpredictable” operating variables (i.e. weather), the exponential costs from simply increasing block time on *all* flights for schedule integrity can not be maintained in the long term.

Increasing Delay from Congestion

Figure 4 shows the average delay for each flight in the entire NAS system as a function of time (traffic growth). Because the “numbers” themselves do not present any intuitive feel for their operational implications, a discussion will follow each figure.

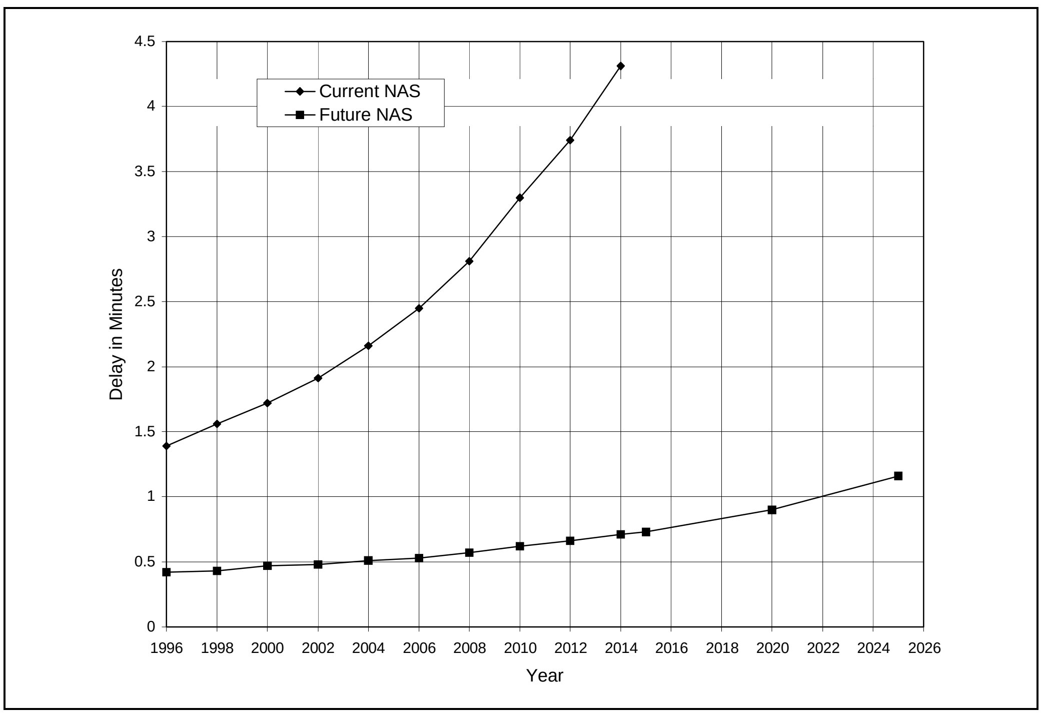

Figure 4. Average Air Delay Per Flight

This data in Figure 4 simply says that each and every flight within the U.S. domestic airspace will incur an average of about four minutes of air delay in 2014. Although a “four minute system average” does not seem serious by itself, its operational impact is extremely onerous for the following reasons. First, four minutes is commonly used as the limit of average delay for scheduled airline operations in airport capacity studies. More importantly, this actually represents a “gridlock” scenario when combined with terminal delay at most of the nation’s fifty busiest airports, where terminal delay will probably average two to three times the average system delay. The terminal area delay expected at a typical major U.S. airport is shown in Figure 5.

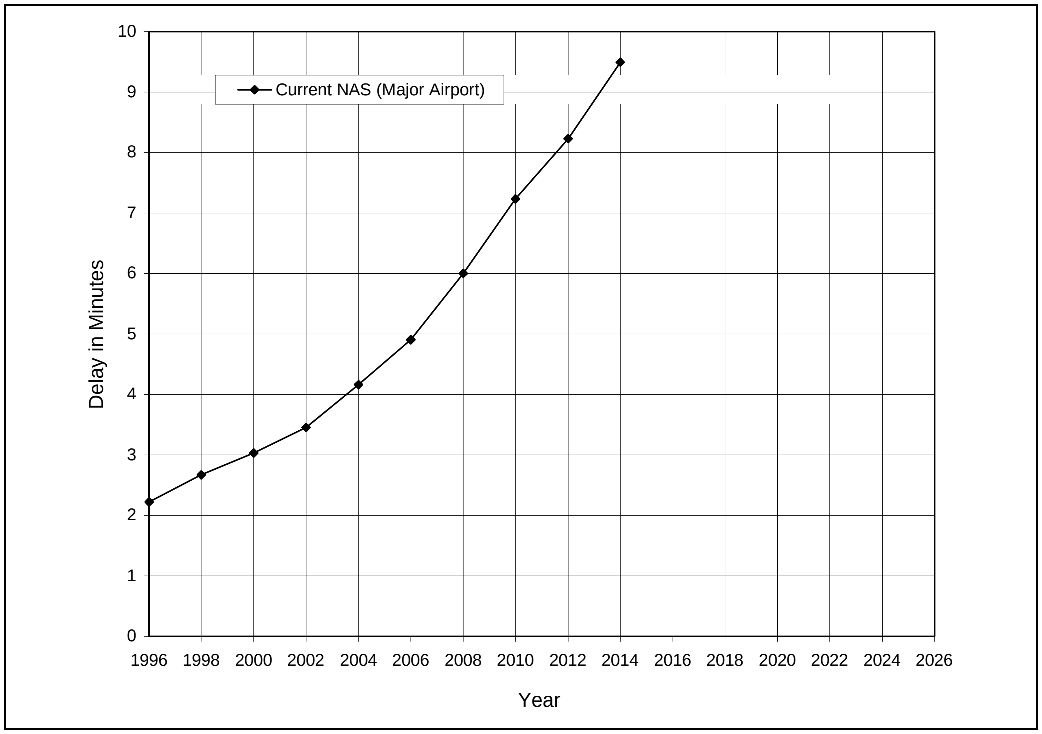

Figure 5. Expected Terminal Delay at a Typical Major Airport

This outcome occurs even with ideally optimized runway and approach fix balancing within the simulation. The study suggests that four minutes of average system delay is also associated with increasing departure queue delays (aircraft waiting for takeoff), where delays as long as two hours was observed in the simulation.

Of equal importance is the relationship between the two curves of average system delay in Figure 4. The lower curve represents the “Future NAS” that estimates the potential of implementing “Free Flight” to its end state. The amount of delay estimated in the year 2025 is not even as large as what we experienced in 1996.

Increasing Range of Delay from Congestion

The results in Figures 6 and 7 serve to demonstrate how variance of the delay affects a scheduled operation, by showing the percentage of flights delayed more than fifteen minutes.

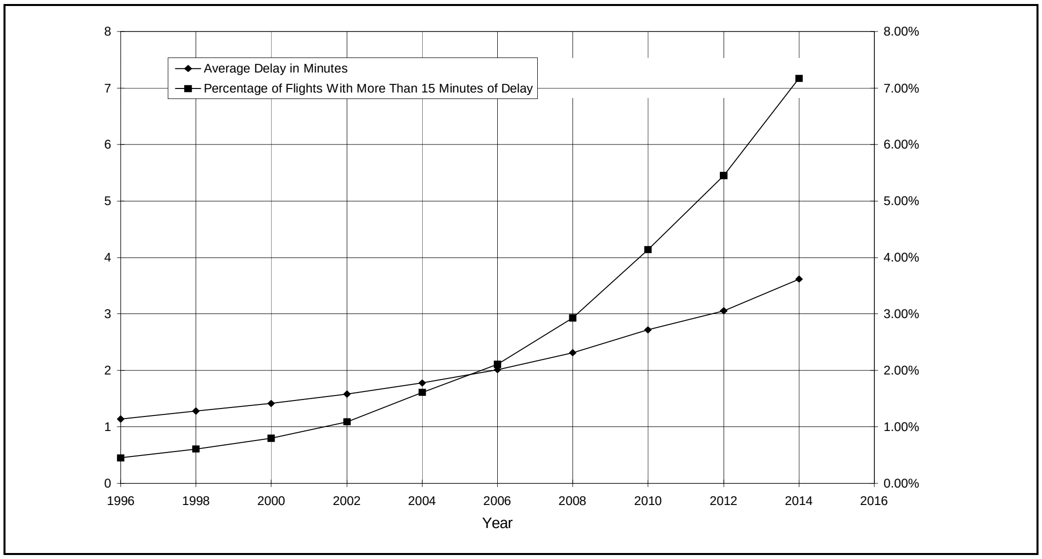

Figure 6. Delay Variance and Minutes for Current NAS

Since the range of delay increases far above the average, the impact to our operation (i.e. schedule integrity) from delay grows faster than the average delay itself.

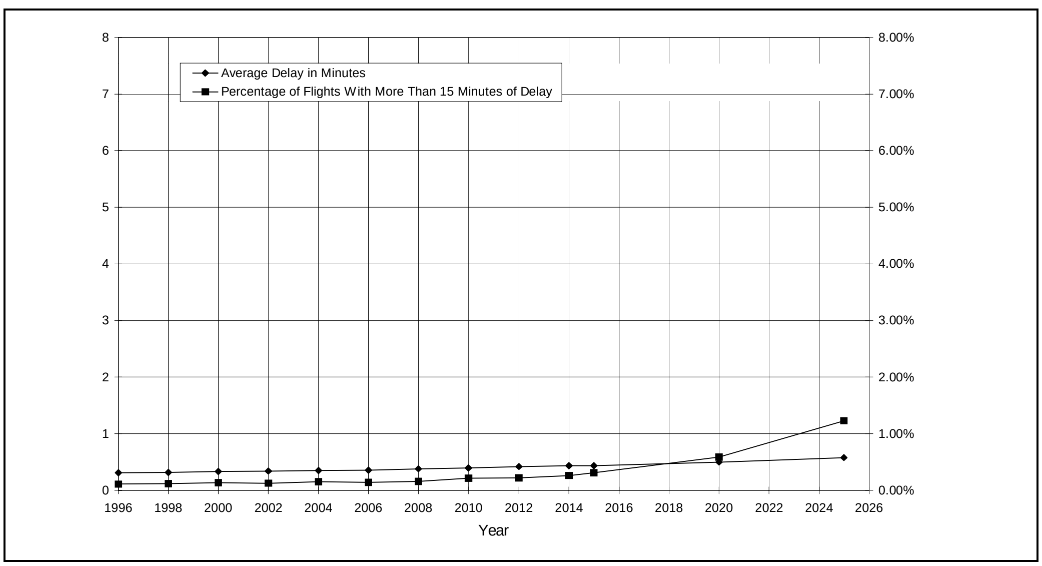

Figure 7. Delay Variance and Minutes for Future NAS

The chart predicts that the percentage of flights delayed more than fifteen minutes in year 2025 under the Future NAS scenario would be roughly equivalent to year 2003 in the Current NAS. The increase in delay beginning in year 2014 is probably attributable to runway limitations, and will be discussed later in this paper.

Figures 8 and 9 attempt to illustrate operational impact by showing the cumulative probability of delay. Note the actual simulation values in the legend.

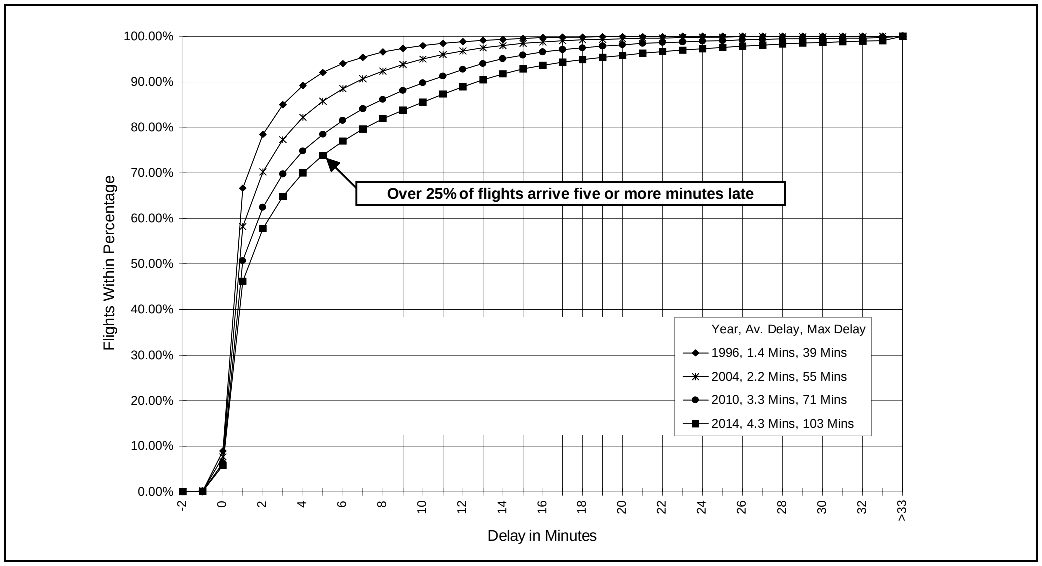

Figure 8. Cumulative Probability of Delay for Current NAS

Figure 8 predicts that in the Current NAS, the probability of five or more minutes of delay increases almost <u>five fold</u> (to more than 25%) when the average delay rises to *just* 4 minutes in 2014. In addition, the maximum observed delay dramatically increases from 39 to 103 minutes.

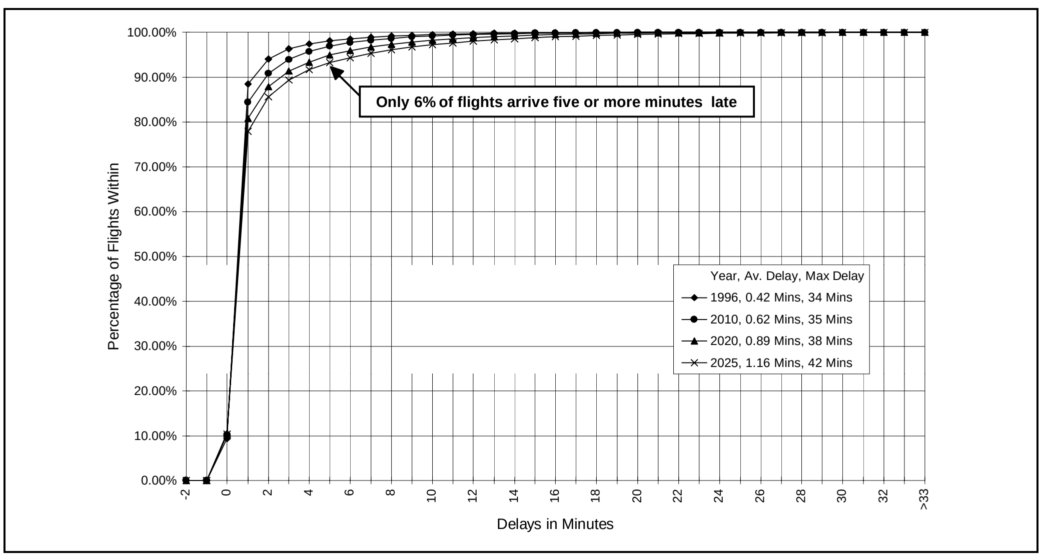

Figure 9. Cumulative Probability of Delay for Future NAS

The cumulative probability of delay for the Future NAS is shown in figure 9. Here the average delay of 1.16 minutes in year 2025 represents a probability of five or more minutes of delay of only about 6% with an maximum observed delay of 42 minutes. This is only a slight increase in average and maximum observed delay over the 39 minutes in the 1996 Current NAS scenario.

Departure Runway Queue

The AA NAS study also took a general look at the potential effects of airspace congestion on departure runway queue. Empirically, our experience told us that airspace congestion leads to longer times waiting for takeoff, as is all too apparent during poor weather events that restrict full use of departure paths that are available in good VFR weather. Consequently, we wanted to look at the broad relationship between air delay and departure runway queue using our current and future NAS simulation conditions.

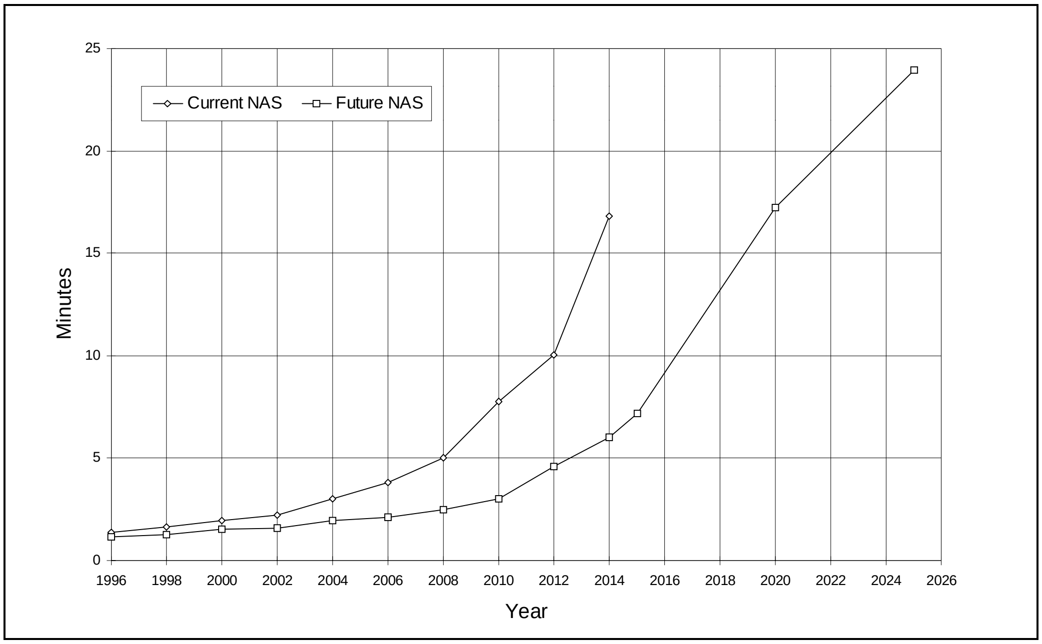

Figure 10. Estimated Departure Runway Queue

AA's data in Figure 10 suggests that increasing arrival traffic density will begin to interfere with growing departure traffic demand. While improving airspace delay will reduce the average departure runway queue for some time, new and more efficient airport runway configurations must be addressed as part of an integrated NAS modernization plan.

Understanding "Average Delay"

There are some general conclusions we can conservatively draw from the overall results of the AA NAS Study.

- Due to terminal area congestion, we expect delays 2 to 3 times the system average at most of the busiest 50 U.S. airports with much greater range of delay.
- We expect greater delay averages and increased range of delay in the already congested en route areas, such as the Northeast region.
- We expect that real world factors will greatly increase actual variance from the simulation averages, such as the effects from IFR and convective weather conditions, and non-ideal runway and taxiway configurations.

The Four Minute Delay Threshold

To help understand why the four minutes of average delay is commonly used as a threshold of operating integrity, figures 11, 12, and 13 pictorially illustrate the effects of average air delay over the time of day. Note that this type of fast-time simulation does not address delay from one flight to the next, so a late arrival does not impact the next departure as they would in real conditions. While simulations can not predict precise outcome in real conditions, airlines use them to estimate the airline's ability to operate on schedule, since our schedules are built to VFR weather standards. The following scatter graphs at an "typical" airport are only meant to lend intuitive meaning to the impact of "average delay" on arrival dependability.

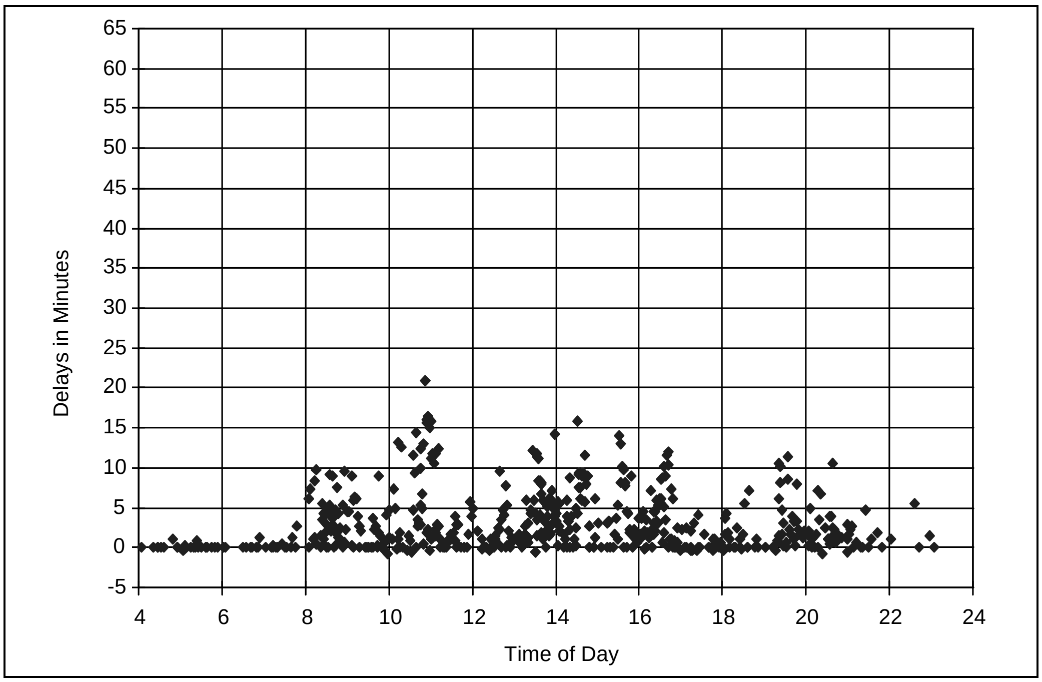

Figure 11. Arrival Dependability at 4.1 Minutes of Average Delay

With 4.1 minutes of average delay, most flights are still contained within the five minute window. Only a few flights arrive more than 15 minutes late.

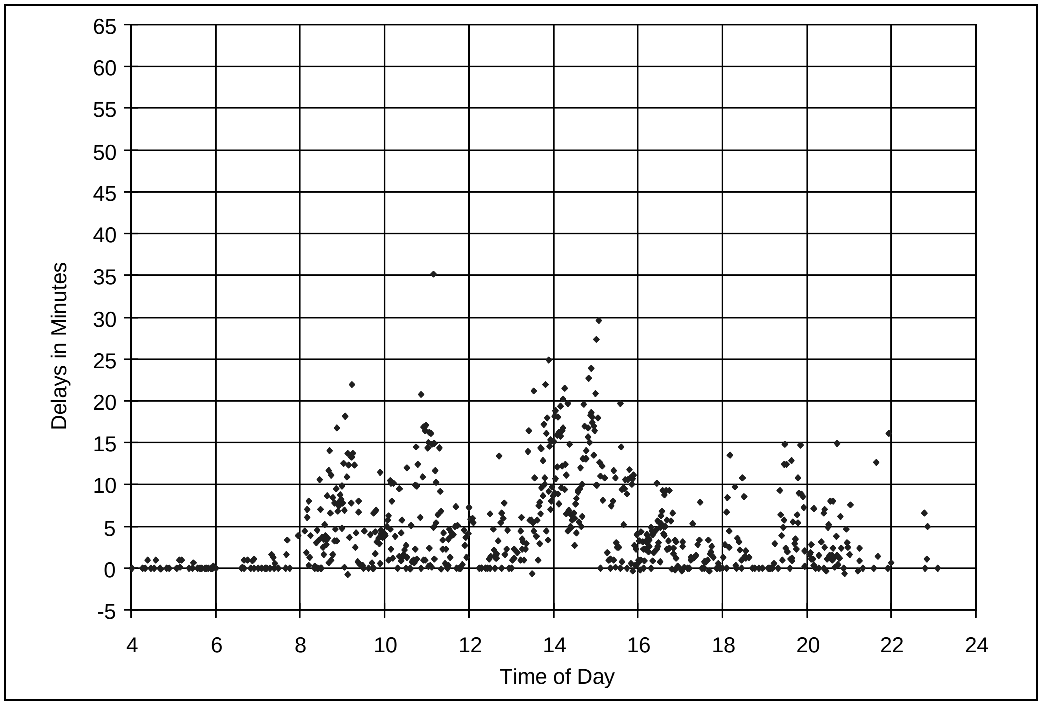

Figure 12. Arrival Dependability at 7.0 Minutes of Average Delay

Increasing to just 7.0 minutes of average delay dramatically changes the arrival dependability. Note that the congested periods of the day are impacted the most, with few flights arriving within the five minutes between 14:00 and 15:00. This represents a condition where airline schedule integrity could not be maintained.

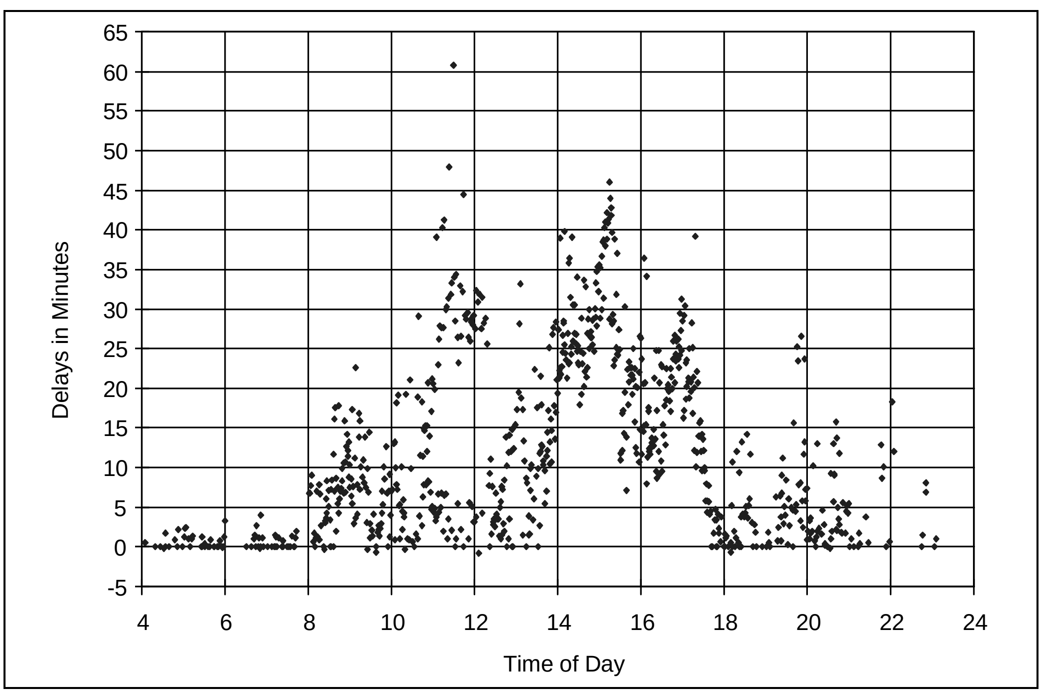

Figure 13. Arrival Dependability at 13 Minutes of Average Delay

When 13 minutes of average delay is reached, the vast number of flights can not predictably arrive without significant delay. This arrival scenario represents a complete breakdown of the scheduled airline business, especially when combined with expected departure queue delays.

General Conclusions from the AA Study

From this study, AA concluded that the Current NAS problems are real, and that with conservative traffic growth projections, traffic delays from congestion of U.S. domestic airspace will increase at an accelerating rate. We expect that the range of delay will increase at an even faster rate, and that airspace delays will begin to economically constrain airline operations and scheduling opportunities in the next decade.

We also generally concluded that a Future NAS solution is possible, and that Free Flight (i.e. global CNS/ATM) can significantly extend NAS capacity, even without new arrival runways in the near term. Eventually, however, more runways will be needed to sustain scheduled operations.

Specific Answers and Conclusions

The specific answers to the questions posed in this paper are as follows.

Question 1: How and when will the waste become critical enough to necessitate a capital investment for improving efficiency?
It has already started and will continue to accelerate.

Question 2: When does saturation become critical to our core product, the flight schedule?
Operating economic constraints will be apparent by 2005.

Question 3: How long will improvements last?
Can extend current conditions by an estimated 25+ years.

Question 4: Is this compatible with expected life-cycle of new capital assets?
Yes, it is compatible with life-cycle of new aircraft and avionics.

Question 5: When would we have to start?
Now.

Question 6: How long will NAS infrastructure changes take?
ATC infrastructure changes by 2005 is optimistic, however the problems can be mitigated to some extent with an incremental approach to ATC improvements.

Question 7: Can we accommodate our normal aircraft down-time maintenance schedules to minimize costs from removing aircraft from service?
Airline phase check schedules can be accommodated.

Corroborative Studies

AA's airspace study is complemented by other studies performed using similar assumptions, but entirely different methods and models. Of particular interest are the studies from the MITRE Corporation and the Logistics Management Institute. The following example is taken from an ongoing study from MITRE Corporation's Center for Advanced Aviation System Development (CAASD).[10]

CAASD's Detailed Policy Assessment Tool

CAASD developed the "Detailed Policy Assessment Tool" (DPAT) to simulate aircraft operations and system interactions under various demand and capacity scenarios. DPAT modeling and analysis can be used to evaluate trends for traffic throughput, flow rates, flight times, and delay at both system wide and individual resource levels. Although originally based on models developed by CAASD for the FAA in the 1980's, DPAT has been continually improved to incorporate new operational knowledge and experience. Currently, its capabilities make it useful as an aid in understanding the implications of new CNS/ATM system capabilities and operating strategies at a system or regional levels.

Using similar assumptions to the AA NAS study, CAASD used DPAT to model and estimate the effects of the air traffic growth on system delay.

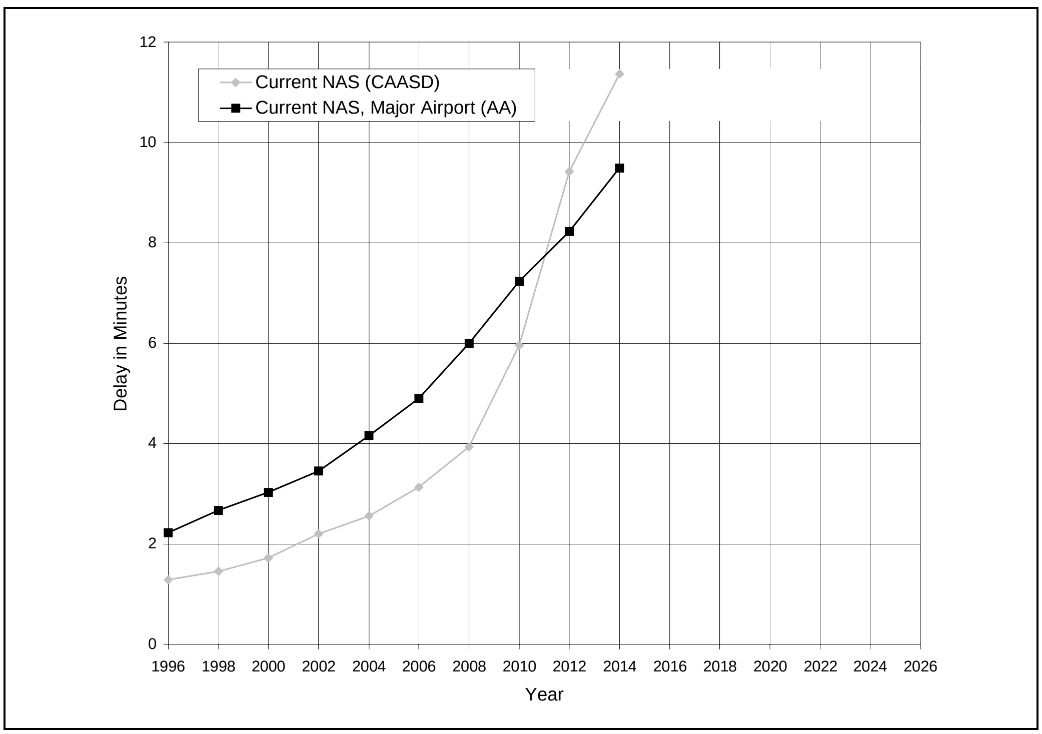

Figure 14. Comparing CAASD System Delay to AA Terminal Delay

[10] MITRE Corporation's Center for Advanced Aviation System Development is a Federally Funded Research and Development Center (FFRDC) for the Federal Aviation Administration.

Figure 14 is a comparison of CAASD DPAT and AA NAS Study delay results. CAASD's study combined all OAG airline traffic with estimated general aviation and military flights to 58 U.S. airports. This figure compares CAASD's delay data against AA's terminal delay data at a typical major airport, as DPAT is more sensitive to aggregate terminal delay than AA's model. The disturbing trend of rising average delay is clear in both cases, even though the assumptions are only similar. The CAASD and AA departure runway queue data have a similar relationship.

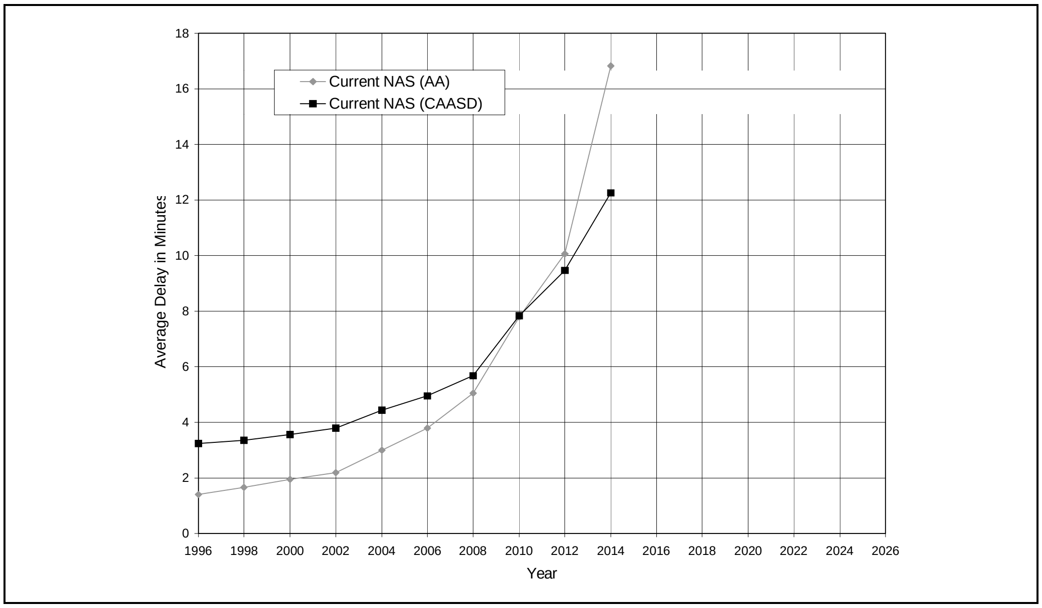

Figure 15. Comparing AA and CAASD Average Runway Queue Delay

Figure 15 shows the CAASD results on the effects of traffic growth on departure runway queue. This comparison of runway queue delay data shows delay against expected air traffic growth. In both studies, the accelerating delay trend is clear.

The Effects of ATC Automation Enhancements

In addition to comparing results with the AA study, CAASD also estimated how incremental improvements made to today's air traffic controller tools, as described in the Free Flight Action Plan, would mitigate congestion effects and for how long. These estimates were from the results of benefit analyses studies for terminal area sequencing tools[11], en route conflict probe[12] , controller-pilot data link[13], and improved traffic flow management[14] through information exchange among users and the FAA.

[11] Center Tracon Automation System (CTAS), Free Flight Action Plan Rec. 20.

[12] User Request Evaluation Tool (URET), Free Flight Action Plan Rec. 19.

[13] ATC data link applications to reduce controller workload, Free Flight Action Plan Rec. 13a.

[14] Collaborative Decision Making (CDM), Free Flight Action Plan Rec. 6, 7, 8, 14, 15, 25.

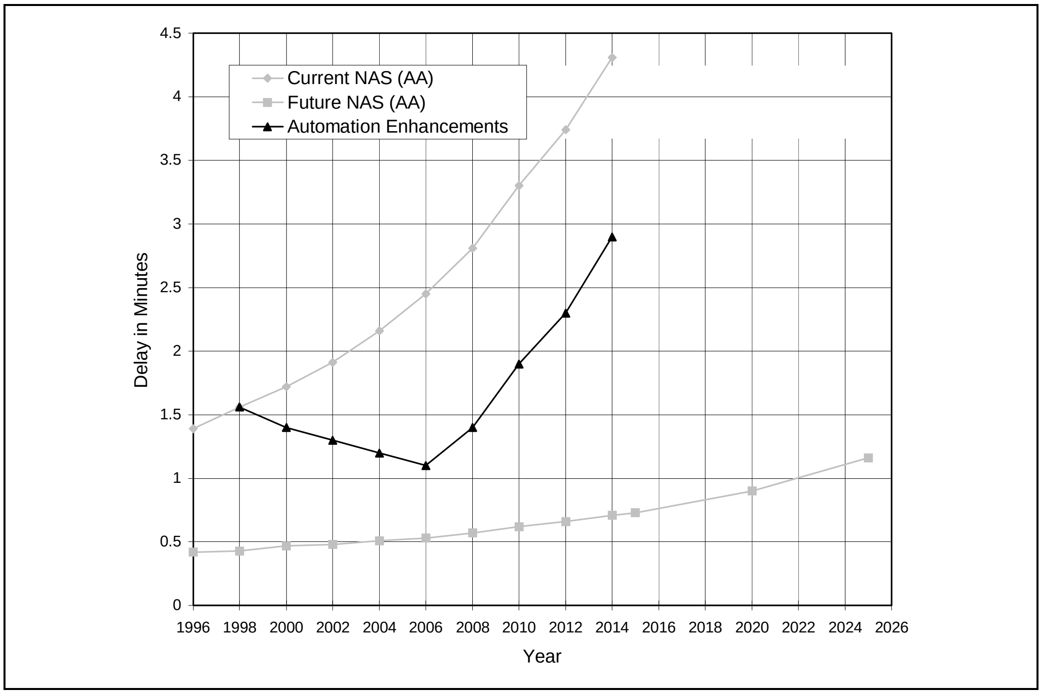

Figure 15. Mitigating Delay with ATC Automation Enhancements

Figure 15 shows the benefits of deploying enhancements to ATC automation over the backdrop of AA's system delay data. This data supports the notion that enhancing today's ATC automation infrastructure can temporarily alleviate the impact of delay while we move ahead with the long term infrastructure changes.

While this has obvious near term operating benefits, it also has very important value to the economics of justifying long term capital improvements. Rapid delay growth and its associated cost/revenue implications can threaten airline health and profitability. This reduces the airlines' ability to borrow the capital needed for required aircraft upgrades as an integral part of the entire NAS modernization plan.

The Logistics Management Institute Studies

The Logistics Management Institute[15] (LMI) has undertaken continuing studies for the National Aeronautics and Space Administration (NASA) to understand the potential performance and economic impact of new technologies. These studies employ completely different models and methodologies co-developed by LMI, the Massachusetts Institute of Technology - Operations Research Center, and Phoenix Integration that are used for analyzing ATC modernization proposals.

In LMI's recent analysis of technical and economic Free Flight issues[16], both the air carrier savings (time and fuel) and its effect on ATC congestion were considered. This study concluded that potential airline fuel savings from using "Free Flight"

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[15] The Logistics Management Institute conducts studies for NASA as a Federally Funded Research and Development Center (FFRDC).

[16] "Technical and Economic Analysis of Air Transportation Management Issues Related to Free Flight", Logistics Management Institute, February 1997.

(optimal routes and altitudes) could range from 3 to 7 percent, depending on the route. But more important, it concluded that these savings were “fragile in the sense that even 10 to 15 minutes’ additional terminal delays that required operations at inefficient altitudes and airspeeds would devour them.”

Although more research is needed, preliminary results from their associated network modeling of system delay suggest that the use of more optimal routes will not significantly reduce peak ATC en route sector loading (i.e. overall sector capacities may not improve). From the long range airline planning perspective, the benefits from improving route and altitude efficiencies are probably secondary to the looming prospect of rapidly growing delay from ATC capacity constraints.

The European Air Traffic Crisis

In Europe, the effects of airspace congestion on regional economic health are well known. In 1989, airspace delays reached crisis proportions as the capacity of the air traffic system became severely strained. Figure 16 depicts actual historical delay data[17] collected during this period, providing valuable insight into the actual effect of air traffic congestion on airspace delay. It is significant to note the increasing rate of rising delay depicted in this example.

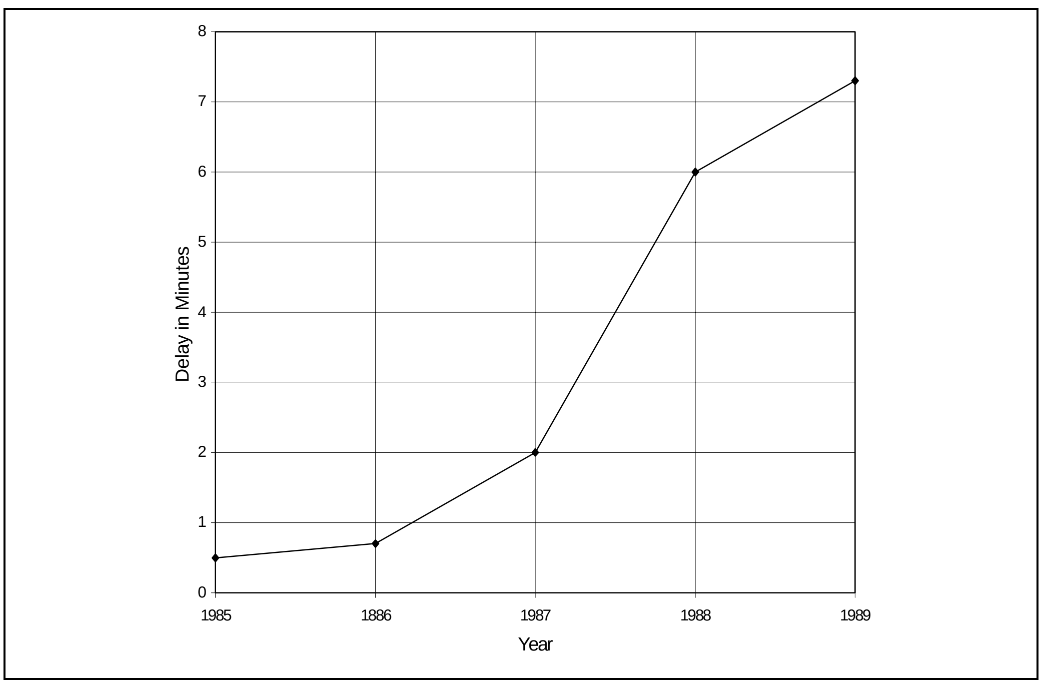

Figure 16. European Delay per Aircraft Movement

With the recognition that ATC capacity was not solely dependent of the number of airports and runways, the European Air Traffic Control system was viewed as another important component of their economic infrastructure. As the first step,

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[17] Source: Eurocontrol statistics.

Eurocontrol implemented new tactical ATC harmonization and central traffic flow control initiatives.

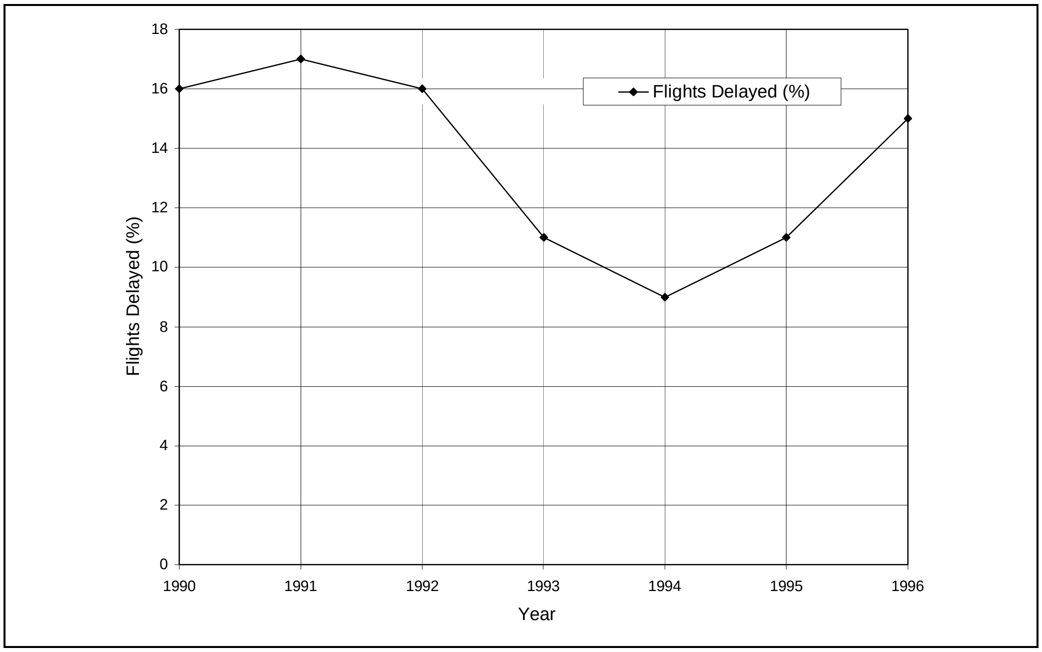

Figure 17. European Airline Air Traffic Service Delay Trend

This airline delay data[18] shown in Figure 17 shows that the actual percentage of total flights incurring ATC delay decreased from 1991 to 1994, but then begins to rise again with growing traffic demand. Despite the traffic abating effects of the Gulf War, it is reasonable to attribute a significant part of these delay reductions to Eurocontrol's ATC improvement initiatives.

With the understanding that its economic liberalization policies depended on the ability of their air transportation system to meet growing demand, European investments into Air Traffic Management have been given a higher priority. To accommodate the expected five percent of annual growth for air traffic demand, the European Commission adopted a Directive[19] for the purchase of new Air Traffic Management systems.

As a result, capital investments in ATM by the European Civil Aviation Conference (ECAC) States have risen sharply. In 1995, these investments by 20 of the ECAC Member States amounted to over 572 million ECU, rising to over 731 ECU in 1996 and almost 900 million ECU in 1997. National service providing costs[20] in the same years rose to 2.4, 2.8, and 3.4 billion ECU respectively.

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[18] Source: Reported by 14-16 member airlines, International Air Transport Association, 1996.

[19] European Commission, Directive EEC/93/65 - JO n* L 187 of 29.7.1993.

[20] Costs include depreciation, interest, operating costs, "other" costs, and staff costs.

Concurrently, European research and development investment is also increasing. Actual 1995 expenditure amounted to 125 million ECU, with 1998 estimated at 183 million ECU.[21] These figures represent the total costs of projects declared by the Eurocontrol Member States proactive in R&D, the European Commission, Eurocontrol, the European Space Agency, and industry.

Summary and Conclusions

From its own and other corroborating studies, American Airlines believes that time is of the essence. Implementing major airspace infrastructure changes in the U.S. in just seven years is optimistic. It is essential that funding and implementation of first-step, near-term ATC improvements not be sacrificed for achieving consensus on final "end-state" technologies and standards.

From the airline point of view, the long term business case for Free Flight is possible if supporting analysis can increase confidence in the probable future of airline costs and revenue opportunities. However, that confidence is also related to the need for a dependable funding stream for FAA infrastructure improvement programs. Both are necessary to reduce the discount and hurdle rates that are crucial in preserving the investment value of the benefits in the long term cost avoidance business case.

Government transportation policy-makers must understand that the long term prospects for growth of our nation's economy depend on a healthy air transportation industry. This capital investment into the U.S. ATC system should be viewed from a global perspective that realizes the contribution of commercial aviation to the nation's economic output. The recent European ATC crisis provides insight into the dependence of all commerce on an efficient air transportation system. As such, all potential alternatives that support a dependable funding commitment for new ATC systems, including private mechanisms, should be explored.

Finally, it is not difficult to understand why Free Flight was first focused on improving efficiency by better managing aircraft route and altitude, since airline profitability is typically so sensitive to operating costs. However, it is apparent that rapidly declining efficiency is a symptom of the far more onerous problem of approaching airspace and airport capacity. From the economic perspective, Free Flight may be better characterized as a broad concept of modernizing the National Airspace System so it can remain capable of supporting our free-market, competition-based economy. By ensuring airline growth and profitability, the U.S. can ensure that the nation's growing demand for scheduled air services can be effectively provided.

[21] Source: Analysis of Research and Development in Eurocontrol Programmes (ARDEP).