Workshop Summary:

Airline and National Strategies for Dealing with Airport and Airspace Congestion

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On March 15 and 16, 2001, NEXTOR, the National Center of Excellence for Aviation Operations Research, together with The Global Airline Industry Center at the Massachusetts Institute of Technology (sponsored by the Alfred P. Sloan Foundation) and the Robert H. Smith School of Business at the University of Maryland sponsored a workshop on "Airline and National Strategies for Dealing with Airport and Airspace Congestion". The event was held at the University of Maryland and featured approximately 40 speakers and discussants from academia, the aviation industry and government. Its organizers were Michael Ball (UMD) and Amedeo Odoni (MIT).

The topics (see Appendix) centered on issues related to possible causes and solutions for growing air traffic congestion. The speakers and discussants offered a broad set of perspectives, leading to lively discussions in practically every session of the workshop. In this report, we provide a brief summary of some of the principal points made at the workshop. References to presentations are made in brackets, using the paper and discussant numbering system shown in the Appendix.

1. Causes and Nature of Delay

There is little question that airport and airspace congestion has increased considerably during the last few years, with 2000 being the worst year on record for air traffic delays in the United States [T1-1]. No single cause is to blame. Demand has been growing faster than system capacity for many years. We now find ourselves at the point where

small increases in demand (such as a 2-3% annual growth in the number of airport operations) or small reductions in capacity (e.g., due to the unusual number of severe thunderstorms during the summer of 2000) can result in large increases in delay. Airline scheduling practices at hubs, with large numbers of movements scheduled over short periods of time, tend to make the problem worse.

The tight relationship between capacity and demand also means that the airport and airspace systems now comprise a transportation network whose components are highly interdependent. A disturbance or bottleneck in one component will quickly propagate to encompass large parts of the network. Moreover, it is difficult to point to causes and effects, due to the complexity of the interactions involved [T1-1].

It is also essential to realize that the statistics on delays reported by various organizations such as the Federal Aviation Administration (FAA), the US Department of Transportation (DOT) and the Air Transport Association (ATA) are partial and incomplete: each set of statistics measures a different aspect of air traffic congestion and many flights are not included in the databases. Equally important, they focus on *aircraft* delays, not on *passenger* delays. For this reason, the delay statistics reported may not adequately reflect the level of service perceived by passengers [T1-3]. For example, the principal measure of on-time performance used by DOT (i.e., the percentage of flights that arrived at their destination more than 15 minutes later than their scheduled time of arrival) has remained almost constant between 1995 and 2000. However, the number of passengers whose travel is seriously disrupted by delays and related events has undoubtedly increased greatly during this same time period as a result of a combination of: (a) a large increase in the percentage of *very late* flights (i.e., flights which are late by 45 minutes or longer) that often cause transferring passengers to miss their connections; (b) a doubling (and tripling in the case of some hubs) of the number of cancelled flights; and (c) a large increase in the average load factor of flights – which makes it difficult to accommodate on subsequent flights those passengers whose flights were cancelled or who missed their connections due to earlier flight delays. The growing incidence of extreme episodes – such as passengers spending a night stranded at an airport – may help explain the phenomenon of "passenger rage", reported widely by the media. There is a clear need for the development of metrics and statistics with a focus on delays as experienced by the passenger [T1-3].

The public discontent and intensive media coverage are symptomatic of the very high economic costs that congestion entails for the airlines and the public. For example, it is estimated that in 1999 delays were directly responsible for $2.2 billion in additional airline fuel and crew operating costs [T2-4]; when associated passenger delays were quantified and added into this estimate, the cost grew to over $5 billion. The long-term implications could be much more dramatic as capacity limitations and delays begin to restrict industry growth. Projections indicate [T2-2] that in 10 years overall airline industry revenues will be between $9 billion (if average aircraft size is increased) and $19 billion (if current average aircraft size is maintained) lower than the revenues that unconstrained demand would otherwise support.

The directions that can be taken to avert the emerging trend toward unacceptable levels of congestion and eventual gridlock can be classified into a small number of categories:

1. Capacity growth through additional airports and runways and through an improved air traffic management (ATM) system.
2. Better "real time" air traffic flow management (TFM) at both the strategic and tactical levels.
3. Demand management at the busiest airports.
4. Airline operational and business strategies aimed at reducing the impact of congestion on airline schedules and costs.

Each of these general directions was addressed during the meeting and will be summarized below.

2. Prospects for Growth in System Capacity

Investments in increasing the capacity of airports and airspace constitute the most obvious (but not necessarily most cost-effective) approach to dealing with congestion. Unfortunately, short- and medium-term prospects in this respect are not particularly good. The surest way to ensure capacity growth is the development of new airports and the construction of new runways at existing airports. Neither of these alternatives is particularly promising at this point at the majority of the locations where the additional capacity is most needed. The main reason, in most cases, is strong local community opposition ("not in my backyard") fueled by environmental and quality-of-life concerns. A number of FAA initiatives to increase ATM system capacity are currently under way, such as Free Flight Phases 1 and 2 in the short term and approach procedures supported by ADS-B and GPS in the medium term. Although estimates of the capacity increases that can be obtained in this way vary, the consensus range [T1-1] is in the order of 5-20% over a period of 15 years – not sufficient to accommodate projected new demand.

The evolution of the system represented by the National Airspace System (NAS) Architecture 4.0 represents a fiscally constrained consensus between government, unions and industry. In order to meet future demands, there is a need to reduce aircraft separations while maintaining safety. This implies a partial transfer of decision-making to the flight deck and an increased importance of aeronautical telecommunications and datalinks [T1-2].

3. Air Traffic Flow Management

As air traffic increases and as demand approaches capacity, the traffic management task has becomes increasingly challenging. The FAA has now created a substantial traffic flow management (TFM) infrastructure together with an associated program of R&D and system enhancements. TFM decision-making responsibility is shared among the Air Traffic Control System Command Center (ATCSCC), the Air Route Traffic Control Centers, the Airline Operational Control Centers (AOCs) and the pilot and crew aboard each aircraft [T4-2]. In fact, part of the challenge in devising new traffic flow management systems lies in properly coordinating the decision making responsibilities of

each of these entities. For example, a case study at Newark Airport [T4-3] has shown that very large delays associated with certain weather events could be greatly decreased by better information exchange and coordination among various FAA facilities. This and other evidence [T1-4] suggests that simply increasing the number of runways would not solve many of today's delay problems. Rather, better TFM information systems and decision support tools are required.

In the past two to three years, the ATCSCC has implemented a number of initiatives to improve TFM by better coordinating FAA-airline decision-making and by integrating a much more strategic element into the TFM processes [T4-1]. Some of these initiatives include an ATCSCC strategic planning team, a standard, widely-shared National Playbook containing rerouting strategies for use in response to certain disruptive events, a standardized set of Coded Departure Routes made available to TFM managers and users through a national database, the Collaborative Convective (weather) Forecast Product (CCFP), Low Altitude Arrival and Departure Routes (LAADR), a hot line between the AOCs and the ATCSCC and Post Event Analysis disseminated through the World Wide Web.

All the major US air carriers are strong participants in the Collaborative Decision Making (CDM) initiative. At the heart of CDM is a communications network, CDMNET, over which the AOCs and the FAA share real-time operational flight information. By combining airline intent information with FAA traffic monitoring information, much more accurate predictions of traffic flows in the NAS have been obtained. By giving airlines greater control over the allocation of unavoidable delays, CDM resource allocation procedures allow airlines to better manage delays and to minimize their impact [T4-2]. While the cancellation of a flight can have a detrimental impact on the passengers on that flight, an airline can reduce or eliminate the delays on several other flights by strategically canceling one or two flights during a major ground delay program, using the flexibility provided by CDM. In turn, this can preserve the schedule of even more downstream flights [T4-5]. To date, CDM has been applied principally to the planning and control of ground delay programs. However, it provides a framework and philosophical approach upon which nearly all new air traffic management systems should be based [T4-2].

4. Demand Management

Demand management is the most controversial of the directions available for restoring a balance between demand and capacity in the air transportation system. Demand management, in the airport system context, refers to any set of regulations or actions aimed at reducing in some way the number of aircraft requesting access to a busy airfield and/or at modifying the temporal characteristics of such demand. An example of the latter are airport pricing schemes aimed at inducing airlines to shift some operations from peak traffic hours to off-peak hours. The concept can, of course, be extended to any facility in an airport or in the National Airspace System, but the focus currently is on runway systems, which are generally believed to be the most critical components of the NAS.

Interest in demand management has been stimulated by events at New York's LaGuardia Airport (LGA) during the second half of 2000. The huge delays that occurred there, as a result of the so-called "AIR 21" legislation (which opened LGA to access by flights of 70 or fewer seats from small communities or operated by new entrants) forced the Port Authority of New York and New Jersey (PANYNJ) and the FAA to conduct a lottery in December 2000, to determine the flights that would be entitled to access to LGA as of January 31, 2001. Since that date, LGA has been operating under the constraints on access that resulted from this lottery. Moreover, the FAA and PANYNJ have committed to developing, by September 2001, a better system than the lottery for allocating the scarce airport capacity available at LGA among prospective users.

The motivation for using demand management approaches as short-term measures for relieving airport congestion is provided by several observations. First, delay reductions that can be obtained from relatively small reductions in total daily demand can be very large. For example, the LGA lottery resulted in a roughly 10% reduction in the number of weekday operations [T5-1]. This translated to a reduction of approximately 80% in the total hours of aircraft delay experienced on days with good weather (from about 1200 aircraft-hours per day to about 250)! "De-peaking" of daily demand profiles can also have significant delay benefits.

At the same time, the *external costs* (or "marginal delay costs") imposed on other flights by aircraft operated at busy airports can be very large. In cases such as LGA and Boston, such external costs may exceed the landing fees that these aircraft pay by a factor of 10 or more [T5-1]. If the size of the aircraft is taken into account, the delays imposed on other flights by small aircraft during busy periods can greatly exceed any possible benefit to the passengers on those flights [F1-2]. These observations motivate interest in experimenting with "market-based" demand management approaches, such as congestion pricing and auctions, both of which are being reviewed by PANYNJ and the FAA for possible application at LGA [F2-1]. It is believed that such approaches are far better suited to the competitive environment of the US airline industry than the purely administrative approaches used elsewhere.

This, of course, does not mean that the notion of airport demand management does not raise a number of concerns. In its review of the subject, the FAA has identified many issues that need to be addressed in formulating federal policies in this respect [T5-2]. These include: potential for improvement in airport operations; impacts on prospects for capacity expansion, on consumer welfare, on airline competition and on regional access to major airports; potential conflicts with airport use agreements and with bilateral and multilateral international aviation agreements; and compliance with existing legislation. This last aspect may be critical. Existing legislation is rather vague on the amount of discretion that local airport operators have in applying demand management initiatives [T5-3]. It is generally felt that operators have considerable legal latitude in exercising ownership rights to preserve the viable functioning of their airports in the face of growing congestion. Rather than developing blanket policies, it may be better to proceed in the direction of very selective application depending on local conditions. Airlines are for the most part apprehensive about demand management [T2-4, F1-1, F2-2]. Concerns include: the impact on costs and, by implication, on airline fares; the possibility that

demand management will divert attention from the need to increase capacity; and the yet-to-be-proved effectiveness of such measures [F1-2, F2-4]. It is recognized, however, that political pressures may force the FAA and local airport operators to proceed with the adoption of such policies.

5. Airline Business Strategies

Since deregulation, airline business strategies have evolved substantially. The most prominent feature to have developed within the US air transportation system is the use of a hub-and-spoke system by most major air carriers. This system has received criticism because of the predominance of two-hop travel itineraries and schedule "brittleness" (a delay on an inbound leg can lead to a missed outbound leg). On the other hand hub-and-spoke systems offer a much more cost-effective way to provide service to cities with lower demand [T1-1]. They have allowed airlines to provide service to markets previously un-served, or poorly served, and much more frequent service to most markets [F3-3]. Another more recent phenomenon is the emergence of the use of smaller regional jets. Like the hub-and-spoke system, these allow more economical and/or higher quality service to smaller markets [F3-3]. While one might argue that the use of larger aircraft would make for more efficient use of scarce arrival and departure time slots, one airline could not unilaterally reduce the frequency of service to a market while using larger aircraft, because competitors would quickly fill in the time gaps in the service profile [F2-2]. From the airline perspective, the business strategies that have emerged since deregulation are a direct response to market forces and consumer needs [F3-3].

In response to the very substantial increase in delays over the past two or three years the air carriers are implementing a variety of short and long-term measures. Examples include providing better passenger information, the generation of more robust fleet schedules and an increase in the number of spare aircraft [F1-1]. Techniques such as robust fleet scheduling involve R&D challenges that may require time to develop and refine; others, such as the use of additional spare aircraft, can be very expensive. As noted in Section 3, the major US air carriers are better able to respond to congestion and FAA initiatives through use of new CDM systems and tools [T4-2]. However, given the growth in delays and their strong impact on overall airline performance and strategy, some would argue that the airlines have not yet invested adequately in improving the dynamic operations component of their business [T2-3].

It was noted that this is not the first time that the industry has faced a shortage of capacity, and that a similar situation existed in the late 1960's [F1-3, F1-4]. Since that time, a combination of technology and airline adaptation has been able to accommodate the growth in demand. There is a need to address improvements in both the metrics and models used to measure the performance of the system and understand the system dynamics. It is particularly critical to link the technology that can be put on the aircraft to the required operational changes.

It was also noted that the aviation sector is not unique in experiencing problems in meeting demand due to difficulties in providing infrastructure [F1-5]. As in other sectors, there is a need to seek market-based solutions and to overcome political obstacles

to matching prices with the cost of providing capacity. It will also be necessary to find a way around the ability of small groups of people to block needed infrastructure expansion.

6. National and International Policy Alternatives

Policies to support the development of future capacity in the US national airspace system need to consider both activities that are largely under airline control as well as actions that the FAA can take [F3-1]. Examples of airline actions include improving schedule reliability, changing fleet mix and schedule alterations The FAA developed a Spring/Summer Plan in 2000, and was in the process of revising this for 2001. The plan addressed the role of the Air Traffic Control System Command Center in Herndon, Virginia, improved communications and coordination, enhanced training within the FAA and other organizations, and increased use of military airspace, especially off the East Coast. Studies have identified seven national choke points that account for a high proportion of total delays. The FAA is addressing these by establishing new sectors and improving coordination with Nav Canada.

The FAA is pursuing new technology solutions, including the Capstone Project in Alaska, that went operational at Bethel, Alaska, in January 2000. A path for expediting the extension of these technologies to the rest of the ATM system is clearly called for. The FAA has developed an Operational Evolution Plan that defines a 10-year vision and identifies links to other initiatives, as well as specific treatment of given airports. This targets capacity-constrained hubs, and is aligned with the capacity benchmarks that the FAA was in the process of finalizing for the top 31 airports. It was stressed that while new runways are needed, people also matter. Collaboration and consensus, supported by review and persuasive analyses, are really the only way to achieve progress [F3-1].

The airport and airspace capacity and delay situation in Europe differs from the US in a number of respects [F3-2]. All major European airports have traffic caps (slot controls), and demand management is exercised through airline scheduling. Bad weather is frequent and airports always operate under instrument flight rules (IFR), even in good weather. Route charges provide for recovery of the costs of providing air traffic control services and are collected centrally, although the rates are set by each air traffic control service provider. Air traffic flow management is exercised through ground holding on a centralized basis, with departure slots based on the most restrictive limitation.

The decade from 1990 to 2000 has been a period of strong traffic growth in Europe, with a 60 percent increase in operations and an 80 percent increase in miles flown. This has led to recent strategic initiatives to increase levels of safety, meet demand, and reduce unit costs. Efforts are underway to harmonize incident reporting between the different air traffic control organizations, and the first such reports were due in March 2001. It is recognized that there is a tradeoff between the costs of providing more capacity and the costs of delay, and efforts are underway to identify the optimum level of service that produces the lowest total unit cost to the users. In the short term, the strategic focus is on best efforts to reduce delays within the existing system capabilities. In the intermediate term, the use of reduced vertical separation minima (RVSM) on a continental basis is

expected to expand capacity significantly. Longer term efforts will focus on research and development. The "Single European Sky" concept is being pursued, and a high level group report was issued in late 2000. The United Kingdom has decided to restructure its National Air Traffic Services as a public-private partnership with economic regulation of prices and incentives for delay reduction. The demand for increased airport capacity in Europe has raised a broad set of policy and technical issues, including the choice between building more runways, setting capacity limits (capping), or using pricing to manage demand. It is also becoming recognized that there are important tradeoffs that will have to be made between safety and capacity, and that airspace capacity will have to be increased to balance increases in airport capacity.

Adoption of a market-based approach to air traffic control modernization should recognize the importance of providing the customers with what they want [F3-3]. The provision of information can help the customer better decide what they want. Although hub-and-spoke networks are an important feature of how airlines provide service, in the US some 62 percent of all passengers travel on the same aircraft for their entire trip. The factors that matter most to passengers have been found to be the type of service offered between their origin and destination, the time involved in making the trip, the value of the service, and baggage concerns. The type of service depends on whether direct flights are available, and whether connecting service is online or interline. Time concerns address the convenience of departure and arrival times, as well as dependability and the additional travel time and uncertainty involved in making connections. The value of the service depends on both the fare paid and the quality of the service received. The pattern of air service in the US is highly concentrated in a relatively few markets, with 54 percent of the traffic traveling in only 1 percent of all origin-destination markets (about 570 markets) and 92 percent of the traffic in only 10 percent of all such markets. This has an important consequence for hub dynamics, with the number of potential markets that can be served increasing exponentially with the size of the hub.

While long-term capacity gains will come from additional runways, the tools being fielded under the Free Flight Phase 1 and 2 Programs will provide some additional capacity [F3-4]. However, the experience at Dallas/Fort Worth was that increased capacity resulted in an increase in traffic peaking. Therefore there is a need for appropriate performance measures. Airlines can reduce delays by performing some rescheduling, such as reducing the size of banks or routing aircraft so as to isolate flights using congested hubs from the rest of their network. Administrative measures aimed at reducing delay through caps on schedules will translate delay reductions into higher fares, because airlines are able to command higher fares at peak periods. It is therefore necessary to ask who is getting the benefits and who is bearing the costs. In the current political climate in the US, the industry may not have the luxury of time to figure out how best to solve the delay problem. The industry will have to show progress soon or Congress will intervene.

The FAA Office of System Development and Air Traffic Services addresses delays in the near term by improving the utilization of existing capacity, by building new tools and by providing well-trained personnel and information [F3-5]. Steps need to be taken to ensure that the controllers have the necessary information to realign assets to respond to

changing conditions, and to address both good weather and bad weather conditions. The Airports Council International has identified three initiatives to address delays: facilitating the construction of new runways, application of new technology, and the use of demand management where appropriate [F3-6]. The FAA capacity benchmarking study provides useful information and shows that adding a runway may not fix the imbalance between visual flight rules (VFR) and IFR capacity in the long run. Thus there is a need to focus on technologies that can fix this problem and accelerate their development.

7. Summary

The presentations and discussion at the workshop made it clear that airport and airspace congestion results from a complex interplay of many factors, and that while steps can be taken to minimize the worst effects currently being experienced throughout the NAS, there are no simple solutions. The development of a coherent set of airline and national strategies to address this growing problem will require a much more sophisticated understanding of the issues involved than has been the case to date. In particular, the formulation of appropriate public policy in this area will require an improved ability to anticipate the consequences of proposed actions that are intended to address delays. The workshop made a useful contribution to this understanding, and served to establish an agenda for future efforts in this direction.

Appendix

Program

THURSDAY, March 15

Welcome
(8:30 – 9:00)

T0: Michael Ball, University of Maryland

T1: The Extent of the Problem and its Underlying Causes
(9:00 – 10:45)

T1-1: "Airport and Airspace Capacity Constraints and the Prospects for Capacity Expansion" (John Hansman, Massachusetts Institute of Technology)

T1-2: "An Evaluation of Overall US and European Airspace Capacity" (George Donohue, George Mason University)

T1-3: "National Trends in Airport Delays and Flight Cancellations" (Cynthia Barnhart and Stephane Bratu, Massachusetts Institute of Technology)

Discussants
T1-4: Jim Evans, MIT Lincoln Laboratories
T1-5: Clyde Miller, Logicon Sterling Federal
T1-6: Agam Sinha, MITRE Corporation

Break (10:45 – 11:00)

T2: Impact on Airline Profitability and Service to the Public
(11:00 – 12:15)

T2-1: "The Economic Impact of Airport Congestion" (Martin Dresner and Robert Windle, University of Maryland)

T2-2: "The Impact of Airport Delays on Airline Costs" (Peter Kostiuk, Logistics Management Institute)

Discussants
T2-3: Mike Wambsganss, Metron, Inc.
T2-4: David Swierenga, Air Transport Association

Lunch (12:15 – 1:30)

T3: "Is It Safe?" (Arnold Barnett, Massachusetts Institute of Technology)

T4: ATC Operational Strategies
(1:30 – 3:15)

T4-1: "Strategic Planning in Traffic Flow Management" (Jack Kies, US Federal Aviation Administration)

T4-2: "Improving System Performance through Collaborative Decision Making" (Michael Ball, University of Maryland)

T4-3: "A Case Study of Delays and Response Strategies at Newark Airport" (John-Paul Clarke and Anthony Evans, Massachusetts Institute of Technology)

Discussants
T4-4: James Wetherly, US Federal Aviation Administration
T4-5: Roger Beatty, American Airlines
T4-6: Don Eddy, US Federal Aviation Administration

Break (3:15 – 3:30)

T5: Demand Management
(3:30 – 5:15)

T5-1: "Demand Management Alternatives for Reducing Airport Delays" (Amedeo Odoni and Terence Fan, Massachusetts Institute of Technology)

T5-2: "Federal Issues Dealing with Demand Management", (John Rodgers, US Federal Aviation Administration)

T5-3: "Federal Regulatory Issues Related to Airport Demand Management" (Scott Lewis, Palmer and Dodge)

Discussants
T5-4: David Plavin, Airports Council International
T5-5: Igor Frolow, Price Waterhouse Coopers
T5-6: Robert Windle, University of Maryland

Wine and Cheese (5:30 – 6:30)

Friday, March 16

Keynote
(8:30 – 9:00)

F0: Jane Garvey, Administrator of the US Federal Aviation Administration

F1: Industry and Competitive Strategies I
(9:00 – 10:45)

F1-1: "Short-to-Medium Term Airline Responses to Delays" (Peter McDonald, United Air Lines)

F1-2: "Influence of Capacity Constraints on Airline Fleet Mix" (Mark Hansen and Geoffrey Gosling, University of California, Berkeley)

F1-3: "The Changing Face of Aviation in View of Airport/Airspace Congestion" (Bill Wangerien, Delta Airlines)

Discussants
F1-4: Robert Schwab, Boeing
F1-5: Curtis Grimm, University of Maryland

Break (10:45 – 11:00)

F2: Industry and Competitive Strategies II
(11:00 – 12:15)

F2-1: "Matching Capacity and Demand at LaGuardia Airport" (William DeCota, Port Authority of New York and New Jersey)

F2-2: "How to Have Your Cake and Eat It, Too: Public Policies on Airport Congestion" (Glenn Hauenstein, Continental Airlines)

Discussants
F2-3: Norman Fujisaki, US Federal Aviation Administration
F2-4: Geoffrey Gosling, University of California, Berkeley

Lunch (12:15 – 1:15)

F3: National and International Policy Alternatives
(1:15 – 3:00)

F3-1: "Future Capacity Developments" (Steve Brown, US Federal Aviation Administration)

F3-2: "Dealing with Airport and Airspace Congestion in Europe" (Xavier Fron, EUROCONTROL)

F3-3: "A Market-Based Approach to ATC Modernization" (Russ Chew, American Airlines)

Discussants
F3-4: Mark Dayton, Office of the Inspector General, US Department of Transportation
F3-5: Stephen Bradford, US Federal Aviation Administration
F3-6: Richard Marchi, Airports Council International