Experience with administrative law suggests that agencies regulate most effectively only when public attention is focused on their activities. Recognizing this, environmental activists have thus far relied extensively on public pressure to urge regulation, although environmental preservation involves a complex blend of technical disciplines. This Comment discusses aircraft emissions—a problem whose engineering and scientific complexities often contradict common-sense conclusions. In surveying this little-understood part of the national air pollution problem, the author indicates how ineffective public pressure has been in formulating a complete solution and how it initially aggravated the problem, only later to succumb to a clean-air masquerade. The author analyzes both legal and technological progress and problems in controlling aircraft emissions, discusses weaknesses in the current enforcement scheme, and suggests alternatives for future regulation that are consistent with air pollution reduction and fuel conservation.

On July 17, 1973, the Environmental Protection Agency adopted performance standards to regulate exhaust emissions from jet aircraft. These standards are the first major federal effort under the authority of the 1970 Clean Air Amendments to regulate jet emissions. Contrary to air industry claims of voluntary progress in the field, these federal standards are the first relatively comprehensive treatment of the problem. Prior to the Clean Air Act, air industry efforts to solve its emissions problem had focused almost exclusively on the control of visible smoke, the least toxic exhaust component, but the most obnoxious in appearance. Insufficient test data for invisible exhaust components and massive public complaint over thick black exhaust trails caused the air industry to attack only a small part of the problem. As a result, today jet exhaust is less visible but pound for pound more toxic than when commercial jets were first intro-

1. 38 Fed. Reg. 19050, 19087 (1973). See also 4 Env. Rptr.—Curr. Dev. 431 (1973) for a brief synopsis of these standards.
3. Interview with Dr. Kay Jones, Senior Staff Scientist, Office of Air and Water Programs, Environmental Protection Agency, in Rockville, Md., July 24, 1972 [hereinafter cited as Jones Interview].
4. See note 50 infra.
duced more than a decade ago.  

The quality of air at most major American airports is already far below standard, and despite EPA attempts at regulation, certain aspects of airport air quality will continue to deteriorate during this decade. Although projected increases in commercial aircraft activity will further degrade air quality, the air industry has used the lower visibility of exhaust trails to proclaim a new generation of "virtually smokeless" jet aircraft. Despite numerous scientific studies which have identified commercial jet exhaust as a serious source of pollution in airport vicinities and despite explicit requirements in the Clean Air Act that aircraft emission standards be established in the interests of public health, both the airline industry and the Federal Aviation Agency contend that the problem of jet exhaust is under control and that it does not pose a serious threat to public health.

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6. The reasoning here is simple. The ambient air quality standard for hydrocarbons (HC) is 160 μg/m³ (micrograms / cubic meter) and the standard for oxides of nitrogen (NOx) is 100 μg/m³. Thus NOx is considered more toxic per unit weight than is HC. Because, as discussed at notes 113-19 infra, current regulatory practice will cause NOx increases that approximate HC decreases at many airports, aircraft emissions per unit weight are becoming more toxic each day as EPA's current strategy is implemented. See Environmental Protection Agency, Aircraft Emissions: Impact on Air Quality and Feasibility of Control 17, 43-49 (1972) [hereinafter cited as EPA Impact]. By 1980, Los Angeles International Airport NOx increases will overshadow HC reductions and at Washington National Airport both NOx and HC will increase dramatically. Id.

7. Most major airports are located in areas classified as priority I regions. This EPA classification simply means that air pollutant levels in such regions exceed levels deemed harmful to human health. See 37 Fed. Reg. 10842 (1972). In particular, Los Angeles International Airport suffers ambient hydrocarbon levels approximately nine times greater than the applicable federal standard. EPA Impact, supra note 5, at 9, 43.

8. See notes 38-45 and 113-19 infra and accompanying text.

9. Significant increases in the number of commercial jet flights are predicted in Northern Research & Engineering Corp., The Potential Impact of Aircraft Emissions Upon Air Quality 94, 266 (1971) [hereinafter cited as NREC Impact]; corresponding increases in aircraft exhaust emissions are predicted which will adversely affect ambient air quality. Id. at 94, 267; effects on air quality are summarized, id. at 96. See also notes 37-45 and 113-19 infra and accompanying text.

10. See, e.g., EPA Impact, supra note 6, at 5.


Much of the industry's claim of progress is based on the low-smoke conversion of a portion of its existing jet fleet, an achievement the airlines describe as an "outstanding example of self-regulation." While reliable data is not yet available to evaluate industry claims about its "virtually smokeless 'jumbo jets,'" the conversion program for its medium-range jet fleet is of limited technological value and reveals a rather sorry history of legal evasion and delay. Voluntary regulation has resulted in little or no real progress in aircraft emission control. Reductions in emissions of one pollutant have been achieved at the expense of massive increases in emissions of another, so that progress to date represents little more than a cosmetic gain in environmental quality.

To appreciate fully the impact of EPA's standards on the aircraft industry and upon air quality, one needs perspective on both the technological and legal development of jet emission controls, as well as an understanding of the Federal Aviation Agency's cooperation with the airline industry in attempting to minimize regulation. This Comment attempts to provide such a background. Part I introduces the problem of aircraft pollution and examines the technical difficulties inherent in emission control. Part II discusses federal and state attempts to alleviate the problem and the air industry's response to these efforts. Part III examines current regulatory efforts and their projected effects on air quality, while part IV describes control techniques which are potentially more effective than those adopted by the airlines but which have thus far been rejected or ignored by the industry and by EPA. Part V proposes a solution to the aircraft emissions problem that utilizes various sections of the Clean Air Act to develop a system of effective regulation which improves both control strategies and enforcement opportunities.

I

JET AIRCRAFT AS AN EMISSION SOURCE

A. Jet Exhaust Components—More Than Meet the Eye

Until recently the air industry has focused its research effort...
exclusively on reducing the visibility of exhaust trails. Visible smoke is only one minor component of jet exhaust, however, comprising less than one percent of total jet exhaust pollutant mass. Smoke is the least toxic component of the exhaust stream, but the size, density, and light-scattering characteristics of smoke particles make them highly visible. It was these thick black trails of smoke which the public vehemently protested when jet aircraft were first introduced. The appearance of smoke particles is not a valid indicator of the pollutant density of an exhaust stream, however, for jet aircraft, like most cars, pollute invisibly.

By far the major components of jet exhaust are hydrocarbons (HC) and carbon monoxide (CO), which are both invisible gases, and oxides of nitrogen (NOx), which form the reddish-brown haze associated with urban smog. These pollutants, singly and in combination with others, are potentially harmful to health and vegetation. Control of these pollutants is difficult because the chemical

18. February Hearings, supra note 12, at 29. The aviation industry claims that it relied on early assurances from pollution control authorities that aircraft emissions did not constitute a pollution problem. Air Transport Ass'n, The Reduction of Pollution by Jet Aircraft 3 (1972) [hereinafter cited as Reduction of Pollution]. This does not justify industry's failure to proceed with its own research when confronted with contrary data.

19. Air Transport Ass'n, Reduction of Smoke from Jet Engines 2 (1972) [hereinafter cited as Reduction of Smoke] (data supplied by HEW Air Quality Emission Group).

20. Jones Interview, supra note 3.


22. See note 5 supra.


24. One prominent authority warns:

It should be stressed . . . that an exhaust plume may be rendered invisible, but the emission of particulate matter may be significant from the standpoint of community air pollution.


25. Butz and Grobman, Progress in Reducing Exhaust Pollutants from Jet Aircraft, in 1 NASA Safety and Operating Problems 405 (1971). These are the usual waste products of fossil-fuel combustion and are the same as those produced by the automobile. HEW Nature and Control, supra note 5, at 3. Hydrocarbons are mainly unburned fuel; they result from air injection cooling processes which prematurely quench combustion in jet aircraft engines. Carbon monoxide emissions, a product of incomplete combustion, arise from jet engines because of local over-rich (fuel-abundant) areas in the combustion zone that prevent complete combustion. Id. at 24. Oxides of nitrogen result from high-temperature combustion; particulates responsible for smoke result from burning rich fuel mixtures. Id. at 6, 26.

26. See Butz and Grobman, supra note 25, at 405. Prolonged exposure to carbon monoxide, for example, in concentrations in excess of 500 parts per million can cause serious deterioration of the nervous system and eventually death. Smog, which is formed by the interaction in sunlight between unburned hydrocarbons and oxides of nitrogen, has long been known to cause plant damage, aggravation of breathing
reactions which govern the combustion process involve inverse relationships between HC, CO, and smoke emissions on the one hand, and NOx emissions on the other. For example, when increased oxygen is mixed with fuel to make it burn more efficiently, thereby reducing emissions of HC, CO, and smoke, the combustion temperature rises, and higher NOx emissions are certain to result unless independent measures are taken to reduce them. The inverse relation between emissions of smoke and oxides of nitrogen is of particular importance in the analysis of jet emissions. Most smoke is formed in the high-power modes of flight—takeoff and cruise, as are the majority of NOx emissions. Thus, every decrease in relatively harmless smoke emissions achieved during takeoff will result, without additional controls, in an increase in the more toxic emissions of nitrogen oxides.

B. Source Characteristics

Much of the confusion surrounding jetcraft emissions and their actual contribution to the air pollution problem has stemmed from the extreme variability of jet engine combustion efficiency and the resulting difficulty in attempting to measure exhaust pollutant levels. In powered flight the jet turbine is an extremely efficient mechanism with a combustion efficiency greater than 99 percent, significantly greater than that of piston engines such as those used in automobiles. Because in-flight combustion is so efficient, the levels of most emissions per pound of fuel burned in powered flight are generally low.

On the ground the situation is quite different. When a jet turbine operates in low-power modes such as taxi or idle, combustion efficiency drops so dramatically that emissions of hydrocarbons and carbon monoxide increase 50- to 100-fold. This increase in emissions during ground operations is so significant that more than 90 percent of jet emissions currently measured occur while aircraft are sitting on the ground. By weight, however, jet emissions represent difficulties for persons suffering from bronchial and respiratory diseases, watery eyes, and shortness of breath. id.

27. See FEBRUARY HEARINGS, supra note 12, at 33 (Testimony of Dr. John Middleton, then Commissioner of the National Air Pollution Control Administration).
28. See, e.g., HEW NATURE AND CONTROL, supra note 5, at 23.
29. Id.
30. See note 27 supra.
32. HEW NATURE AND CONTROL, supra note 5, at 23.
33. Id. at 23. Hydrocarbon and carbon monoxide emissions follow this pattern, while nitrogen oxide emissions increase somewhat during powered flight. Id.
34. See McAdams, Analysis of Aircraft Exhaust Emission Measurements: Statistics (Nov. 19, 1971) (prepared for the Environmental Protection Agency, Division
only about one percent of the national air pollution problem.\textsuperscript{35} This misleading statistic propounded by the aviation industry satisfied government authorities for a number of years and focused attention away from the real problem: that the great bulk of jet emissions are deposited intensively over relatively small land areas.\textsuperscript{36} Even at a rate of only one percent, four billion pounds of jet exhaust were vented into the atmosphere in 1970 alone.\textsuperscript{37}

Under the current scheme of regulation, prospects for adequate control of jet emissions during the present decade appear bleak at best. EPA acknowledges that emissions from particular engines will not decrease absent regulation,\textsuperscript{38} and that the types of aircraft in use will not change substantially for at least the next ten years.\textsuperscript{39} Thus the only major hope for non-regulatory emission reduction lies in airport activity—that is, in the number of takeoffs and landings occurring annually.\textsuperscript{40} But this figure is increasing;\textsuperscript{41} EPA has predicted

<table>
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<tr>
<th>Pollutant Type</th>
<th>CO</th>
<th>ORGANICS (HC)</th>
<th>NOx</th>
<th>PARTICULATES</th>
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</thead>
<tbody>
<tr>
<td>GROUND</td>
<td>164.3</td>
<td>70.7</td>
<td>5.24</td>
<td>0.80</td>
</tr>
<tr>
<td>FLIGHT</td>
<td>11.2</td>
<td>19.0</td>
<td>8.00</td>
<td>2.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td>175.5</td>
<td>89.7</td>
<td>13.24</td>
<td>2.80</td>
</tr>
</tbody>
</table>

\textsuperscript{HEW NATURE AND CONTROL, supra note 5, at 16. For a discussion of possible legal ramifications of the ground emission phenomenon, see note 110 infra and accompanying text. For more LTO emission data see Appendix I, infra.}

35. See \textit{HEW NATURE AND CONTROL, supra note 5, at 17, 20.} Since by weight carbon monoxide is the largest component of aircraft exhaust, comparisons by weight deceptively emphasize the carbon monoxide component over other toxic components such as nitrogen oxides, hydrocarbons, and particulates. \textit{See id. at 17.}

36. See text accompanying notes 47-54 infra. \textit{HEW} had considered this problem only cursorily. \textit{See HEW NATURE AND CONTROL, supra note 5, at 20-21.} The report concluded that, on the average, emission densities (tons emitted per square mile) in airports are not higher than emission densities in the surrounding cities. However, the land area used to compute airport emission densities is the entire land area of the airport rather than that immediately surrounding the terminal facility, where a large percentage of emissions are deposited. \textit{Id.} No separate analysis was made of emissions known to come from ground idling operations at the gate.

37. \textit{Jones Interview, supra note 3.}
38. \textit{Id.}
39. \textit{Id.}
40. \textit{Id. at 13-14.} See also note 8 supra.
41. \textit{Id. at 14.}
total activity for all FAA-operated airports will double by 1980. For specific major airports where aircraft pollution is already a problem, substantial activity increases are also predicted. Notably, Los Angeles International Airport, located in a region where air quality control is most difficult, will suffer the greatest activity increase of all major airports—32 percent in the decade ending in 1980.

II

RECOGNIZING THE PROBLEM

A. HEW's Initial View—The One-Percent Barrier

Prior to EPA's creation, the Department of Health, Education and Welfare (HEW) was responsible for air pollution control. HEW viewed the jet smoke problem not as a threat to public health but rather as an embarrassing airline public relations problem. In a report to Congress in 1968, the Secretary of HEW accepted the one-percent statistic, stating that aircraft emissions posed little or no national air pollution problem. The report compared emission densities at airports with those in surrounding urban areas and surprisingly concluded that because there was not much difference between these levels, aircraft emissions were not a significant local or national source of pollution. The Secretary's position, although explainable in part by unsophisticated measurement techniques then in use, made little sense in

42. Id. These projections are now subject to some revision in view of fuel shortages which will cause temporary decreases in activity, but will at most only slow the long-run growth rate of activity.
43. Id.
44. Apparently EPA has entirely abandoned hope that the Los Angeles Region will meet federally mandated air quality by the 1975 deadline established by the Clean Air Act. See 38 Fed. Reg. 17683 (1973).
45. See note 40 supra. This figure is also subject to revision. See note 42 supra.
46. This responsibility was then shifted to the Secretary of the Interior, and finally to the Administrator of EPA. See Reorg. Plan No. 2 of 1966, 3 C.F.R. 1021 (Comp. 1966-70) (eff. May 10, 1966); Reorg. Plan No. 3 of 1970 § 2(a)(1), 3 C.F.R. 1072 (Comp. 1966-70). EPA was created by the latter plan.
47. See HEW NATURE AND CONTROL, supra note 5, at 3.
48. Id.
49. HEW NATURE AND CONTROL, supra note 5, at 20, 21. See note 52 infra. The conclusion seems to reflect an unstated belief that localized sources could not present an air quality problem. EPA reached a contrary conclusion in a report required by section 231 of the Clean Air Act, 42 U.S.C. § 1857f-9(a) (1970). See EPA IMPACT, supra note 6, at 5. See also synopses of statements by EPA representatives in 3 ENV. RPTR.—CURR. DEV. 909 (1972). HEW's conclusion in 1968 that aircraft emissions posed no significant problem provided a basis for close cooperation between the airlines and FAA in supporting the airline position. See note 80 infra.
50. See HEW NATURE AND CONTROL, supra note 5, at 4, 6, 7-8. The detection,
view of a report, then in his possession, that expressed considerable concern over the problem. The Secretary had employed Northern Research and Engineering Corporation, a respected expert in the field of aircraft emission control, to assist him in analyzing and evaluating data. Northern Research had concluded in part that the federal government should begin to develop plans for abatement and control of aircraft emissions as soon as possible. Although the Secretary incorporated this conclusion into his report, the control philosophy he suggested was a passive one. He recommended that Congress take no regulatory action at the time, but rather that it allow the airline industry to respond voluntarily to public pressure under HEW's supervision. This suggestion was made despite the Secretary's acknowledged lack of regulatory authority to compel airline compliance should voluntary efforts later prove unsatisfactory.

monitoring, and control of mobile sources had been developed primarily in the field of automotive air pollution, since that source had been recognized as by far the major one.

51. Northern Research was the major investigator employed by the Secretary to conduct an emission survey and analyze data. The one-year time limit imposed by Congress on the study was too short to allow full laboratory testing. HEW NATURE AND CONTROL, supra note 5, at v. Therefore, the data evaluated by Northern Research was obtained from other testing organizations. *Id.*

52. On the issue of emission densities Northern Research reached a conclusion directly contradictory to that of HEW. See EPA IMPACT, supra note 6, at 5; see also note 49 supra and accompanying text. Northern Research concluded in part:

The density of aircraft emissions at air terminals and the resulting concentrations of pollutants are comparable . . . [to those in neighboring communities]. . . . On this basis, the impact of aircraft emissions on persons in the vicinity of the air terminal is considered to be comparable to the impact on persons in urban areas of emissions from other sources. . . . [Because of the lead time and the cost of implementation required in the industry] . . . [it is imperative that the federal government establish a control philosophy for aircraft emissions as soon as possible. The early development of an emission control philosophy for aircraft is the first and principal recommendation of this report.

NREC NATURE AND CONTROL, supra note 24, at 15, 19.

53. HEW NATURE AND CONTROL, supra note 5, at 4.

54. While there are no laws or regulations to compel the industry to follow through on this work [smoke control], it appears that public pressures resulting primarily from the adverse effects of odors and visibility obscuration will lead the industry to initiate the application of this technology as soon as possible and to complete it within the shortest possible time. Accordingly, it is the intention of this Department to encourage such action by engine manufacturers and airline operators and to keep close watch on their progress. If, at any time it appears . . . that completion of the work is unduly prolonged . . . the Department will recommend regulatory action to the Congress. . . . [As measures to achieve [further control of aircraft emissions] becomes available through research and development, it is the Department's expectation that engine manufacturers . . . [and] . . . airline operators will take the initiative in the development and application of such control measures . . .

*Id.*

55. *Id.*
B. Implementing Available Technology—Getting By with a Little Help from Your Friends

In 1968 the airlines already had certain technological advances available to begin reducing engine smoke, although it was a profitable military contract rather than independent industry research that provided them. The American military had long been concerned that its combat aircraft were easily detected because of their smoky exhaust trails. Consequently, in 1965 Pratt and Whitney, the major manufacturer of aircraft engines, was awarded a contract to reduce visible smoke produced by the J52 engine, the most visible military emitter and the combat counterpart of the JT8-D, which powers the Boeing 727, 737, and the McDonnell-Douglas DC-9. Approximately one-half of all jet engines in the commercial airline fleet are JT8-D's, but because they power short-haul craft which takeoff and land more frequently than long-range planes, JT8-D's have been responsible for approximately 70 percent of the smoke problem. Conveniently, the product of Pratt and Whitney's federally-funded J52 research was a modified combustor which reduced visible smoke and was easily adaptable only to the JT8-D. It was this limited technology that lay behind airline promises of progress, and not simply hard work and public ire, as the airlines like to tell it.

HEW had assigned the task of monitoring the airline smoke reduction effort to the National Air Pollution Control Administration (NAPCA). NAPCA was the enforcement arm of HEW and the forerunner of EPA. Subsequently the air industry offered informally to implement its limited but available anti-smoke technology by replacing the standard smoky combustors at the end of their useful

56. See Northern Research and Engineering Corp., Assessment of Aircraft Emission Control Technology 93 (1971) [hereinafter cited as NREC Assessment].
57. Reduction of Pollution, supra note 18, at 5; March Hearings, supra note 12, at 995.
58. While the combustion principles which reduced JT8-D smoke are generally applicable to all jet engines, the hardware developed in the research effort could only be adapted to the JT8-D. Osmun Interviews, supra note 13. Thus, the remaining half of all civilian jet engines in the United States airline fleet would remain smoky even after all technological improvements had been implemented.
59. Osmun Interview, supra note 13. The substance of the program and some of its technical aspects are described in HEW Nature and Control, supra note 5, at 23-25. A more detailed description is given in an industry narrative, Reduction of Pollution, supra note 18, at 6-8. The modification in large part consists of holes punched in the engine combustor cans in appropriate places. Id. Industry spokesmen imply that much of the research was conducted independently by the air industry. February Hearings, supra note 12, at 6. The reduction in visible smoke was cited in the Secretary's report as proof of the air industry's willingness to respond to the pollution problem. See HEW Nature and Control, supra note 5, at 4. However, the federal funding for these technological advances has never been publicly acknowledged.
lives at a rate that would have resulted in conversion ("retrofit") of the entire JT8-D fleet by December 1974. Assistant NAPCA Commissioner for Standards and Compliance, William H. Megonnell, met with the industry trade group, Air Transport Association (ATA), to discuss retrofitting the JT8-D's, but at the meeting the airlines, through ATA, refused to formalize their own previous offer of cooperation.

C. The Long Road to Federal Regulation

1. State Efforts

Although the federal government indicated it would be satisfied with the airlines' voluntary efforts, a number of states wanted more vigorous control. Under the Air Quality Act of 1967, regulation of aircraft emissions was left primarily to the states within each air quality control region defined pursuant to the Act. Proceeding under this authority, several states sought to reduce smoke emissions from aircraft as rapidly as was feasible. New Jersey and Illinois filed suit in their respective state courts to prevent further aircraft emissions in violation of applicable state laws. A third action filed by the state of New York sought to limit emissions of both smoke and noxious gases. Other states sought enforcement by various means. By

60. Osmun Interview, supra note 13.
61. Id.
62. The meeting was held August 28, 1969. Although 43 airlines were invited, 17 never responded, 12 refused to discuss the matter, and a total of 24 were represented by General Clifton F. von Kann, Vice-President of ATA, the industry trade association. At the meeting von Kann relied on the "one percent" figure cited in the HEW report (see notes 19 and 48 supra and accompanying text as "proof" that aircraft emissions were not a pollution problem, and he refused to sign a memorandum of agreement setting forth the retrofitting schedules ATA had itself suggested. J. Esposito, supra note 5, at 146.
64. Id. § 102, 81 Stat. 485. Once HEW designated a region, and published pollutant control criteria and control technology information, the governor or governors of the state or states affected were given 180 days to hold hearings and adopt emission standards.
65. Dept. of Health, State of New Jersey v. American Airlines, No. C3330-68 (N.J. Super. Ct., Essex County, filed Aug. 12, 1969). The action originally consisted of seven separate actions which were consolidated. New Jersey filed two weeks prior to Megonnell's meeting with ATA seeking, inter alia, orders requiring each of nine defendant airlines to submit schedules for implementation of plans to abate JT8-D smoke emissions.
66. State of Illinois v. Air France, No. 69-4458 (Ill. Cir. Ct., Cook County, dismissed Apr. 3, 1970). Illinois filed in November 1969, seeking to enjoin continued air pollution by 23 airlines using O'Hare and Midway airports. The Illinois suit was broader than the New Jersey action; it sought to control noxious gases as well as smoke, and was not limited to the JT8-D, but included all aircraft.
67. People of State of New York v. American Airlines et al., No. 6981/70, (N.Y. Sup. Ct., Nassau Co., action discontinued, Aug. 1, 1973). This suit, brought in January 1970, was not based upon a state air pollution statute, but upon the state
January 1970 the airlines were confronted with a number of pending state court actions, and other state and local actions were certain to follow. The FAA had also been accused of attempting to shield the airlines from state regulation.\textsuperscript{9} It is probable that such attacks prompted the FAA to issue an Advanced Notice of Proposed Rulemaking with regard to smoke emissions.\textsuperscript{10}

2. The Finch-Volpe Agreement—Flying United

Rather than proceeding under FAA rulemaking authority, however, FAA and HEW arranged an informal conference among 31 airlines, HEW Secretary Robert Finch, and Secretary of Transportation John Volpe.\textsuperscript{71} The result of this meeting was the "Finch-Volpe Agreement," a verbal understanding in which the airlines agreed to "substantially complete" the JT8-D retrofit program by December 31, 1972,\textsuperscript{72} fully two years earlier than the airlines had first claimed was feasible.\textsuperscript{73} Fearing that the legal actions instituted by the

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\textsuperscript{68} In February 1970, the Minnesota Pollution Control Agency issued citations to airlines serving the Twin Cities area, alleging violations of the state air pollution code. In March, Massachusetts initiated a rulemaking proceeding before the Massachusetts Department of Health. Inquiries were filed by Missouri and Maryland requesting schedules for retrofit of JT8-D combustors. The Los Angeles County Air Pollution Control District advised the airlines serving Los Angeles that as of January 1, 1971, the District would begin full enforcement of the state air pollution code with respect to aircraft emissions.

\textsuperscript{69} See 115 CONG. REC. 38210 (1969) (remarks of Senator Edmund S. Muskie). Senator Muskie believed the JT8-D retrofit program would significantly reduce aircraft pollution. His beliefs were shared by most people involved in the project. Id.


\textsuperscript{71} ATA was not invited to this meeting, which consisted of a private session followed by a press conference. No memorandum of agreement was signed, but a fair record of the meeting is the press release issued at the conclusion of the private conference. See FEBRUARY HEARINGS, supra note 12, at 9-10. A more complete summary may be found in the stipulated settlement to a subsequent lawsuit. See note 76 infra.

\textsuperscript{72} Since Secretary Volpe's admission that no written agreement existed (FEBRUARY HEARINGS, supra note 12) no writing signed by the parties involved has formalized the matter. Osmun Interview, supra note 13. A more detailed description of the agreement is provided in the settlement stipulation of the New Jersey suit against the airlines. See note 76 infra.

\textsuperscript{73} Letter from Stuart G. Tipton, President of ATA, to FAA Administrator
states would result in permission for the states to apply varying emission control standards,\textsuperscript{74} ATA used the Finch Agreement as the basis of settlement in all pending actions.\textsuperscript{75} The New Jersey action was the first to be settled under the terms of the agreement,\textsuperscript{76} and included

\begin{quote}
John Shaffer, Jan. 14, 1970. The letter was sent only six days before the Finch Agreement was reached; in it ATA maintained that conversion could not be achieved until December 1974. The speed-up was to be accomplished by replacing each old JT8-D combustor can at its first major engine overhaul, rather than at the end of its useful life. \textit{Id.} The airlines first predicted that significant cost increases would result because expensive parts would have to be scrapped during conversion. They indicated that modification of a single engine would cost $10,000, for a fleet total of $30 million. Shortly after the Finch Agreement was reached, Pratt and Whitney developed a "kit" for retrofitting combustors that allowed the re-use of parts the airlines had claimed would have to be discarded. This innovation reduced modification costs by approximately half. Osmun Interview, \textit{supra} note 13. The air industry, however, has continued to claim its original estimated cost as an investment in pollution control with no valid justification for citing a cost figure inflated by 100%. Mr. Osmun of ATA explained that in using the larger figure the airlines were making allowance for "hidden costs" which would arise. When asked whether or not there would be expected savings on fuel consumption and aircraft cleaning costs once the low-smoke burner cans had been in operation, he explained that calculations on those subjects had not been made, but that such savings seemed reasonable. When asked what the "hidden costs" were, Osmun replied that comprehensive calculations had not yet been performed. He would not name categories in which the airlines expected these costs to arise, nor would he venture estimates as to their magnitude. \textit{Id.}

74. \textit{See March Hearings, \textit{supra} note 12, at 1001 (statement of Stuart G. Tipton, President, ATA).}

75. Memorandum from John Stephen, ATA General Counsel, to carrier attorneys, Mar. 10, 1970. ATA represented nine of its member carriers in Minnesota proceedings where it urged acceptance of the Finch Agreement and appeared in Massachusetts Department of Health proceedings (see note 68 \textit{supra}). Air Transp. Ass'n, Federal, State and Local Regulations of Aircraft Engine Emissions at 5 (1970). In addition, ATA applied direct pressure against airlines expressing willingness to accelerate the conversion process. When Maryland, not fully satisfied with the terms of the Finch Agreement, filed separate inquiry to ATA member carriers to determine the earliest possible target date for retrofit completion, some carriers proposed a date earlier than the December 31, 1972 deadline set by the Finch Agreement. Washington Post, Feb. 22, 1970, at E 1, col. 4. In response to such statements by the carriers, ATA counsel Stephen warned other carriers not to set an earlier date than that stipulated in the Finch Agreement because "... such a commitment will be demanded elsewhere." Memorandum from John Stephen, ATA General Counsel, to carrier attorneys, Feb. 27, 1970. The Stephen memo raises significant antitrust issues. \textit{See, e.g., American Column & Lumber Co. v. United States, 257 U.S. 377 (1921). It also appears that much of ATA's activity in the smoke litigation has violated CAB Order No. E20409 ¶ 2b, which prohibits ATA from furnishing legal services to carrier members except for the purpose of advising on ATA's activities those carrier representatives involved in ATA committees and conferences.

76. The New Jersey action was settled according to terms set forth in a stipulation dated March 5, 1970, in which the airlines agreed to order the modified combustors from the manufacturer within 90 days from January 20, 1970 (the date of the Finch meeting). They agreed that installation of the combustor cans would take place at the next major engine overhaul of each JT8-D, and that installation for the fleet would be substantially completed by December 31, 1972. Each airline defendant agreed to present a schedule of retrofit progress to the New Jersey Department of Health on a
provisions for periodic reporting to the State on retrofit progress.\textsuperscript{77} Notably, New Jersey did not contest the airlines' commerce clause objections to state jurisdiction over aircraft emissions.\textsuperscript{78}

D. The Clean Air Act—1970 Amendments

At the same time, growing demands for federal regulation of aircraft pollution made it clear that some congressional action would soon be forthcoming. Nevertheless, the airlines sought in every way possible to forestall the inevitable. Continuing airline opposition to the creation of federal aircraft emission standards is reflected in the history of the 1970 Clean Air Amendments.\textsuperscript{79} ATA sought to secure an FAA and Department of Transportation (DOT) veto over any standards which the EPA Administrator might propose.\textsuperscript{80}

The airlines also agreed to integrate smoke-reducing technology in new craft as purchased. Stipulation of the Parties, Docket No. C3330-68, filed Mar. 9, 1970, at 5-7 [hereinafter cited as New Jersey Stipulation]. A copy of the complaint and the stipulation of settlement may be found in LandaU, THE ENVIRONMENTAL LAW HANDBOOK 276, 280 (1971). Because the Finch Agreement was not reduced to writing, the New Jersey settlement provides the most complete record of the substance of the Finch Agreement. See note 72 supra.

77. See New Jersey Stipulation, supra note 76. The Finch Agreement required similar periodic reports to FAA and HEW. Interview with Edward Sellman, Office of Noise and Pollution Abatement, FAA, Washington, D.C., July 6, 1972 [hereinafter cited as Sellman Interview].

78. See New Jersey Stipulation, supra note 76. For a discussion of the merits of related commerce clause and preemption objections under applicable sections of the Clean Air Act, see note 110 infra and accompanying text.


80. See draft of Comments by Stuart Tipton, ATA President, to be delivered on March 25, 1970, during MARCH HEARINGS, supra note 12. The ATA version of section 232(c) of the Clean Air Act would have rendered ineffective any aircraft emission standard, rule or regulation issued by the Administrator unless the Secretary of Transportation issued a written finding that it was economically reasonable, technologically practicable, and consistent with the highest standards of safety. Id. at Appendix p.1. FAA and DOT could be expected to have used such a veto power frequently, since FAA remains unconvinced that aircraft emissions are a serious problem. As late as 1971, a member of the three-man FAA staff responsible for monitoring industry progress in pollution and noise abatement wrote that the only real basis for concern about aircraft emissions was the "subjective appearance of this symbol of pollution." See Westfield, supra note 12. ATA, when pressed, will admit that in areas around airports, aircraft emissions are a bigger problem than they at first suspected. FAA staff personnel refuse to admit even this. Osmun Interview, supra note 13; Sellman Interview, supra note 77. When independent testing of smoke-fixed JT8-D's was performed for EPA in order to expose any manufacturer's bias, two of three independent testing organizations reported increases in emissions of NOx which agree within a few percentage points. Analysis, supra note 34, at 32. FAA claimed these results are wrong and that the manufacturer's data, which shows no increase in NOx emissions, is correct. Sellman Interview, supra note 77. FAA staff have written articles attempting to substantiate airline claims that aircraft emissions are an insignificant contribution to the air pollution problem. See, e.g., Westfield, supra note 12. FAA briefs have included airline and ATA public relations charts marking prog-
Although unsuccessful in obtaining such a veto, ATA did prevail in its request that any federal standards established preempt similar state efforts. Because most airlines operate interstate, the need for uniform standards, and hence for federal preemption, is compelling. Sections 231(a) and 233 of the Clean Air Act acknowledge this need, requiring the EPA Administrator to establish controlling federal emission standards by regulation. Although these standards were to be proposed within 270 days after passage of the Act, they were not actually issued until late 1972, more than a year beyond the statutory deadline. Final regulations embodying those standards were not adopted until July 17, 1973, almost two years behind schedule.

III

THE CURRENT REGULATORY STRUCTURE

A. Problems Under the Clean Air Act

EPA acknowledges that little progress will result absent regulation. Thus, the effectiveness of recently adopted regulations will determine the benefit to accrue from aircraft pollution control. EPA's aircraft emission standards prescribe for each engine type the maximum

82. March Hearings, supra note 12, at 1001.
85. 37 Fed. Reg. 26488 (1972). Proposed regulations were issued approximately two weeks after suit was filed by the Massachusetts Attorney General in United States District Court to compel the EPA Administrator to issue proposed regulations as required. The action was grounded on the "citizen-suit" provisions of the Clean Air Act. Clean Air Amendments of 1970 § 304, 42 U.S.C. § 1857 h-2 (1970); see also 3 Env. Rptr.—Curr. Dev. 882 (1972).
86. Section 231(a)(3) of the Clean Air Act requires final regulations to be issued within 90 days from the issuance of the proposed regulations. 42 U.S.C. § 1857f-9(a)(3) (1970). This deadline has not been met either. Proposed regulations were issued December 12, 1972. 38 Fed. Reg. 26488 (1972); final regulations were adopted July 17, 1973, 38 Fed. Reg. 19089 (1973), although the Act became law December 31, 1970.
87. See note 37 supra.
emissions to be permitted per landing and takeoff. For planes now in use, the regulations merely formalize the Finch-Volpe Agreement. The standards for new planes being developed, however, are exceedingly strict and will require significant advances in aircraft combustion technology within the next decade. Because of the long lead time necessary to develop and implement required technology, hardware innovations alone will produce little or no improvement in airport air quality before the mid-1980's.

The current regulatory scheme is subject to further potential impediments imbedded in the Clean Air Act itself. Section 231(b) of the Act provides that any regulations regarding aircraft emissions shall take effect only after such period as the Administrator finds necessary (after consultation with the Secretary of Transportation) to permit the devel-

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**ENGINE/REPRESENTATIVE AIRCRAFT**

<table>
<thead>
<tr>
<th>ENGINE/REPRESENTATIVE AIRCRAFT</th>
<th>HC</th>
<th>CO</th>
<th>NOx</th>
</tr>
</thead>
<tbody>
<tr>
<td>JT3D/ B707</td>
<td>96</td>
<td>81</td>
<td>39</td>
</tr>
<tr>
<td>JT8D/ B727, B737</td>
<td>70</td>
<td>73</td>
<td>63</td>
</tr>
<tr>
<td>JT9D/ B747</td>
<td>60</td>
<td>55</td>
<td>57</td>
</tr>
</tbody>
</table>

Table compiled from representative emission levels noted in Analysis, supra note 34, Appendix III, and from applicable standards listed below.

The regulatory scheme is as follows:

1. New civilian jet engines manufactured and certified after January 1, 1979, must meet the following standards:

<table>
<thead>
<tr>
<th>HC</th>
<th>CO</th>
<th>NOx</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>4.3</td>
<td>3</td>
</tr>
</tbody>
</table>

   (All units are pounds of pollutant per 1000 lb. thrust-hour per LTO cycle.) Smoke emission limits are derived from a thrust-related curve which assures that jet smoke will be near or below the limits of visibility. 38 Fed. Reg. 19091, 19092 (1973) (printing error corrected 38 Fed. Reg. 20327 (1973)).

2. Engines in use by January 1, 1979, must meet these same standards.

3. Proposed standards have been issued for engines used on long-range aircraft such as the Boeing 707 that are in use on January 1, 1983. These standards are identical to those stated in (1), supra. Smoke opacity will be determined according to the variable scale noted above. 38 Fed. Reg. 19050-51 (1973).

89. See 37 Fed. Reg. 26502 (1972). EPA's Advanced Notice of Proposed Rule Making regarding modification of ground operating procedures indicates that hardware-oriented standards proposed the same day would not produce HC and CO reductions projected until the late 1970's and early 1980's due to the long time required to phase in the new engines. The final regulations adopted imposed no HC or CO regulation until January 1, 1979, compared with the earlier proposal requiring significant reductions by 1976. See 38 Fed. Reg. 19088 (1973). Thus the entire emission reduction program has been set back at least three years in addition to the initial delay in issuing standards. See text accompanying notes 84-86 supra.
Numerous delays can be expected. Airlines will no doubt object on grounds of cost as they have done in the past. These objections should be scrutinized most carefully, given the industry practice of overstating costs of pollution control. EPA's required consultation with the Secretary of Transportation will undoubtedly produce long delays in enforcement of emission standards. If past performance is a guide, even a conservative standard package promulgated by EPA would provoke arguments by the airlines and DOT that the standards are too harsh too soon. Given the strictness of aircraft emission standards to be implemented in the coming decade, however, EPA may be unable to enforce its engine-design regulations because they require too much. Furthermore, because the Act requires the EPA Administrator to confer with the Secretary of Transportation before aircraft emission standards can take effect "in order to assure appropriate consideration for aircraft safety," other airline objections will undoubtedly be tied to questions of safety, thus providing the aviation industry with both an excellent objection to proposals designed to reduce emissions and an effective defense to charges of environmental footdragging.

91. See, e.g., March Hearings, supra note 12, at 1008.
92. See note 73 supra.
93. The Administrator first thought 1979 would provide sufficient lead time for development of required technology. He also believed that interim progress would produce a useful "hardware solution" by 1976. See proposed regulations, 37 Fed. Reg. 26488 (1972). As events have proved his earlier assessment incorrect, initial enforcement has been moved back until 1979, and fully adequate hardware will not appear until 1981. See final regulations, 38 Fed. Reg. 19088-92 (1973). Given the repeated delays attributable to hardware failures, EPA should give more immediate consideration to operating modifications which could produce immediate reductions in emissions. See notes 132-48 infra and accompanying text.
94. Dr. Kay Jones, Senior Staff Scientist with EPA's Office of Air and Water Programs and a draftsman of the proposed standards, believes that stricter standards can be achieved if the airlines are given a reasonable length of time to comply, thus providing a greater long-term reduction. Jones Interview, supra note 3. This philosophy was incorporated into the proposed EPA standards package promulgated in December 1972 and finally adopted with revisions in July 1973. Emission goals included massive reductions in HC, CO, and NOx emissions from aircraft engines in production at the end of the decade. 37 Fed. Reg. 26491; see note 88 supra. The standards finally adopted do require advanced technology. See note 88 supra and note 128 infra. The overall "strictness" is disputable, however, for published analyses of ground operations procedures indicate that at least two of these goals (HC and CO) might currently be met without engine modifications. See generally Condren, Minimization of Air Pollution at New York's La Guardia Airport (paper delivered at the Fifth Annual Northeast Regional Antipollution Conference, 1972) [hereinafter cited as LaGuardia Study].
95. See note 88 supra.
Other provisions of the Clean Air Act raise significant questions about the enforceability of current aircraft emission standards. Section 232 of the Act requires the Secretary of Transportation to prescribe conformance regulations to assure compliance with all emission standards issued by EPA.\textsuperscript{97} The job of enforcing prescribed emission standards thus rests with DOT, the cabinet-level agency encompassing FAA, for the aircraft-related sections of the Clean Air Act give no enforcement authority to the EPA Administrator.\textsuperscript{98} In addition, no time limits are established for issuance of conformance regulations by the Secretary of Transportation.\textsuperscript{99} Therefore, if he delays issuing the regulations, EPA will not be in a position to apply legal pressures.\textsuperscript{100}

If excessive delay resulted under the current regulatory scheme, the public could not participate in the enforcement process either, as it is denied access to the “citizen suit” provision of the Act. Section 304 creates a federal cause of action only against those persons and instrumentalities of the federal government who are alleged to be “in violation of . . . an emission standard or limitation” of the Clean Air Act,\textsuperscript{101} or in violation of “an order issued by the [EPA] Administrator or a State with respect to such a standard or limitation.”\textsuperscript{102} The same section provides that only the EPA Administrator is subject to citizen suits for (1) failure to perform an act or duty not within his discretion, that is (2) required of him under the Act, and that (3) is not required by an applicable implementation plan.\textsuperscript{103}

\textsuperscript{97} Clean Air Amendments of 1970 § 232(a), 42 U.S.C. § 1857f-10(a) (1970). His orders to comply with EPA standards may be amended or revoked upon successful appeal to the National Transportation Safety Board only upon a finding by the Board that no violation of regulations exists and that such amendment or revocation is “consistent with safety in air transportation.” Id. § 232(b), § 1857f-10(b).

\textsuperscript{98} If certain sections of the Act are read together, the EPA Administrator might improve his enforcement posture. See notes 161-76 infra and accompanying text. If EPA were to adopt ground operation regulations as part of state implementation plans, EPA could exert its enforcement authority under section 113, and section 304 citizen suits could be brought against non-complying airlines. See text accompanying notes 101-04 and 174-76 infra.


\textsuperscript{100} A tentative draft of FAA enforcement regulations is now circulating through agency channels. See Tentative FAA Regulatory Draft re Environmental Protection Agency Proposed Aircraft Emission Standards, 1973. Legitimate delays can be expected, given the necessary safety tests which high-technology aircraft engine modifications must pass. See Airworthiness Standards for Aircraft Engines, 14 CFR § 33 (1973).


\textsuperscript{102} Id. § 304(a)(1)(B), 42 U.S.C. § 1857h-2(a)(1)(B).

\textsuperscript{103} Id. § 304(a)(2), 42 U.S.C. § 1857h-2(a)(2). For a discussion of the effect of adopting aircraft regulations as part of an implementation plan, see notes 174-76 infra and accompanying text.
Thus a citizen suit under section 304 could not be brought against the Secretary of Transportation to enforce EPA's aircraft emission standards, nor could one be brought against the EPA Administrator since under section 232 of the Act he has no power to enforce emission standards he is required to promulgate.\(^{104}\)

If DOT is recalcitrant in its enforcement of the standards, the best enforcement opportunities may be under state law. Section 233 of the Clean Air Act preempts enforcement of any standard regarding aircraft emissions "unless such standard is identical to a standard applicable to such aircraft under this part."\(^{105}\) Thus an aggressive state enforcement authority could adopt aircraft emission standards identical to those promulgated by EPA and seek to enforce them, if DOT does not, through actions in its own courts. The airlines, however, have not yet agreed that states have jurisdiction over aircraft operating in interstate commerce.\(^{106}\) Whether section 233 can properly be interpreted as creating a state right to enforce federal standards depends in part on the rationale for preemption. The history of the Clean Air Act suggests that the only concern in this regard was the creation of a uniform set of emission standards.\(^{107}\) Given the spirit of the Act, its broad grant of standing in other sections,\(^{108}\) and the explicit exception to federal preemption whenever state and federal standards are identical,\(^{109}\) a court could reasonably conclude, despite objections related to interstate commerce, that Congress intended to create an implied right of enforcement.\(^{110}\) Clearly Con-

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104. Id. § 1857f-10 (1970). The Secretary of Transportation would not be in violation of a standard or limitation under the Act as required by the citizen suit provisions of section 304, and therefore that avenue is foreclosed. The airlines, which would otherwise be subject to suit for violating an emission standard under the Act, would have a defense in that they cannot operate aircraft without certification from DOT. See 14 CFR §§ 21.19, 21.21, 21.171-.189, 121.3, and 121.27 (1973).

105. Section 233 is quoted in full, infra note 176.

106. Each of the state court settlements preserved airline objections to state jurisdiction over aircraft emissions. See e.g., New Jersey Stipulation, supra note 76.


110. Until June 1973 it appeared possible that states might lawfully regulate aircraft ground operations despite the explicit preemptive provisions of section 233. Allway Taxi Inc. v. New York City, arising under other preemptive provisions of the Clean Air Act dealing with automotive emission standards, held that where the exercise of local police power serves the purposes of that Act, its preemptive aspect should be narrowly construed. 340 F. Supp. 1120, 1124 (S.D.N.Y. 1970), citing Chrysler Corp. v. Tofany, 419 F.2d 499 (2d Cir. 1969). Effective regulations could be adopted locally to regulate excessive emissions during ground operations. See notes 132-47 infra and accompanying text. Since these regulations would further the purpose of the
gress would not have preempted regulation of this matter only to assure that no regulation would ensue. The airlines, however, would appear to have a strong defense if the Secretary of Transportation could not certify needed aircraft engine modifications as safe by the required deadline. Once again, it appears the technological complexity of EPA's chosen regulatory scheme and its dependence on future engine modification will work against prompt enforcement of needed emission limitations.

Clean Air Act and would be compatible with its goals, a court could reasonably conclude that such regulation was not barred by it. *Id.* at 1124, *citing* Huron Portland Cement Co. v. Detroit, 362 U.S. 440 (1960). The argument is particularly compelling since the only reason for section 233 preemption was fear of varying engine performance standards applicable to aircraft in transit across state lines. See note 107 *supra* and accompanying text. Unbridled state authority to regulate aircraft engine emissions would have allowed the strictest state standard to determine performance characteristics of a national industry, since aircraft engines in interstate commerce would have to meet the strictest standard of all the states they served. Ground operation regulations on the other hand, would be limited geographically and would therefore burden interstate commerce to a far lesser degree. This argument for state regulation of ground operations was all but laid to rest by the United States Supreme Court in June 1973 in *City of Burbank v. Lockheed Air Terminal Inc.*, 411 U.S. 624 (1973). The Court held that because federal regulation of aircraft noise is thoroughly detailed by provisions of both the Federal Aviation Act of 1958, 49 U.S.C. § 1301 *et seq.* and the Noise Control Act of 1972, 86 Stat. 1234 and regulations thereunder, 14 C.F.R. Pts. 71-77, 91-97, the field is preempted. *Id.* at 626. While Justice Rehnquist's dissent (*id.* at 640) is vigorous and his technological arguments parallel some made here, the history of regulation in this area, combined with the majority opinion will most likely assure that the approach outlined in this footnote will not generally be followed.

Regulations adopted under other sections of the Act may be interpreted to give states land-use authority to control ground operations. Because aircraft pollution is so concentrated around airports, an airport might be considered a stationary source of air pollution. See note 34 *supra*. In this context, "complex-source" regulations recently adopted pursuant to section 110 of the Act may bring aircraft pollution under state jurisdiction. Complex sources are merely stationary structures that produce air pollution indirectly by attracting traffic or other pollution-producing activities. Although the prime concern expressed is regulation of automobile exhaust pollution produced by sources such as sports complexes and airports, the regulations are sufficiently broad to include aircraft emissions from non-flight activities. *See* 38 Fed. Reg. 15834 (1973). The regulations require state implementation plans to contain authority to:

> [p]revent construction, modification, or operation of a facility, building, structure, or combination thereof, which directly or indirectly results or may result in emissions of any air pollutant which will prevent the attainment or maintenance of a national standard.

38 Fed. Reg. 15836 (1973) (emphasis supplied). Although these complex-source regulations appear to lend some support to arguments for direct state regulation of aircraft ground operations independent of EPA, state attempts at regulation absent identical federal regulation would still contradict the pre-emptive provisions of section 233 (quoted in full at note 176 *infra*). Attempted state regulation through the complex source route alone thus appears to be an inferior approach to that suggested in the text accompanying notes 150-71 *infra*, although complex-source authority may prove an appropriate means for enforcing federal aircraft ground regulations once they are established. For an excellent discussion of land-use questions arising under the Clean
B. Results of Regulation to Date

Both the aviation industry and independent testing organizations have evaluated current industry efforts to reduce jet emissions, and the results are not encouraging. A recurring problem in analyzing aircraft emission data has been the wide variation in HC and CO test measurements reported. Large data variations create problems in detecting significant differences among test groups.111 Since successive HC and CO test results obtained from the same engine vary widely, without extensive testing it is difficult to determine whether apparent variations in test results are due to engine modifications or to random statistical fluctuations.112 In the case of the JT8-D retrofit program, sufficient testing was not performed to warrant fully industry claims

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111. Analysis, supra note 34, at 48-49. One notable example of wide variation in results obtained by different testing groups is the discrepancy between data reported by Pratt and Whitney and by EPA. In tests performed on the JT3-D, the engine which powers the Boeing 707 and Douglas DC-8, the following results were reported:

<table>
<thead>
<tr>
<th></th>
<th>CO (pounds of pollutant per takeoff and landing)</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pratt and Whitney</td>
<td>38.5</td>
<td>19.9</td>
</tr>
<tr>
<td>EPA</td>
<td>67.9</td>
<td>62.1</td>
</tr>
</tbody>
</table>

Id. The problem is not merely that EPA and Pratt and Whitney average results do not agree; successive tests of the same engine often yield equally inconsistent results; variation in test results of engines of a given type is often comparable to the mean value recorded for all engines of that type. Id. at 49.

112. Whenever a number of items is tested to establish a mean or average value for some characteristic, there is a measurable probability that the average value calculated from the test sample lies within a given percentage of the true mean for the total population of such items. The more consistent successive test results are, the more probable it is that the mean value calculated from the test sample lies within a given percentage of the true mean. Thus the more variable or inconsistent test data are, the more individual test values will be required to establish the same confidence in a reported mean as could be obtained by fewer tests of a more consistent sample.

This relationship is quantified in the statistical concept known as “confidence interval.” A confidence interval is merely a range of values around a reported mean within which the true population mean will lie with a stated probability. The relative consistency of test data is expressed by the coefficient of variation which is defined as the standard deviation of the test sample divided by the sample mean. A confidence level usually sought in scientific study is 95%; that is, one wishes to know within what range of the reported sample mean the true mean lies with a probability of 95%.

Where one wants to observe the effects of a given modification on the true population mean (e.g., if retrofit really reduced HC emissions), one measures the mean both before and after modification and compares the two values. If the sample mean calculated after modification lies within the confidence interval about the mean of the unaltered sample, one cannot conclude at that confidence level that the change had any effect at all.
that HC and CO had been significantly reduced as a by-product of smoke reduction.\textsuperscript{113} Emission data for NOx, however, is sufficiently consistent to prove emission increases of that pollutant with 95 percent certainty.\textsuperscript{114}

The only engine emission data presently available for the new "jumbo jets" has been provided by the manufacturer, Pratt and Whitney. In every comparison made by Cornell Aeronautical Laboratory between the production model of the "jumbo jet" JT9-D en-

\begin{table}[h]
\centering
\caption{Factors for Confidence Intervals}
\begin{tabular}{lcccc}
\multicolumn{1}{c|}{Coefficient of variation, p (\%)} & 15 & 30 & 45 & 60 & 75 \\
\hline
Sample Size, N & & & & & \\
1 & 29.4 & 58.8 & 88.2 & 117.6 & 147.0 \\
4 & 14.7 & 29.4 & 44.1 & 58.8 & 73.5 \\
9 & 9.8 & 19.6 & 29.4 & 39.2 & 49.0 \\
16 & 5.9 & 11.8 & 17.6 & 23.5 & 29.4 \\
25 & 4.9 & 9.8 & 14.7 & 19.6 & 24.5 \\
36 & 4.2 & 7.7 & 12.6 & 16.8 & 21.0 \\
49 & 3.7 & 7.4 & 11.0 & 14.7 & 18.4 \\
64 & 3.3 & 6.5 & 9.8 & 13.1 & 16.3 \\
81 & 2.9 & 5.9 & 8.8 & 11.8 & 14.7 \\
100 & & & & & \\
\hline
\end{tabular}
\end{table}

\textsuperscript{113} Although aircraft emission data are generally subject to extreme variation, the variability is most pronounced for HC and CO emissions in the low-power ranges of operation such as taxi and idle. Analysis, supra note 34, at 48. This results from the difficulty involved in duplicating specific power settings in these ranges and from large emission variations which result from even small deviations in power settings in the low-power ranges. Id. at 20. For HC and CO emissions particularly, test results vary widely among test organizations. Appendix I presents emission data analyzed by Cornell Aeronautical Laboratory. The various testing organizations participating are identified, as are the pertinent summary statistics. Table I compares coefficients of variation plotted horizontally with perfect-square sample sizes charted vertically. At the intersection of each corresponding horizontal and vertical entry is the percentage of the sample mean within which the true population mean will lie with 95% confidence. For example, where available emission data display a coefficient of variation of 15%, nine engine tests would be required to be 95% certain that the true population mean lies within 10% of the reported mean, either above it or below it. Thus it appears from Appendix I and Table I that too few tests were performed to make meaningful assessments of HC or CO emissions, but NOx emissions are predictable at the 95% confidence level.

\textsuperscript{114} In seeking to compare emission levels before and after low-smoke conversion, one seeks to compare differences between two successively drawn samples. The variation of these differences is larger than the variation in any given sample simply because the large variation in test values heightens the probability of larger variations between successive sample means. Table II presents an estimate of the least significant difference between two successive means to assure with 95% confidence that the difference is not merely due to chance. The tabular entries are expressed as a percentage of the midpoint of the two means being compared.
erie and current jet engines, JT9-D NOx emissions were significantly higher.\textsuperscript{115} The industry claims these planes are capable of carrying more passengers so that the amount of pollution per passenger may be reduced. This fact, however true, is irrelevant, since only total emissions affect air quality, and these will increase, there being no plans to reduce significantly the number of scheduled flights.\textsuperscript{116} Northern Research concludes that NOx emissions from aircraft already contribute significantly to poor air quality in airport vicinities and predicts that

\textbf{TABLE II}

\textbf{LEAST SIGNIFICANT DIFFERENCE BETWEEN MEANS}

\begin{center}

\begin{tabular}{|c|c|c|c|c|c|}
\hline
Coefficient of variation, p (%) & 15 & 30 & 45 & 60 & 75 \\
\hline
Sample & 1 & 41.6 & 83.2 & 124.7 & 166.3 & 207.9 \\
Size, N & 4 & 20.8 & 41.6 & 62.4 & 83.2 & 103.9 \\
& 9 & 13.8 & 27.7 & 41.6 & 55.4 & 69.3 \\
& 16 & 10.5 & 20.8 & 31.1 & 41.6 & 52.0 \\
& 25 & 8.3 & 16.7 & 24.9 & 33.2 & 41.6 \\
& 36 & 6.9 & 13.9 & 20.8 & 27.7 & 34.6 \\
& 49 & 5.9 & 10.9 & 17.8 & 23.8 & 29.7 \\
& 64 & 5.2 & 10.5 & 15.6 & 20.8 & 26.0 \\
& 81 & 4.7 & 9.2 & 13.9 & 18.5 & 23.0 \\
& 100 & 4.1 & 8.3 & 12.4 & 16.7 & 20.8 \\
\hline
\end{tabular}

Source: Analysis, supra note 34, at 36.

Referring to Appendix I, a comparison of NOx emission means for JT8-D's tested by the SWRI-TWA group indicates an approximate NOx mean difference of 1.3, or 21 percent of 6.2 (the approximate midpoint of the "regular" and "smokeless" means reported in Appendix I for that test group). Referring to Table II, interpolating between the two sample sizes (i.e., N=16) and interpolating coefficients of variation, the resulting NOx increase appears to be twice that necessary for significance. Conversely, the results of CO and HC calculations indicate reductions are not significant at the 95% confidence level. Thus it appears that insufficient testing was performed to substantiate fully claims of reduced HC and CO emissions, but sufficient evidence exists to verify predicted increases in NOx emissions. These results do not necessarily imply that no HC or CO reductions will occur, only that they cannot be predicted with the degree of certainty usually required in precise scientific analyses.

\textsuperscript{115} See Analysis, supra note 34, at 39. Similarly, where an experimental model JT9-D was compared with other commercial jet engines, in every case JT9-D NOx emissions were significantly higher; the usual result obtained was a JT9-D NOx emission level four times that of engines used in the majority of standard passenger jetcraft. \textit{Id.} NOx emissions for the JT9-D were even higher than those of the "smoke-fixed" JT8-D's. \textit{Id.}

\textsuperscript{116} The air industry frequently argues that the new "jumbo" jets pollute less per passenger than do standard jets. \textit{See, e.g., Reduction of Smoke, supra note 19, at 4.} This argument is misleading, since emissions do not vary directly with the number of passengers, but rather with the emissions per engine per LTO cycle. Total aircraft emissions thus remain comparable because many of the "jumbo" jets have the same number of engines as their smaller predecessors, and there is no apparent intention by the industry to reduce the number of flights scheduled because of increased passenger capacity. \textit{See EPA Impact, supra note 6, at 14.} At best the engine modifications which have resulted in "reduced" emissions from "jumbo" jets have done no more than prevent the aircraft emission problem from becoming significantly worse.
total aircraft NOx emissions will triple by the end of the decade,\textsuperscript{117} although it also predicts significant decreases in HC and CO emissions during the same period, basing its predictions on the unverified data just discussed.\textsuperscript{118} Even if such reductions do in fact occur, the predicted 1980 pollutant levels in passenger areas of at least one major airport would be at least twice allowable levels.\textsuperscript{119}

The jet emissions problem is thus made even more severe because control of NOx is one of the most difficult problems currently facing air quality enforcement authorities,\textsuperscript{120} and the emphasis on engine modification only aggravates enforcement difficulties. While HC and CO emissions could be sharply curtailed by relatively simple modifications in aircraft ground operations,\textsuperscript{121} the high-technology solution pronounced by EPA increases NOx emissions, which predominate in flight where they cannot be easily controlled.

Furthermore, sufficient research has not been performed to prove conclusively that by making smoke "invisible," current technology has not made it a greater menace than it was before anyone bothered with it. Although air industry publications indicate the total weight of particulates has been reduced from .42 to .19 pounds per landing and takeoff,\textsuperscript{122} no work has yet been done to determine the size distribution of particles now emitted. If these particles

\textsuperscript{117} NREC IMPACT, \textit{supra} note 9, at 94-95. The conclusion is based both on projected increases in aircraft activity and upon recorded emission values for existing aircraft. \textit{Id.} Oxides of nitrogen are predicted to increase 275\% at Los Angeles, 146\% at Kennedy, 98\% at O'Hare, and 33\% at Washington National airports respectively. EPA IMPACT, \textit{supra} note 6, at 15. Fuel shortages may blunt these spectacular rates of increase by slowing the increase in aircraft activity. There is some question regarding the true ambient level of NOx in the atmosphere, since EPA has recently discovered that its approved NOx testing procedure provides erroneously high readings at critical NOx concentrations. \textit{See} 38 Fed. Reg. 15174 (1973). EPA still believes its ambient standard of 100\mu g/m\textsuperscript{3} (micrograms/cubic meter) is valid, however. \textit{Id.} Thus there can be no excuse for ignoring these NOx increases where, as in Los Angeles, for example, NOx standards are already grossly exceeded. \textit{Id.} at 15181. Yet EPA has required implementation of airline low-smoke technology that will aggravate the NOx problem. 40 CFR § 87 (1973); 38 Fed. Reg. 19089, 19092 (1973).

\textsuperscript{118} For the decade ending 1980, EPA predicts HC decreases of 60-70\% at Los Angeles, Kennedy, and O'Hare airports and an 18\% increase at Washington National Airport. EPA IMPACT, \textit{supra} note 6, at 15. As far as can be determined, Northern Research used the mean reductions in gaseous emissions as reported by the engine manufacturer who supplied data for analysis. The manufacturer did not perform adequate statistical analysis of the data to validate its significance. See notes 113-14 \textit{supra}.

\textsuperscript{119} EPA IMPACT, \textit{supra} note 6, at 44, 45, for discussion concerning Los Angeles International Airport.

\textsuperscript{120} Jones Interview, \textit{supra} note 3.

\textsuperscript{121} EPA predicts HC and CO reductions of 50\%-70\% achievable by modifying ground operations. \textit{See}, e.g., 3 \textit{ENV. RPRTR.—CURR. DEV.} 909 (1972).

\textsuperscript{122} \textit{REDUCTION OF SMOKE}, \textit{supra} note 19, at 2.
have become significantly smaller, they may present a greater hazard to public health than when they were highly visible, and although the total mass of particles emitted has been reduced, a corresponding reduction in their size may be such that the total number of particles emitted has actually increased. M.I.T. has warned of this latter hazard, and Northern Research has pointed out that visibility alone is not a conclusive test of the pollutant effect of exhaust plumes. At the very best, the chief result of aircraft emission control to date will have been some reduction in pollutants easily controlled, coupled with a shift from the production of relatively less toxic emissions to those which are more toxic, more difficult to control, but less visible. One certain result has been a failure to meet air quality standards on schedule at airports where the bulk of jet pollutants are deposited. The specific engine modification control strategy pursued by the aviation industry thus appears to be a poor one, particularly when compared with additional or alternative controls which might have been employed.

IV

ALTERNATIVE MEANS OF CONTROL

A. Engine Modifications

Since the air industry has thus far investigated only emission control research directed toward engine modifications, it is appropriate to consider what results the industry might have achieved had it sought to eliminate more than the disagreeable appearance of jet exhaust. Pratt and Whitney has spent approximately six million dollars on combustor development to achieve its current emission control capability. In the meantime, the National Aeronautics and Space Administration (NASA) has been working since 1964 to develop a more efficient jet aircraft engine. At an annual cost of approximately $200,000, NASA has designed a combustor which does far more than camouflage smoke; it emits 90 percent less HC and NOx

123. Smaller particles are more easily ingested by the human respiratory system and may lodge in the lungs. Jones Interview, supra note 3.

124. Members of the Massachusetts Institute of Technology Fluid Mechanics Laboratory raise this very point. See Linden and Heywood, Smoke Emissions from Jet Engines 2-4 (1970) (available on microfilm, Dep't of Science and Technology, Library of Congress, Washington, D.C.); NREC NATURE AND CONTROL, supra note 24, at 101.

125. See text accompanying note 34 supra.


than combustors currently in use.\textsuperscript{128} The NASA combustor is now the basis for future technological innovations required by EPA's regul-

\textsuperscript{128} Butz and Grobman, \textit{Progress in Reducing Exhaust Pollutants from Jet Aircraft, supra} note 25, at 405. In addition, substantial reductions in CO emissions have been achieved at very low fuel-air rates. \textit{Id.} The basis of the HC reductions is improvement in idle combustion efficiency; the basis of NOx reductions is the comparatively slow reaction rate of formation of NO (nitric oxide) which is later oxidized to NO\textsubscript{2}, the reddish-brown gas associated with smog. It was NASA's conclusion that low combustor inlet temperatures and pressures, lean primary-zone fuel-air ratios, and poor fuel atomization were principally responsible for the low combustion efficiencies observed at idle. \textit{Id.} Figure I presents a comparison of combustion efficiencies of production combustors and the NASA experimental combustor. The J57 combustor noted in Figure I is the military version of the JT3-D which powers long-range craft such as the Boeing 707. On July 28, 1972, Pratt and Whitney indicated to the author that the two combustors are quite similar in performance.

\textbf{FIGURE I—EFFECT OF AIR-ASSIST NOZZLES ON COMBUSTION EFFICIENCY (J57 COMBUSTOR)}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\end{figure}

Using a modified fuel nozzle, the NASA combustor exhibits an HC emission index of 3 as opposed to 26 gm/Kg. fuel burned. \textit{Id.} Indications are that the use of alternate fuel nozzles rather than the full complement, while not particularly effective in reducing emissions in this particular combustor, would be effective in other combustor types. \textit{Id.} at 406. Figures II and III present the effects of these modified nozzles on HC and CO emissions on the J57 combustor.
FIGURE II—EFFECT OF AIR-ASSIST NOZZLES ON HYDROCARBON EMISSIONS (J57 COMBUSTOR)

HC EMISSION INDEX (g/m^3/kg fuel burned)

- PRODUCTION NOZZLE
- AIR-ASSIST NOZZLES

FIGURE III—EFFECT OF AIR-ASSIST NOZZLES ON CO EMISSIONS (J57 COMBUSTOR)

CO EMISSION INDEX (g/m^3/kg fuel burned)

- PRODUCTION NOZZLE
- AIR-ASSIST NOZZLES

IDLE FUEL/AIR RATIO
tions. Thus, once again, a governmental body has paid for development of technology which will benefit the airline industry and reduce its cost of compliance. In light of NASA's results, past claims by

As for NOx emissions, the relatively long time required for NO formation suggests decreasing the combustor dwell time of the reactants by shortening the combustor. NASA experimented with a 30% shorter combustor and reported a 90% reduction in NOx emissions. Id. at 407. NASA presents a suggested compromise solution to the HC-NOx trade-off problem. A lean primary zone (front end of the combustor) would reduce the smoke, while a shorter combustor would eliminate much of the resulting NOx by utilizing the exit-temperature relationship presented in Figure IV, which indicates that a sufficiently high exit temperature will reduce NOx emissions.

FIGURE IV—EFFECT OF COMBUSTOR EXIT TEMPERATURE ON NO FORMATION

129. See, e.g., 38 Fed. Reg. 19088 (1973); Roudebusch Interview, supra note 127. All the "bugs" have not been ironed out, however. Remaining technical problems relate to the requirement of an in-flight, high-altitude engine re-light capability. FAA requires for safety reasons that commercial jet engines be capable of being re-started during flight. As a result of combustor modifications designed to reduce exhaust emissions, the NASA experimental combustor does not currently possess the same re-light characteristics as do current high-emitting combustors. This problem is expected to be resolved within three to five years. Id.

130. At the time of this writing, NASA was in the process of awarding a three-year, multi-million dollar contract for the development of a "clean combustor." Bidders for this contract are aircraft engine manufacturers who will obtain information and techniques developed at public expense for commercial manufacture of low-polluting engines. Roudebusch Interview, supra note 127.
the air industry that substantial aircraft emission control technology did not exist are little more than admissions that the industry had simply not bothered to develop it.

B. Modification of Ground Operations

However, engine modifications are but one means of aircraft emission control. Other techniques which could be employed concurrently involve modification of aircraft operating procedures. Since more than 90 percent of all aircraft HC and CO emissions result from low-power ground operations, many researchers have pointed out the opportunities for emission control in these modes. One suggested technique for reducing HC and CO idle emissions is a small increase in engine idle speed. Both Pratt and Whitney and EPA have suggested this method to the airlines. The airlines have countered to EPA that such a practice would present a hazard to passengers and ground crews, but they are also unwilling to increase engine idle speeds even slightly because of accompanying cost increases for tire and brake maintenance. Maximum pollution reduction would be achieved under this limited ground control strategy if the airlines would reduce the number of engines used in taxi and idle modes in addition to increasing idle speed on the remaining engines under power. While the airlines claim this would still produce an intolerable exhaust blast for ground crews and passengers, at least one airline currently saves fuel by shutting down the center engine on arriving 727 craft as they taxi to the gate. Northern Research has estimated that reductions in ground operation emissions of 50 percent for HC and 70 percent for CO could be achieved simply by reducing the number of engines used in taxiing to and from the runway.

131. See March Hearings, supra note 12, at 999.
132. Analysis, supra note 34, at 14.
133. See, e.g., NREC Assessment, supra note 56, at 54-60.
134. Id. at 54. This method is effective because the efficiency of combustion is highly dependent on idle speed in low-power ranges. No perceptible NOx increases are predicted for this strategy.
137. Jones Interview, supra note 3; see Air Transport Ass'n, Comments on Proposed EPA Regulations, at 3, 9 (1973) [hereinafter cited as ATA Comments].
139. NREC Assessment, supra note 56, at 55. Northern Research predicts an annual fuel saving of $3 million if the industry adopts this procedure at Los Angeles International Airport alone. Id. at 148.
140. Osmun Interview, supra note 13.
141. NREC Assessment, supra note 56, at 55.
142. Id. at 140.
143. Id. at 56.
Another alternative in the control of ground operations involves the departure of aircraft. Powered operations could be restricted primarily to taxi modes. Engines would be shut down at the gate and started only upon receipt of clearance to taxi to the runway for immediate takeoff. Long delays with engines idling at the gate or at runway's end would be eliminated, as no plane would be allowed to depart from the gate without assurance of prompt takeoff.\textsuperscript{144}

A more comprehensive variation of this strategy involves rescheduling flights to improve the flow of airport ground traffic. Professor Arthur Condren's analysis of operations at New York's La Guardia Airport indicates that more consistent and uniform flight scheduling would eliminate peak rush hours when many aircraft line up for several minutes, engines idling, awaiting takeoff.\textsuperscript{145} Dr. Condren predicts that abandoning the present on-the-hour peak departure scheme could reduce ground engine-idle times at La Guardia by as much as 75 percent and result in a nearly comparable decrease in HC and CO emissions.\textsuperscript{146} Localized measures to improve airline ground traffic flow will not be especially effective without flight rescheduling, for under current practice aircraft are often cleared for departure from the gate not to take off, but rather to provide space for incoming aircraft.\textsuperscript{147} Since the number of commercial flights is currently being reduced because of fuel shortages, massive flight rescheduling may be required. Combining the goals of fuel economy and emission reduction should not prove to be an impossible task, since reduced ground idle time saves fuel even as it curtails exhaust emissions.

Hearings have already been held to examine the feasibility of the various control strategies outlined above to bring airport air quality up to standard.\textsuperscript{148} Of all means suggested, the rescheduling of flights to render more efficient the use of existing airport facilities

\textsuperscript{144} Id.

\textsuperscript{145} See La Guardia Study, \textit{supra} note 94.

\textsuperscript{146} Id. at 15. Northern Research predicts small pollution reductions achievable through this method but has made no on-site evaluations. Reductions calculated for Los Angeles International Airport are approximately 10\%. \textit{NREC ASSESSMENT, supra} note 56, at 56-57.

\textsuperscript{147} \textit{NREC ASSESSMENT, supra} note 56, at 57, referring obliquely to the uniform scheduling concept. While the La Guardia study indicates annual fuel cost savings of $1 million as a result of uniform scheduling, it fails to consider the costs of ground control systems to monitor engine start-up times. La Guardia Study, \textit{supra} note 94, at 13.

\textsuperscript{148} See Feb. 6, 1973, transcript of hearings held pursuant to notice in 37 Fed. Reg. 26502 (1972). The strategies discussed are only a few of several ground operation choices. Other possibilities include towing aircraft and bussing passengers, but these strategies do not appear particularly effective. \textit{See EPA IMPACT, supra} note 6, at 74. Towing aircraft is unworkable. \textit{See ATA COMMENTS, supra} note 137, at 7, 8. Bussing passengers would reduce HC and CO by only a few percent. EPA IMPACT, \textit{supra} note 6, at 74.
appears to be most advantageous, although EPA does not seem to be seriously considering this alternative. More efficient and uniform scheduling of flights would reduce rush-hour ground traffic, resulting in fewer traffic jams as well as lower emissions. Current ground operations problems which have forced airport expansion could be minimized, while peak-hour stacking of aircraft would be lessened, improving safety by removing a substantial burden from already overworked air traffic controllers. The most satisfactory plan may be a combination of these and other proposed solutions, but the search for some preferable alternative is already long overdue. EPA should proceed with an airport-by-airport analysis of the ground operations problem and should determine for each airport the optimum mix of ground operation modifications required to attain air quality standards at each airport analyzed.149

V

A PROPOSED SOLUTION

A. Preferred Regulatory Strategy

EPA recognizes its hardware-oriented approach to jet pollution will not solve the problem until a decade or more from now. To achieve required emission reductions in the interim, EPA has sought to supplement its hardware approach by regulating ground operations, since its analysis indicates immediate substantial reductions can be achieved by such techniques at comparatively little cost.150 EPA's proposal involving increased engine idle speed during ground operations151 would take advantage of greater turbine efficiencies obtainable at higher power settings and would lower emissions.152 Unfortunately the resulting stronger jet blast might harm persons and property153 and might produce problems in maneuvering aircraft on the ground.154

Noting these objections and citing large variations in operating conditions among airports, ATA has attempted to convince EPA

149. See discussion of EPA's duty to adopt ground operation regulations, infra notes 161-71 and accompanying text.

150. See EPA IMPACT, supra note 6, at 71-79. EPA's approach was rather narrow however. Restricted by the results of its cost/effectiveness analysis, id. at 77, EPA stressed only proposals such as increased engine idle speed that are relatively unattractive from the standpoint of safety. See transcript of Los Angeles Hearings on Proposed Regulations, Feb. 6-7, 1973. Other potentially superior proposals were not considered. See notes 144-47 supra and accompanying text.


152. See, e.g., 37 Fed. Reg. 26502 (1972); NREC ASSESSMENT, supra note 56, figures 13 and 14, at 170-71; EPA IMPACT, supra note 6, fig. 12, at 73.

153. See ATA COMMENTS, supra note 137, at 3, 9.

154. See, e.g., id. at 2.
that ground procedure regulations are inappropriate. In their place ATA has proposed another voluntary program limited in scope and lacking detail, in which the airlines would assess certain modified ground operations at Los Angeles International and Washington National airports on an experimental basis. The airline proposal involves no more than shutting down certain engines on selected aircraft forced by airport congestion to wait in long queues prior to takeoff. If EPA accepts this offer and goes no further, it will not only ignore more creative and potentially more cost-effective techniques for achieving substantial emission reductions, but it will also effectively grant ATA unfettered discretion to prescribe what operations will be assessed, leaving EPA no choice but to accept whatever reductions may result.

Rather than setting target emission reductions for specific classes of engines and depending upon developing technology to clear the air, EPA should treat aircraft as it has other mobile sources under the Clean Air Act. The agency should prescribe target reductions in overall airport pollution levels that must be achieved in order to meet air quality standards by the statutory deadline and require the airlines to determine how best to modify their operations to achieve those reductions. Such an approach would place immediate pressure on the airlines to experiment with various combinations of available ground operation modifications to supplement long-range improvements in engine technology.

B. A Statutory Solution

A close reading of the Clean Air Act leads one to the inevitable conclusion that in its approach to the aircraft emissions problem EPA

155. Id. at 1; Kittredge Interview, supra note 88.
156. See note 157 infra and accompanying text.
157. ATA COMMENTS, supra note 137, at 4. Recently, the study at Los Angeles International Airport was abandoned because few takeoff queues occur there. Telephone Interview with Edward Sellman, DOT, Nov. 7, 1973. It will be recalled Los Angeles International suffers a severe aircraft emission problem. See notes 7 and 44 supra.
158. No letters of agreement have been signed, although ATA has offered such documents on behalf of its member carriers. See ATA Comments, supra note 137, at 5. The offer was made in February 1973, but as of August 23, 1973, no such letters had been signed. Kittredge Interview, supra note 88. Apparently ATA has decided it will deal with the government on a more formal level than previously. See discussion of the Finch-Volpe agreement, supra notes 71-73 and accompanying text.
159. See notes 144-47 supra and accompanying text.
160. EPA's approach to the automotive exhaust problem required substantial reductions in vehicle miles traveled. When the states did not adopt travel-reducing strategies, EPA stepped in as required by section 110 of the Clean Air Act. EPA regulations proposed for automobiles run the gamut from simple lane restrictions to periodic
has been reading its statutory duty too narrowly. Aircraft are but one emissions source which must be regulated as part of an overall plan to achieve clean air by 1975. When read as a whole, this plan, prescribed by various sections of the Clean Air Act, requires as one of its integral parts that EPA adopt more effective ground regulations. An effective argument can be made that EPA has violated an expressed statutory duty by failing to adopt available ground operation strategies that will achieve required air quality at all airports by the statutory deadline. The argument runs as follows:

1. Section 110 of the Act requires the states to develop implementation plans to achieve specified air quality by 1975, with a possible two-year extension of time if required emission-reducing technology is not available to meet the primary deadline. Wherever a state plan fails to fulfill these precisely defined goals, EPA must promulgate curative federal regulations which become part of the state plan and which are subject to enforcement by both state and federal authorities. These implementation plans are required to contain transportation controls.

2. EPA has already acknowledged that without significant reductions in aircraft emissions, air quality standards will not be met in various regions and has included in its promulgation of implementation plans levels of aircraft emission reductions it believes necessary to achieve required air quality. Since EPA freely admits its


161. Section 110 of the Clean Air Act, 42 U.S.C. § 1857c-5(a)(2)(A)(i) (1970), requires that air quality standards be met within three years of approval of the applicable state implementation plan. In most cases the deadline is May 31, 1975. Delays may occur if technology necessary to meet the standards is not available in time, for under section 110(e) of the Act, 42 U.S.C. § 1857c-5(e) (1970), the Administrator may grant a two-year extension in such circumstances. In extreme cases, an additional one-year postponement is available under section 110(f), 42 U.S.C. § 1857c-5(f) (1970).

It can hardly be said that modification of aircraft ground operations is an unavailable strategy, since EPA was prepared to implement some form of this strategy by the 1975 target date. See note 167 infra. The Clean Air Act thus appears to require implementation of appropriate ground operation regulations before any extension may be granted under section 110 to a state whose airports suffer substandard air quality.


164. See EPA IMPACT, supra note 6, at 5.

165. See, e.g., 38 Fed. Reg. 18951 (1973), for EPA's San Francisco transportation control plan. Seven percent of all mobile-source HC reductions required by the San Francisco transportation control plan are to be achieved through aircraft emission controls (calculation based on information contained in id. at 18951, Table 1). Those controls are simply the smoke-reducing technology required by the Finch Agree-
current aircraft regulations will not achieve the requisite air quality by 1975, and since highly effective ground operation regulations could be adopted by that time, transportation control portions of state implementation plans must contain such regulations where required to attain mandated air quality levels.

3. However, the Clean Air Act forbids state adoption of any aircraft emission standard or regulation which is not identical to one already adopted by EPA, so state adoption of any aircraft emission standards as part of an implementation plan prior to EPA adoption of such standards would be unlawful.

4. Therefore, since certain state implementation plans must contain ground operation regulations and since only EPA may take the lead in adopting them, section 110(c)(2) of the Act requires the Administrator to adopt aircraft ground operation regulations as part of those implementation plans applicable to areas where airport air quality is below standard. Naturally, since these regulations are to be part of state implementation plans, they must be adopted according to the timetable required for all such regulations. They must be issued promptly after EPA consideration of state hearing records on their implementation plans, and are thus long overdue.

5. Although an action to challenge adequacy of state implementation plans must normally be brought under section 307 within 30 days of approval of such plans, a citizen suit under section 304 would not be time-barred. Such a suit could be brought to require EPA promulgation of such regulations, because, under the above theory, the Administrator has failed to perform a non-discretionary duty required

ment. The bulk of remaining emissions reductions are attributed to a severe program of gas rationing applicable to the entire San Francisco automobile population. at 18951. Aircraft ground operation modifications would produce nearly one-third those reductions attributed to gas rationing.

166. See note 89 supra.

167. EPA originally planned to put ground operation regulations into effect by 1975 to help attain required air quality in that year. See 38 Fed. Reg. 26502 (1972).


of him by the Act. EPA not only has clear authority to adopt needed regulations in this area; the Clean Air Act requires it to do so. EPA is prevented by law from repeating the HEW mistake of relying on voluntary industry efforts, and the public can take the agency to court if it fails to follow this statutory command.

EPA adoption of ground regulations as part of applicable state implementation plans would also considerably improve enforcement prospects. First, the Administrator's ill-defined enforcement powers in this area would be clarified, since enforcement of all elements of state implementation plans is precisely defined under section 113 of the Act, whereas sections of the Act relating to aircraft emission standards prescribe no enforcement role for the EPA Administrator. Section 113 brings into play the full array of the Administrator's enforcement powers, including the power to issue compliance orders which are enforceable by fines or imprisonment. Second, barriers to state enforcement would be lowered because of the parallel enforcement scheme applicable to state implementation plans. Specifi-

172. Section 307 provides in part:

... A petition for review of the Administrator's action in approving or promulgating any implementation plan under section 110 ... may be filed only in the United States Court of Appeals for the appropriate circuit. Any such petition shall be filed within 30 days from the date of such promulgation or approval, or after such date if such petition is based solely on grounds arising after such 30th day.

42 U.S.C. § 1857h-5(b)(1) (1970). Section 304 does not involve any such time limitation:

... [A]ny person may commence a civil action on his own behalf—

... (2) against the Administrator where there is alleged a failure of the Administrator to perform any act or duty under this Act which is not discretionary with the Administrator. ...

(b) No action may be commenced—

(2) under subsection (a)(2) prior to 60 days after the plaintiff has given notice of such action to the Administrator, except that such action may be brought immediately after such notification in the case of an action under this section respecting a violation of section 112(c)(1)(B) or an order issued by the Administrator pursuant to section 113(a). Notice under this subsection shall be given in such manner as the Administrator shall prescribe by regulation. ...


The tenth circuit has created a minor point to be observed in section 307 pleadings. In NRDC v. EPA, — F.2d —, 5 ERC 1509 (10th Cir. 1973) the court of appeals declared section 307 plaintiffs must allege standing. This holding was issued the same day SCRAP v. United States, — U.S. —, 5 ERC 1449 (1973) was decided. While SCRAP fundamentally broadened classical notions of standing in environmental cases, the tenth circuit summarily refused to reconsider plaintiff's challenge when plaintiff amended its complaint in accordance with the court's directive.

173. The author is proceeding under the theory outlined in the above text and has notified the Administrator in accordance with section 304 and applicable regulations thereunder.

175. Id. § 113(c), 42 U.S.C. § 1857c-8.
cally, if ground regulations were adopted pursuant to both section 110 and sections 231-34 of the Act, states and private persons could use section 304 citizen-suit provisions to compel airline compliance, thereby enforcing "emission limitations" which are part of state implemention plans in accord with section 304(f). The Administrator would retain his section 113 enforcement powers, completing the parallel enforcement pattern.

Maximizing public and private enforcement opportunities in this manner would help build pressure for speedy regulation of ground emissions, since both public-interest groups and dissatisfied state authorities would be monitoring EPA from a position of strength rather than from their current status as frustrated preemptees. The choice rests with EPA. By adopting the above strategy, the agency can invoke legal and practical pressures demanding strict regulation of the air industry, or it can follow its present course, allowing the airlines to retain their current unique position as exalted and protected polluters.

CONCLUSION

Aircraft emission control to date has been a failure. The federal government failed to acknowledge the problem posed by such emissions, most state and federal authorities believing that only visible smoke had to be controlled, although in fact smoke merely annoyed people while other emissions poisoned them. Airport pollution levels currently exceed those determined to be harmful to health. However, in seeking methods to control smoke visibility, the airlines utilized some of the least satisfactory choices available to control toxic exhaust components, while resisting cheaper and more effective control techniques. Just as state enforcement activity in this area appeared to move the industry to some action, the Clean Air Act deprived the states of enforcement power and gave the EPA Administrator no authority to enforce the emission standards he was to promulgate. Meanwhile, air quality in airport vicinities continues to deteriorate.

Several factors have contributed to this failure. First, the regulatory scheme was initially developed because the public was indignant and not because enforcement authorities understood the mag-

176. Section 233 provides:
No state or political subdivision thereof may adopt or attempt to enforce any standard respecting emissions of any air pollutant from any aircraft or engine thereof unless such standard is identical to a standard applicable to such aircraft under this part.

42 U.S.C. § 1857f-11 (1970) (emphasis supplied). Apparently a state might enforce its standards only where federal aircraft standards are adopted under Title II, Part B of the Act (beginning with section 231). Since Title II, Part B does not include section 110, to maximize enforcement opportunities, EPA should adopt its ground regulations under both the authority provided in section 110 and that in section 231.
Nitude of the problem. Beyond the routine observation that regulators were once again not doing their job, one ponders in disbelief the lack of foresight and planning in choosing particular enforcement strategies. Statutory requirements do exist to compel more orderly federal planning, however. The National Environmental Policy Act (NEPA)\footnote{42 U.S.C. § 4321 et seq. (1970).} requires federal agencies to analyze significant environmental consequences of their actions and to explain them in an environmental impact statement.\footnote{42 U.S.C. § 4332(2)(C) (1970).} The statement is simply a report enumerating beneficial and adverse results of a proposed agency project, action, or activity. Courts have required agencies in preparing these reports to compare and discuss alternatives to their proposals.\footnote{See, e.g., Sierra Club v. Froehlke, 359 F. Supp. 1289, 5 ERC 1033 (S.D. Tex. 1973); NRDC v. Morton, 458 F.2d 827, 3 ERC 1558 (D.C. Cir. 1972).} Although the standard of review under NEPA appears to become more comprehensive with time,\footnote{See generally Comment, Substantive Review Under the National Environmental Policy Act: EDF v. Corps of Engineers, 3 Ecology L.Q. 173 (1973).} courts have thus far exempted EPA from NEPA, often on the ground that the substance of NEPA is the very mission assigned to EPA—to evaluate competing alternatives and select those which will best protect and enhance the environment.\footnote{See generally, Comment, Implementation of the Clean Air Act: Should NEPA Apply to the Environmental Protection Agency?, 3 Ecology L.Q. 597 (1973).}

The history of jet smoke abatement leads one to consider whether NEPA ought to apply to EPA activities.\footnote{See, e.g., Anaconda Co. v. Ruckelshaus, 482 F.2d 1301, 5 ERC 1673 (10th Cir. 1973); Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375, 5 ERC 1593 (D.C. Cir. 1973); Buckeye Power Inc. v. EPA, 481 F.2d 162, 5 ERC 1611 (6th Cir. 1973). See also Comment, Implementation of the Clean Air Act: Should NEPA Apply to the Environmental Protection Agency?, 3 Ecology L.Q. 597 (1973).} It has often been suggested that industry's arguments that NEPA should apply reflect a devious desire to hamstring costly environmental regulation. Irrespective of any such motive, the pitiful failure to regulate jet emissions demonstrates that EPA does not always consider fully and explicitly broad alternatives as NEPA would require it to do. In the case of jet pollution, a report was prepared justifying the standards adopted because the Clean Air Act specifically required one,\footnote{EPA IMPACT, supra note 6, is the report required by section 231 of the Clean Air Act.} but the report came too late. Control strategies had been adopted before it was begun, so that in many ways the report reflects fixed choices rather than available alternatives. Had a complete analysis been performed earlier in the selection process, perhaps EPA would have avoided a number of pitfalls. Had NEPA been fully applied to EPA in this case, the standards might well have been adequate, and
a better record would have been produced to support them against judicial challenge.

Some argue applying NEPA to EPA would slow pollution control. *Anaconda Co. v. Ruckelshaus*\(^{184}\) has demonstrated that ill-drafted standards themselves delay enforcement. Certainly an initial delay to comply with NEPA and thereby assure proper standards is preferable to discovery in court of massive regulatory flaws. If a court strikes down EPA regulations or remands to the agency for reconsideration, EPA will be forced to redesign its regulatory scheme at the very time Congress has demanded active enforcement, thereby causing even further delays as the reevaluation of standards drags on. Applying NEPA to EPA could provide more effective long-term environmental regulation.

Apart from the NEPA-EPA issue, the history of aircraft emissions also reveals an inherent bias, despite evidence to the contrary, that technology alone will be the most effective and the most cost-effective means of reducing air pollution. Initially, it was thought that controls over hardware would be sufficient. This choice was reasonable in the beginning. When later data proved hardware alone had not done the job, regulators and industry sought more expensive technology to eliminate remaining pollutants. When EPA suggested procedural modifications as more effective alternatives, it was easily dissuaded by industry arguments. EPA reticence apparently stemmed from a reasonable belief that the airlines know their business better than anyone else.

But airline opposition to procedural changes was based on the more fundamental objection that such changes are too much trouble to bother with. Our society has consistently relied on technology to reduce human effort. In the case of aircraft emissions, it was easier to purchase expensive devices to meet the standard than to require extra human effort by modifying airline ground operations. Generally we have proceeded on the belief that because we reached the moon with machines, we can clean up the earth with machines and continue to live as we have. The aircraft emission experience suggests otherwise—that business practice as well as business hardware will have to be revised to clean up the planet.

Another factor contributing to the failure to control aircraft emissions, and not an encouraging one, is the lack of continued public interest regarding environmental damage caused by jet emissions. The public has tolerated expedient, less effective remedies preferred by the air industry because the most obvious aspect of the emissions prob-

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\(^{184}\) 482 F.2d 1301, 5 ERC 1673 (10th Cir. 1973).
lem—the smoky black exhaust trail—has disappeared, and because invisible hazards with complex chemical names simply are not newsworthy. If effective enforcement of environmental regulation must depend upon the existence of a visible hazard, an insidious process of technological natural selection will work toward abatement only of visible hazards, while the obscure but deadly ones remain.

Up to now, environmental regulation has been concerned primarily with designing standards and programs to meet established goals. We have developed a regulatory structure believed capable of handling complex scientific problems, and we have given its enforcement agents sufficient power and authority to protect public health from both visible and invisible emissions, whether or not the public complains about them. But just as we are patching up remaining cracks in the structure, legislative timetables usher in the second major phase of environmental regulation—the enforcement period.

Throughout the coming enforcement period, marginal costs of pollution reduction will increase as visible pollution is reduced. Direct costs of technological control will grow in accord with the law of diminishing returns, but we will suffer additional costs of altering our habit patterns to an extent we do not yet comprehend. As this Comment suggests, once the smoke plumes disappear we must also incur the cost of maintaining massive staffs of government and public-interest scientists to monitor not only emission sources but also a reticent bureaucracy. Whether the public will be willing to bear these costs and whether the remedy of the citizen suit will adequately supplement waning public indignation will be major questions in the second great environmental battle yet to come.

Paul M. Kaplow
### LTO-CYCLE TOTAL MASS EMISSIONS

<table>
<thead>
<tr>
<th>Engine Category</th>
<th>Test Organization</th>
<th>No. Engines</th>
<th>Pollutant Mass Total for Cycle (lbs)</th>
<th>CO Mean</th>
<th>CO Std. Dev.</th>
<th>CO Coef. Var (%)</th>
<th>HC Mean</th>
<th>HC Std. Dev.</th>
<th>HC Coef. Var (%)</th>
<th>NOX Mean</th>
<th>NOX Std. Dev.</th>
<th>NOX Coef. Var (%)</th>
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**Weighted Average**

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