cast ignores. As momentum gains and such carriers become more numerous and larger -- and "old" carriers convert to the new cost and price structure -- overall air travel growth could expand at an annual rate of 12 to 15 percent per year, the rate experienced during the great three-decade-long postwar boom.

In addition, deregulation is already producing a higher degree of concentration of flights at various key hub airports by shifting historic travel patterns. This phenomenon has been caused by the current fad being followed by most of the older airlines to develop one or more spoke and hub systems to mutually feed both regional and long haul flights. As significant as these developments have been in the last three years, they are in large part defensive strategies that are of optimum value during periods of secular traffic decline. (Air travel declined during 1980, 1981, and 1982 in the United States due to a combination of the negative impact on travel of general economic conditions and operational constraints imposed on aircraft operations by the FAA following the controllers strike in August 1981). Rapid air travel growth will cause airlines seeking competitive advantage to overfly hub connections by offering nonstop service or faster elapsed time one stop service. In addition, in many instances passengers will be offered competing schedules via different less congested hubs and, all else being equal, the less congested hub will be favored. For example, Piedment has for some years drawn traffic from Delta and Eastern Atlanta hub schedules. Nevertheless, because of its synergistic advantages for on-line travel, hub and spoke patterns will co-exist, particularly for the older airlines, with expanding point-to-point nonstop and other low fare services.

Taken together these conditions suggest that peak period saturation of several key hub airports in populated areas will be a major problem well before the end of the decade.

One predictable effect will be to encourage airlines to operate larger aircraft configured to higher density seating and to operate at high load factors. Current trends toward smaller aircraft are, therefore, likely to change in due course. It is also likely that airlines will adopt peak/off peak fare structures that will tend to even traffic flows by diverting discretionary travel to off-peak periods.

The last development would occur immediately and on a large scale if air carriers were to pay, as they do in the case of other inputs, for the use of runways and the ATC system on the basis of their market value. The failure to signal through the price mechanism the true economic value of peak hour departure and landing slots, as well as the ATC system, constitutes the most important institutional flaw in the air transportation system at this time. The older airlines, as a group, oppose such changes in the correct but shortsighted belief that they would be more costly than the present system (and because they seek to gain monopolies or duopolies at key hub airports by expanding high volume hub and spoke systems). They fail to recognize that the large volume of new entry in city pair markets for both old and new carriers is stimulated by the uneconomically low price of peak hour operations. The cost advantage of new carriers would be reduced significantly if the full economic costs of peak hour flying were borne by them.

The extraordinary expansion of air travel that has already begun and is likely to gain momentum in the years immediately ahead, combined with the saturation during peak periods of major hub airports, including in some cases all the hub airports serving the same population area, is likely to produce the single most important change in aircraft and airport design since the origin of air transportation. Broadly, airports are designed to accommodate particular aircraft at some assumed level of operation. Since the 1930s, through each successive aircraft cycle to the current period, the sequence of decision-making has been as follows:

1. U.S. military aircraft requirement developed by private U.S. airframe and engine manufacturers;
2. Civil adaptations developed by U.S. manufacturers in conjunction with leading U.S. airlines;
3. Production of (2), above, for world markets; and
4. Construction of airports to accommodate the type on a worldwide scale.

This sequence no longer obtains. First, for over ten years, military requirements have not been in the mainstream of airframe and engine development. Today military investment is largely in missile systems and, on a small scale, in highly specialized aircraft which so far have not yielded significant civil counterparts.

Second, airline economic deregulation may have broken a crucial link between leading U.S. airlines and the manufacturers. The Boeing 757 and 767, now in production, may represent the last aircraft developed under the old regime.

That regime called for heterogenous aircraft designed for generalized operations over a wide range of distances. In the future it is likely that aircraft will become much more specialized to meet the requirements of the deregulated environment. The number one requirement will be to operate over short stage lengths -- where the large scale traffic growth will occur -- and at peak periods. This will be manifestly impossible for any conventional aircraft, no matter how specialized. Instead, it is likely that design will move toward STOL configurations capable of utilizing 2,000 ft. runways. Such runways can be rapidly built as adjuncts at existing airports or as independent facilities.

AIRCRAFT NOISE - ITS EFFECTS/CONSEQUENCES

James P. Muldoon, The Port Authority of New York and New Jersey

The Problem

Aircraft noise is the single major impediment to airport expansion and to the development of new airports in the United States. The issue of aircraft noise must continue to be addressed on a national and local basis to avoid the imposition of onerous operational restrictions, such as curfews, and to eventually progress to the point where significant expansion of the system can be seriously considered.

The Federal Aviation Administration's 1976 Aircraft Noise Policy document estimated that approximately six million people reside within aircraft noise impact zones around our major air carrier airports. The following table was extracted from the policy statement (Table 1).

While it can be argued that six million people represent a relatively small share of the total U.S. population, it should be noted that the impacted

Table 1. Population - Aircraft Noise Impacted (in thousands).

Airport	Moderate Impact Zone	High Impact Zone
Atlanta	99.8	27.0
Boston	431.3	32.0
Buffalo	113.8	9.7
Chicago-Midway	38.5	1.8
Chicago-O'Hare	771.7	66.6
Cleveland	128.7	11.2
Denver	180.3	28.3
Dulles	3.5	-
J. F. Kennedy	507.3	111.5
La Guardia	1057.0	17.1
Los Angeles	292.4	51.1
Miami	260.0	29.7
Minneapolis/St.Paul	96.7	8.8
Newark	431.9	27.5
New Orleans	32.5	8.9
Philadelphia	76.9	0.3
Phoenix	20.5	6.2
Portland	1.2	0.3
San Diego	77.3	24.0
San Francisco	124.1	11.4
Seattle	123.2	17.3
St. Louis	100.0	8.5
Washington National	24.4	2.0
TOTAL	5.0M	0.5M
All Other Airports	1.1M	0.1M
GRAND TOTAL	6.1M	0.6M

population around an airport usually represents a significient portion of the electorate in that area. These people can and do exert substantial pressure on the officials having responsibility for the operation of the airports, which in this country, are operated by units of local government or governmental authorities, and which are, to a great extent, responsive to such pressures. It should also be recognized that aircraft noise problems and the attendant community reaction are more often the rule rather than the exception. Specifically, the 23 noise impacted airports identified in the preceding table accounted for over half of the nation's commercial aviation activity in 1980, as measured in passenger enplanements.

Successful opposition to plans for major new facilities, such as those in New York, St. Louis, Miami, and Los Angeles, as well as to the expansion of existing facilities, not only caused the abandonment or deferral of these projects, but perhaps more importantly, established a climate where such programs are not seriously considered for fear of anticipated community opposition.

The Existing Situation

Jet transport aircraft were introduced in this country in the late 1950s. As recognization of the jet noise problem grew and as jet aircraft noise technology developed, it became clear that the problem could best be attacked at the source. Based to a large extent upon research sponsored by the National Aeronautics and Space Administration (NASA), a lobbying effort on the part of the Airport Operators Council, airport neighbors, and environmental groups, resulted in legislation and Federal regulations which attempted to apply the best available noise reduction technology to the production of new aircraft and to accelerate the retirement of old technology aircraft. A brief review of the regulations in place today and of the status of currently operating jet aircraft is helpful at this point.

Part 36 of the Federal Air Regulations adopted in 1969, established noise standards as a certification requirement for new aircraft. The standards vary with the weight of the aircraft, permitting higher noise levels for heavier aircraft. Aircraft certified under the regulation are referred to as Stage 2, examples of which are the L-1011 and the DC-10. Those aircraft in operation prior to the regulation are referred to as Stage 1 - these include the DC-8, the B-707, and the BAC-111.

In 1973, an amendment to FAR-36 applied these standards to the continuing production of Stage 1 aircraft. Those versions of the B-727, DC-9 and B-737 produced after the amendment satisfied Stage 2 standards and are noise certified. These aircraft are all powered by versions of the low bypass JT-8D engine, which was acoustically treated to meet the requirements. It should be noted that aircraft designed to meet the requirement, such as the DC-10 and the L-1011, comply to a much greater degree than those modified to meet the standard such as the B-727 and the DC-9.

In 1977, FAR-36 was again amended to apply more stringent standards to aircraft certificated after the amendment. These standards are typically 3 to 5 decibels lower than Stage 2 requirements for the same aircraft weight. Aircraft certificated under this provision are referred to as Stage 3 and include the A-300, the DC 9-80, B-756, the B-767 and the reengined DC-8.

The Aviation Safety and Noise Abatement Act of 1979 addressed the issue of replacing or retrofitting those aircraft certificated or manufactured prior to the application dates of FAR-36 and established a schedule for the replacement or retrofitting of these airplanes. This is now incorporated into Subpart E of FAR-91, which basically requires that: All B-707s and DC-8s be retired or reengined, in the case of DC-8, by January 1, 1985, all early versions of the B-727s be treated to meet Stage 2 standards by January 1, 1983, and that all early versions of the B-737s and DC-9s be treated prior to January 1, 1988.

These regulations have and will continue to have a positive effect in reducing aircraft noise impact at the source. They have been accompanied by a variety of local airport restrictions aimed at noise reduction. The basis of many of these restrictions is found in the State of California's Airport Noise Regulations adopted in 1970, which, in essence, require that existing airports take the steps necessary to eliminate the noise impact on affected residential areas. The law has led to a variety of studies and proposed local airport restrictions which, depending upon your point of view, have either exacerbated the problem or represented good-faith efforts on the part of the airport operators. Other airport operators, not prodded by a state law, also have taken a variety of mitigation measures, some of which provide a degree of noise relief.

In some cases, the airport operator, working with the other industry participants , the FAA, the airlines and the pilots, has established local noise abatement landing and takeoff procedures, preferential and rotational runway systems, or other mutually agreed-upon operating restrictions. In other cases, the operator, unilaterally, has established local noise rules which range from a requirement that aircraft operators conduct their

operations so as not to exceed a specific noise level at the New York airports, to a requirement that aircraft operators exert their best efforts to meet specific percentage requirements for quieter aircraft at Boston. While these operating procedures and the local restrictions undoubtedly add incrementally to the cost of air transportation in terms of extended flight paths or less than optimum equipment deployment, the related costs are still relatively small and are well justified in view of the noise reduction benefits provided and the mitigating effect that these actions have upon community opposition.

The Outlook

Total compliance with the federal fleet noise rule will improve the situation at most major airports by eliminating 4-engined narrow-bodied aircraft with low bypass ratio engines (B-707 and DC-8) and by improving, to some extent, the noise performance of 2 and 3-engined aircraft of the same type (B-727, B-737 and DC-9). These 2 and 3-engined aircraft that remain, however, will dominate the noise picture at the nation's impacted airports for many years.

Noise impact contours developed by The Port Authority of New York and New Jersey for the three metropolitan airports for the years 1979 and 1990, based upon forecasts, clearly illustrate the range of the changes to be expected. At Kennedy, where the B-707 abd DC-8 were the noisiest aircraft in 1979, their elimination dramatically improved the situation - a reduction of over 50 percent in the impacted area. At La Guardia, where 2 and 3-engined narrow bodies will continue to dominate, the improvements are less dramatic - less than a 30 percent reduction. At Newark, the elimination of 4-engined narrow-bodied activity will, according to Port Authority forecasts, be accompanied by a substantial increase in 2 and 3-engined narrow-bodied operations, which will offset the improvement to the point that no significant change in the impact contour area is anticipated. In the absence of creditable analyses on a national basis, it would, based upon the Port Authority studies, seem safe to conclude that less than six million people will be aircraft noise impacted in 1990 but not dramatically less. The problem will clearly remain.

From a source noise point of view, the answer is clear; replace those aircraft powered by low bypass JT-8D engines. If these aircraft were replaced by new technological wide-bodied aircraft or re-engined to meet FAR-36 Stage 3 standards, the aircraft-noise problem would virtually disappear. Applying a method developed by the Civil Aeronautics Board for assessing noise impact to La Guardia, the 1979 contour would be reduced by over 80 percent.

Unfortunately, the competition fostered by airline deregulation and the present state of airline economics lead to the conclusion that the aircraft powered by the JT-8D, which currently represent almost three quarters of the United States' fleet, will remain in service much longer than might have been anticipated several years ago, based upon normal depreciation of this type of equipment and the operational cost-differential in favor of new technology replacement. Unless conditions change radically, the continued operations of these aircraft promises that there will not be a significant perceptible reduction in the impact of aircraft noise at the major U.S. airports over the next decade and beyond and that the noise constraint on system capacity will become more rather than less severe in that time frame.

WAKE VORTEX AND ITS EFFECTS/CONSEQUENCES

Joseph D. Blatt, Aviation Consultant

One of the most effective methods for increasing airport and airspace capacity, and thus reduce delays, would be to reduce the permissable separation standards, both longitudinal and lateral. Numerous electronic, operational and procedural techniques have been suggested which, if fully and successfully developed, might reduce safe separation requirements. However, even if these techniques could be developed and implemented, the wake vortex phenomenon would limit their usefulness.

Wake vortex has been with us since the first day of powered flight. All aircraft generate trailing wake vortices as a result of generating lift, but it was not until the introduction of the wide bodied jets with their increased weight and stronger vortices that the potential danger of these wake vortices became apparent. The vortices generated by heavy aircraft can present a severe hazard to other aircraft which may inadvertently encounter the vortices. The following aircraft, that is the aircraft encountering the wake, may be subject to rolling moments which exceed the aircraft roll control authority, may experience a dangerous loss of altitude, engine damage or structural failure.

Prior to 1970, landing aircraft, under Instrument Flight Rules (IFR) maintained a minimum of three nautical miles separation. In recognition of the potential hazards of trailing wake vortices, in March 1970 the rules were changed to increase the separation standards behind the heavy jets (a heavy jet was defined as an aircraft which has a maximum certificated take-off weight in excess of 300,000 pounds) for the following heavy aircraft to four nautical miles and to five nautical miles for the following non-heavy aircraft. The standards were further increased in November 1975 to six nautical miles for an aircraft with a maximum certificated take-off weight less than 12,000 pounds following a heavy. The increased separation standards effectively reduced the hazard created by wake turbulence but, at the same time, created or increased the congestion problem at busy airports.

During the past decade research and development activities aimed at reducing the adverse operational effects of wake vortex have concentrated on investigations in the following areas:

1. The development of a wake vortex advisory system.
2. The development of a wake vortex avoidance system.
3. The alleviation of wake vortices through aircraft aerodynamic modifications.

The development of a wake vo~tex advisory system is premised on the analysis of extensive data available on vortex behavior as a function of meterorological conditions. This analysis indicated that there are wind conditions which predictably remove vortices. The goal of the advisory system therefore would be to provide information on the presence or absence of potentially hazardous vortices. Obviously, whenever vortices are determined to be innocuous, separation standards could be reduced. A wind rose criterion could be developed to determine when the separation could be uniformly reduced to three nautical miles (or maybe to two miles if other system parameters would permit) for all aircraft types rather than using the three, four, five, and six mile separations currently required.