

# UC Berkeley

## Proceedings

### Title

2001: An Airspace Odyssey SUMMARY PROCEEDINGS OF THE 2001 AIRPORT NOISE SYMPOSIUM AND AIRPORT AIR QUALITY SYMPOSIUM

### Permalink

<https://escholarship.org/uc/item/3np823tt>

### Author

Gosling, Geoffrey D.

### Publication Date

2001-12-01

Institute of Transportation Studies  
University of California at Berkeley

**2001: An Airspace Odyssey**  
**SUMMARY PROCEEDINGS OF THE**  
**2001 AIRPORT NOISE SYMPOSIUM AND**  
**AIRPORT AIR QUALITY SYMPOSIUM**

**Geoffrey D. Gosling**

PROCEEDINGS  
UCB-ITS-P-2001-1

December 2001  
ISSN 0192 4117

## **Preface and Acknowledgments**

These proceedings summarize the presentations made at the 16th Airport Noise Symposium and 2nd Airport Air Quality Symposium, organized by the Technology Transfer Program of the Institute of Transportation Studies (ITS) and held in San Diego, California, from February 25 to March 2, 2001. The presentation slides for many of the presentations at both symposia are available on the ITS Technology Transfer Program website at <<http://www.its.berkeley.edu/techtransfer>>.

The symposia were organized in conjunction with the National Center of Excellence for Aviation Operations Research, the Federal Aviation Administration, the Federal Interagency Committee on Aviation Noise, and the Port of San Diego, and with the active support and assistance of the individuals and organizations represented on the Symposia Program Committee, listed at the end of these proceedings.

## Table of Contents

	Page
Preface and Acknowledgments	ii
Table of Contents	iii
Overview	iv
1. Airport Noise 2001	1
2. Inter-Symposium Session – Environmental Justice: Interpretations and Applications	26
3. Airport Air Quality 2001	29
Program Committee	53

## Overview

### Airport Noise 2001

The presentations in the 16th Annual Airport Noise Symposium covered a broad range of current topics in aircraft noise management, from policy and regulatory issues, through prospects for source noise reduction through advances in engine and airframe design and management of air traffic flows, to economic considerations and recent findings on measuring the effects of aircraft noise on the population near airports. The sessions took an international perspective, addressing recent developments within the International Civil Aviation Organization and presenting viewpoints from other countries, including Australia, Canada, South Africa, and a number of European countries. The discussions provided an opportunity for symposium participants to explore issues in more detail with the presenters, and contribute their own views and concerns.

In view of the wide range of issues addressed during the symposium, it is not an easy task to select the most significant issues to emerge from the symposium, and such an exercise runs the risk of appearing to overlook important aspects that were covered in the sessions. However, there were several important findings that became clear from the presentations and discussions, and that deserve special mention. The first was that while the proposed new Chapter 4 aircraft noise standards that have been recommended by the ICAO Committee on Aviation Environmental Protection may at first sight appear to represent a significant step forward in reducing future levels of aircraft noise, in reality the compromises that were necessary to reach international agreement mean that any real reductions in aircraft noise will be very limited for the foreseeable future. Many current production aircraft already meet the proposed standards, so there is no requirement to make these any quieter, and the proposed rules include no phase-out provisions for aircraft that meet current Chapter 3 standards. Thus the new standards do little, if anything, to reduce the noise generated by the current U.S. fleet, and will have limited effect on future additions to the fleet.

The second is that while prospects for the application of new engine and airframe technology to achieve further reductions in aircraft noise beyond the proposed Chapter 4 standards are quite promising, it will take many years for the results of current research and development efforts to appear in commercial products, and even longer for those aircraft to form a significant fraction of the fleet. Aircraft have long operational lives, unless required to be phased out by regulation, and thus the existing fleet, particularly recent additions to the fleet, will be around for a long time. Furthermore, growth in traffic will absorb most of the additional capacity provided by future additions to the fleet, so these new aircraft will mostly add operations to existing traffic levels, rather than replace operations by the current fleet. Adding more operations by quieter aircraft does nothing to reduce existing noise levels, and in fact tends to increase them. Therefore, better management of air traffic operations in the terminal airspace offers better prospects to achieve significant noise reductions in the immediate future. Enabling aircraft to stay as high as possible for as long as possible on approach and routing departures over less noise-sensitive areas can significantly reduce community noise impacts. However, there may be difficult trade-offs to be made between reducing community noise exposure and increasing airport capacity.

It is increasingly recognized that the exclusive use of the Day-Night Average Sound Level metric for measuring the noise impact of aircraft activity on communities fails to capture many important attributes of aircraft noise, which severely constrains efforts to find solutions acceptable to the affected communities. Low frequency noise is becoming recognized as an important issue at some airports and overflight activity at relatively low noise levels at considerable distance from the airport is emerging as a growing concern in many regions. Effective dialogue between the aviation industry and local communities is not helped by a rigid insistence on the use of metrics that are viewed as inappropriate or worse by those affected by the noise. An interesting new approach to communicating expected aircraft noise impacts to affected communities, that has experienced some success in Australia, was presented at the symposium.

Finally, the economic implications of aircraft source noise reduction, airport access restrictions, and noise insulation and land use controls need to be better understood, and integrated into airport noise management policy. Access restrictions impose costs on the users of the air transportation system, replacing noisier aircraft imposes costs on the aircraft operators, which are ultimately borne by air passengers and air cargo shippers, community noise insulation programs impose costs on airport authorities, which flow back to users of the air transportation system in various ways, and land use controls impose opportunity costs on the communities affected. The objective of rational public policy should be to understand how these various costs interact with each other, and pursue policies that balance environmental goals with air transportation goals, in order to achieve the most cost-effective outcome for society as a whole. This will require appropriate pricing signals and mechanisms to allow those who benefit from the air transportation system to mitigate the adverse environmental impacts resulting from their use of it, and to compensate those who experience adverse unmitigated impacts. This is not only a matter of social equity, but of economic efficiency and even self-interest by users of the air transportation system. Failure to appropriately mitigate community noise impacts of aviation activity results in understandable opposition to airport expansion by the affected communities, which can result in even greater delay costs borne by the users of the system than the mitigation measures would have cost.

In conclusion, the development of effective policies and programs to manage and mitigate the adverse impacts of aircraft noise is fundamentally a matter of tradeoffs and compromises. By contributing to an increased understanding of the technical issues involved in these tradeoffs, and bringing a broad range of stakeholders together to explore the limits of what it is reasonable to expect to achieve through various measures, the Symposium made a useful contribution to the policy debate over what changes may be required to existing approaches to manage aircraft noise.

### **Inter-Symposium Session on Environmental Justice**

The inter-symposium session on environmental justice addressed an emerging area that is becoming of increasing importance in defining appropriate responses to both airport noise and airport air quality issues in the United States. The session examined the legal context of environmental justice requirements and regulations, as well as the sources of guidance on how these issues should be addressed within the context of Federal and state environmental impact statements, and broader requirements to achieve appropriate public participation in the airport development decision process and ensure that minority and low-income communities are not

subjected to disproportionate levels of adverse impacts. Presentations in the session described recent efforts to address these issues at both Boston Logan International Airport and Los Angeles International Airport, and identified a number of concerns with the way these issues have been handled to date.

### **Airport Air Quality 2001**

The symposium explored a wide range of issues involved in airport air quality from prospects for improvement in aircraft engine technology, through measurement of toxic emissions and their implications for human health, to strategies to reduce emissions from ground service equipment and ground access vehicles. It also examined the issues surrounding the contribution of aviation to greenhouse gasses and global climate change. While these are not primarily issues of airport air quality, their resolution appears likely to affect aircraft emissions at airports in ways that are far from clear. Some speakers suggested that there may well be difficult tradeoffs that will have to be made between reducing aircraft emissions that affect local air quality and those that affect global climate change. There are also potential tradeoffs between reducing emissions and reducing aircraft noise that may have to be considered.

However, perhaps the most difficult tradeoff of all will be between reducing emissions and the economic benefits of air transportation. It appears likely that achieving significant reductions in aircraft emissions will be very costly. For this reason alone, it is understandable that near-term efforts have focused on easier problems, such as reducing emissions from auxiliary power units, ground service equipment and ground access vehicles, for which alternative technologies are readily available and the additional costs manageable. For emissions that are generated by a wide range of different sources, it is clear that reduction efforts should focus on those sources where it is least costly to achieve reductions, which forms the justification for emissions trading programs. It may be far more cost-effective for aviation to pay other sectors to reduce CO<sub>2</sub> emissions, say, than to reduce its own CO<sub>2</sub> emissions. There are two important caveats to this approach. The first is that it may matter where the emissions occur as well as how much is emitted, requiring some care in establishing the rules on what is considered an allowable trade. The second is that some emissions may be unique to aviation, either in their quantity or location. Aircraft contrails are an obvious example.

The discussions at the symposium suggested that two categories of aviation emissions are not well understood, either in terms of their consequences or how much is currently being emitted. These are toxic chemicals and particulate matter, especially smaller particles. Until these issues are better understood, it is difficult to know the extent to which they can be addressed through emissions trading and the extent to which direct reduction in emissions will be required. It was also clear from the discussions at the symposium that the scientific debate very quickly becomes clouded by the economic interests of the parties involved. Just as the question of the extent to which global warming is taking place is fraught with difficult measurement issues, so the question of how much exposure to airborne toxic chemicals produced by aviation activities do people living near major airports experience, much less the consequences of that exposure, is not at all easy to answer.

Another major theme to emerge from the presentations at the symposium was the tension between the flexibility offered by voluntary emissions reduction programs and technology push that comes from more restrictive regulations. The U.S. airline industry has sought and obtained

the opportunity to show that it can significantly reduce aviation-related emissions through voluntary measures. However, if it fails to do so, it seems likely that it will quickly find itself struggling with a complex set of new state and local regulations. On the international front, two European countries have already implemented aircraft emissions charges and it seems quite likely that this approach may soon become more widely adopted within Europe.

In conclusion, the symposium provided an opportunity for a broad range of stakeholders to explore the complex scientific and technical issues that arise in formulating appropriate policies and implementation strategies to reduce the emissions from aviation activity. Air quality has emerged as one of the most important environmental issues at many major airports, not only in the United States, but worldwide, and it appears clear from the symposium that it is likely to become even more so in the future. The symposium provided a useful forum for the participants to better understand the difficult nexus between the scientific and policy dimensions of the topic, and to share ideas on promising strategies that airports and other stakeholders can pursue to both satisfy regulatory requirements and meet the larger goal of achieving improvements in air quality at a local and global level.



# **Airport Noise 2001**

## **Summary Proceedings of the 16th Annual Airport Noise Symposium**

The 16th Annual Airport Noise Symposium organized by the Technology Transfer Program of the Institute of Transportation Studies at the University of California at Berkeley was held in San Diego from Monday, February 26 through Wednesday, February 28, 2001. This report provides an overview of the presentations and discussion at the symposium. Further details, including the full program and copies of the slides or text for many of the presentations are available on the Symposium website at: <http://www.its.berkeley.edu/techtransfer>.

The symposium opened with welcoming remarks by Thella Bowens, Senior Director of Aviation for the Port of San Diego and Prof. Martin Wachs, the Director of the Institute of Transportation Studies at Berkeley. On behalf of the Port of San Diego, Thella Bowens welcomed the symposium participants to the City of San Diego, described the activities of the Port, that include operating the principal airport serving the city, and encouraged participants to enjoy their time in the city. She noted that the Port views aircraft noise as a critical issue in its operation and development of the city's airport system, and has made a major investment in aircraft noise monitoring and airport noise mitigation programs. She introduced some of her staff involved in these issues, and extended an invitation to symposium participants to visit the noise monitoring facilities at the airport while they were in the city.

Prof. Wachs extended the welcome on behalf of the Institute of Transportation Studies. He noted the importance of airport noise issues in developing the nation's airport system, and remarked on the parallels with the development of the interstate highway system in the 1960's, that had triggered a growing concern for the environmental consequences of building highways and the recognition of the need to include environmental concerns in planning. He pointed out that the nation is witnessing a growth in air travel that exceeds even that of the growth in automobile use in the 1950's and 1960s, and that airports are increasingly assuming a role of growth enters in urban areas. Thus he suggested that environmental issues have to become central to policy making, and was pleased that the Institute could contribute to this through its role in organizing the symposium.

### **Keynote Address**

The technical program of the symposium began with a keynote address by the Honorable Gerald Baliles, former Governor of the Commonwealth of Virginia, and currently a Partner with Hunton & Williams and Chairman of the Coalition for a Global Standard on Aviation Noise. Gov. Baliles began by noting that concerns about aircraft noise have heavily influenced the limited number of runways that have been built over the last 20 years. These concerns also result in operational restrictions, and he indicated that there is some question whether the new Airbus A380 will be able to meet the noise standards at London Heathrow Airport. He suggested that the ability to expand the airport system capacity should be of great concern to passengers, who will otherwise experience growing delays, and that adoption of a Chapter 4 noise standard is critical to the future of air transportation. Several months before the January 2001 meeting of the Committee on Aviation Environmental Protection (CAEP) of the

International Civil Aviation Organization (ICAO) that had taken place in Montreal it had not been clear that CAEP could agree on a new standard and whether a phase-out of older aircraft could be implemented. It was an open question whether the international air transportation industry would be governed by international standards or by a patchwork quilt of local regulations.

Gov. Baliles then turned to what had happened in Montreal, and noted that agreement had been reached on a wide range of aircraft noise and emissions issues. He suggested that reaching agreement on these issues is vital, because there is no real substitute for air transportation, which moves 40 percent of the world's international freight by value and some 2 billion passengers per year. The new standards established by CAEP, which are expected to be adopted by the ICAO General Assembly in September of 2001 and to be implemented by 2006, will help allow the air transportation to continue to grow by reducing aircraft noise by 10 dB.

However, he reported that CAEP was not able to agree on all issues. The committee could not agree on a balanced program of operating restrictions and land use controls, and the airport community is not completely satisfied with the results of the CAEP meeting. He indicated that airport authorities are placing increasing pressure on governments to permit local restrictions on aircraft operations. While some of the busiest airports in Europe and elsewhere are already restricting operations, others are moving toward such actions. He indicated that the Coalition for a Global Standard on Aircraft Noise will be working with governments and ICAO to address these issues between the symposium and September 2001.

He concluded with the observation that airport capacity is an issue that is finally being addressed, although this is long overdue. The system is adding twice the number of passengers handled by Washington National Airport every year, while very few additional airports and runways have been built, with noise concerns a major factor in limiting infrastructure expansion.

Following his remarks, he was asked how ICAO is addressing noise from general aviation aircraft and responded that it is probably not addressing the issue well enough. However, he stressed that the Coalition that he represents is primarily concerned with airline operations, and has three major principles: recognition of the need to maintain the integrity of the air transportation system, preservation of the investment in the existing Chapter 3 aircraft, and the importance of a technically effective noise standard. Another questioner asked about the Coalition's view of hushkits and Gov. Baliles indicated that it had decided not to get involved in this issue, although it did support the principle of coordination of re-certification procedures.

### **International Policy**

The first session of the symposium was moderated by Prof. John Paul Clarke of the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology and presented a range of perspectives on one of the most critical aspects of international policy on aircraft noise, namely the discussions underway within ICAO and its Committee on Aviation Environmental Protection to establish agreed international standards for the next generation of aircraft noise certification criteria. These standards, termed Stage 4 in the United States or Chapter 4 elsewhere, provide the framework within which states establish regulations that define how quiet newly manufactured aircraft must be in the future in order to receive operating certificates, as well as how long existing aircraft that do not meet the new standards may continue to be operated. The session consisted of three presentations that provided industry and

Federal Aviation Administration (FAA) assessment of plans for Stage 4, followed by a general discussion and a review of the current status of the ICAO process by two people who are closely involved in this as representatives of their respective governments to CAEP.

The first presentation on the industry perspective of plans for Stage 4 standards was given by Larry Craig, Chief of Emissions and Noise at Boeing Commercial Airplane Group, who addressed technology development and implementation for Stage 4 standards. He began by reviewing the certification noise levels of existing aircraft relative to the current Chapter 3 standards, and presented data that showed that most Airbus aircraft already have a 10 dB margin. However, many of the heavier Boeing aircraft do not achieve a 10 dB margin, especially the B747-100, 200, and 300 series. He indicated that Boeing will be designing future aircraft to achieve a 16 dB margin below Chapter 3 standards.

Mr. Craig then discussed some of the noise reduction technologies that will be required to help achieve this goal. Noise improvements for quiet engines include achieving an optimum bypass ratio, although this tends to increase the weight of the nacelle, the use of advanced fan blade design and low noise fan exit guide vanes, and jet noise suppression using chevrons or tabs. He indicated that the latter might give as much as a 3-5 dB reduction. Additional noise reduction can be achieved from nacelle design and acoustic treatment. A scarf inlet design, in which the lower edge of the nacelle is forward of the upper edge, reduces noise propagated downward and allows an increase in acoustic lining area. Acoustic treatment of the inlet lip can also reduce compressor fan noise, and the design of the nacelle linings can be optimized at each location for maximum impact.

He concluded the presentation by addressing opportunities to reduce airframe noise. Current plans at Boeing include improvement of flaps and slats, the development of low noise landing gear, and improved low speed performance. He indicated that a 2-3 dB noise reduction may be possible with low noise landing gear. The use of winglets can result in reduced fuel burn and lower noise and emissions, and Mr. Craig suggested these might reduce noise by about 0.5-0.7 dB.

The second presentation by Gaëtan Dureau, Manager of Sales and Marketing Support at Bombardier Aerospace, provided a second industry perspective on plans for Stage 4 from the business jet community. He began by noting that the proposed Stage 4 standard requires a cumulative reduction of 10dB below the Stage 3 noise levels with no tradeoff allowed between the measurement points, but stressed that realistic “green machines” must balance environmental goals against aircraft stakeholder needs. Noise reduction presents a particular challenge for business aircraft due to the smaller engine diameter and greater nacelle curvature as well as the smaller production runs making it harder to achieve economies of scale. However, Mr. Dureau also had some good news to report: the Bombardier Global Express business jet has an 11dB cumulative margin below the proposed Stage 4 standard.

He also noted that operating costs of newer aircraft are significantly lower than Stage 2 aircraft, although the higher ownership costs of newer aircraft largely offset any operating cost savings, since most business jets are only operated for about 500 hours per year. Among the concepts for noise reduction that can be applied to new business aircraft, Mr. Dureau suggested that the most promising are noise absorption materials, improved low speed performance, and the use of flight management system capabilities to support operational restrictions.

The third presentation was by Carl Burleson, Director of the Office of Environment and Energy at the Federal Aviation Administration. He began by noting that there had been a considerable improvement in the noise environment over the ten years since the passage of ANCA, with a dramatic reduction in the number of people “significantly impacted by aircraft noise.” He indicated that the FAA supports the proposed Stage 4 standard that would apply to new aircraft certificated after January 1, 2006. The noise reductions that were achieved with Chapter 3 aircraft involved the use of new technology, but the FAA does not believe that similar technology options are readily available to achieve a similar reduction with Stage 4. He also stated that an analysis of the global cost of a phase-out of aircraft within 8 dB of the Chapter 3 standard had been estimated to cost between 35 and 52 billion dollars.

A critical issue affecting the pace at which new technology can be deployed is the time required for technology to make it from research to market. Mr. Burleson noted that it has been found to take at least 5 years for NASA research results to appear in commercial products. He also warned that operating restrictions may not be the most cost-effective solution, and suggested that there is a need to address specific mitigation measures at specific airports, as well as the need for a commitment to an integrated approach that combines land use planning with operating restrictions. He concluded by stating that the FAA intends to give full support to the international process through ICAO.

Following the three presentations, the topic was opened to discussion from the floor. One participant expressed dismay that the CAEP process was not open to public input, and asked why the FAA did not attempt to identify what the public felt the future standards ought to be. Carl Burleson replied that the FAA had in fact consulted widely within government and stakeholder groups, and noted that there were up to 180 participants within the CAEP process. He indicated that the proposal put forward by the Airports Council International was fully discussed at the CAEP meeting. A second participant asked what is being done to look at new airframe concepts such as flying wings. Larry Craig responded that these concepts are being looked at with regard to future product lines. A third participant stated that if the cost of a Stage 3 phase-out is compared to other environmentally driven phase-out decisions, such as asbestos or freon, the costs are not as high as they might appear, and asked whether the FAA should not give greater attention to these issues. Carl Burleson responded that the FAA believes that it is necessary to ensure that there are consistent international standards, which would be difficult if the United States made a unilateral decision to phase out certain Stage 3 aircraft.

Following a break, the session continued by examining where things stood in the ICAO process to define new aircraft noise certification recommendations. Karin Sjolín, the CAEP Representative of the Swedish Civil Aviation Administration, summarized the outcome of the fifth CAEP meeting (CAEP/5) the previous month and described the subsequent steps. She noted that the CAEP/5 meeting had recommended a balanced approach with four aspects: reduction of aircraft noise at source; land use planning to reduce incompatible land uses; operational procedures to reduce aircraft noise impact; and operational restrictions. The meeting had agreed on a total reduction in the noise certification standard of 10dB at a closed-door discussion session. Other recommendations included procedures for re-certification of existing aircraft to meet the new standard. There was no final conclusion on operating restrictions on Chapter 3 aircraft. She suggested that this can be viewed as an interim result pending a planned Colloquium to be held by CAEP later in 2001 and the ICAO General Assembly in September 2001.

Regarding aircraft emissions, Karin Sjolin reported that CAEP was pursuing four initiatives: an emissions trading program, with further work to be done to define an international program; voluntary mechanisms and charges; analysis of the environmental benefits of Communications, Navigation and Surveillance/Air Traffic Management (CNS/ATM) technologies; and development of an ICAO Circular on operational opportunities to minimize fuel use and best industry practices. She noted that the European Union was currently looking at charging programs for carbon monoxide (CO) and nitrogen oxides (NO<sub>x</sub>), while both Sweden and Switzerland already had such programs. She described the role of the European Civil Aviation Conference (ECAC) as harmonization of regulations affecting the operation of air transport in Europe and promoting the development of the European air transport system. She noted that there is a widely held belief that failure to address the noise environment around airports will limit the ability of the European air transport system to meet the future growth in demand. It is considered inevitable that there will be an increase in noise impact around major airports without future reduction in aircraft noise emission standards, since the benefits of Chapter 3 standards have largely been realized. She expressed a concern that the potential for new aircraft complying with proposed Chapter 4 rules to reduce airport noise is limited, due to the slow increase in the proportion of these aircraft in the fleet, and noted that the ECAC states have been working with CAEP to agree on re-certification procedures for existing aircraft.

Following Karin Sjolin's remarks, Carl Burluson, Director of the FAA Office of Environment and Energy, provided a U.S. perspective. He began with some general observations about the discussions at CAEP/5. He had been struck by the diversity of people and views, and by the fact that the models used to inform the discussions had received a great deal of work and produced a much more informed debate. He also felt that the developing world had clearly found its voice, and that the developed countries could no longer shift environmental problems to other parts of the world. He reported that there will be an updated ICAO Annex 16 that that will document the revised re-certification procedures agreed at CAEP. He noted that the European states seem to be more positive on emissions charges than the United States, which feels that the benefits do not justify the costs. He concluded by noting that the contracting states have a couple of months to comment on the CAEP recommendations, and then the ICAO Council will vote on the recommendations in May 2001.

Following these remarks, the session was opened for questions. One participant asked whether CAEP had recommended more stringent standards for helicopters. Carl Burluson responded that the discussions had focused on the process of how certification is done. Another participant asked whether the re-certification process addresses re-certification to Chapter 3 as well as Chapter 4, and Carl Burluson responded that the recommended process affects all re-certification activities. In response to a question of whether ECAC has any plan to avoid a proliferation of local restrictions, Karen Sjolin remarked that ECAC hoped to achieve a regional consistency, but to do this through an international approach.

### **Domestic Policy Implementation**

The second session began after the lunch break on the Monday afternoon and consisted of a panel discussion that addressed the domestic policy results of the Airport Noise and Capacity Act (ANCA) during the ten years since its passage. At the time the Act was passed, expectations were high that a noticeable reduction in noise impacts would occur as a result of the Act and the conversion to an entirely Stage 3 fleet. However, concern over aircraft noise

continues and the question was posed to the panel whether this is due to the continued operation of noisier aircraft equipped with hushkits, increases in air traffic, or changes in perceptions and expectations. The session was moderated by Neal Phillips, Noise Abatement Manager of the Metropolitan Washington Airports Authority.

The first presentation by John Meenan, Senior Vice President for Industry Policy, Air Transport Association, presented a retrospective view of the contribution of ANCA and discussed some of the issues that it did not resolve and are now being addressed through the CAEP process. He stated that the authors of ANCA are to be commended for introducing a level of analysis into the debate over aircraft noise, and summarized the objectives of the Act as responding to the need to quiet the noise environment around airports, establishing a legal structure required to balance the interests involved, and recognizing the need to increase the capacity of the system. He noted that the Magenta model developed by ICAO, which analyzes the size of the population exposed to various levels of aircraft noise under different proposed aircraft noise standards, predicts that the population exposed to noise levels over 65dB DNL would decline to around 400,000 over the coming decade. He also remarked that a number of urban legends have arisen from ANCA. The first is that the number of aircraft fitted with hush kits was a surprise. The second is that eliminating aircraft fitted with hush-kits would eliminate the noise problem around airports. The third is that Part 161 of the Federal Aviation Regulations, which provides a procedure for airports to implement access restrictions on certain aircraft types, is unduly complex.

He stated that over the past ten years there has been a significant reduction in the number of proposed operational restrictions at different airports, and that the focus of the debate shifted to systemwide strategies. However, the cost-benefit studies undertaken by CAEP have demonstrated that the costs of a phase-out of Chapter 3 aircraft could not be justified by the benefits to those impacted by aircraft noise. In assessing the current situation, he noted that ANCA did not consider the interaction between noise and air quality emissions, and on the capacity front, has not been as successful at meeting the needs of air travel growth. He suggested that the current record levels of system delay are symptoms and warnings of a future crisis.

The second speaker, Steven Pflaum, a Partner with McDermott, Will & Emery, offered a look beyond Stage 3, addressing ways to build on ANCA's success and avoid its failures. He suggested that it will be important to understand the lessons of ANCA when Congress gets around to defining its successor legislation (ANCA II). He defined ANCA's key objectives as stopping the proliferation of local restrictions and phasing out Stage 2 aircraft. This had a number of consequences. There were no new restrictions on aircraft operations, hush-kits were developed to allow some Stage 2 aircraft to qualify as Stage 3, and there was a growth in residential sound insulation programs. He noted that billions of dollars have been spent on sound insulation programs, and that there was a need to measure the efficacy of these programs. He pointed out that it was important not to confuse means with ends, and mentioned that he was aware of only one study that had really looked at this issue, in Atlanta, and the results were not very encouraging.

He noted that a number of issues had been raised by the CAEP/5 meeting, the most important of which was that the recommendations did not address the distinction between new aircraft types and continued manufacture of existing aircraft types. This left a number of options

for ANCA II. The first is to simply implement the ICAO standards and not add any additional U.S. requirements. This approach would rely on the aging of the aircraft fleet to phase out the existing Stage 3 aircraft. The second would be to require all newly manufactured aircraft to comply with Stage 4 by a specified date. The third would be to ban the operation of aircraft equipped with hush-kits to meet Stage 3 standards. Finally, the fourth would be to implement rules defining a Stage 3 phase-out. He suggested that the preferred solution would be an ambitious Stage 4 goal for noise reduction, noting that most existing aircraft already meet CAEP/5 standards. However, he cautioned that a phase-out of aircraft equipped with hush-kits could have an adverse effect on competition, particularly in the current cycle of consolidation.

The third presentation by Richard Marchi, Senior Vice President for Technical and Environmental Affairs, Airports Council International - North America (ACI-NA), offered another perspective on ANCA ten years after its passage. He suggested that the goals of ANCA have not been achieved. The industry is experiencing record delay levels and airports are continuing to struggle with aircraft noise controversies. He noted that noise is still the largest concern at many airports, and contrasted airport expectations in 1990 with the reality in 2000. In 1990 it was expected that aircraft equipped with hush-kits would be used, but mostly by the cargo carriers, and that fuel prices would drive the older Stage 3 aircraft out of the fleet. The reality is that some 1,100 older aircraft remain in the fleet. He noted that ACI-NA supported two new initiatives at CAEP: a 14dB reduction in the Stage 4 standard, and some restrictions on noisy aircraft within 5dB of the Stage 3 standard. He felt that failure to reach agreement on retirement of the noisiest aircraft is more serious than the lower proposed Stage 4 standard, since this could lead to more local restrictions. He noted that the next steps in the CAEP process were a CAEP Colloquium on April 9-10 in Montreal, and the ICAO General Assembly in September 2001. He indicated that ACI-NA planned to participate in the April colloquium and work with European countries to submit a resolution directly to the ICAO Council allowing restrictions on operations by aircraft within 5dB of Stage 3 as part of a "balanced approach".

He also summarized the status of various efforts to establish restrictions under FAR Part 161. So far there were no current applications for restrictions on Stage 3 aircraft. Pease International Tradeport, Portsmouth, New Hampshire and Burbank Airport in California were conducting studies. San Francisco International Airport had withdrawn its application. There had been five applications thus far. Minneapolis-St Paul had submitted three applications, two had been withdrawn and one was adopted as a contingency. Flying Cloud airport in Minneapolis, Minnesota had withdrawn its application. Naples Airport in Florida had adopted the restrictions in its application and the FAA was pursuing enforcement actions against the airport.

The fourth speaker was Arlene Mulder, the Mayor of Arlington Heights, Illinois and Chair of the O'Hare Noise Compatibility Commission. She described the organizational structure of the commission, consisting of three standing committees addressing residential sound insulation, schools, and technical issues. The residential sound insulation program has spent \$130 million through 2000 to insulate 3,900 homes. The school insulation program has spent \$250 million through 2000 to insulate 94 schools, and the program for the current year will address a further 22 schools. She noted that this is the world's largest school insulation program. The technical committee has defined three work elements addressing how to improve the effectiveness of the City of Chicago's Fly Quiet program, working with airlines on advanced flight track procedures, and development and operation of a community outreach vehicle.

## **Small Jet Issues and Air-21**

The third session took place following the break on Monday afternoon and addressed small jet issues and the recent Air-21 legislation. It was chaired by Kenneth Feith, Office of Air and Radiation, Environmental Protection Agency.

The first presentation addressed the consequences of the increasing number of regional jets, and was given by Gregory Juro, Manager for Traffic Management at the Dallas/Fort Worth Air Traffic Control Tower and Terminal Radar Approach Control facility. He noted that regional jet (RJ) operations have grown to about 7 percent of total traffic in the U.S. National Airspace System, with the activity currently concentrated in the northeast of the country. The impacts of the growing levels of RJ traffic can be divided into airport impacts and airspace impacts. Airport impacts primarily involve the effect on capacity of the different performance characteristics of RJs compared to the turboprop aircraft that they often replace. At Dallas/Fort Worth International Airport (DFW) operational procedures are designed to segregate turboprop and jet aircraft. These procedures include having the turboprops make an immediate turn on departure to allow faster jet aircraft following them to be released earlier, and the use of the diagonal runways by turboprops. Replacing turboprop operations with RJs increases the amount of traffic using the parallel runways and standard departure routes. Airspace impacts arise from both the altitude and speed at which the RJs typically fly. Increasing use of RJs in place of turboprops will shift traffic from lower altitudes used by turboprops to altitudes above Flight Level 290 (29,000 feet), with a potential increase in congestions at the higher altitudes. In the terminal airspace, the slower speeds of the RJs compared to larger jets can reduce the capacity of arrival and departure routes, due to the need to provide larger initial separation to prevent faster aircraft overtaking the RJs, as well as the gaps that develop when an RJ follows a faster aircraft. The use of dual arrival routes at DFW has created different flight tracks for the slower and faster aircraft, which then merge prior to final approach. Approaches to accommodate both increased RJ activity and air traffic growth include new procedures, major airspace redesign, and implementation of new air traffic control and navigation technology.

The second presentation by Gerald Dillingham, Director of Civil Aviation Issues at the U.S. General Accounting Office, addressed the issues that arise in balancing airport system capacity demands with environmental challenges. He began by summarizing the principal environmental constraints on expanding airport capacity as aircraft noise, emissions, and water quality. He also noted that the national airport system is experiencing significant capacity problems. From 1995 to 1999, aircraft delays increased by 58 percent and flight cancellations increased by 68 percent. In the first seven months of 2000, some 900,000 flights were delayed or cancelled. He noted that it has been estimated that the U.S. airport system will need to expand capacity by 60 percent by 2015 to meet projected needs. Immediate options to expand capacity involve construction of new runways. However, these plans are often constrained by noise concerns. General Accounting Office studies have found that many airport officials face severe noise challenges. The most frequently cited challenge is the use of noisy aircraft, while the second most frequent problem is incompatible land use around airports. Federal efforts to address airport noise include the noise management process defined by the Federal Aviation Regulations (FAR) Part 150 and funding of noise mitigation and noise management programs through Passenger Facility Charges and the Airport Improvement Program. He suggested that there is a need to reduce the bureaucratic obstacles to airport participation in FAR Part 150 programs. He concluded by offering some thoughts on what the future may hold. Noise and air



quality issues are likely to become more contentious as airport operations increase, and there is a good prospect of more stringent noise standards as a result of the proposed Stage 4 standards being defined by ICAO. This will create an opportunity to take a holistic, strategic view of capacity options. Finally there are efforts currently under way to streamline the environmental review process.

The next presentation was given by Adam Tsao, member of the Professional Staff of the Aviation Subcommittee of the U.S. House of Representatives Committee on Transportation and Infrastructure, and provided a view of current aviation issues from Capitol Hill. He stated that there is no question that the country faces a serious airport capacity problem and that something has to be done to move forward. The Air-21 legislation increased funding levels for airport development to \$3.2 billion per year, with an increased set-aside for airport noise programs. However, for this funding to be effective, there is a need to reduce the time involved in the review process to build new airports.

The fourth presentation addressed FAR Part 161 restrictions on business jet aircraft, and was given by Jeffrey Gilley, Manager for Airports and Ground Infrastructure, National Business Aircraft Association (NBAA). He noted that about 3,000 of the aircraft operated by NBAA members are jets, and about 400 of these are Stage 2 aircraft. He stated that airport proprietors appear generally reluctant to pursue efforts under FAR Part 161 to impose restrictions on these Stage 2 aircraft, and indicated that the NBAA is not opposed to reasonable efforts by airports to implement restrictions on Stage 2 aircraft. He then reviewed four current efforts by airports to pursue restrictions under FAR Part 161. Naples Airport, Florida, has about 2.5 operations per day by Stage 2 aircraft and undertook an analysis of the noise impacts based on land use within the 60 DNL contour. The NBAA filed a lawsuit objecting to the use of 60 DNL and questioning the value of a restriction that affects so few aircraft. At Aspen Airport in Pitkin County, Colorado, business jets account for about a third of all operations. There are only two houses within the 65 DNL contour, but the airport undertook a study that examined land uses within the 60 DNL and 55 DNL contours. Burbank Airport, California, is considering a mandatory nighttime curfew for Stage 3 aircraft. Van Nuys Airport has implemented a Stage 2 non-addition rule that is viewed by the FAA as exempt from Part 161 as a previous rule preceded the ANCA legislation. The rule limits aircraft that were not based at the airport for at least 90 days in 1999 from being based at the airport for more than 30 days in any year. The NBAA has challenged the rule, and the case was scheduled to go to trial in May 2001.

The final presentation by Peter Kirsch, a Partner in the Denver office of Akin, Gump, Strauss, Hauer & Feld, L.L.P., also addressed the pressure on business jets from FAR Part 161 restrictions. He began by addressing some practical realities. Stage 2 jets drive the DNL noise contours and airports are required to use DNL in measuring airport noise. The remaining Stage 2 aircraft are virtually all corporate and business aircraft. Thus the focus has shifted to general aviation airports. He suggested that this will lead to continuing pressures, and noted recent Congressional attention to small jet aircraft in proposed legislation introduced by Congressman Steven Rothman of New Jersey.<sup>1</sup> He also noted that operators of Stage 3 aircraft pay for the noise costs of Stage 2 aircraft, and thus may not be opposed to restrictions. He suggested that there are three categories of airport considering Part 161 restrictions: general aviation airports,

---

<sup>1</sup> The Aircraft Noise Reduction Act of 1999, which would have banned all Stage 1 and Stage 2 jet aircraft from airports in the 20 largest metropolitan areas.

such as Flying Cloud, Minnesota; airports with only a small amount of commercial traffic, such as Naples, Florida; or Aspen, Colorado, and airports with limited buffer land, such as Pease, New Hampshire, or Burbank, California. The challenges of developing restrictions at small airports include identifying the operators involved and measuring the costs of the restrictions, particularly to non-commercial users. He then presented a case study of the experience of Naples Municipal Airport, describing the sequence of studies and actions taken by the airport authority and the current status. The airport had put a rule into effect banning Stage 2 aircraft, but had issued some two dozen waivers and had suspended enforcement of the rule until March 15. The FAA had initiated enforcement proceedings and litigation was under way. He concluded by remarking that the lessons from the first Part 161 studies were that efforts to impose restrictions through the Part 161 process were likely to focus on smaller airports and that the FAA role in this process needed to be better defined.

### **Airspace, Air Traffic Management and Growth**

The fourth session occupied the Tuesday morning and addressed issues of airspace, air traffic management and growth in activity levels, and their relation to aircraft noise management. It comprised seven presentations and was moderated by Karen Robertson, Manager for Noise Compatibility, Dallas/Fort Worth International Airport.

The first presentation by William Marx, Manager of the Environmental Programs Division of the FAA Office of Airspace Management, addressed the perception of changing flight tracks that often arises in public discussion about aircraft noise. He suggested that this perception may be the result of increases in traffic volume or the use of routes and radar vectoring previously established but not always accurately followed. The FAA has established an environmental strategy for airspace design, that is described on the FAA Air Traffic Services website<sup>2</sup> and that places an emphasis on community involvement in the process. Changes to airspace structure involve a review of low altitude and high altitude charts, as well as standard instrument departure and arrival procedures. However, interactions within the low altitude airway system limit the nature of changes that can be implemented. He stressed the need for community consultation and input and the increasing recognition of the need to be conscious of environmental justice considerations. He noted that quality of life issues are very important to the FAA. He described the process for changing airspace structure and procedures as involving four elements: a Noise Compatibility Plan; a study to address the requirements of FAR Part 150 in order to ensure that strategies being proposed are feasible; an analysis of operational and safety considerations; and public involvement.

The second presentation was made by John Leyerle, Manager for Access and Noise at John Wayne Orange County Airport in California, and explored the question of how aircraft flight tracks can stay the same but seem so different to residents in communities surrounding airports. He described a situation that has occurred in Orange County, and doubtless many other regions, where the public expresses concern about greater numbers of aircraft overflights, which they perceive as new to their community. However, the FAA air traffic representatives insist that they have not changed any procedures. He explained that this situation arises from two effects. The first is that as the volume of air traffic increases, air traffic control separation rules increasingly require aircraft to be vectored clear of other aircraft in the same flight corridor, or to

---

<sup>2</sup> <http://www.faa.gov/ats/ata/ata300>

be assigned lower altitudes than they might otherwise. This results in an increase in aircraft overflights of neighborhoods that previously experienced relatively little air traffic activity, or louder operations due to the lower altitudes. While the communities notice the increase in aircraft noise events, the FAA air traffic managers are still operating according to the established procedures and rules that have been in effect for many years. The second effect results from an increase in flight activity that causes communities to become more aware of aircraft overflights simply due to their greater frequency. This in turn leads to increased media attention to the issue and greater individual sensitivity to aircraft operations and noise. Thus communities that previously did not perceive themselves as being under a major flight track now come to believe that the pattern of flight activity has changed, as indeed in one sense it has. He suggested that the role of the airport noise office staff is to understand the factors behind the changes and to communicate these to the concerned residents.

The next presentation, by Mary Griffin, a former Chair of the San Francisco International Airport Community Roundtable and former Supervisor of San Mateo County, California, addressed the challenge of overflight noise beyond the 65dB Community Noise Equivalent Level (CNEL) contour (the aircraft noise standard and metric used in California). She noted that communities well beyond the 65 CNEL (or 65 DNL) contour are increasingly reporting concern over aircraft noise impact, and that as a result airports are having to grapple with the conflict between regulated standards and public perception. She described the San Francisco Airport Community Roundtable that evolved as an effective forum where the airport and communities could meet and confer, as well as the organization structure of regional airport system planning in the San Francisco Bay Area and the composition of the membership of the Regional Airport Planning Committee (RAPC). She presented a diagrammatic representation of the complex pattern of flight tracks in the Bay Area, that have to flow traffic into and out of three commercial airports with significant volumes of air traffic, and noted that there was an increasing need to react to complaints about overflight noise from communities as much as 50 miles from the airports. She suggested that these growing concerns result from increased levels of air traffic, rather than any changes in the way the airspace is operated. The characteristics of this type of overflight noise are that the noise impact is felt many miles from the airport at relatively low single-event noise levels, aircraft overflight altitudes are relatively high (often 5,000 feet above ground level or higher), and the noise levels generated by aircraft may be close to or less than ambient noise levels in the affected area. She reported that the FAA has recently introduced a new process to evaluate the impact of overflight noise through the use of the Noise Integrated Route System. In the Spring of 2000, the Bay Area RAPC conducted a series of public forums on aircraft noise throughout the region, that included presentations by aviation industry organizations. She commented that the forums furthest from the airports received the highest attendance, and the concerns expressed by the participants included flight track changes, an increase in the number of operations, and use of lower altitudes. In consequence, the RAPC decided to undertake a special study on overflight noise.

The fourth presentation provided another regional case study. Naren Doshi, Director of Airport Planning for the Greater Toronto Airport Authority, described how smaller noise contours around Pearson International Airport have invited the development of new incompatible land uses. He began by describing the growth in activity at Pearson International Airport, where passenger traffic has been projected to increase to 50 million annual passengers by 2020, and the current airport development plans that include reconstruction of the terminal

area, building a fifth runway and plans for a sixth. Responsibility for airport land use planning in Canada is divided between the Federal government, which publishes land use guidelines, the provincial governments, that are responsible for land use policy, municipal governments, that are responsible for land use controls, and airport authorities, that work with the municipal governments adjacent to the airport. He noted that the criteria for land use development varied among the municipalities surrounding Pearson International Airport, with residential development generally allowed outside the 30 or 35 Noise Exposure Forecast (NEF) contours. The Greater Toronto Airport Authority (GTAA) had begun working with the municipalities to develop a consistent land use policy that would clearly establish 30 NEF as the threshold for residential development and would establish a fixed Airport Operating Area (AOA) that would be defined using natural features and would follow the 30 NEF contour as closely as possible. The next steps planned by the GTAA were to explore methods to ensure that other land uses, such as schools, could be addressed.

After the four presentations, the session was opened to questions from the symposium participants and discussion. One participant stated that it would be very helpful if the FAA could hire community affairs personnel to help with public liaison. The concern was expressed that FAA explanations of air traffic issues are not always intelligible to the public. Another participant asked how to find historical data on aircraft flight tracks and routes. William Marx responded that this is a real problem, because the FAA does not have good historical data. In response to a question about what the FAA is doing to address overflight noise from aircraft above 6,000 feet, he responded that the FA is looking at airspace changes to take advantage of new navigation technology.

Following a break, the fifth presentation, by Leonard Tobias, Senior Research Scientist in the Terminal Air Traffic Management Research Branch, NASA Ames Research Center, addressed air traffic control decision support tools for noise mitigation. He began by describing several decision support tools that have been developed by NASA researchers to enhance airspace and airport capacity. The Center-TRACON Automation System (CTAS) is an evolving suite of tools to increase the capacity of arrivals and departures in the enroute Air Route Traffic Control Centers and the Terminal Radar Approach Control (TRACON) facilities. He explained that the foundation of CTAS is a sophisticated trajectory prediction algorithm. This is combined with expert rules to improve efficiency by providing advisory information to controllers, and is designed to be adaptable to different facilities. He then described two of the CTAS decision support tools, the Final Approach Spacing Tool (FAST) and the Expedite Departure Path (EDP) tool. A passive version of FAST is currently being fielded that provides runway assignment and aircraft sequence advice to controllers, but leaves the controllers to decide how to achieve this. An active version is under development that would provide aircraft heading and speed advisories to result in the desired sequence of traffic. The EDP tool provides aircraft departure release time advisories to assist controllers in merging traffic over departure fixes. He then described the five-year Quiet Aircraft Technology program, that NASA has recently initiated. This will investigate airframe and engine system noise reduction technologies, and will include a community impact element. Under this element, NASA will develop controller aids for noise mitigation that can assist in implementing noise mitigation procedures during low traffic levels, as well as provide support to controllers during periods of high traffic density and diverse traffic mix. The objectives of these decision support tools include reducing the need for vectoring. He mentioned the concept of a 3 degree decelerating approach that is being explored in a study by

John-Paul Clarke at MIT with the goal of accommodating a wider mix of traffic. Another study under way by Metron Corporation is developing a Departure Noise Avoidance Planner.

The following presentation described advanced flight track procedures being developed for Chicago O'Hare International Airport, and was made by Christopher Arman, Assistant Commissioner, Chicago Department of Aviation. He described the Advanced Flight Track Procedures (AFTPro) Initiative being pursued by the City of Chicago to enable aircraft to better adhere to preferential nighttime flight tracks that keep aircraft over less noise sensitive areas. He noted that the project involves industry-wide participation and is adopting a comprehensive approach with the goals of improving efficiency, enhancing safety and reducing noise impacts. Current flight track monitoring has shown that there is room to improve nighttime flight tracks. The initiative is designed to enhance the Fly Quiet Program that has been in place at O'Hare for several years and is oriented to encourage flight crew to follow flight tracks and procedures that reduce community noise impacts. This is supplemented with an airport noise monitoring system that collects flight track and noise data that is available to the public through a website. Enhancements to the Fly Quiet Program through the initiative include equipping aircraft with area navigation technology such as flight management systems for improved execution of flight procedures, implementing Global Positioning System (GPS) technology for higher navigation precision, implementing a new air traffic control simulator for training FAA controllers in the new procedures, and publishing data on flight track conformance by airline. These data are used to support follow-up letters to airlines to encourage greater conformance to the preferred flight tracks and to the air traffic control service to encourage greater use of airport operating modes that generate less noise impacts on surrounding communities. He reported that the current status of the initiative is that the City of Chicago has submitted the required FAA forms and has provided briefings to FAA personnel in the O'Hare control tower, TRACON, and regional office, as well as representatives of the National Air Traffic Controllers Association. The FAA has recommended that environmental impact studies be undertaken and has designated a proposed FAA implementation team.

The final presentation was made jointly by Terry Flieger, Environmental Protection Specialist with the Air Traffic Division, FAA New England Region, and Benjamin Raemer, Consultant with Harris Miller Miller & Hanson, Inc., and addressed the use of advanced navigation procedures for departures from Runway 27 at Boston Logan International Airport. The FAA Record of Decision on the Environmental Impact Statement for the construction of the new Runway 27 at Boston Logan issued in August 1996 defined a noise-abatement departure corridor and established performance standards for the proportion of flight tracks that should remain within the corridor. During the first couple of years after the runway was opened, this performance standard was not being met. Subsequent efforts to improve conformance of the flight tracks included revisions to the Standard Instrument Departure and the introduction of a Flight Management System (FMS) procedure.

In an attempt to further improve the conformance of flight tracks to the corridor, the FAA undertook a three month test from December 1999 to February 2000 in cooperation with Northwest Airlines (NWA), which involved changing how the departure procedure was flown with their FMS equipped aircraft. An analysis was undertaken of data for over 1,800 flight tracks for FMS-equipped aircraft obtained from Automated Radar Terminal System recordings. In discussions with airlines, it was found that normally airlines do not allow flight crew to engage the autoflight system below a certain altitude. This tended to result in aircraft

overshooting the turn that formed part of the procedure. During the test, NWA crews armed their FMS lateral navigation function prior to take-off and used the flight director in all phases of the departure procedure. Crews were also provided with information about this specific procedure as part of the required documentation they had to review prior to departure. As a result of the test a modification to the departure procedure was proposed that would move one of the GPS waypoints further away from the runway and change the procedure from an FMS procedure to an area navigation procedure, in order to allow more aircraft to use the procedure. A further modification was proposed, if necessary, to move the waypoint to the south to allow aircraft to enter the corridor at a shallower angle. These modifications required further flight-testing. Other recommendations from the test addressed crew education, and the FAA was currently evaluating alternatives.

In the question and discussion period following the presentations, a participant asked whether there was any plan to evaluate the impact of the change to the Boston Logan Runway 27 procedure on the community response to aircraft noise. Terry Flieger responded that concerns have been raised about the effect of concentrating flight tracks in a narrow corridor and there may be an environmental justice lawsuit by the communities under the flight track centerline.

### **Technological Advances in Noise Reduction**

Following the lunch break, the fifth session explored technological advances in noise reduction. The session consisted of three presentations and was moderated by Jia “Jake” Yu, Chief Engineer, Acoustics, BF Goodrich Aerospace, who also gave the first presentation that addressed the tradeoffs between noise reduction and air quality emissions goals. He noted that different issues arise with emissions that affect the global climate, principally carbon dioxide (CO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>), and those that affect local air quality, primarily carbon monoxide (CO), hydrocarbons (HC) and also NO<sub>x</sub>. For emissions that affect climate, recent quiet aircraft technology has improved fuel consumption and hence related CO<sub>2</sub> emissions, although NO<sub>x</sub> emissions are increasing on a fleet-wide basis, as improvements in combustion efficiency are not enough to offset the increased levels of activity. For emissions that affect local air quality, newer aircraft generally increase the amount of NO<sub>x</sub> for each landing-takeoff (LTO) cycle but decrease the related CO and HC. He indicated that advanced low emissions combustor technology, which has recently become available, will allow some reduction in NO<sub>x</sub> but increase CO emissions.

The second presentation was given by Philip Rose, Director for Business Acquisition, Aerospace/Aerostructures Group, B.F. Goodrich Aerospace, and examined the issues that arise in moving technology for aircraft noise reduction from research to implementation. He began by observing that the reduction in noise levels of successive new aircraft types that has occurred over the past 40 years has begun to flatten out, and that achieving national noise goals of a further reduction in cumulative noise margin of 30 EPNdB poses major technological challenges. He suggested that closing the gap between research and having products in service may take 20 years. Addressing the question why a gap exists between the noise goal and implementing the means to achieve this, he noted that CAEP recommends that noise regulations must be technically feasible and economically reasonable, while noise technology implementation is risky and expensive. He suggested that the QC/2 night quota count rule at London Heathrow

airport<sup>3</sup> will drive the future noise standards for wide-body aircraft, while the proposed ICAO Chapter 4 criteria will be the driver for narrow-body aircraft. Even so, achieving acceptable community noise levels will be a major challenge.

He noted that aircraft noise comes from many different sources on the aircraft, and suggested that airframe noise will become increasingly important in the future as engines become quieter. To illustrate the tradeoffs involved, he described how engine nacelle design must balance many factors, with noise reduction being just one of many requirements. Other considerations include the structural role of supporting the thrust reverser and engine mounts, as well as blade containment in the event of the engine compressor or turbine losing blades. He stated that the U.S. airlines had spent roughly \$100 million to make the fleet Stage 3 compliant, while the aerospace industry has spent billions of dollars to develop noise reduction technology. He pointed out that reducing only one noise source and leaving others unchanged produces much less reduction in total noise levels compared to reducing every noise source by an equal but lesser amount, which implies that noise sources must be reduced in a balanced approach. He noted that aircraft noise reduction is a cooperative effort, with academia, NASA and the industry cooperating in performing research, and the airframe, engine and nacelle manufacturers integrating their efforts in developing new products. In conclusion, he suggested that finding a total community solution to the problem of aircraft noise that closes the gap between national noise goals and implementation will be challenging, and the aerospace industry, airlines and airport authorities will need to work together to achieve a solution.

The third presentation addressed the progress towards quieter aircraft through NASA aircraft noise reduction research programs, and was given by William Willshire, Program Manager for the Advanced Subsonic Technology Noise Reduction Division, NASA Langley Research Center. He began by describing NASA's enterprise noise reduction goal of reducing the perceived noise impact of future aircraft compared to current subsonic aircraft by half within 10 years and three quarters within 25 years. He noted that achieving these goals would enable the 65 DNL contour to be contained within airport compatible land-use areas in 10 years and the 55 DNL contour to be contained within compatible areas in 25 years. He observed that noise impact issues currently delay and inhibit the growth of civil aviation, and that technology is needed to enable projected growth while improving the quality of life for those affected by aircraft noise. A recent survey of the nation's busiest 50 commercial airports by the U.S. General Accounting Office found that noise issues are by far the primary environmental concern for the air transportation system, and that this will remain true in the future, although air quality concerns will increase in importance. He also noted that by 2010 the majority of the current U.S. air carrier fleet will be over 25 years old, and will begin to be replaced, presenting a technology insertion opportunity.

He then described the results of a series of NASA research activities directed at developing technologies for reducing engine fan and jet noise, including swept stators, chevron nozzles, scarfed inlets, and hybrid active/passive nacelle liners, and the implementation of those technologies in the current generation of engines coming onto the market. As a result of the success at reducing engine noise, he noted that airframe noise is becoming the major source on approach and in the future will become a major source on takeoff. He described the use of

---

<sup>3</sup> The night quota count regulations at Heathrow airport can be found in *Night Restrictions at Heathrow, Gatwick and Stansted (revised restrictions with effect from 31 October 1999)* at <http://www.aviation.detr.gov.uk>.

computational fluid dynamics analysis techniques to develop noise reduction concepts that can be applied to the design of flaps and slats. He mentioned that analysis of the system benefit of integrating these different engine and airframe technologies on a large four-engine transport aircraft has suggested a reduction of 6 to 7 dB in community noise impact relative to 1992 production technology. He concluded by describing tests performed using a NASA Boeing 757 aircraft to measure the reduction in community noise levels under the approach path that can be achieved by using an advanced approach profile that intercepts the glide slope from a much higher altitude and delays deployment of landing flaps.

In the question and discussion period at the end of the session, in response to the question of how much more noise reduction can reasonably be expected to be obtained through technology, William Willshire replied that NASA is currently looking at new concepts other than the traditional cigar fuselage and thin wing. He suggested that it may not be possible to meet the 25-year noise reduction goals with traditional aircraft concepts.

### **Management of Noise Mitigation and the Use of Military Bases**

The sixth session took place following a break on the Tuesday afternoon and comprised three presentations on international experience with the management of aircraft noise and two presentations on noise issues that arise in the conversion of military bases to civil airports. The session was moderated by Thomas Lowrey of the Noise Management program at Transport Canada.

The first presentation on the international experience with aircraft noise management was made by Axel Schmidt, Head of the Environmental Department at Hamburg Airport. He began by noting that Hamburg Airport is the fourth largest in Germany, with about 130,000 commercial operations per year and 14,000 employees. The noise contours used for airport planning are based on peak noise levels, and the airport is currently implementing its fifth noise reduction program based on 180,000 annual operations. This program addresses building ventilation as well as windows, and allows the equivalent of \$350 per square meter for windows and \$450 per square meter for ventilation. Another concern being addressed is odor from ramp operations, and the airport has deployed active carbon filters to remove odor. He reported that the airport has been using differential landing fees and curfews to encourage the use of quieter aircraft, although curfews will no longer be allowed after 2002. The airport has installed ground power and preconditioned air and has reduced use of aircraft auxiliary power units to only 15 percent. Finally, he mentioned that the airport is in the process of constructing a new hangar with a hush-house for engine test run-ups. A 1:200 scale model was tested at the University of Munich, and the hangar is designed to accommodate Boeing 747-400 and Airbus A380 aircraft.

The next presentation by Darren Rhodes, of the Environmental Research and Consultancy Department of the United Kingdom Civil Aviation Authority, described a U.K. study to explore airport noise mitigation through better management of aircraft arrival descent profiles. The aim of the study was to monitor aircraft performance and the approach noise climate around London Heathrow Airport and to determine typical operating practices. The study was conducted with the participation of the Arrivals Noise Sub-Group established by the Aircraft Noise Monitoring Advisory Committee of the U.K. Department of the Environment, Transport and the Regions. The study used the Equivalent Noise Level ( $L_{eq}$ ) metric based on a 16 hour day and a traffic level corresponding to an average day of the summer months. Contours



were plotted from 57 to 72 dBA in 3 dBA steps. He reported that 250,000 people were found to live within the 57 dBA contour, and the arrivals noise contours have been increasing. The principal aircraft type contributing to the noise levels was the Boeing 747.

In order to understand the role of ATC factors in descent and approach flight profiles, data were collected for a sample of approaches by four aircraft types: the Airbus A320, the Boeing 737-400, the Boeing 747-400 and the Boeing 767. Data on the flight profile and thrust levels were extracted from flight data recorder (FDR) information for each flight. Noise measurements were made using both attended and unattended measurement stations. Finally, the air traffic control (ATC) instructions for each arrival were also recorded. The noise monitoring found that large numbers of complaints came from areas below 57 dBA  $L_{eq}$  and there was a large variation in noise levels. The analysis of ATC factors was based on matching the recorded radio message data with the FDR data and data from the Noise and Track Keeping (NTK) monitoring system. It was found that the ability to achieve a continuous descent approach (CDA) was related to the distance to touchdown when the aircraft was passing or leaving 7,000 feet altitude and that controllers tended to underpredict the distance to run, resulting in early descents and the use of more power in the final stages of the approach. The descent profile was also affected by the use of speed control to regulate the arrival flow. The use of low power/low drag approaches was found to only give a reduction of about 1 dBA in Single Event Level (SEL), while the use of CDA gave a benefit of about 5 dBA reduction in SEL. Darren Rhodes concluded by noting that use of higher glideslopes than 3 degrees raises aircraft certification issues. Aircraft need to be certificated to fly glideslopes 2 degrees higher than actually used. Also, Category 2 and 3 instrument approaches would need to be re-certificated.

The third presentation reported on the experience in Australia with communicating with the public on aircraft noise issues, and was made by David Southgate, Director, Airports, Sydney Environment, Australian Department of Transport and Regional Services. The presentation suggested that communications could be viewed as “adding a fourth leg to the stool” formed by existing efforts in land use planning, developing quieter aircraft, and implementing operational restrictions. He began by describing how the opening of the new runway at Sydney Airport in 1994 created a major adverse public reaction, with a widely held belief that the ANEF noise contours (the aircraft noise measurement system in use in Australia) had been used to lie to the people. This led to a reassessment of how to describe the future noise environment to those affected. He suggested that people want to know three things: the flight paths and number of aircraft movements, the time of day when those movements will occur, and how loud the overflights will be. Information should describe conditions during sensitive times of day, as well as for average conditions over the entire day, and noise contours should show the loudest single event, as well as the combined effect of multiple events. The objective of providing information should be to empower individuals to make their own decisions. He then described how this approach led to the development of several products: a flight path and movement chart, a chart showing hours of respite from aircraft noise, and a chart showing the number of events exceeding 70 dBA. These products have been implemented in a software tool called the Transparent Noise Information Package (TNIP) that allows the charts to be customized and is distributed free.

The next presentation shifted the theme of the session to the reuse of former military bases. Tamara Moore, Airport Planner with the City of Austin Department of Aviation, addressed noise constraints on military base closures from the perspective of the reuse of

Bergstrom Air Force Base at Austin, Texas. She described the growth in enplanements at the former civil airport serving Austin resulting from the city's role as the state capital, as well as the presence of several large academic institutions and the growth of high technology industry in the region, that had also resulted in air cargo growing rapidly and exceeding master plan projections. After the decision was made to relocate the airport to the former air base, a noise study was undertaken in 1994 and showed that the number of housing units within the 65 DNL noise contour would be reduced to 600 with a population of about 1,500. The noise study was updated in 1998 and found that only about 370 housing units with about 600 people would lie within the 65 DNL contour. She reported that in addition to developing mitigation measures addressing these communities, the airport also offered mitigation programs to two communities outside the 65 DNL contour. She noted that the airport had been getting more complaint calls when flight activity at the airport is operating in north flow conditions, although this only occurs about 20 percent of the time, and suggested that this may be a consequence of the airport having focused its community information programs on the noise impacts of the more frequent south flow conditions.

The final presentation was by Tim Merwin, Project Manager with HNTB in Los Angeles, and addressed the ingredients in the conversion of a military base to civilian use. He began by noting that a large number of military bases in Southern California were converted to civilian airports at the end of World War II. More recent closures and conversions in the region include Oxnard Air Force Base, which became Camarillo Airport, George Air Force Base, Naval Air Station Point Mugu, and Palmdale Plant 42. He suggested that the rise in local opposition to airport development could be traced to the noise impacts of the Boeing 727-100. He felt that the key to effective reuse of closed military bases is to protect the surrounding land use for future aviation uses. Mixed uses should also be considered as a reuse strategy. He noted that the potential role of former military bases as civilian airports depended on their location with respect to the pattern of demand. Air travel propensity varies widely across the Southern California region, with a high concentration of demand in the area surrounding Los Angeles International Airport. He described the proposed conversion of Marine Corps Air Station El Toro to civilian use as the most controversial of the military base reuse issues in the region, and suggested that the former air base community outreach office had been so effective that it was a hard act to follow. As a result of the previous military activity, communities in southern Orange County had become sensitized to oppose any civilian activity at the air base. They had suppressed their irritation in the interest of the Marine Corps and national defense, but were not willing to extend this to a new civil use.

In the question and discussion period following the presentations, Tamara Moore was asked how long elapsed between the decision to close Bergstrom AFB and it opening for service as a civil airport. She responded that the Defense Base Closure and Realignment Commission announced the planned closure of the base in 1990, it closed in 1993, and the new airport opened for service in 1998. In response to the question of what can be done to redistribute the air passenger demand from Los Angeles International Airport to other airports in the region, Tim Merwin suggested that the region needs to continue with the process of planning additional capacity elsewhere in the region. In particular, he felt that Orange County will need to do a better job of meeting the airport capacity needs of that part of the region.

## **Modeling the Global Impact of Noise Certification Standards**

Following the last scheduled session on the Tuesday afternoon, Ben Sharp, Director of the Acoustics Group at Wyle Laboratories presented an overview of the MAGENTA model that had been developed to support the discussions at the CAEP/5 meeting to those interested in the technical aspects of the model. The MAGENTA model (Model for Assessing Global Exposure to the Noise of Transport Aircraft) was developed to predict the number of people exposed to different levels of aircraft noise on a worldwide basis as a result of adopting different certification standards and policies. He described the motivation for developing the model as arising from the recognition that CAEP needed a noise assessment tool capable of evaluating alternative noise policy options. The model development was initiated as an FAA project in 1996 and CAEP established a working group chaired by John Ollerhead of the United Kingdom Civil Aviation Authority to guide the project. The model is based on aircraft noise contours for a worldwide sample of airports developed using the FAA Integrated Noise Model (INM) version 5.2. The working group relied on the airports in the sample to provide flight track data. He described how these airports were classified into three categories: those that could provide existing INM files, those for which the INM files had to be manufactured from data that the airport could provide; and those with no suitable data available. The data for each airport was normalized to a baseline year of 1998, and baseline and future year operations forecasts were based on projections developed by CAEP.

A key component of the model is the fleet mix forecast processor, which predicts how the aircraft fleet mix at each airport would change in response to alternative aircraft noise certification standards and policies. This operates on the baseline fleet at each airport and accounts for growth in activity, retirement of existing aircraft based on a survivor curve, and aircraft replacement and phase-out in response to the stringency of operating restrictions under different noise policies. The fleet replacement assumptions are based on a best practice database developed by CAEP, termed Jet-9. The impacted population at each airport was determined from the noise contours and population databases obtained from the U.S. Bureau of the Census for the United States and supplemented by a military database for other countries and some airport specific data. He described how the complexity of the INM analysis was reduced by the use of four surrogate aircraft in combination to represent each aircraft type in a particular fleet mix. He concluded by mentioning a key finding of the analysis that a phase-out of noisier aircraft in the developed world transfers the size of the population exposed to the threshold level of aircraft noise to the rest of the world in a 1 to 3 ratio (three more people become exposed to aircraft noise above the threshold level in the rest of the world for every person reduction in the number so exposed in the developed world).

## **The Economics of Noise**

The seventh session started the Wednesday morning program and consisted of four presentations addressing different economic aspects of aircraft noise. It was moderated by Geoffrey Gosling, Assistant Research Engineer with the Institute of Transportation Studies at the University of California at Berkeley.

The first presentation was given by William Langham, Managing Director, Strategic Market Analysis, Federal Express, and addressed trends in air cargo and electronic commerce. He noted that current trends in the air cargo industry are driven by customer requirements,

including the growth of just-in-time manufacturing and the need for time-definite services, increasing information intensity that demands tracking and tracing capabilities, and worldwide geographic coverage. He commented that the time-critical nature of the industry creates particular transportation constraints, and gave the example of how it would be difficult to service the Long Beach area in Southern California through Los Angeles International Airport due to highway travel time concerns during the morning and evening peak periods. He suggested that two transportation and logistics trends that will shape the future of the industry are increasing miniaturizing and mass customization. He noted that a recent study by the Collography Group found that air cargo moves at least 8 percent of the U.S. Gross Domestic Product (GDP) as product and a further 2 percent as services, while the Forrester Group has projected that electronic commerce (e-commerce) will grow from 3.5 percent of sales in 2000 to 17.3 percent in 2004. He suggested that the implications of this for aircraft operations will be a trend toward an increased use of wide-body aircraft for air cargo operations at larger airports and the redeployment of smaller aircraft to secondary airports in large metropolitan areas.

The second presentation addressed the aircraft noise implications and economic benefits of air express services, and was given by Brian Campbell, President, Campbell-Hill Aviation Group in Alexandria, Virginia. He suggested that the air cargo industry has allowed firms to locate almost anywhere and obtain their supplies from almost anywhere. The formation of Federal Express in 1973 created an entirely new market for door-to-door overnight express service, that resulted in a highly integrated multimodal transportation system. He noted that air express shipments have increased by about 8 percent per year in both number and weight from 1994 to 2000. He stressed that the design of the hub and spoke system is critical to the effective movement of overnight shipments, as illustrated by the night sorting activities at hubs such as Memphis and Indianapolis. In consequence, some two thirds of all air cargo flights occur between 10 pm and 7 am. Although this increases the noise impacts of this activity, he stated that studies have suggested the economic impact of each one-way flight could be as high as \$1.4 million, with about 1.8 annual jet departures per airline employee (on a full-time equivalent basis).

The following presentation shifted focus to the cost-benefit analysis required to support proposed operating restrictions under FAR Part 161. Robert Rodine, Principal Consultant with the Polaris Group in Sherman Oaks, California, presented a home value accretion model that examined the effect of changing noise levels on home values. He described a recent study by the consulting firm Booz-Allen & Hamilton of the effect of aircraft noise on home values in the Los Angeles area that had examined similar homes with like amenities and classified their noise exposure as either "noisy" or "quiet". He reported that his analysis of these data concluded that a home worth the median value for the area of \$300,300 would experience a 13.2 percent increase in value if its noise exposure changed from noisy to quiet. However, he pointed out that restrictions on aircraft operations would only result in part of this increase occurring, depending on the change in sound levels, and suggested that a better way is needed to measure the effect of aircraft noise than simply comparing the difference in value between noisy and quiet areas. He then presented the results of an analysis of house sales in the vicinity of Van Nuys Airport, California, and noted that ownership of some 6,100 homes within the airport impact area turns over each year. He suggested that a proposed restriction of operations at the airport might result in home values increasing by about 23 percent of value premium that would result from a change from noisy to quiet, based on the expected change in sound levels from the restrictions. He

concluded by contrasting his estimates of the resulting annual change in sale prices with the increase in value of the entire housing stock if the entire noise impacted area changed from noisy to quiet.

The fourth presentation, by Eliot Lees, a Vice President with Simat, Helliesen & Eichner, Inc., in Cambridge, Massachusetts, also addressed FAR Part 161 cost-benefit analysis, and discussed the issues that arise in balancing the reduction in the noise impact with the costs imposed on the aircraft operators. He suggested that the issues involved in assessing the costs have been addressed fairly well. However, those involved in quantifying the benefits are still under debate. He stressed the need to take account of changes in house values over time prior to the introduction of any new rules and commented on the challenge of developing forecasts in an uncertain world that is subject to changing airline strategies and the effects of market dynamics. He raised the issue of what is the appropriate definition of an airport impact area, and noted that many aircraft noise complaints arise from people who live outside the traditional noise contours. Once this is defined, he observed that the next question is how much should society be willing to pay to eliminate one person from the impact area. He suggested that the policy must be defined through what in fact is done, and that it is too soon to tell how effective these measures will be.

The final presentation was made by David Gillen, Adjunct Professor of Civil and Environmental Engineering and Research Economist with the Institute of Transportation Studies at the University of California at Berkeley, and addressed an approach to framing the assessment of alternative noise management strategies. He noted that benefit-cost analysis is fundamental to most transportation decisions, and considers both sides of the equation. He observed that it tends to be data intensive and dynamic, and reveals who is benefiting and who is paying. He also suggested that the state of the macroeconomy influences the discounts paid for adverse impacts, or in other words that people will be less willing to put up with adverse environmental impacts in good economic times. Turning to the measurement of costs and benefits of airport noise strategies, he noted that the benefits result from the changes in noise exposure, although there may also be by-products from safety and air quality changes that need to be considered. He suggested that costs can be viewed from three perspectives: capital theory provides a basis for considering the effect of noise management strategies on fleet depreciation; these strategies may affect airport productivity; and finally these strategies may affect airline competition and service delivery.

He stressed the need to balance the reduction in noise against the marginal cost of reducing the noise, since additional measures will generally produce diminishing marginal benefits but increasing marginal costs, as well as the need to address the different attributes of noise impacts on different people. He pointed out that aircraft noise raises property rights issues over who owns the quiet, and whether businesses should have to pay for using the quiet resource. However, he noted the fundamental problem of the lack of a market for quiet, and the resulting use of home price as a surrogate measure. He commented that there is extensive experience with the use of hedonic analysis to value attributes of homes, including their exposure to noise, although he suggested that more work was needed to understand the differential impact of different noise characteristics. He summarized the components of noise costs as: noise nuisance, asset depreciation, transaction costs involved in moving, and lost householder surplus, defined as the loss of value based on the willingness to pay. He concluded by discussing the role of expert opinion on assessing the impact of different strategies, through such methods as focus groups and delphi techniques.

## Effects of Aviation Noise on People

The eighth and final session provided an update on recent studies addressing the effects of aviation noise on people. It consisted of three presentations and was moderated by Vince Mestre, Principal, Mestre Greve Associates in Newport Beach, California.

The first presentation, by Willy Passchier-Vermeer, Senior Scientist, Public Health Division, Institute for Prevention and Health, Netherlands Organization for Applied Scientific Research, provided an overview of current knowledge about the adverse effects of aircraft noise exposure. She noted that the World Health Organization had issued community guidelines on noise in early 2000, while a 1997 report by the Health Council of the Netherlands had recommended measures to be used to assess noise exposure. A subsequent study examined the health effects of exposure to aircraft noise in communities near a large airport. She suggested that we do know quite a bit about the health effects of noise, but we do not know everything that we need to. In particular, it is not clear whether there are any adverse effects on children that are different from those on adults. She summarized the adverse effects of aircraft noise as: hearing impairment (although this is unlikely to result from aircraft overflight noise), annoyance, sleep disturbance, stress-related health effects, effects on task performance, and speech interference. She noted that laboratory studies have shown effects of noise on cognitive performance, although there are few (or no) epidemiological studies. She indicated that the European countries generally use the  $L_{den}$  (day/evening/night noise level) metric, and noted that this is about 1 dBA different from DNL. She commented that studies relating annoyance to measured noise level have shown that annoyance curves are higher for aircraft than for road traffic, which in turn are higher than for railroad traffic. She reported that studies near Schiphol International Airport, Amsterdam, found that some 100,000 people claimed to be “highly annoyed” by aircraft noise, although only about 10,000 live within the 65  $L_{den}$  contour, suggesting that annoyance is a much more serious problem than is generally acknowledged. She reported that studies of health effects had shown an increase in the relative risk of both hypertension and myocardial infarction (heart attacks) among people exposed to noise levels above 70  $L_{den}$ , with a 60 percent increase in the risk of hypertension at 80  $L_{den}$  and a 140 percent increase in the risk of myocardial infarction at 80  $L_{den}$ . She suggested that we do not really have a good understanding of the health effects of sleep disturbance, and presented the results of a study of the percentage of people who were highly annoyed by sleep disturbance as a function of noise level during the period from 11 pm to 7 am. She noted that the results of annoyance studies suggest that half of the variation in annoyance can be explained by the fear of aircraft crashes. Thus changes in the factors that modify the response of individuals to aircraft noise may increase the number of people who are highly annoyed, even if the actual noise exposure reduces.

The second presentation addressed the adverse effects of nighttime aircraft noise in more detail, and was made by Nicole Porter of the Environmental Research and Consultancy Department of the United Kingdom Civil Aviation Authority. She proposed a framework for assessing the effects of nighttime aircraft noise on people that considers both objective effects and subjective effects, and addresses the time dimension in terms of acute responses at the time of an event, total night effects, next day effects, and longer term chronic effects. She noted that objective short-term effects include reduced slow-wake sleep and sleep fragmentation, while chronic effects can include chronic annoyance and reduced quality of life. She described a 1992 field study of sleep disturbance that was performed in the United Kingdom and that included measurement of limb movement and electroencephalograph monitoring. The results of this

study did not find a significant difference between the aircraft events and a control group at levels below an outdoor Single Event Level of about 90 dBA. These findings suggest that on a typical summer night at London Heathrow Airport there will be about 8,700 awakenings. She concluded that future research directions should attempt to determine if there is a long-term effect of perceived disturbance, and develop ways to disentangle the web of interactions.

The final presentation was made by Roy Fuhrmann, Manager, Aviation Noise and Satellite Programs, Minneapolis-St. Paul International Airport, and addressed low frequency noise impacts at Minneapolis-St. Paul Airport (MSP). He explained that a Low Frequency Noise Policy Committee was formed in December 1998 in response to concerns expressed by the City of Richfield, a community adjacent to the airport. The airport had proposed to construct a new runway closer to the city than the existing runways, that was planned to handle about 37 percent of departures and 17 percent of arrivals at the airport. The committee formed a low frequency noise expert panel to undertake a literature review on the subject and examine the results of previous studies at other airports, determine the expected levels of low frequency noise at MSP, identify criteria for acceptability of low frequency noise in residences, and determine the types of residential sound insulation treatment required to improve low frequency noise reduction. Based on input from the expert panel, the Policy Committee found that the primary effect of low frequency noise on people is rattle-related annoyance, and that low frequency noise is more annoying than aircraft overflight noise heard at the same A-weighted sound level. The addition of even minor amounts of rattle to low frequency noise increased its judged annoyance by about 5 dB. The Policy Committee adopted a preferred descriptor of low frequency noise, and Roy Fuhrman presented the results of studies at both MSP and Los Angeles International Airport into the community response to low frequency noise and its relation to sideline distance from the closest departure runway. He concluded by discussing low frequency sound level contours around MSP developed by the expert panel and adopted by the Policy Committee, and describing the recommended low frequency sound level treatment for existing and new residential construction.

During the question and discussion period following the presentations, Willy Passchier-Vermeer was asked whether the analyses discussed in her presentation examines the relative contribution of noise level and frequency of events. She responded that they could not identify any effect that is not accounted for by the  $L_{den}$  metric. Another participant asked her to comment on the reasons for the differences in response to aircraft, road and rail noise. She noted that road noise has a different characteristic from aircraft noise, and suggested that there were also likely to be other factors, such as a concern for safety issues.

## **Summary**

The presentations in the symposium covered a broad range of current topics in aircraft noise management, from policy and regulatory issues, through prospects for source noise reduction through advances in engine and airframe design and management of air traffic flows, to economic considerations and recent findings on measuring the effects of aircraft noise on the population near airports. The sessions took an international perspective, addressing recent developments within the International Civil Aviation Organization and presenting viewpoints from other countries, including Australia, Canada, South Africa, and a number of European countries. The discussions provided an opportunity for symposium participants to explore issues in more detail with the presenters, and contribute their own views and concerns.

In view of the wide range of issues addressed during the symposium, it is not an easy task to select the most significant issues to emerge from the symposium, and such an exercise runs the risk of appearing to overlook important aspects that were covered in the sessions. However, there were several important findings that became clear from the presentations and discussions, and that deserve special mention. The first was that while the proposed new Chapter 4 aircraft noise standards that have been recommended by the ICAO Committee on Aviation Environmental Protection may at first sight appear to represent a significant step forward in reducing future levels of aircraft noise, in reality the compromises that were necessary to reach international agreement mean that any real reductions in aircraft noise will be very limited for the foreseeable future. Many current production aircraft already meet the proposed standards, so there is no requirement to make these any quieter, and the proposed rules include no phase-out provisions for aircraft that meet current Chapter 3 standards. Thus the new standards do little, if anything, to reduce the noise generated by the current U.S. fleet, and will have limited effect on future additions to the fleet.

The second is that while prospects for the application of new engine and airframe technology to achieve further reductions in aircraft noise beyond the proposed Chapter 4 standards are quite promising, it will take many years for the results of current research and development efforts to appear in commercial products, and even longer for those aircraft to form a significant fraction of the fleet. Aircraft have long operational lives, unless required to be phased out by regulation, and thus the existing fleet, particularly recent additions to the fleet, will be around for a long time. Furthermore, growth in traffic will absorb most of the additional capacity provided by future additions to the fleet, so these new aircraft will mostly add operations to existing traffic levels, rather than replace operations by the current fleet. Adding more operations by quieter aircraft does nothing to reduce existing noise levels, and in fact tends to increase them. Therefore, better management of air traffic operations in the terminal airspace offers better prospects to achieve significant noise reductions in the immediate future. Enabling aircraft to stay as high as possible for as long as possible on approach and routing departures over less noise-sensitive areas can significantly reduce community noise impacts. However, there may be difficult trade-offs to be made between reducing community noise exposure and increasing airport capacity.

It is increasingly recognized that the exclusive use of the Day-Night Average Sound Level metric for measuring the noise impact of aircraft activity on communities fails to capture many important attributes of aircraft noise, which severely constrains efforts to find solutions acceptable to the affected communities. Low frequency noise is becoming recognized as an important issue at some airports and overflight activity at relatively low noise levels at considerable distance from the airport is emerging as a growing concern in many regions. Effective dialogue between the aviation industry and local communities is not helped by a rigid insistence on the use of metrics that are viewed as inappropriate or worse by those affected by the noise. An interesting new approach to communicating expected aircraft noise impacts to affected communities, that has experienced some success in Australia, was presented at the symposium.

Finally, the economic implications of aircraft source noise reduction, airport access restrictions, and noise insulation and land use controls need to be better understood, and integrated into airport noise management policy. Access restrictions impose costs on the users of the air transportation system, replacing noisier aircraft imposes costs on the aircraft operators,



which are ultimately borne by air passengers and air cargo shippers, community noise insulation programs impose costs on airport authorities, which flow back to users of the air transportation system in various ways, and land use controls impose opportunity costs on the communities affected. The objective of rational public policy should be to understand how these various costs interact with each other, and pursue policies that balance environmental goals with air transportation goals, in order to achieve the most cost-effective outcome for society as a whole. This will require appropriate pricing signals and mechanisms to allow those who benefit from the air transportation system to mitigate the adverse environmental impacts resulting from their use of it, and to compensate those who experience adverse unmitigated impacts. This is not only a matter of social equity, but of economic efficiency and even self-interest by users of the air transportation system. Failure to appropriately mitigate community noise impacts of aviation activity results in understandable opposition to airport expansion by the affected communities, which can result in even greater delay costs borne by the users of the system than the mitigation measures would have cost.

In conclusion, the development of effective policies and programs to manage and mitigate the adverse impacts of aircraft noise is fundamentally a matter of tradeoffs and compromises. By contributing to an increased understanding of the technical issues involved in these tradeoffs, and bringing a broad range of stakeholders together to explore the limits of what it is reasonable to expect to achieve through various measures, the Symposium made a useful contribution to the policy debate over what changes may be required to existing approaches to manage aircraft noise.

## Inter-Symposium Session

### Environmental Justice: Interpretations and Applications

The inter-symposium session on environmental justice addressed an emerging area that is becoming of increasing importance in defining appropriate responses to both airport noise and airport air quality issues in the United States. The session was moderated by Katherine Andrus, an Attorney at Law with Akin, Gump, Strauss, Hauer & Feld, L.L.P. of Washington, D.C., who introduced the topic by providing an overview of the legal framework within which issues of environmental justice are currently addressed. She defined the concept of environmental justice as ensuring that certain sectors of the population should not disproportionately bear the burden of exposure to environmental hazards, and incorporating the recognition that certain groups may have been excluded from the decision-making process that affects their environment. She described the evolution of the legal and regulatory approach to environmental justice from Title VI of the Civil Rights Act of 1964, which proscribed discrimination on the ground of race, color or national origin in programs or activities receiving Federal financial assistance, to Executive Order 12,898 in 1994, which directed each Federal agency to make achieving environmental justice part of its mission. She noted that the Executive Order does not create any legal rights, and that environmental justice claims must be brought under another legal theory, such as Title VI or the National Environmental Policy Act (NEPA). While Title VI prohibits intentional discrimination, subsequent court decisions have established a standard of review that agencies may adopt regulations which prohibit the use of criteria or actions which have the *effect* of subjecting persons to discrimination.

The U.S. Department of Transportation (DOT) has issued regulations that establish procedures for administrative complaints, although she noted that it is an open question whether private plaintiffs may also file lawsuits directly against the recipients of federal funds to enforce DOT regulations, and that there is a case before the U.S. Supreme Court related to the route of a proposed light rail project at Kennedy International Airport in New York that will decide this. She reviewed the requirements of these regulations, defined in DOT Order 5610.2, which directs each operating administration to implement Executive Order 12,898, reinforces considerations already embodied in the National Environmental Policy Act and Title VI, and requires specific determination and findings with respect to the impacts of a proposed action on minority and low-income populations. She noted that this two-part requirement is very similar to that for Title VI.

The next presentation was given by Chebryll Edwards, an Environmental Engineer with the Office of Air and Radiation of the U.S. Environmental Protection Agency (EPA), who serves as the Environmental Justice Coordinator for the agency. She stated that the goal of environmental justice considerations is the fair treatment and meaningful involvement of communities affected by specific projects, and noted that the Executive Order on Environmental Justice had resulted in much more attention being given to environmental justice within the EPA, which had established a National Environmental Justice Advisory Committee in 1993. She remarked that Title VI complaints could impact agency funding, and that in such situations the EPA may have to step in and run programs. She mentioned several documents that define the EPA requirements for environmental justice, including Title VI Guidance, Draft National

Environmental Justice Guidance, Regional Interim Environmental Justice Guidance, NEPA Guidance, and a Model Plan for Public Participation.

She noted that the federal government approach to environmental justice is based on the Community Bill of Rights, that states that all Americans are entitled to the right to clean industry, safety from harmful exposure, know the basis for and to participate in decisions, protection and enforcement, compensation, and cleanup. She proposed a series of fundamental questions that should be addressed in order to satisfy environmental justice concerns. These include: How is the project impacting the local community, and are there social costs? How can the community be effectively involved in the decision-making process? How early does the community need to be informed about what is being planned? Who does the project sponsor need to talk to? Which key Federal documents provide guidance and a broader framework for addressing environmental considerations? What are the needs of the community? She suggested that parties that need to be involved in the decision-making process include local elected officials, religious leaders, medical and health-care officials, and (in appropriate cases) Indian tribal leaders. She described the role of alternative dispute resolution procedures that seek to answer the question whether adverse impacts can be reduced or eliminated. She concluded by stating that trust is the key to effective public participation. If communities trust the process, they are more likely to trust the outcome. Turning to specific projects, she noted that the EPA has taken a role in reviewing the master plan process at Los Angeles International Airport, as well as the proposed expansion of Boston Logan International Airport.

The third presentation was given by Jake Plante with the Airport Environmental Division of the U.S. Federal Aviation Administration (FAA). He described the approach to environmental justice issues within the FAA, and stated that internal guidance had been prepared in 1999 in the form of questions and answers, and that an FAA Order was in development. He noted that the FAA has a requirement to investigate whether proposed actions have a disproportionate impact on minority or low-income communities, and mentioned that the FAA has been working with Indian tribes concerning airspace routings in the vicinity of the Grand Canyon. He stated that environmental justice can be a particular problem for airport expansion, since there are often limited options for runway location, and commented that there is no evidence that minority or low-income communities react any differently to aircraft noise than other communities. An analysis at Atlanta Hartsfield International Airport demonstrated that low-income and minority communities were disproportionately impacted compared to the surrounding three-county average. He also noted that there were increasing concerns over the health impacts of airport air pollution. He concluded by suggesting that environmental mitigation may need to be targeted toward affected communities, and mentioned two FAA web sites that contain relevant information: <http://aee.faa.gov> and <http://www.alaska.faa.gov/annette> (which describes the Annette Island Coordinated Cleanup project).

The next presentation, by Flavio Leo, Manager of the Logan Airside Improvement Program with the Massachusetts Port Authority (Massport), described how environmental equity issues were being addressed in airport development projects at Boston Logan International Airport. He began by describing the context at Logan Airport, then described the approach taken with respect to environmental justice within the environmental impact statement (EIS) process, and concluded by raising other equity issues. He stated that the Massachusetts Environmental Protection Agency had issued draft guidance on environmental justice in the spring of 2000, and that Massport had revisited their environmental impact analysis in a draft Supplemental EIS that

had expanded the noise impact area to that within the 60 dB DNL contour and included a more detailed analysis of minority and low-income community issues. He indicated that they had also undertaken a public health review and had identified off-setting benefits for the impacted communities. He suggested that airports need to raise the bar on the treatment of environmental justice issues. The analysis should focus on the airport rather than specific projects, and examine who benefits and who bears the burden, as well as address cumulative impacts. He proposed adopting the broadest definition of impacts that would consider all effects that could adversely impact surrounding communities. Particular attention needed to be given to establishing effective public participation. He also suggested that large airports would experience pressures to limit growth in order to reduce emissions, and that this would result in efforts to off-load traffic to other airports. He noted that airports need to explore options to reduce emissions from aircraft, but that improved aircraft engine technologies encounter the dilemma of the trade-off between noise and nitrogen oxides. Congestion management strategies are promising, but will need to address the increased use of regional jets, which are clean but small.

The following presentation was given by Roger Johnson, Deputy Executive Director for Environmental Affairs of Los Angeles World Airports (LAWA). He provided an overview of the elements of the master plan currently being prepared for Los Angeles International Airport, and described the environmental justice analysis that had been performed. He stated that the initial approach “went by the book”, following Federal and State guidelines and definitions of significant impacts. The resulting administrative draft projected no disproportionate impacts, but it was felt that this was not supported by the facts. As a result, an Environmental Justice Task Force was formed in June 2000 consisting of LAWA staff, consultants, and public interest groups. This task force has addressed three questions to date: How are minority and low-income communities impacted by the master plan alternatives? How are the benefits distributed? How are the burdens distributed? Future steps will involve meetings with community leaders from affected communities, and the comment period on the draft EIS for the master plan has been extended to 180 days. The task force will also focus on development of off-setting benefits and reduction of impacts.

The final presentation was given by Jerilyn Medoza, Staff Attorney with Environmental Defense in Los Angeles, who provided a different perspective on the LAX master plan EIS. She stated that the analysis performed by LAWA has demonstrated both that the current conditions at LAX and the projected changes disproportionately impact low-income and minority communities. She noted that Environmental Defense was asked to participate on the Environmental Justice Task Force, but declined to do so as the public interest representatives were paid by the airport. She also raised the question why the Task Force was not convened earlier, when the issues had been identified long ago, and expressed a number of concerns with the process. These included who was actually present at the meetings that are discussed in the Draft EIS and how much feedback was actually solicited and acted upon, as well as legalisms contained in the aviation easement agreements that were required to be signed by home owners in order to get soundproofing. She suggested that use of obscure legal language tends to undermine trust in the process and even trust in the local officials who have been supporting these programs. She also expressed concern over the lack of specificity, particularly with regard to dates, in the memorandum of understanding (MOU) between LAWA and the City of Inglewood, and the lack of public opportunity to comment on the MOU before it was signed by the City of Inglewood.

## **Airport Air Quality 2001**

### **Summary Proceedings of the Second Annual Airport Air Quality Symposium**

The Second Annual Airport Air Quality Symposium organized by the Technology Transfer Program of the Institute of Transportation Studies at the University of California at Berkeley was held in San Diego on Thursday, March 1 and Friday, March 2, 2001. This report provides an overview of the presentations and discussion at the symposium. Further details, including the full program and copies of the slides or text for many of the presentations are available on the Symposium website at: <http://www.its.berkeley.edu/techtransfer>.

Symposium participants were welcomed by Linda Howe, Director of the Technology Transfer Program at the Institute of Transportation Studies. She noted that airport air quality issues are becoming increasingly important and that the current symposium had been organized in response to the strong interest in the topic that was shown at the first symposium on the topic the previous year.

#### **Keynote Address**

The symposium began with a keynote address by Scott Belcher, Managing Director for Environmental Affairs at the Air Transport Association, that provided an overview of efforts by the aviation industry to achieve compliance with federal, state and local air quality regulations. He began by noting that aviation is a critical component of the national economy, accounting for 3 percent of gross domestic product and over 621,000 employees. At the same time, the airline industry is extremely competitive, with low profit margins, a low return on investment (with a 10 percent return considered above average), and a low share price to earnings ratio (averaging around 7). It is capital intensive but perceived as a commodity by its customers. He noted that airline profit margins are well below the average across all industries while airline prices have continued to fall in real terms, although recently there had been a small increase. Aviation activity is also continuing to grow, although there is a large variation in the growth estimates. He expressed the concern that the industry is starting to experience real limits on its ability to grow, as a result of slot and gate constraints at airports, congestion on air routes, international agreements, inadequate airport infrastructure, environmental constraints, and air traffic management issues. Turning to the topic of emissions, he noted that during the rapid growth of the industry over the past 20 years aircraft fuel efficiency had increased from about 15 passenger-miles per gallon in 1971 to over 35 passenger-miles per gallon today. However, while this has reduced emissions, there are tradeoffs between aircraft noise and emissions, with reductions in carbon dioxide emissions tending to increase noise and emissions of oxides of nitrogen and hydrocarbons. He also pointed out that there are limitations on technological solutions to reduce aircraft emissions, and that many of the emission control methods for other modes, such as post combustion controls and alternate fuels, are not appropriate for aircraft.

He remarked that every phase of aviation operation is regulated through a complex web of international, national, state and local regulations. Emission reduction efforts need to focus on two different issues: climate change and local air quality. He suggested that the International Civil Aviation Organization (ICAO) is the appropriate body to regulate aircraft emissions.

ICAO can bring together the world's experts on aviation and evaluates the environmental benefits, economic reasonableness, technological feasibility, and operational impacts of proposed regulations. The fifth meeting of the ICAO Committee on Aviation Environmental Protection (CAEP/5) addressed climate change issues through working groups that addressed technology, operational measures, and market-based options, and a forecasting and economic subgroup. For the longer term (2008 to 2012), they recommended the development of an open emission trading system, while in the shorter term voluntary mechanisms can be used, for which ICAO should develop guidelines. They also concluded that emissions taxes and charges require further study and that guidance should be developed. He noted that in the U.S., the industry was facing increased regulatory pressure, with the introduction of a 1 hour ozone standard and a recent Supreme Court decision upholding the new 8 hour ozone standard. At the international level, ICAO had deferred consideration of new standards for nitrogen oxide (NO<sub>x</sub>) emissions to the next meeting of CAEP (CAEP/6), where it was expected that they would examine the effectiveness of the current landing/takeoff (LTO) certification regime and consider a production cutoff for the NO<sub>x</sub> standard established by CAEP/4. They might also consider a more stringent NO<sub>x</sub> standard, as well as address NO<sub>x</sub> emissions in cruise.

He indicated that the U.S. Environmental Protection Agency (EPA) and Federal Aviation Administration (FAA) have generally followed ICAO criteria in managing aircraft emissions, and described efforts to reduce emissions through reduced fuel usage, including single engine taxi, reduced thrust takeoff, reduced additional weight, and gate electrification and preconditioned air. He noted that the benefits of advanced communications, navigation and surveillance and air traffic management (CNS/ATM) techniques had been estimated to achieve a 6-10 percent emissions reduction. Turning to non-aircraft emissions, he stated that stationary sources at airports are required to comply with existing permitting and regulatory requirements. Related efforts include the use of environmentally-friendly materials, recycling and source reduction, and improvements to fuel storage and dispensing. In the case of mobile sources, such as ground service equipment (GSE), he observed that the EPA has proposed stringent non-road emissions standards based on California standards, as well as stringent new fuel standards. He described a local air quality initiative jointly sponsored by the EPA and FAA. As part of this initiative the airlines have spent about \$1 million on baseline and options studies. Activities under the initiative include the development of a national GSE proposal, support for research and development by the National Aeronautics and Space Administration (NASA) and aircraft manufacturers, support for CAEP recommendations for a new NO<sub>x</sub> standard, evaluation of aircraft options and operational opportunities, and efforts to clean up the State Implementation Plan (SIP)/conformity process. He concluded by mentioning several state or airport specific initiatives, including development of a GSE memorandum of understanding between the airlines and the State of California and settlement of GSE litigation in Texas, as well as an FAA program to fund deployment of inherently low emissions vehicles.

In the discussion period following the presentation, in response to a question of whether the U.S. Supreme Court had addressed a PM 2.5 standard (particulate matter of 2.5 microns) Scott Belcher indicated that there will definitely be a PM 2.5 standard although he felt that aircraft emissions are likely to be of greater concern at PM 10. He also noted an emerging concern in California with the toxic aspects of diesel particulates. Another symposium participant asked whether there is any discussion within the industry about towing aircraft out to runways with tugs. Scott Belcher responded that it is not clear that there are much fuel savings

to be gained from the use of diesel tugs, and he noted that there are also significant safety concerns.

### **International, Federal, State and Local Air Quality Requirements**

Following the keynote address, the first session examined international, federal, state and local air quality requirements, and was moderated by Bonnie Wilson, Vice President for Airport Facilities and Services, Airports Council International – North America. It consisted of three presentations that offered perspectives from three different countries and regulatory environments.

The first presentation provided a Canadian perspective on air quality management at airports, and was given by Alec Simpson, Manager of Environmental Protection with the Environmental Affairs division of Transport Canada in Ottawa. He began with an overview of the regulatory and operating role of Transport Canada, and explained that in aviation Transport Canada serves as the regulator and landlord for 26 major airports. In the air quality area, regulatory measures derive from the Canadian Environmental Protection Act, which establishes goals and procedures and sets emission standards, as well as provincial and local standards. Canadian aviation regulations related to emissions incorporate the requirements of ICAO Annex 16 and provide interpretation as well as establish emission standards and testing procedures. Turning to climate change issues, he noted that the transportation sector is expected to exceed 1990 emission levels by 26 percent by 2010. He also indicated that there is a growing concern with smog in Canada, and that Transport Canada has developed a management plan to address acidifying emissions and ozone depleting substances. Domestic programs within Canada include the development of a climate change transportation table, that needs to be coordinated with international partners, and federal, provincial and local smog management plans. International programs addressing air quality issues include Canada/United States Air Quality Agreements, efforts in response to the Kyoto Protocol on Global Climate Change, and participation in the ICAO Committee on Aviation Environmental Protection. Air quality management issues that are addressed by Transport Canada include the development of Air Quality Management Plans for each airport and the establishment of Environmental Management Systems. He concluded by presenting a case study of Ottawa Airport and described a 12 month study that included an air quality monitoring vehicle that was on site continuously. He mentioned that the report from this study is available on the Transport Canada web site ([www.tc.gc.ca](http://www.tc.gc.ca)).

The second presentation was given by Kristi McKenney, Senior Projects Administrator for Oakland International Airport, Port of Oakland, California, and addressed airport air quality requirements and efforts beyond compliance with current regulations. She began with a review of the evolution of air quality requirements in California as they affect airports, starting with the federal Clean Air Act of 1970 and its subsequent amendments, that established national ambient air quality standards and required attainment and maintenance plans, and the California Clean Air Act of 1988 that established corresponding state air quality standards and attainment and maintenance plans. She summarized the respective roles of the EPA, FAA, California Air Resources Board, and regional and county air quality management districts and noted a shifting focus toward off-road vehicles, trains, ships and aircraft, as significant gains had been achieved in reducing emissions from other sources, but further reductions were proving harder to obtain and exceedances of the ambient air quality standards were going up. In the case of airports,

project development requirements are shaped by the demand for aviation, and she observed that airports tend to have an inherently efficient design for operational reasons, which reduces opportunities to reduce emissions through design changes, while airport demand is shaped by economic development actions that occur in the community served. She gave the example of Las Vegas, where one hotel can generate about 300,000 annual air trips.

She then discussed issues that arise in the environmental review for projects, including treatment of emissions between the project and no-project alternatives, the impact of aircraft sources versus available mitigation, and the relationship between the requirements of the National Environmental Protection Act and the clean air conformity process. She drew attention to the technical challenges that arise in performing the required analysis, including the need for high quality data and sophisticated analytical tools, and commented that modeling regional behavior in response to airport developments is a huge challenge. She also stressed the difficulty of keeping regional and state planning up to date. Among the conflicts that arise in this process are the lack of provisions for addressing major sources of pollutants which are beyond the airport's control and conflicts with other efforts to control emissions that remove the only mitigation available to airports. She noted that these conflicts can result in contorted and ineffective mitigation, and observed that it is important to be able to understand the effectiveness of different mitigation measures and ensure that resources are being directed at the best options. In looking beyond achieving compliance with the current state implementation plan (SIP), she suggested the need to integrate physical and environmental planning, to partner with other regional and state agencies, and to lobby for a more timely and realistic SIP. She noted that this would require far more extensive analyses and studies, and that it will be necessary for airports to support research and the development of the knowledge base, and to press for the coordination of state and national emission reduction efforts with conformity and other regulations. She concluded by describing the mitigation measures that Oakland International Airport is currently pursuing as part of its airport development program and provided an overview of the existing airport activity and the new facilities proposed under the development program.

The third presentation, by Karin Sjolín, with the Environmental Department of the Swedish Civil Aviation Administration and the Swedish representative to CAEP, described the implementation of emissions-related landing charges at Swedish airports. She began by noting that the International Panel on Climate Change found that the transport sector was growing at 9 percent per year, compared to an annual growth in gross domestic product of 3 percent, and that air transportation contributes to both local emissions as well as global emissions. In 1989 Sweden imposed an environmental tax on NO<sub>x</sub> emissions that was applied to Swedish registered aircraft on domestic commercial flights. In 1991 this was extended to carbon dioxide (CO<sub>2</sub>) emissions. An environmental tax was subsequently determined to be in conflict with European Union directives, so in 1998 environmental charges were established at all Swedish airports. These are similar to the Swiss system of environmental charges and impose a percentage increase in landing charges based on aircraft emissions in grams per kiloNewton aircraft weight. She explained that the model adopted for the charges is intended to be revenue neutral and increases the landing charge based on the emissions of hydrocarbons (HC) and NO<sub>x</sub>. She reported that a concern has been expressed by Denmark that aircraft with higher emissions have been reassigned from Stockholm Arlanda airport to Copenhagen airport. She noted that the CAEP/5 recommendations on emissions had only proposed an emissions trading program and voluntary reductions, and mentioned that a working group on the Abatement of Nuisance Caused



by Air Transport (ANCAT) had been formed in Europe to address ways to reduce aircraft emissions. This initiative comprised a group of experts that had held their first meeting in January 2001 and planned to examine emissions related charges with a view to harmonize the Swedish and Swiss systems and formulate proposals to be submitted to the European Commission.

In the subsequent discussion period, Roger Johnson of Los Angeles World Airports commented that they were starting to get some resistance from fleet operators to continued conversion of equipment to compressed natural gas (CNG) due to lack of infrastructure. Kristi McKenney responded that this is a problem and that Oakland Airport had built a CNG refueling station on the airport to address this.

### **What are Air Quality Regulations Designed to Address?**

The second session followed a break and comprised three presentations that explored what can and needs to be done to address air quality at airports. The session was moderated by Gary Honcoop, Manager of Strategic Analysis for Air Quality and Transportation Planning with the California Air Resources Board. In introducing the session, he noted that air quality is primarily an issue of public health and observed that while we have come a long way in achieving clean air, we still have a long way to go. He suggested that the recent U.S. Supreme Court decision on 8-hour ozone and PM 2.5 standards means that we will have even more to do.

The first presentation was given by Alan Lloyd, Chairman of the California Air Resources Board, and addressed the need for cleaner airports. In explaining why cleaner airports are important to California, he stated that to protect public health and the environment, California needs the maximum feasible emissions reductions from all sources in order to cut community exposure to air toxics and to reduce regional emissions. He described the role of the California Air Resources Board (CARB) in setting and enforcing air quality standards and promoting strategies to achieve these standards. He noted that from 1980 to 1999 the California economy had grown by 84 percent, vehicle travel had increased by 67 percent, and the emission of air toxics had increased by 50 percent. He mentioned that particulates from diesel engines have been estimated to contribute about 70 percent of the risk of cancer from air toxics.

Turning to the effect of airports on community health, he stated that communities are concerned about airport emissions, and airports need to be using the cleanest technology. He noted that airport activity has been growing by more than 3 percent per year and that air travel forms the fastest growing transportation link to the Pacific Rim. As a result it has been estimated that aircraft emissions will have increased by 60 percent from 1975 to 2010, while cars will have reduced their emissions by 50 percent. He observed that history tells us that we are often surprised by the pace of new technology, which comes sooner than we think and costs less. He then discussed actions that could be taken to reduce emissions from aviation sources. Aircraft emissions could be reduced through airports enabling operational changes and airlines introducing new engine technology. Reductions in emissions from ground support equipment could be achieved through airports providing electrical infrastructure for all support equipment and supporting the use of alternative fuels, while air carriers could accelerate the turnover of old equipment, retrofit diesel engines with filters, and move to the use of zero-emission vehicles. Strategies to reduce emissions from on-site stationary sources need to address paint removal and degreasing techniques. Finally, he discussed actions to reduce emissions from ground access

vehicles used to move both goods and people. Emissions from the movement of goods can be reduced through the use of the cleanest trucks. Actions to address the movement of people include increasing transportation choices, using the cleanest available vehicles, and promoting employee commute programs.

In summary, he indicated that airports need to address environmental justice issues, and take actions to support efforts to reduce the health risk from diesel engines, and reduce ozone and particulates. In particular, they should pursue opportunities to use zero and near-zero emission technology.

The second presentation addressed opportunities for airport community partnership in environmental protection, and was given by Sabrina Johnson, Policy Analyst with the Office of Policy Analysis and Review at the U.S. Environmental Protection Agency. She began by reviewing the challenges and opportunities for airport air quality in the 21<sup>st</sup> century, which will have to address the need for air quality improvement and the growth in air travel. She suggested that designing a path for progress will need to achieve a balance between short-term and long-term goals, as well as a balance between flexibility and accountability. She noted that significant progress had been achieved in the transportation sector. Tier I vehicles are 40 percent cleaner than average new model car in 1990 and so-called Northeast cars that are 50 percent cleaner than Tier I vehicles are now becoming available nationwide under the National Low Emissions Vehicle (NLEV) Program. In addition, about 30 percent of gasoline consumed in the U.S. is cleaner burning reformulated gasoline. However, she pointed out that more than 120 million people live in areas with unhealthy levels of smog, and that the majority of the nation's busiest airports are located in these urban areas. Furthermore, aircraft are the only mobile source for which NO<sub>x</sub> emissions are projected to increase, and the relative contribution of airport activities to overall emissions will increase over time. She observed that airports are becoming the largest point sources of emissions in many urban areas, emitting as much NO<sub>x</sub> as a large power plant.

She described the EPA activities in aviation air quality as comprising both voluntary and regulatory measures. Voluntary measures include a voluntary aviation emission reduction program jointly sponsored with the FAA and involving aviation stakeholders, development of the California GSE memorandum of understanding with the airlines, and support for a "Green Airports" initiative. Regulatory measures include regulations that codified the aircraft emissions standards developed by ICAO and new emission standards for heavy-duty engines, non-road diesel and spark-ignition engines, and passenger cars and light trucks. She concluded by suggesting that airports have opportunities to become environmental leaders due to their role as hubs of economic activity forming an ideal platform to showcase innovative new technology. Such efforts could build upon similar strategies in other sectors, such as the NLEV program, and should recognize the airport community to include all stakeholders.

The third presentation was given by Arthur Marin, Deputy Director, Northeast States for Coordinated Air Use Management (NESCAUM), and addressed environmental regulation and technology innovation. By drawing on examples from other industries, he set out to make the case that technology-forcing standards are needed to reduce emissions from aircraft engines. He suggested that concerns and issues faced by the aviation sector mirror those of other industries faced with the need to reduce sector emissions. He presented data that showed that while major power plants in Massachusetts were projected to significantly reduce their NO<sub>x</sub> emissions by 2010, not only were those from aircraft at Boston Logan Airport projected to increase, but to

exceed any of the plants. On a national level, emissions of NO<sub>x</sub> from aircraft were projected to double between 1999 and 2030 under current standards. However under a clean fleet scenario based on the introduction of NASA stretch goal technology, total NO<sub>x</sub> emissions would only increase slightly by 2010 and remain relatively constant thereafter.

He then discussed in some detail the findings of a report prepared by NESCAUM that investigated the role of environmental regulation in technology innovation to reduce emissions and performed three case studies addressing reduction in sulfur dioxide (SO<sub>2</sub>) and NO<sub>x</sub> from power plants, and automobile emissions. In the case of SO<sub>2</sub> from power plants, the cost of scrubber technology declined far below projections in response to the 1990 Clean Air Act Amendments (CAAA). Key technology drivers in reducing NO<sub>x</sub> from power plants were the new source performance standards (NSPS) in the 1970 and 1977 CAAA, California initiatives addressing NO<sub>x</sub> as a precursor to ozone, the 1990 CAAA requirements that significantly reduced emissions allowed under the NSPS, and subsequent efforts in response to State Implementation Plan requirements. The NESCAUM study found that estimated costs of achieving these standards had declined by over 60 percent between the early to mid 1980s and 1998. Emissions from automobiles are projected to decline by 95 percent between 1965 and 2005 as a result of the introduction of a broad range of technology innovations in response to California regulations and Title II of the Clean Air Act. The NESCAUM study found that the incremental cost per vehicle of achieving some of the most restrictive standards ranged from \$35 to \$251, far below industry estimates in 1994.

Arthur Marin ended with the conclusion that advanced air pollution control technologies do not become commercially available at reasonable cost until regulatory requirements are put in place. He noted that technology advances are achieved at significant cost and effort to industry, and require tremendous innovation and ingenuity on the part of industry. Sector-wide reductions in emissions have occurred in electrical power industry and from automobiles in the face of substantial growth in the number of cars and demand for electricity. He suggested that technology-forcing standards would lead to innovative approaches to reduce NO<sub>x</sub> emissions from aircraft engines at costs significantly below initial projections.

In the discussion period at the end of the session, concern was expressed about the difficulty of extrapolating from technology developments in the other industries because of differences between the technology of aircraft engines and those of other sectors, particularly the operating environment, and issues of safety and reliability.

## **Health Effects**

The third session began after the lunch break and addressed the health effects of emissions resulting from airport activity. It was moderated by Mike Kenney, Air Quality Scientist with URS Greiner in Tampa, Florida and consisted two presentations that examined the health impacts of airport-related emissions and two presentations that explored some of the issues and difficulties involved in measuring those emissions in practice.

The first presentation was given by Wim Passchier, Deputy Executive Director of the Health Council of the Netherlands and Professor of Health Risk Analysis at Maastricht University, and was titled "Clear Air-ports: Good for Health". He stated that an assessment of the impact of airports on air quality needs to take account of the entire system surrounding the aviation activities, and not just the landing and takeoff of aircraft, or even the associated ground

service activities. Rather, in the vicinity of a large hub airport, industrialization occurs, commercial and residential activities develop, and road and rail transport activities increase. Therefore he suggested that in considering the health effects of large airports, it is appropriate to examine the activities in an area with a radius of some 50 km around the airport. Assessment of health effects needs to consider not only manifest phenomena, such as mortality and morbidity, but less obvious phenomena that are only observable from specific surveys or investigation, such as adverse health effects and functional or structural changes. He noted that health and quality of life are influenced by a complex set of factors that include such aspects as open space and trees, noise and air quality, perceptions of safety, the work and residential environment, and trust in the way decisions are made.

He suggested that there is sufficient evidence that exposure to air pollution has adverse health effects. Odor annoyance is often not considered, but may adversely affect the quality of life or even stimulate psychophysical effects. A recent study by the Health Council of the Netherlands found no empirical evidence for health effects from airports or jet fuel specific substances, although there was annoyance from jet fuel odor. The study found that emissions from road traffic dominate all other airport-related sources, and concluded that the levels of air pollution and the associated health effects from the operation of a large airport system are comparable to those from other industrial areas. He presented results of surveys around Schiphol Airport, Amsterdam, that found that while aircraft noise was the principal source of severe annoyance, about five percent of respondents expressed severe annoyance at odor and particulate matter (soot) from both road traffic and aircraft. He concluded by suggesting that the way ahead in reducing environmental health risk associated with airports involves a comprehensive health assessment around major airports, the involvement of stakeholders in negotiating general standards and policy guidance, and an integrated approach to assessment and monitoring.

The second presentation also addressed the health effects of airport air quality and was given by Michael Kleinman, Adjunct Professor of Community and Environmental Medicine at the University of California, Irvine. As background he noted that airports rank among the top ten industrial air pollution sources in their cities and a single Boeing 747 arriving and departing from an airport generates the same NO<sub>x</sub> emissions as a car driven nearly 26,500 miles. In addition to the health effects of toxic air pollutants, there are related effects on human welfare, including decreased income as a result of illness and decreased recreational opportunities, and ecological impacts, such as effects on wildlife. He then discussed the health effects of various air pollutants. High levels of nitrogen oxides have been found to increase respiratory illness and increased susceptibility to infections. He reported that experiments on rats have showed that cancer cells resulted in tumors at a higher rate when exposed to NO<sub>x</sub>, suggesting a reduced immunological response. Exposure to elevated levels of carbon monoxide (CO) has been found to result in increased hospital admissions for congestive heart failure and increases in cardiac arrhythmia, bronchitis and asthma. Particulate matter generated by airport activities contains toxic constituents and the particles are of a size that can readily penetrate to the deep lung. They can also remain airborne for a long time and so can spread over a wide area and even at low levels can affect visibility over long distances.

He noted that children growing up in polluted areas have been found to have lower lung development than in less polluted parts of the country. He commented that this has been shown to result in higher levels of respiratory illness, and that childhood respiratory illness is the best

predictor of bronchitis later in life. He then described how inhaled particles interact with the functioning of the lung and how the size and composition of the particles determine the resulting health effects. He stated that particles reduce the ability of the lung to sterilize pathogens. Insoluble particles are retained in the lung for long periods and can be carriers for toxic chemicals. He concluded by mentioning the classical principle that the size of the dose determines whether something is a poison, and commented that particle size clearly influence the dose. He pointed out that particles of the size emitted by airport activity are those most likely to produce adverse health effects.

The third speaker, K. Meng Chng, Principal Consultant with KM Chng Environmental, Inc., of Burlington, Massachusetts, addressed methods for assessing air quality effects of airport operations by presenting a case study analysis of emissions at Chicago O'Hare International Airport. He described techniques for chemical fingerprinting the source of soot deposits, and discussed the results of an analysis of soot deposition at several sampling locations in the vicinity of the airport, as well as an analysis of the emission of volatile organic compounds (VOC) from airport and other sources. This analysis concluded that in 1998 airport-related sources accounted for about 2.6 percent of VOC emitted from all sources within a 10 mile radius of the airport, of which about 1.6 percent were from aircraft. The emissions from aircraft were also estimated to have declined by 33 percent since 1990. The proportion of specific toxics emitted by airport-related sources varied widely, with aircraft accounting for as much as 12 percent of the 1,3 butadiene and 21 percent of the formaldehyde. He stated that the chemical fingerprinting suggested that the source of most of the soot was regional background emissions and motor vehicles.

The fourth presentation was given by Frank Jarke, Manager of Analytical and Quality Assurance with Mostardi-Platt Associates, Inc., of Elmhurst, Illinois, and described a second study that measured organic pollutants from Chicago O'Hare International Airport and was performed for several cities near the airport. He described the technical details of the sampling enclosures that were installed at three locations adjacent to the airport, one upwind and two downwind, and were used to collect 8-hour samples. The downwind locations were established under the approach paths to Runways 22, 27L and 27R, aligned fairly closely with the runway centerlines. A control location was established in a residential area some 40 miles from the airport. He then presented and discussed the chromatograms that were obtained from an analysis of VOC in the samples collected during the study, including a number of grab samples. He suggested that while the results show a difference between the upwind and downwind locations, and between the airport locations and the control location, with elevated levels of various chemicals, particularly aldehydes, the differences were not as great as might be expected from the level and proximity of airport activity at the time. He also presented results of the analysis of grab samples that showed a significant difference between a sample taken when a strong odor was present and one taken a few minutes later when the odor had gone. He concluded that emissions from aircraft engines may form a fairly narrow plume, depending on ambient conditions. If a sample is taken at a location in the plume, it will show high levels of emitted pollutants. However, samples taken a short distance on either sides of the plume will not show this effect. Since the path of the plumes will vary with the oscillation of local wind direction, a fixed sampling location near the source will only detect the plume for a small proportion of the events, resulting in any emissions from these events being diluted by ambient conditions. He

suggested that variation in measurements of emissions may be due to highly localized concentrations, many of which miss the sensor location.

### **Global Warming: Technology Challenges and Solutions**

Following the afternoon break, the fourth session consisted of three presentations that examined technology challenges and potential solutions to address global warming, and was moderated by Ram Uppuluri, an attorney with Environmental Defense in Washington, D.C. In introducing the session, he commented that negotiations in The Hague the previous November over proposed international actions to reduce greenhouse gas emissions had reached an impasse over substitution rules. Therefore the Kyoto Protocol has not entered into force, since it requires ratification by 55 percent of the states representing 55 percent of the greenhouse gas emissions. He commented that emissions from aviation contribute 3.5 percent of radiative forcing,<sup>4</sup> and that this is expected to increase by between 2 and 11 times by 2050. He noted that the U.S. Administration had agreed to re-enter the negotiations over the Kyoto Protocol in July 2001.

The first presentation was given by Don Caniparoli, Senior Air Consultant with CH2M Hill in Portland, Oregon, and discussed scientific issues associated with global climate change. He began by describing some of the recent findings contained in the Third Assessment Report prepared by two working groups of the Intergovernmental Panel on Climate Change (IPCC). These suggest that global average temperatures have increased by 0.6°C in the 20<sup>th</sup> century, with the largest increase occurring in the periods 1910 to 1945 and 1976 to 2000. Globally, the 1990s were the warmest decade and 1998 the warmest year since 1861. Snow and ice cover has decreased, with a retreat of mountain glaciers and a decrease in the extent of sea ice in the arctic. The global average sea level has risen and the ocean heat content has increased. It is also very likely that precipitation and heavy precipitation has increased, with a likely 2 percent increase in cloud cover. The El Nino Southern Oscillation has increased in frequency and intensity. The Third Assessment Report also indicates that impacts of these effects on physical and biological systems have already been experienced, with those with the least resources to adapt being the most vulnerable.

He also discussed a minority position held by some scientists. This is based on meteorological station reports that show sustained warming, cooling, and warming again over the last 100 years and data from microwave sounding units mounted on satellites. Mixing in the troposphere (lower atmosphere) should show the same temperature changes at the surface and throughout the troposphere. However, measurements of the temperature in the lower troposphere since 1979 show much less increase than at the surface, with the warming mostly a result of the 1998 El Nino, although there is close agreement in North America, Western Europe and Australia. This position suggests that the apparent changes in surface temperatures may be due in part to environmental changes, such as the urban heat island effect or changes in vegetation, as well as various potential measurement errors. He suggested that in spite of this scientific debate, the issue will not just go away, and public concern and policy debate will determine the outcome. Because of the costs involved in taking actions to address global warming, he suggested that actions will not be taken in advance of an agreed framework. However, he noted that greenhouse gas reductions are often associated with other business

---

<sup>4</sup> *Radiative forcing* refers to a change in the balance between incoming solar radiation and outgoing infrared radiation due to the presence of greenhouse gasses. See <http://www.epa.gov/globalwarming/glossary.html>.

efficiencies such as reduced maintenance costs, and suggested that operations should be planned with an eye toward reductions. He recommended tracking greenhouse gas emissions and exploring ways to create value through market-based tracking and emissions trading.

The second presentation provided a federal government perspective on the challenges of and solutions to global warming, and was given by Cindy Newberg, Policy Analyst with the Office of Atmospheric Programs at the U.S. Environmental Protection Agency. She began by noting that aviation is the third largest sector in terms of greenhouse gas emissions measured as tons of carbon equivalent after utilities and motor vehicles, and that growth in jet fuel use is projected to outpace energy consumption in most other sectors. She noted that two recent major international assessments have underscored the role of aviation in climate change, the IPCC Special Report on Aviation and Global Environment in 1999 and the Third Assessment Report in 2001. The IPCC has estimated that aviation could contribute 5 percent of total radiative forcing by 2050, and the global climate impacts of subsonic aircraft extend well beyond emission of CO<sub>2</sub>. She summarized recent findings of global climate change and noted that the most recent estimates of future global warming are greater than previously predicted. She stated that Article 2.2 of the Kyoto Protocol calls for actions by ICAO to limit or reduce greenhouse gas emissions from aviation bunker fuels (*i.e.* aircraft fuel), and described efforts under way by CAEP working groups to examine technology, operational strategies, and market-based options.

The CAEP working group on market-based options (Working Group 5) has considered levies, including taxes and charges, voluntary mechanisms such as industry agreements and negotiated agreements, and emissions trading. She suggested that market-based approaches offer a number of attractive features, including flexibility and incentives to innovate, a means to internalize costs, and avoidance of winners and losers that could result from mandated technology solutions. Of the three options analyzed, CAEP concluded that open emissions trading offers the best opportunity for aviation to reduce emissions. However, this could not be implemented unless the Kyoto Protocol enters into force. Therefore CAEP recommended that in the short term voluntary mechanisms should be developed. Future work planned by Working Group 5 (WG5) will address voluntary mechanisms, levies and emissions trading. Work on voluntary mechanisms include development of a template agreement establishing goals and guidance, and development of an optional “learning by doing” trading program. Guidance on formulating and assessing levies would address the identification and calculation of emissions-related costs. Work on developing the key elements of an open emissions trading program would address requirements for reporting, monitoring, compliance and enforcement. She summarized additional areas of future work for WG5 and the next steps by the ICAO Council and Assembly that are required to implement the recommended measures. She concluded with a brief discussion of contrails, the linear ice crystal clouds produced by aircraft engine exhaust water vapor, and described a joint fact sheet on the effects of contrails produced by EPA, NASA, FAA and the National Oceanographic and Atmospheric Administration.

The third presentation, by Willard Dodds, Manager of Combustion Technology Programs at General Electric Aircraft Engines, addressed ways to mitigate the potential climate effects of aviation. He began by reviewing the estimated impact of aviation on climate change and observed that it is important to consider the length of time over which different factors have an effect on climate. He noted that CO<sub>2</sub> has a life of about 100 years, and that continued scientific work is needed to reduce uncertainty. He suggested that potential mitigation measures should take a balanced approach that considers climate, local air quality and noise, as well as

technology, operational and resource management approaches. Technical considerations include cost and the need to avoid compromising safety. He then discussed strategies to achieve CO<sub>2</sub> reductions through technology, operations and resource management. Improvements in engine efficiency involve tradeoffs with NO<sub>x</sub> emissions and noise, and may affect contrail formation. Improved aerodynamics and reduced weight may also incur tradeoffs with noise. Improved air traffic management and more efficient aircraft operations would reduce emissions but could also involve noise tradeoffs. Resource management strategies include higher load factors, changes in fleet and route structure, and use of low carbon fuel. He noted that the first two may involve tradeoffs with noise while the third would reduce CO<sub>2</sub> but increase water vapor and affect contrail formation.

Technology options to reduce NO<sub>x</sub> emissions include lean staged combustors and rich/quench/lean combustors, but involve tradeoffs with emissions of CO and particulate matter, and possibly contrail formation, as well as an increase in engine complexity. He noted that operational and resource management strategies to reduce NO<sub>x</sub> are similar to those for CO<sub>2</sub>. Technology options to reduce contrail and cloud formation include increased engine efficiency and reduced particulate emissions, although he suggested that it is not clear how effective increased engine efficiency will be. He suggested that operational and resource management strategies to reduce contrail formation include avoiding contrail conditions, the use of higher load factors and larger aircraft, and use of low sulfur fuel. Avoiding contrail conditions is likely to involve a tradeoff with fuel burn and CO<sub>2</sub> emissions. In conclusion, he observed that potential mitigation approaches exist and should be studied. He pointed out that improved engine efficiency is a win-win solution that would reduce both operating cost and adverse climate impacts. He believed that the ICAO working groups have the appropriate resources to address the issues, but that in striving for a balanced approach that considers climate, local air quality and noise, the optimum overall environmental solution may not be best for local air quality or noise.

### **The Voluntary Emissions Reduction Stakeholders Process**

The fifth session concluded the Thursday afternoon with a status report on the FAA and EPA Voluntary Emissions Reduction Stakeholder Process, moderated by David Jensen of Federal Express. The session started with a presentation by Bryan Manning, Aircraft Standards Manager with the Office of Transportation and Air Quality at the Nonroad Vehicles and Engines Center of the U.S. Environmental Protection Agency in Ann Arbor, Michigan, that provided an overview of the Voluntary Emissions Reduction Stakeholder Process. He began with a discussion of emission trends in aviation compared to other mobile sources, and noted that a recent EPA study of NO<sub>x</sub> emissions in nine non-attainment areas and one maintenance area projected significant growth in emissions from 1990 to 2010. The percentage of mobile source NO<sub>x</sub> emissions in each region due to commercial aircraft in 2010 was projected to vary from 2 percent to over 10 percent. However, he noted that the airlines have pointed out that there is a high level of uncertainty in the projections of emissions from future operations, both due to the effects of supply-side constraints and fleet mix changes. He then described the background to the voluntary stakeholder process that was initiated by a memorandum of understanding between the EPA and FAA in March 1998, and responded to concerns expressed by the EPA, state and local air agencies, and environmental groups that emissions standards for NO<sub>x</sub> established by ICAO, and upon which EPA had based U.S. regulations, required fairly modest efforts to satisfy.



The voluntary stakeholder process brought together airlines, aircraft engine manufacturers, airports, state and local agencies, environmental groups, auxiliary power unit (APU) and ground service equipment (GSE) manufacturers, NASA, the Department of Defense, FAA and EPA to identify voluntary measures that could reduce aviation NO<sub>x</sub> emissions. The initial focus was on aircraft main engines, but this was broadened to include APUs, GSE, stationary sources at airports, and ground access vehicles. The process has involved three simultaneous efforts: a baseline study of current and future conditions, and evaluation of the effectiveness, cost, and implementation feasibility of over 30 control options, and the development of an overall framework of an agreement which could be signed by all the parties. He indicated that the two studies should be completed in about another two months and stated that the parties had reached preliminary agreement on a two-tier program. Tier 1 would achieve national reductions in a two-part effort. The first part would focus on GSE emissions reductions in the near term and the second part would focus on aircraft emissions in the longer term. Tier 2 would achieve additional reductions at airports in a limited number of non-attainment areas that need reductions beyond the national program. He reported that the air carriers are developing a proposal to reduce GSE emissions. Senior management of the stakeholders met in early January 2001 and agreed to continue meeting on a quarterly basis to move the process along. He concluded by expressing the concern that this process may be the only national opportunity to reach consensus among the stakeholders on ways to voluntarily reduce emissions from aviation sources. Failure to achieve consensus would force the EPA, as well as state and local regulatory agencies, to pursue independent actions to achieve reductions.

Following the presentation by Bryan Manning, David Jensen provided an airline perspective on the prospects for reducing aircraft emissions. He noted that CAEP comprises the foremost aviation experts on environmental issues and the ICAO standards represent the consensus of what can reasonably be achieved through the certification process. He expressed the concern that the airline industry uses capital assets that are manufactured to last for a very long time, and that it is not obvious that there are any new aircraft engine technologies that are readily available in the near term.

In the discussion following the two speakers, Bryan Manning was asked whether EPA can set more stringent standards than ICAO. He responded that the Clean Air Act certainly allows EPA to set different standards if these are technologically feasible and economically justified.

### **The Interface of Conformity with State Implementation Plans**

The sixth session began the Friday morning program and consisted of four presentations that addressed the role of general conformity regulations and state implementation plans in shaping emissions reduction programs at airports. The session was moderated by Kim Hughes, Manager of Environmental Services with HNTB Corporation in Alexandria, Virginia.

The first presentation provided an overview of the general conformity process at airports, and was given by David Stonefield, Senior Environmental Planner, Office of Air Quality Planning and Standards of the U.S. Environmental Protection Agency in Research Triangle Park, North Carolina. He began by explaining that the purpose of the General Conformity Program is to ensure that Federal actions will not interfere with the relevant State Implementation Plan (SIP), to foster communications with state and local air quality agencies, and to allow for public

participation in the Federal review of each SIP. He remarked that the requirement for public participation is likely to provide an opportunity for legal intervention by interested groups. As far as airports are concerned, he noted that general conformity regulations apply to both FAA approval and funding and that airports can be significant sources of air pollution. He observed that a large airport generates a similar level of NO<sub>x</sub> emissions to a medium-sized coal-fired power plant, but much higher levels of VOC and CO.

He then discussed the general conformity regulations, and explained that emissions covered by the rule include both direct and indirect emissions above *de minimis* levels in non-attainment and maintenance areas. Direct emissions are those directly covered by the action, while indirect emissions are those removed in time and space, such as emissions from ground access vehicles in the case of airports. He noted that indirect emissions were required to be reasonably foreseeable and under continuing program responsibility. Airports could determine the attainment status of their area by contacting their state or local air quality agency, or the EPA regional office or the EPA website at <http://www.epa.gov/oar/pagesp/greenbook>. He commented that airports could avoid general conformity requirements by building in an attainment area (or bringing the area into attainment), keeping emissions below the *de minimis* levels, being part of a conforming plan (such as being covered by a conforming master plan), or if the emissions are covered by a new source review program or transportation conformity. He explained that requirements for conformity demonstration depend on the pollutant and situation. The simplest way is for the project to be included in the SIP or for the state to indicate that it intends to include the emissions in a new SIP, although he noted that this triggers the need to submit a new SIP. If the project is not included in the SIP, then conformity can be demonstrated through mitigation measures, or depending on the pollutant, through offsets or modeling.

He then reviewed a number of questions that are often raised by airport operators. He stated that both direct and indirect construction emissions should be included, since they are not included in transportation conformity. Regulated source emissions, such as GSE, are included because regulations limit the emission rate, not the quantity of emissions, and these emissions need to be addressed if an air quality review is required to assess the impact of the project on regional air quality. He stated that a “continuing program responsibility” is defined as the ability to regulate the activity directly or the ability to impose conditions on the activity and explained that an analysis of *de minimis* emission levels should consider the maximum net emission increase and address both the construction period as well as full operation. He noted that emissions may be included in the SIP in two ways, either by the project being explicitly named or by being included in other categories. In the latter case, a written statement would be required from the state or local air quality agency and these are assessed on a sliding scale. The less specific the category, the more documentation would be required. He commented that “regional significance” is defined differently in general conformity from transportation conformity, and requires that emissions exceed 10 percent of the emissions inventory of the area. Finally, he concluded by discussing what airport operators can do to assist in the general conformity process. This includes having a good understanding of emission sources and levels, working closely with state and local air quality agencies, and identifying potential emission reductions. He noted that the regulations do not address whether early reductions in emissions can be used for conformity determinations and that airports should address this through agreements with their state and local air quality agencies.

The second presentation, by Everard Ashworth, Principal of the Ashworth Leininger Group in Thousand Oaks, California, addressed techniques for estimating emissions from ground service equipment. He discussed a number of tools for estimating GSE emissions and provided some observations on GSE inventories and efforts to document their emissions. He began by describing the treatment of GSE emissions in the Emissions and Dispersion Modeling System (EDMS), the model required by the FAA for use in airport air quality analysis. He noted that this model is approved by the EPA for SIP planning purposes, although the EPA allows other tools and requires the use of the best available data. EDMS calculates GSE emissions on the basis of landing/takeoff (LTO) cycles, based on estimates of minutes of activity per cycle. Emission factors are expressed as kg per hour based on values given in the 1995 draft EPA NONROAD model. He noted that users can modify the minutes of activity but should not modify the emissions factors, and commented that the FAA is working to refine the GSE emission factors in the model and allow use of data on actual GSE population at an airport. He suggested that the defaults in the existing model may underestimate emissions.

He then described the EPA GSE inventory tools, beginning with the 1991 NONROAD Engine and Vehicle Emissions Study. He indicated that this study provides nonroad engine emission inventories for 13 metropolitan areas, but cautioned that the study should not be used for GSE due to incorrect assumptions about the type of equipment used. He also suggested that the current draft of the EPA NONROAD model should not be used for GSE as the default values are not appropriate, but noted that the EPA is working to refine the inputs for GSE and when completed it will provide a powerful tool that will predict changes in emissions over time. He stated that the EPA currently supports its GSE tool that allows analysis of emissions from each category of equipment at a single point in time. He also briefly described the California Air Resources Board OFFROAD model, which is limited to use in California as it applies the California off-road emissions regulations. He noted that this model can be tailored to local situations, as it allows the user to predict changes in equipment fleet and emissions over time and adjust the population and activity levels.

He concluded by discussing studies undertaken by the Air Transport Association (ATA) of GSE fleet characteristics and activity at airports in Southern California, Texas and other states. He commented that these studies suggest that regulatory models usually underestimate the GSE population, which typically includes about 20 percent on-road equipment, and also underestimate the age of the equipment and activity, although he noted the issue of whether the measured activity includes idle periods. He suggested that the ATA studies imply a higher level of baseline emissions than calculated by the regulatory models, and also a slower fleet turnover than predicted by the NONROAD and OFFROAD models, thus reducing the impact of new engine standards. He ended by stressing the need for a refined GSE model that can address these deficiencies.

The third presentation described California's Airport Air Quality Program, and was given by Gary Honcoop, Manager of Strategic Analysis for Air Quality and Transportation Planning with the California Air Resources Board (ARB). He stated that the goals of the program are to reduce airport emissions to help meet clean air goals, reduce community exposure, and to mitigate the impacts of airport expansion. He identified the four elements of the program, comprising issuing airport certificates, review of environmental documents, preparation of input to the State Implementation Plan, and support for General Conformity activities. He noted that airport certificates are required by state law and that this currently requires about 3 person-years

of ARB staff time. Application is limited to specific types of project and recognizes all emissions increases. He stated that the certificate can require mitigation where necessary, and that statutory language requires consistency during the period of operation. He mentioned that the ARB has developed a list of potential mitigation measures that can be used to address these mitigation requirements. The ARB review of environmental documents begins with a review and comment on the Notice of Preparation, that identifies the elements to be addressed, notifies the project proponent if certification is needed, and offers assistance in performing the environmental analysis. Subsequent review and comment on the draft Environmental Impact Report or Environmental Impact Statement assesses the scope and accuracy of the air quality analysis, defines any additional work needed, evaluates the adequacy of the proposed mitigation measures, and recommends any additional measures that may be necessary.

Turning to issues related to the SIP, he mentioned that the 1994 California Ozone SIP is based on the federal measure for cleaner aircraft, which should result in a reduction of 7 tons per day of hydrocarbons and NO<sub>x</sub> in the Los Angeles air basin by 2010. Current efforts include development of the California GSE Memorandum of Understanding (MOU), participation in the national voluntary emissions reduction stakeholder process, and work underway to prepare new SIPs for Los Angeles and the San Francisco Bay Area. He noted that new SIPs will be needed for several areas to meet the 8-hour ozone and PM 2.5 standards. He described the GSE MOU as a work in progress and explained that it focuses on five airports in the South Coast air basin and expects to get about an 80 percent reduction in emissions. Major elements under the MOU include a fleet average target, an accelerated equipment turnover rate, the use of electric equipment where feasible, reductions in diesel particulate matter, and enforceable agreements that are creditable under the SIP. He indicated that ARB hoped to be able to finalize the MOU fairly soon. He briefly discussed efforts to achieve aircraft emission reductions, noting that this was identified in 1994 California Ozone SIP, but not addressed in the U.S. EPA consultative process. The ARB was participating the EPA/FAA voluntary stakeholder process, and the California goal was to establish a consistency in approach with other emission generators.

He then discussed the role of the ARB in General Conformity, and explained that the agency works with project proponents and the FAA to identify emission budgets and appropriate emission inventories. They provide feedback on assumptions in the analysis and coordinate with local air districts on comments. He mentioned the need to improve the clarity of emission budgets in future SIPs. He concluded with several observations. He noted that airports and other stakeholders have common interests. Airports need emissions reductions for expansion projects, air agencies need reductions for SIP compliance, and the public wants a reduction in exposure. He pointed out that means to achieve emissions reductions are available now. However, there will need to be a coordinated, concerted effort to address aircraft emissions.

The final presentation was given by David Kircher, Manager of the Engineering Department of the Puget Sound Clean Air Agency in Washington State, and described collaborative approaches to mitigating the impacts of airport expansion at Sea-Tac Airport in Seattle. He described current efforts by the Port of Seattle to implement the Master Plan Update, that includes a multi-year capital improvement project to be completed by 2010. This involves the construction of a third runway, renovation of the main passenger terminal and Concourse A, renovation of the inter-terminal transit system, expansion of parking facilities, and construction of a new northend passenger terminal and other facilities. He reported that the airport and the Clean Air Agency (CAA) began discussions about two years ago regarding emissions reduction

“banking” to offset future expansion. This would involve voluntary reductions below current requirements that can be withdrawn later. A memorandum of understanding was signed in April 2000 between the Port and CAA that established the need for the banking process and its purpose, as well as the roles of the two agencies and steps that each would take to implement the program. A regulatory order was issued by the CAA in March 2000 that describes the procedures that the Port and CAA will follow to implement the program and exempts credits from the requirements of other current banking programs.

Under the program, the Port submits applications to the CAA that describe the actions creating credit and quantify the emissions reductions. If the CAA determines that the reductions are properly quantified, state and federally enforceable, in excess of regulatory requirements, and permanent, it then issues a Certificate of Title under the program. This includes conditions to ensure that the reductions are permanent and enforceable, specifies the amount of credit in tons per year, and has an expiration date of ten years from the date of issuance. The CAA holds back 10 percent of any bankable reductions to help improve regional air quality. He described the first project under consideration to generate bankable credits, consisting of a hydrant fueling system to replace the use of diesel fueling trucks. He noted that the emission reduction credit proposal is looking at a new approach to quantifying diesel engine emissions in order to account for the unique operating cycle of these vehicles. This is based on the fuel consumption and emission factors expressed in terms of the heating value of the diesel fuel.

In the question and discussion period following the presentations, Gary Honcoop was asked when the California ARB will apply regulations to general aviation (GA) airports. He responded that it will be difficult to get much reduction in emissions at GA airports, so it may be a while before they address this issue. Another participant noted that airport projects often extend well beyond the time frame of the SIP and asked how this is addressed in General Conformity. David Stonefield replied that the EPA is aware of this issue and is trying to figure out how to reconcile the time frames of the SIP and the airport planning process. He was then asked whether there are any considerations in the regulations about tradeoffs between air quality and other pollutants, such as water quality or noise. He responded that proposed air quality regulations are coordinated with other parts of the EPA, but there are no explicit considerations of tradeoffs. Gary Honcoop was asked how to deal with the problem of air quality agencies reducing emissions in the SIP below the baseline forecast developed by an airport. He responded that the SIP is not simply a technical exercise, but is a political process and noted that achieving attainment is a zero-sum game. He suggested that the ARB and local agencies need to give more attention to airport emissions budgets. A participant asked whether airport emission budgets should be approved by the FAA. Gary Honcoop replied that he could not see air agencies giving up that responsibility.

### **Case Studies of Intermodal Ground Access Planning**

Following a break, the next session examined the contribution of airport access vehicles to the emissions generated by airport activity and addressed strategies to reduce these emissions. The session consisted of four presentations and was moderated by Mary Vigilante, President of Synergy Consultants in Seattle, Washington.

The first presentation, by Peter Mandle, Principal with Leigh Fisher Associates in San Mateo, California, addressed factors affecting the use of public access modes at airports, and

described the results of a study performed for the Transit Cooperative Research Program on the same topic. The study classified public transportation modes by cost and level of service. A comparative analysis of access mode use of major airports worldwide found a much higher use of rail and bus transportation at many large overseas airports. He noted that U.S. airports rarely exceed 15 percent mode share of public transportation. He stated that key factors affecting the use of public transportation included the concentration of trip ends in the central business district, the characteristics of the passenger market, regional travel times, the ability to walk between rail stations and the final destination, the extent of regional coverage of urban rail systems, on-airport travel time, frequency of service, and the availability of parking at non-airport stations. He commented that some overseas airports have a restricted number of landing slots, so airlines promote use of rail access in place of regional feeder flights. Other differences between U.S. airports and overseas airports that favor a higher use of rail access to overseas airports include a more extensive rail network and a higher concentration of trip ends in overseas cities, single terminals at many overseas airports, and a greater travel time differential between rail and road access to overseas airports. The study suggested that there is very limited opportunity for rail service at most U.S. airports, since use of public transportation modes exceeds 15 percent at only three airports and is less than 10 percent at all but ten airports. He suggested that relatively few U.S. cities have the airport user characteristics, layout, and rail system required for a successful rail access system.

He stated that key factors affecting the use of bus and van service by airline passengers include the availability of door-to-door transportation and express or non-stop service, on-airport travel time, pick up/drop-off locations, frequency of service, regional travel times, the extent of competition, and the extent of regional coverage. He suggested that U.S. airports may present more opportunities for bus and van service, since these services respond to passenger desire for greater convenience and it is easier to design special airport services to respond to the characteristics of the market. He also noted that these services require a much smaller investment than rail and are typically operated by the private sector. In conclusion, he stated that although there is a limited market for public transportation at U.S. airports, the primary market for any rail service consists of passengers with trip ends in the downtown or other well-served areas, traveling alone with little baggage and familiar with the rail service. Since relatively few U.S. cities have the characteristics required for successful rail systems, he suggested that the objectives of increasing the use of public transportation at airports might be best served by plans based on bus and van service.

The second presentation addressed analysis tools and issues in modeling airport ground transportation emissions, and was given by Geoffrey Gosling, an Assistant Research Engineer with the Institute of Transportation Studies at the University of California at Berkeley. He began by discussing the role of ground transportation in overall airport emissions and presented data from the recent Draft Environmental Impact Report for the Los Angeles International Airport Master Plan Update. These showed that for the no action/no project alternative, emissions from ground access vehicles, including both on-airport and off-airport parts of the trip, in 2005 were projected to be over three times all other airport sources combined for CO and over six times all other airport sources for VOC. Projections of NO<sub>x</sub> emissions were about the same for ground access vehicles and all other sources, predominantly aircraft. Projections for 2015 showed that emissions of CO and VOC by ground access vehicles would still exceed all other sources, although by a smaller margin as the ground access vehicle fleet becomes cleaner over time.

Reduced emissions of NO<sub>x</sub> by ground access vehicles were projected to more than offset the increase from aircraft, leading to lower total levels of NO<sub>x</sub> emissions as well as a much smaller share due to ground access vehicles. He noted that ground access emission levels are responsive to airport policies and programs, whereas aircraft emissions are largely outside airport control, and suggested that this could create opportunities for emissions reduction credits. He also commented that in addition to overall emission levels, consideration should be given to local concentrations of pollutants from ground transportation vehicles in such locations as curbside areas and access roadway intersections.

He then reviewed the various models and analysis techniques that are used to assess airport ground transportation emissions, and described the ground transportation component of the FAA Emissions and Dispersion Modeling System. He noted that this is designed to primarily model on-airport facilities and discussed how the airport roadway, curbside and parking facilities are represented in the model and the model restrictions on vehicle fleet composition. He identified a number of issues that arise in modeling ground access vehicle emissions, including the extent of the trip to consider, the effect of trip characteristics on hot soaks and cold starts, the effect of roadway and curbside congestion, and the impact of mitigation measures on fleet composition and trip characteristics. He mentioned that assessment of the impacts of proposed mitigation measures needs to consider the behavioral response of both airport users and ground transportation service providers as well as the cost-effectiveness of different measures. He described the range of potential mitigation measures that have been considered at various airports, including conversion of vehicle fleets to alternative fuels, trip reduction programs, and efforts to improve links to public transportation or develop off-airport terminals.

He concluded with a discussion of the challenges involved in modeling changes in ground access mode use in response to proposed mitigation measures and the typical structure of such models. He noted the lack of industry-standard models to support this type of analysis and commented that these models need to be configured and calibrated for each application and are very data intensive, although they have broad application to airport ground transportation planning. He suggested that while procedures and models for estimating emissions and dispersion for a given traffic volume with known characteristics are well defined, techniques for assessing the likely effect of proposed mitigation measures are not so well defined and need to be based on behavioral choice modeling.

The third speaker, Jim Humphries, Air Quality Coordinator at Sacramento International Airport (SMF), presented the findings of parking and traffic studies at SMF that were undertaken to examine the effectiveness of efforts to reduce vehicle trips to and from the airport. He explained that in 1982 the California Air Resources Board imposed air quality control mitigation requirements on SMF for construction of a new runway that limited parking capacity to 4,270 spaces with the objective of encouraging ridesharing and mass transit use. He noted that environmental groups want the airport to fund a light rail link with increased parking fees. He then described the current traffic levels at the airport, which handled 7.5 million passengers in 2000 and generated about 30,000 vehicle trips per day. He commented that the total airport emissions are roughly equivalent to the amount generated by vehicle trips associated with a large shopping mall. He discussed the characteristics of SMF customers, about 20-30 percent of which are traveling on government business. Most users of long term parking are on 2-4 day business trips, while most passengers dropped off at the airport tend to be on longer nonbusiness

trips. He suggested that most air passengers are unwilling to pay high fees for taxis, vans or parking, and have a low awareness of public transportation options. Taxi and van use accounts for about 5-6 percent of passengers, and only 1-2 percent of vehicle trips.

Estimates of the passenger mode split show that drop-off is the most common access mode, particularly for single person air parties, followed by short-term parking. He noted that the vehicle trip pattern on the airport access roadway is much more volatile than the variation in passenger traffic on a monthly basis. Analysis of the use of the parking lots over time showed that use of the remote overflow lot declined when the spaces available in the long-term lot were expanded. Roadway traffic flows show significant amounts of recirculating traffic, particularly at weekends when the short-term lot tends to fill up. He described a number of successful landside management techniques at SMF, including the development of dual terminals with their own curb, roadways and parking shuttles, provision of additional parking spaces and adjustment of parking rates, development of a consolidated rental car facility with a single shuttle bus service, and improved taxi and van services. He commented that the introduction of door-to-door van service by Supershuttle resulted in a significant increase in van ridership. He also reported several unsuccessful efforts to reduce vehicle trips and emissions, including limiting parking capacity, "pay-on-foot" parking, taxi and van discount coupons, improvement of public bus service, and "major user" rideshare policies. He concluded by summarizing the lessons learned from these efforts, the most important of which was that the largest trip reductions came from eliminating drop-off trips by providing enough parking. He suggested that airport customers want speed and convenience, and will out-manuever efforts to get them to use inconvenient modes. He recommended that management of parking capacity should relate pricing to the perceived value of the different facilities, and stressed the need to understand the seasonal variation in the access and parking habits of the airport customers. He also suggested increasing public outreach and encouraging passengers to plan their ground transportation at the time they plan their flights.

The third presentation addressed plans for rail connections at Dallas/Fort Worth International Airport (DFW), and was given by James Crites, Executive Vice President for Airport Operations at DFW. He explained that the motivation for considering rail connections to the airport came from a concern that the Dallas/Fort Worth metropolitan area is becoming more like European cities in terms of congestion and air traffic delays. Significant shortfalls in urban highway capacity is forcing increased attention to light rail and other rail transit systems. He noted that while only two of the top 12 U.S. airports apart from DFW had existing rail access, an additional five were planning rail access systems. He indicated that this could affect the competitive position of DFW, and presented examples of the rail travel times to employment centers from Atlanta Hartsfield International Airport, Ronald Reagan National Airport in Washington, D.C., and St. Louis Lambert International Airport, as well as rail travel time to downtown from six overseas airports, in London, Paris, Frankfurt, Hong Kong and Tokyo. He also noted increasing pressure from air quality regulatory requirements. The region continues to experience a number of days exceeding the 1-hour ozone standard that varies from 4 to 16 per year, and he mentioned that the airport recently found that GSE emissions would have to be reduced by 90 percent to be consistent with the SIP. He suggested that some thought was also being given to a bid for the 2012 Olympics.

He noted that an existing bus link to commuter rail lines from DFW was predominantly used by employees, and stated that the airport had moved from watching rail development at



other airports to promoting it, and had held 14 agency meetings since June 2000 and a planning charette with local transit agencies in December 2000. He reported that the agencies had agreed to commence a multi-agency rail implementation study immediately, with a top-level executive steering committee. He indicated that this would be a priority commitment by all agencies and would supplement on-going rail planning efforts. He then described some of the possible options for rail access implementation, including a connection to a rail link being planned between Fort Worth and Dallas, a link to the Dallas Area Rapid Transit (DART) system, a route alignment in the State Highway 114 corridor, a plan proposed by the North Central Texas Council of Governments (NCTCOG) that would combined a commuter rail and light rail network, and a proposal in the DFW airport master plan for a connector link between two commuter rail lines to the north and south of the airport. He stated that the goal was to develop a new vision of a seamless rail system that would serve a decentralized urban region with multiple employment and activity nodes. He commented that DFW had agreed to participate in the four-stage rail implementation study, the first two stages of which would identify the preferred technology, rail alignment, and implementation phasing by December 2001, with subsequent stages addressing preliminary engineering and environmental planning. The first two stages of the study would be conducted through the NCTCOG and the \$500,000 cost would be divided three ways between the airport, the NCTCOG and the regional transit authorities. He indicated that the target implementation schedule was to commission the DFW rail service in 2010. In conclusion, he stated that DFW has become active in rail planning for the metroplex, and is defining its priorities and setting the agenda. The airport has fostered inter-agency cooperation and is aligning its planning with regional rail development timetables.

### **Emerging Issues**

The eighth session concluded the symposium with a panel discussion that took place at the end of the morning program and addressed emerging issues in airport air quality. The panel was moderated by Bonnie Wilson, Vice President of Airport Facilities and Services at the Airports Council International – North America. The other panel members comprised Scott Belcher, Managing Director for Environmental Affairs at the Air Transport Association, Jake Schmidt, Policy Associate with the Center for Clean Air Policy in Washington, D.C., and Darcy Zarubiak, Senior Environmental Planner at Dallas/Fort Worth International Airport.

Scott Belcher identified five issues for future consideration. The first was the continuing role of ICAO. He noted that opinion is split on whether CAEP will be successful in establishing new standards for NO<sub>x</sub> and CO<sub>2</sub> emissions. The second was the need to expand airport capacity. From a policy perspective, the failure to expand airports has very real adverse environmental consequences. The third issue comprised the composite set of concerns involving environmental justice, particulate matter, and air toxics. The fourth issue was the tension between the need for a coordinated approach and the tendency of states and airports to pursue their own solutions. The last issue involved the management of expectations and the need to identify what can be accomplished both on the part of the industry and the states.

Bonnie Wilson remarked that the Airports Council International – North America represents a significant number of the airports in the U.S. and Canada, and that these airports have an enormous stake in how the system operates. She suggested that the various stakeholders need to work together to be able to achieve as much reduction in emissions as possible, while also recognizing the worldwide interconnection of air transportation issues. She stated that

airport expansion is the number one priority. Delays in the environmental review process limit the ability to reduce environmental impacts. She stressed the importance of developing regional approaches to airport planning and the need to seek out partnerships with communities that are not constrained by revenue diversion limitations to implement ground access improvements. She suggested that the program for the next symposia should devote some time to address the new standards that will result from the recent Supreme Court decision. She also suggested that it was important to clean up some of the science surrounding the issue of toxics generated by airports.

Jake Schmidt commented that it is clear that concerns over emissions are not going to go away as aviation growth continues. He noted that policy makers are looking for reductions across all sources of emissions. He also believed that the policy debate over climate change would continue and he saw action on the horizon regarding domestic policy on greenhouse gasses. He suggested that it is important to keep in mind that the U.S. is only one member state within ICAO but is in a position to take a leadership position. He identified three key policy issues and four emerging issues that he would propose be addressed at the next symposium. The three policy issues were how to develop policy drivers to achieve new technology for cleaner aircraft and GSE, how to implement market-based solutions to the environmental impacts of aviation, and how to meet airport capacity constraints. He suggested that market-based solutions could stimulate research and development and provide flexibility in emissions reduction strategies. These could include taxes and charges, as well as emissions trading programs. The four emerging issues were the role of greenhouse gasses in climate change, NO<sub>x</sub> at cruise and contrails, particulate matter (especially PM 2.5) and ozone standards, and how to deal with domestic greenhouse gasses in aviation.

Darcy Zarubiak suggested six emerging issues. The first was the need to address the differences between build and no-build alternatives in demand forecasting, and how to define the constrained demand. The second was the increase in airside delay resulting from the replacement of turboprops by regional jets. The third was the need to establish emission factors for PM 2.5 and air toxics. He noted that we do not have any analytical tools to even know if there is a problem. The fourth issue is the emerging requirement to ask airlines to perform conformity analysis as part of their operational service plans. The fifth issue is a growing concern about strategies that may in fact make the air quality situation worse, and the importance of airports sharing their experiences. The final issue is the limitations on what airports can do to reduce emissions that arise from airline use and lease agreements that may not expire for many years. He noted that these agreements affect how infrastructure improvements are funded but were not established with a view to environmental considerations.

Following the remarks by the panel members, Bonnie Wilson was asked what actions could be taken to get greater service at secondary airports. She responded that she did not advocate greater regulation or limiting where airlines offer service. She remarked that airlines offer service at airports because people want to go there. This prompted a question whether environmental constraints inhibit the distribution of service, and Scott Belcher responded that it was not clear that redistribution of service would be a major benefit. Another participant raised the issue of alternative fuels for aircraft, and Scott Belcher suggested that this might be a good topic to cover in the next symposium. A participant from outside the U.S. commented that from an international perspective it would be more useful if future symposia focus on experiences and the underlying information rather than the details of U.S. policy.

## Summary

The symposium explored a wide range of issues involved in airport air quality from prospects for improvement in aircraft engine technology, through measurement of toxic emissions and their implications for human health, to strategies to reduce emissions from ground service equipment and ground access vehicles. It also examined the issues surrounding the contribution of aviation to greenhouse gasses and global climate change. While these are not primarily issues of airport air quality, their resolution appears likely to affect aircraft emissions at airports in ways that are far from clear. Some speakers suggested that there may well be difficult tradeoffs that will have to be made between reducing aircraft emissions that affect local air quality and those that affect global climate change. There are also potential tradeoffs between reducing emissions and reducing aircraft noise that may have to be considered.

However, perhaps the most difficult tradeoff of all will be between reducing emissions and the economic benefits of air transportation. It appears likely that achieving significant reductions in aircraft emissions will be very costly. For this reason alone, it is understandable that near-term efforts have focused on easier problems, such as reducing emissions from auxiliary power units, ground service equipment and ground access vehicles, for which alternative technologies are readily available and the additional costs manageable. For emissions that are generated by a wide range of different sources, it is clear that reduction efforts should focus on those sources where it is least costly to achieve reductions, which forms the justification for emissions trading programs. It may be far more cost-effective for aviation to pay other sectors to reduce CO<sub>2</sub> emissions, say, than to reduce its own CO<sub>2</sub> emissions. There are two important caveats to this approach. The first is that it may matter where the emissions occur as well as how much is emitted, requiring some care in establishing the rules on what is considered an allowable trade. The second is that some emissions may be unique to aviation, either in their quantity or location. Aircraft contrails are an obvious example.

The discussions at the symposium suggested that two categories of aviation emissions are not well understood, either in terms of their consequences or how much is currently being emitted. These are toxic chemicals and particulate matter, especially smaller particles. Until these issues are better understood, it is difficult to know the extent to which they can be addressed through emissions trading and the extent to which direct reduction in emissions will be required. It was also clear from the discussions at the symposium that the scientific debate very quickly becomes clouded by the economic interests of the parties involved. Just as the question of the extent to which global warming is taking place is fraught with difficult measurement issues, so the question of how much exposure to airborne toxic chemicals produced by aviation activities do people living near major airports experience, much less the consequences of that exposure, is not at all easy to answer.

Another major theme to emerge from the presentations at the symposium was the tension between the flexibility offered by voluntary emissions reduction programs and technology push that comes from more restrictive regulations. The U.S. airline industry has sought and obtained the opportunity to show that it can significantly reduce aviation-related emissions through voluntary measures. Now it has to produce. If it becomes clear that this is simply an exercise in foot-dragging, it seems likely that it will quickly find itself struggling with a complex set of new state and local regulations. On the international front, two European countries have already

implemented aircraft emissions charges and it seems quite likely that this approach may soon become more widely adopted within Europe.

In conclusion, the symposium provided an opportunity for a broad range of stakeholders to explore the complex scientific and technical issues that arise in formulating appropriate policies and implementation strategies to reduce the emissions from aviation activity. Air quality has emerged as one of the most important environmental issues at many major airports, not only in the United States, but worldwide, and it appears clear from the symposium that it is likely to become even more so in the future. The symposium provided a useful forum for the participants to better understand the difficult nexus between the scientific and policy dimensions of the topic, and to share ideas on promising strategies that airports and other stakeholders can pursue to both satisfy regulatory requirements and meet the larger goal of achieving improvements in air quality at a local and global level.

## **Program Committee**

### **AIRPORT NOISE**

- Steve Alteman  
Cargo Airline Association
- John-Paul Clarke  
Massachusetts Institute of Technology
- Paul Dykeman  
Federal Aviation Administration
- Mary Ellen Eagan  
Harris, Miller, Miller and Hanson, Inc.
- Kenneth E. Feith  
Environmental Protection Agency
- Jeff Gilley  
National Business Aircraft Association
- Geoffrey Gosling  
University of California, Berkeley
- Laetitia Jacob  
DGAC/Service des Bases Aeriennes
- Carla Kell-Smith  
C. Kell-Smith and Associates
- Anne Kohut  
Airport Noise Report
- Lori Lehnerd  
National Association of State Aviation Officials
- John Leyerle  
John Wayne Orange County Airport
- Thomas Lowrey  
Transport Canada
- William Marx  
Federal Aviation Administration
- Dennis McGrann  
N.O.I.S.E.
- Vince Mestre  
Mestre & Associates
- Mayor Arlene Mulder  
Arlington Heights, Illinois
- Steven F. Pflaum  
McDermott, Will & Emery
- Neal Phillips  
Metropolitan Washington Airports Authority
- Karen L. Robertson  
Dallas/Fort Worth International Airport
- Nancy Young  
Air Transport Association
- Jia “Jake” Yu  
BF Goodrich Aerospace

### Ex-Officio

- Walter Gilfillan  
Walter E. Gillfillan & Associates
- Donna Reid  
University of California, Berkeley

## **AIRPORT AIR QUALITY**

- Katherine Andrus  
Akin, Gump, Strauss, Hauer & Feld,  
L.L.P.c
- Howard Aylesworth, Jr.  
Aerospace Industries Association
- Scott Belcher  
Air Transport Association
- Don Caniparoli  
CH2M Hill
- Paul Dykeman  
Federal Aviation Administration
- Susan M. Gander  
Center for Clean Air Policy
- Geoffrey Gosling  
University of California, Berkeley
- Gary Honcoop  
California Air Resources Board
- Kim Hughes  
HNTB Corporation
- Mike Kenney  
URS Greiner
- Annie Petsonk  
Environmental Defense Fund
- Mary Vigilante  
Synergy Consultants, Inc.
- Bonnie Wilson  
Airports Council International – North  
America
- Darcy Zarubiak  
Dallas/Fort Worth International Airport

### Ex-Officio

- Walter Gilfillan  
Walter E. Gillfillan & Associates
- Donna Reid  
University of California, Berkeley