Decision Analysis in Environmental Decisionmaking: Improving the Concorde Balance

I. INTRODUCTION

Existing knowledge about the environment is technical[1] and incomplete,[2] posing major problems for "generalist" decisionmakers who lack the technical expertise to handle the uncertainties of the environmental issues confronting them. Forced to rely on technical experts for the development of data and analysis, generalist decisionmakers may make judgments based on inaccurate and incomplete information.[3]

Several approaches to alleviate this handicap might be suggested. One approach would be to provide decisionmakers with complete information about the environment, a task not yet feasible. Another

1. *See* Ohio v. Wyandotte Chemicals Corp., 401 U.S. 493 (1971); International Harvester Co. v. Ruckelshaus, 478 F.2d 615 (D.C. Cir. 1973); City of Romulus v. County of Wayne, 392 F. Supp. 578 (E.D. Mich. 1975); Sierra Club v. Froehlke, 359 F. Supp. 1289 (S.D. Tex. 1973), *modified sub nom.* Sierra Club v. Callaway, 499 F.2d 982 (5th Cir. 1974); B. ACKERMAN *et al.*, THE UNCERTAIN SEARCH FOR ENVIRONMENTAL QUALITY 9-66 (1974) [hereinafter cited as UNCERTAIN SEARCH].

2. *See* Reserve Mining Co. v. United States, 498 F.2d 1073 (8th Cir. 1974); UNCERTAIN SEARCH, *supra* note 1, at 9-66; Gelpe & Tarlocke, *The Uses of Scientific Information in Environmental Decisionmaking*, 48 SO. CALIF. L. REV. 570, 588-589 (1972).

3. "Decisionmakers" include agency and department heads, judges and members of Congress. The difficulties these individuals experience in making judgments about technical matters have been well documented. *See* Ohio v. Wyandotte Chemicals Corp., 401 U.S. 493 (1971); International Harvester Co. v. Ruckelshaus, 478 F.2d 615, 650 (D.C. Cir. 1973); CONGRESSIONAL RESEARCH SERVICE, 92D CONG., 1ST SESS., TECHNICAL INFORMATION FOR CONGRESS, REPORT TO THE SUBCOMM. ON SCIENCE, RESEARCH AND DEVELOPMENT OF THE HOUSE COMM. ON SCIENCE AND ASTRONAUTICS 5-13 (1971); Leventhal, *Environmental Decisionmaking and the Role of the Courts*, 122 U. PA. L. REV. 509 (1974); Wright, *Court of Appeals Review of Federal Regulatory Agency Rulemaking*, 26 AD. L. REV. 199 (1974).

solution would be to choose decisionmakers who could analyze scientific data without assistance. This suggestion, too, is utopian. A third approach would be to improve the effectiveness of the transfer of knowledge between decisionmakers and technical experts. As advocated in this article, this solution entails the use of "decision analysis," a technique for organizing limited knowledge and quantifying uncertain impacts.

The argument for the use of decision analysis will be advanced in three stages. First, the technique will be explained. The need for the technique will then be demonstrated by reviewing a major environmental issue: United States Secretary of Transportation William Coleman's decision permitting Concorde landings in the United States. This examination will show that the process leading to that decision could have been improved by implementation of the technique. Finally, the article will suggest a structure for using decision analysis in environmental decisionmaking.

II. Decision Analysis

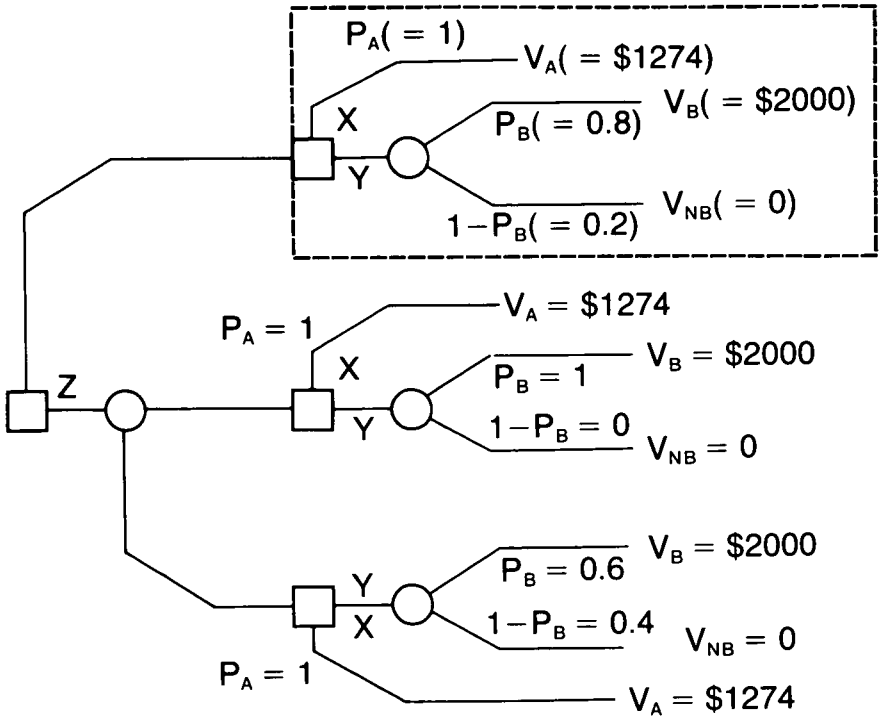
Decision analysis is described best by example.[4] Suppose that a decisionmaker must choose between alternatives X and Y. If he chooses X, harm A will certainly result, and harm B will be avoided. If he chooses Y, harm A will be avoided, but harm B might result. Although no one knows the costs of harms A or B or the probability that harm B will occur, experts can estimate values for the uncertain variables.

A decision analyst investigates this problem in four steps. First, the relationships among decision variables are displayed along the decision tree, circumscribed by a dotted line in Figure One (disregard parenthetical material). The squares denote junctures where the decisionmaker may exercise his judgment to affect outcomes, and the circles indicate occasions when chance determines results. The variables controlling the value of any branch of the tree are listed along that branch.

Second, a decision analyst generates equations describing how variables should be combined to determine the value of any decision tree branch. For example, the "value" or "cost" of X, desig-

4. The discussion of decision analysis has been derived from two books: H. Raiffa, Decision Analysis (1968); R. Schlaifer, Analysis of Decisions Under Uncertainty (1969).

Figure One: Decision Tree Showing Opportunity for Additional Research



where: P_A = Probability harm A will result = 1.
P_B = Probability harm B will result.
$(1-P_B)$ = Probability harm B will not result.
V_A = Value of world that contains harm A.
V_B = Value of world that contains harm B.
V_{NB} = Value of world where harms A and B are avoided.

nated V, should be calculated by multiplying the cost resulting from harm A by the probability that harm A will occur:

$$V_X = V_A \times P_A$$

Similarly, the "value" or "cost" of Y, designated V_Y, should be calculated by multiplying the cost resulting from harm B by the probability that harm B will occur, and subtracting the value of avoiding

harms A and B multiplied by the probability that neither A nor B will result:

$$V_Y = (V_B \times P_B) - (V_{NB} \times (I - P_B))$$

Analysts quantify variables in the third step of decision analysis. The values of some variables, such as P_A, may be definitely known, but the values of V_A and others are uncertain. In the latter case, expert appraisers estimate several values for the unknown variable, each corresponding to a different level of certainty. For example, if an appraiser estimates that there is a twenty-five percent chance that the actual cost of harm A, should it occur, will be less than a particular figure, he will assign that figure to V_A at certainty level twenty-five, designated V_{A25}. Similarly, experts assign values for V_A at other certainty levels (V_{A1}, V_{A2}, V_{A3}, . . . V_{A100}).[5] The value for V_A may then be calculated by averaging the various estimates using Equation One.

$$V_A = \left(\sum_{i=1}^{100} V_{Ai} \right)/100$$

$$\text{where: } \sum_{i=1}^{100} V_{Ai} = V_{A1} + V_{A2} + V_{A3} + \ldots V_{A100}$$

Equation One

For example, if values for V_A are estimated at one hundred levels of certainty as shown in Table One, the averaged value of harm A is 1274.

The final step of decision analysis—the compilation of results—may be accomplished in two ways. First, the costs estimated at various levels of certainty may be compiled as in Table One. Such information enables the decisionmaker to understand the implications of uncertainty by examing both the seriousness and likelihood of possible impact levels. Alternatively, these estimates can be averaged using Equation One.

A second type of compilation determines the desirability of un-

5. For a more detailed discussion showing how this is accomplished, see H. RAIFFA, DECISION ANALYSIS 161 (1968). For a discussion of the problems encountered in the use of these procedures, see Tuersky & Kahneman, *Judgment under Uncertainty: Heuristics and Biases*, 185 SCI. 1124 (1974).

Equation One
Table One: Calculating Average Values for V_A[a]

x	V_{Ax}	x	V_{Ax}	x	V_{Ax}	x	V_{Ax}
1	2	26	20	51	200	76	2,000
2	2	27	20	52	200	77	2,000
3	2	28	20	53	200	78	2,000
4	20	29	20	54	200	79	2,000
5	20	30	20	55	200	80	2,000
6	20	31	20	56	200	81	2,000
7	20	32	20	57	200	82	2,000
8	20	33	20	58	200	83	2,000
9	20	34	200	59	200	84	2,000
10	20	35	200	60	200	85	2,000
11	20	36	200	61	200	86	2,000
12	20	37	200	62	200	87	2,000
13	20	38	200	63	200	88	2,000
14	20	39	200	64	200	89	2,000
15	20	40	200	65	200	90	2,000
16	20	41	200	66	200	91	2,000
17	20	42	200	67	200	92	2,000
18	20	43	200	68	2,000	93	2,000
19	20	44	200	69	2,000	94	2,000
20	20	45	200	70	2,000	95	2,000
21	20	46	200	71	2,000	96	2,000
22	20	47	200	72	2,000	97	2,000
23	20	48	200	73	2,000	98	20,000
24	20	49	200	74	2,000	99	20,000
25	20	50	200	75	2,000	100	20,000

$$V_A = \sum_{i=1}^{100} V_{Ai}/100 = 127{,}406/100 = 1274$$

x = certainty level
V_{Ax} = V_A at certainty level x

[a] Any values of V_{AX} might be used.

dertaking additional research to estimate more accurately the range of possible outcomes. The option of doing additional research shall be designated as alternative Z. Under this method of compilation, the possible experimental conclusions are outlined. Each conclusion is then in turn assumed to be true, and the decision analysis is

repeated to determine the resulting values. These values are next averaged according to the estimated probability that each conclusion will occur. The cost of conducting the research is added to this average. The resulting value, which is more informative than the pre-experimental value of the branch, indicates the advisability of additional research.

For example, assuming averaged values for uncertain quantities in the above example as follows:

$$\begin{aligned} V_A &= \$1274 \\ V_B &= \$2000 \\ V_{NB} &= \$0 \\ P_B &= 0.8 \\ (1-P_B) &= 0.2 \end{aligned}$$

The value of X would be calculated:

$$V_X = V_A \times P_A = \$1274 \times 1 = \$1274$$

while the value of Y would be:

$$\begin{aligned} V_Y &= (V_B \times P_B) - (V_{NB} \times (1 - P_B)) \\ &= (\$2000 \times 0.8) - (\$0 \times 0.2) = \$1600 \end{aligned}$$

To minimize damages, the decisionmaker would choose alternative X resulting in $1274 of damage. Now, suppose the decisionmaker is allowed to choose option Z, which is to conduct $30 worth of additional research before choosing between X and Y. Scientists estimate that if the additional research is conducted, they will know whether P_B equals 1.0 or 0.6. Scientists also estimate that either P_B value is as likely as the other. Figure One shows the new decision tree.

If P_B equals 1.0, V_X = $1274 and V_Y = $2000, the decisionmaker will choose X. If, however, P_B equals 0.6, V_X = $1274 and V_Y = $1200, the decisionmaker will choose Y. Thus:

$$V_Z = \$1274 \times 0.5 + \$1200 \times 0.5 + \$30 = 1267$$

Since the cost of Z is less than the cost of X or Y, the additional studies should be undertaken.

Decision analysis is, thus, a technique which explicitly communicates the limits of existing knowledge rather than producing new information. Such explicit communication is valuable because it

provides the decisionmaker with information about the impact of uncertainty on the value of any option, including that of seeking new information. In addition, explicit communication enables others to examine the analysis readily and point out its weaknesses to the decisionmaker, thereby lessening the chance that analytical errors will occur.

III. THE CONCORDE DECISION

Having described the fundamental characteristics of decision analysis, this article will now focus upon a particular instance of environmental decisionmaking. The Concorde decision merits examination in some detail because it reveals the weaknesses of a fairly sophisticated and rational decisionmaking process which lacked the rigorous completeness of decision analysis techniques.

A. *The Decision and Its History*

On February 4, 1976, Secretary Coleman announced his decision[6] permitting the Concorde, a supersonic transport, to provide commercial service to the United States for a sixteen-month demonstration period.[7] The decisionmaking process spanned several months. As early as July, 1974, the Federal Aviation Administration (FAA) foresaw the advent of the Concorde and began studying the environmental threat it posed.[8] Following the British and French owners' requests for permission to fly the Concorde between Europe and the United States in early 1975,[9] the FAA released its Draft Environmental Impact Statement (DEIS).[10] The

6. U.S. DEP'T OF TRANSPORTATION, THE SECRETARY'S DECISION ON CONCORDE SUPERSONIC TRANSPORT 3 (1976) [hereinafter cited as SECRETARY'S DECISION].

7. FEDERAL AVIATION ADMINISTRATION, U.S. DEP'T OF TRANSPORTATION, CONCORDE SUPERSONIC TRANSPORT AIRCRAFT: FINAL ENVIRONMENTAL IMPACT STATEMENT A-3 (1975) [hereinafter cited as FEIS]. Up to four daily roundtrip flights to New York's Kennedy Airport, and two to Dulles Airport near Washington, D.C., were permitted. Half the flights would be flown by Air France from Paris, and half by British Airways from London.

8. *Aircraft Noise Abatement: Hearings Before the Subcomm. on Aeronautics and Space Technology of the House Comm. on Science and Astronautics*, 93d Cong., 2d Sess. 364 (1974) (statement of Frederick A. Meister).

9. Before any foreign air carrier can operate planes in commercial service to this country, it must obtain permission from the United States government. *See* Operations of Foreign Air Carriers, 14 C.F.R. §129 (1977).

10. FEDERAL AVIATION ADMINISTRATION, U.S. DEP'T OF TRANSPORTATION, CONCORDE SUPERSONIC TRANSPORT AIRCRAFT: DRAFT ENVIRONMENTAL IMPACT

FAA's multivolume Final Environmental Impact Statement (EIS)[11] was released on November 13, 1975, followed on February 4, 1976 by an EIS Addendum.[12] The last step leading to the decision was a day-long hearing on January 5, 1976,[13] over which Secretary Coleman presided.[14]

B. *An Exceptional Decisional Process*

The Concorde decisional process was exceptional by any conventional standard of evaluation for several reasons. First, experts devoted much effort to gathering information. Substantial information was generated from government agency research. In particular, the FAA's Climatic Impact Assessment Program (CIAP)[15] and continu-

STATEMENT (1975) [hereinafter cited as DEIS]. The DEIS is mandated by the National Environmental Policy Act of 1969, 42 U.S.C. §§ 4321-4347 (1970). The statutory provisions regulating the preparation of an EIS are discussed below. *See* text accompanying notes 121-127 *infra*.

11. 40 Fed. Reg. 53,612 (1975).

12. FEDERAL AVIATION ADMINISTRATION, U.S. DEP'T OF TRANSPORATION, CONCORDE SUPERSONIC TRANSPORT AIRCRAFT: FINAL EIS ADDENDUM (1975) [hereinafter cited as EIS ADDENDUM].

13. *The Concorde Furor*, NEWSWEEK, Feb. 16, 1976, at 16.

14. The Secretary's demonstration program survived a challenge in the Circuit Court of Appeals for the District of Columbia in the case of *Environmental Defense Fund v. United States Dep't of Transp.* [1976] 14 AV. CAS. (CCH) ¶ 17,140 (D.C. Cir.). The initiation of the program was at first delayed by the refusal of the Port Authority of New York and New Jersey to grant permission for the Concorde to land at Kennedy Airport. Federal District Judge Milton Pollack overruled this refusal on grounds of federal preemption. British Airways Bd. v. Port Auth. of N.Y., 431 F. Supp. 1216 (S.D.N.Y. 1977). On appeal from Judge Pollack's order, the Court of Appeals for the Second Circuit rejected the preemption argument and remanded for consideration of the reasonableness of the thirteen-month delay by the Port Authority in promulgating noise regulations for supersonic aircraft. 558 F.2d 75 (2d Cir. 1977). Judge Pollack found that the Port Authority's delay had indeed been unreasonable, and that this delay constituted a forfeiture of the Port Authority's limited privilege to establish noise regulations. 437 F. Supp. 804 (S.D.N.Y. 1977). Judge Pollack was affirmed by the Second Circuit, which modified his order to provide that the Port Authority might in the future adopt a new, uniform and reasonable noise standard if the existing noise limitation was ultimately determined to be inadequate. 564 F.2d 1002 (2d Cir. 1977).

15. CLIMATIC IMPACT ASSESSMENT PROGRAM, U.S. DEP'T OF TRANSPORTATION REPORT OF FINDINGS: THE EFFECT OF STRATOSPHERIC POLLUTION BY AIRCRAFT (1974) [hereinafter cited as CIAP REPORT]. CIAP spent $22 million and three years of research to discover the impact of the Concorde on ozone. *See Inadvertent Modification of the Upper Atmosphere: Research and Development Relating to Halocarbons and Ozone Depletion: Hearings Before the Subcomm. on the Environment and the Atmosphere of the House Comm. on Science and Technology*, 94th Cong., 2d Sess. 8 (1975) [hereinafter cited as *Inadvertent Modification*].

ing governmental aircraft noise research[16] contributed to the body of knowledge influencing decisionmakers.[17]

Second, the Concorde decisionmaking was remarkable for the candidness which marked its progress. Notice of the pending decision was provided by the news media,[18] and a release by Secretary Coleman on November 13, 1975 announced the relevant decisional issues.[19] Participation by affected parties was encouraged; more than 120 witnesses representing governmental agencies of all levels as well as private organizations spoke at the EIS hearings and again at the hearing sponsored by Coleman.[20] Moreover, the final de-

16. *Implementation of the Noise Control Act of 1972 (Aircraft-Airport Noise): Hearing Before the Subcomm. on Environmental Pollution of the Comm. on Public Works*, 93d Cong., 2d Sess. 13 (1974) (statement of Frederick A. Meister). Extensive tests of the Concorde's noise level were also conducted. *See* ENVIRONMENTAL PROTECTION AGENCY, NOISE MEASUREMENT OF CONCORDE 02 APPROACH AND TAKEOFF AT DALLAS-FT. WORTH AND DULLES INTERNATIONAL AIRPORTS (1974); ENVIRONMENTAL PROTECTION AGENCY, CONCORDE 02 MEASUREMENTS MADE AT BOSTON (1974); OFFICE OF NOISE ABATEMENT, U.S. DEP'T OF TRANSPORTATION, SOUND AND VIBRATION MEASUREMENTS FOR CONCORDE SUPERSONIC TRANSPORT AND SUBSONIC JET AIRCRAFT (1974); TRANSPORTATION SYSTEMS CENTER, NOISE EMISSIONS AND BUILDING STRUCTURAL VIBRATION LEVELS FROM THE SUPERSONIC CONCORDE AND SUBSONIC TURBOJET AIRCRAFT (1975).

17. Foreign affairs information was obtained form the Secy. of State. *See* letter from Henry A. Kissinger to Secy. Coleman (Oct. 6, 1975), *reprinted in F.A.A. Certification of the SST Concorde: Hearings Before a Subcomm. of the House Comm. on Government Operations*, 94th Cong., 1st & 2nd Sess. [hereinafter cited as *FAA Certification*] 375-76 (1976) (statement of Rep. William Randall); *Oversight Hearings on the SST, Hearings Before the Senate Subcomm. on Commerce*, 94th Cong., 2d Sess. 19 (1976) (statement of Sen. Lowell Weicker). The National Aeronautics and Space Administration also reported on the technological advantages of the Concorde. *See* letter to Secy. Coleman (Dec. 24, 1975), *reprinted in part* in SECRETARY'S DECISION, *supra* note 6, at 52-53.

18. *See, e.g., The Concorde: Who Will Let It Fly?*, BUSINESS WEEK, Jan. 19, 1976, at 54; *Coleman's Way: Concorde Debate;* NEWSWEEK, Dec. 29, 1975, at 47-48; *The Concorde Still Faces A Rough Flight;* BUSINESS WEEK, Oct. 6, 1975, at 29; *Concorde Decision Delayed to February,* AVIATION WEEK, Nov. 17, 1975, at 25; *Across Atlantic at 1400 mph: Concorde*, U.S. NEWS & WORLD REPORT, Sept. 22, 1975, at 63; *Hearing on Concorde's Permit for Dulles Flights Eyed,* Washington Post, Apr. 9, 1975, § B, at 7, col. 1; *C.O.G. Votes to Oppose Concorde Flights into Dulles,* Washington Post, Apr. 10, 1975, § A, at 36, col. 1; *U.S. Seate Committe Approves Ban on Concorde at U.S. Airports,* Washington Post, July 19, 1975, § A, at 4, col. 1; *EPA Reviews Possible Noise Problems of Concorde Jet,* Washington Post, Nov. 23, 1975, § B, at 1, col. 1. *See generally,* articles cited in 1 NEW YORK TIMES—INDEX 1975 55 (1976).

19. 40 Fed. Reg. 53,612 (1975).

20. *U.S. Dep't of Transportation, Public Hearings on Applications of Air France and British Airways to Operate Concorde Aircraft in Limited Commercial Service to New York and Washington* (1976). At the hearings testimony was heard from rep-

cision was made by an impartial decisionmaker, Secretary Coleman, who explained his opinion in writing[21] as well as before Congressional committees during the hearings.[22]

Of final note is the high level of authority at which the Concorde decisional process occurred. Secretary Coleman directed an unusual amount of attention to the Concorde issue between his November, 1975 release and his February 4, 1976 decision.[23]

Despite the laudable aspects of the Concorde decisional process noted immediately above, other characteristics of the process detracted from fully rational decisionmaking. In the next few sections, this article will examine the costs resulting from the Concorde's operation, and it will focus on ways in which decision analysis techniques could have evaluated these costs more accurately than did the techniques actually employed.

C. *The Costs of a Decision Allowing the Concorde to Land*

1. Damage to Ozone

One negative consequence of the Concorde's operation is damage to the ozone.[24] Since the Concorde flies above the weather its

resentatives of the British and French governments, the Coalition Against the SST, the Sierra Club, Friends of the Earth, the Environmental Defense Fund, the Hotel Association of Washington, D.C., the City Council of Los Angeles, the Anti-Concorde Project, the Wilderness Society, and the Fairfax County (Virginia) Chamber of Commerce.

21. SECRETARY'S DECISION, *supra* note 6.

22. *FAA Certification, supra* note 17; *Current and Proposed Federal Policy on the Abatement of Aircraft Noise: Hearings Before the Subcomm. on Aviation of the House Comm. on Public Works and Transportation*, 94th Cong, 1st & 2d Sess. (1976) [hereinafter cited as Federal Policy]; *Oversight Hearings on the SST: Hearings Before the Senate Comm. on Commerce*, 94th Cong., 2d Sess. (1976) [hereinafter cited as *Oversight Hearings*]; *Review of the Secretary of Transportation's Decision on the SST Concorde: A Joint Hearing Before Certain Subcommittees of the House Comm. on Government Operations and the House Comm. on International Relations*, 94th Cong., 2d Sess. (1976) [hereinafter cited as *Joint Review*].

23. *William Coleman: Not Afraid to Decide*, N.Y. Times, Feb. 1, 1976, § 3, at 1, col. 1.

24. Recently, some scientists have concluded that the Concorde's impact may be less significant than was believed in 1976. *See* Broderick, *Stratospheric Effects from Aviation*, 15 J. AIRCRAFT, 43-53 (1978). Such shifts in scientific thinking are not unprecedented. Between 1930 and 1970, scientists believed that atmosphric ozone levels were controlled by chemical reactions upon which the Concorde would have little effect. *See* CIAP REPORT, *supra* note 15, at C-30 to C-34. *See also* NATIONAL ACADEMY OF SCIENCES, ENVIRONMENTAL IMPACT OF STRATOSPHERIC FLIGHT 126-134 (1975) [hereinafter cited as NAS REPORT]. Because this article is concerned

exhausts remain in the atmosphere for several years.[25] The exhaust product nitrogen oxide catalyzes the destruction of atmospheric ozone,[26] a process dangerous to humans because ozone shields the earth from most of the sun's ultraviolet radiation (UVR) which causes non-melanoma, a disfiguring but seldom deadly skin cancer.[27] Moreover, the catalyzing action leaves nitrogen oxides unharmed and able to renew catalysis.[28] Thus, small amounts of nitrogen oxide can destroy a great deal of ozone, allowing more ultraviolet radiation to reach the surface of the earth and cause additional skin cancer. The measurements of the Concorde's impact on the ozone used by decisionmakers, however, were inaccurate due to the inadequacies of the mathematical model on which they were based.

Scientists employed mathematical models to estimate the Concorde's impact on the ozone because only very large amounts of ozone depletion can be measured directly. This is due to the dramatic variation in "overhead ozone"[29] measured by stations located on earth.[30] Since only eight or ten independent measurements can be made each day, scientists are unable to conclude that any amount of ozone depletion has occurred unless average ozone measurements remain five or ten percent below normal for several years.[31] Such changes would be costly; at least 25,000 Americans would contract skin cancer for each year that a five percent reduction continued while at least 50,000 additional skin cancers would result in the United States for each year that a ten percent reduction continued.[32] Unwilling to risk this catastrophic

more with the decisionmaking process than with the relative benefits and dangers of the Concorde, no attempt will be made to analyze this most recent shift in scientific thinking. Rather, this article will focus on the beliefs of scientists in 1976 with respect to the Concorde's impact, and the ineffectiveness of the process by which their knowledge was communicated to Secretary Coleman.

25. FEIS, *supra* note 7, at VI-108; NAS REPORT, *supra* note 24, at 27.

26. NAS REPORT, *supra* note 24, at 183.

27. FEIS, *supra* note 7, at VI-115 to VI-116. The EIS also assessed the impact an expanded fleet of 40 Concordes would have upon the ozone. *Id.* at VI-124, VI-181.

28. NAS REPORT, *supra* note 24, at 129.

29. CIAP REPORT, *supra* note 15, at 25; FEIS, *supra* note 7, at VI-112.

30. CIAP REPORT, *supra* note 15, at 71. *Inadvertent Modification*, *supra* note 15, at 74; NAS REPORT, *supra* note 24, at 176.

31. Pittock, *Ozone Climatology, Trends and the Monitoring Problem in* INTERNATIONAL CONFERENCE ON STRUCTURE, COMPOSITION, AND GENERAL CIRCULATION OF THE UPPER AND LOWER ATMOSPHERE AND POSSIBLE ANTHROGENIC PERTURBATIONS PROCEEDINGS 455-66 (1974).

32. These numbers were calculated by following ozone modelling steps three and four, which are described below.2 See text accompanying notes 56-76 *infra*.

result, scientists resorted to models to determine the Concorde's impact on the ozone.

As a first step in model building, EIS scientists estimated the yearly Concorde emission of nitrogen oxide to be 4.5×10^9 grams.[33] This figure is derived from Equation Two.[34]

$$S = (E \times R) \times (T \times N) \times 365$$

where: S = Concorde emissions of nitrogen oxide = 4.5×10^9 grams/year.

E = Emissions Index = $\frac{\text{Amount of nitrogen oxide omitted}}{\text{Amount of fuel burned}}$ = 18 grams of nitrogen oxide/kilogram of fuel burned.[35]

R = Rate of fuel consumption by each aircraft = 19,000 kilograms/hour.

T = Daily time that each Concorde operates = 6 hours/day.

N = Number of Concordes operating to the United States = 6.

D = Days in a year = 365 days.

Equation Two

Due to possible errors in estimating the Emissions Index, however, nitrogen oxide emissions might be much larger than was calculated. The Emissions Index was determined by sampling the exhaust products of a Concorde engine operated in simulated atmospheric conditions.[36] During CIAP, however, researchers discovered that a different experimental technique yielded an Emissions Index value three to five times larger than did the technique used in fixing the Concorde's Emissions Index at eighteen.[37] Currently no one knows which Emissions value is correct. By assuming the

33. FEIS, *supra* note 7, at VI-120.

34. NAS REPORT, *supra* not 24, at 135.

35. FEIS, *supra* note 7, at VI-119.

36. CLIMATIC IMPACT ASSESSMENT PROGRAM, U.S. DEP'T OF TRANSPORTATION, MONOGRAPH 2: PROPULSION EFFLUENTS IN THE STRATOSPHERE 4-3 to 4-9 (1975) [herenafter cited as CIAP MONOGRAPH 2].

37. CIAP REPORT, *supra* note 15, at D-90; EIS ADDENDUM, *supra* note 12, at 37; *see FAA Certification, supra* note 17, at 74 (statement of Dr. Harold S. Johnston).

index to be eighteen, the EIS discounted the likelihood of other values. The ultimate decision was therefore based on a potentially less accurate estimate of nitrogen oxide emissions than might have been obtained by the use of decision analysis techniques, since the latter would have quantified the uncertainty factor which stemmed from the divergent experimental results.

Uncertainty also weakens the EIS calculation of ozone depletion which would be caused by the Concorde. After determining the Emissions Index value, EIS researchers used CIAP procedures to calculate that ozone depletion would total 0.04%.[38] Another calculation, based upon the National Academy of Science (NAS) critique of CIAP,[39] indicated that at the estimated level of Concorde emissions, ozone depletion might total 0.06%.[40] Due to uncertainty about the accuracy of their estimates, CIAP researchers admitted that actual damages might be one-half as large or twice as great as their models predicted.[41] The more skeptical NAS scientists thought actual damages could be one-third as much or three times as large as predicted by their models.[42] Although the EIS reported both uncertainty estimates, the probability that actual damages might equal these higher predictions was never factored into its analysis of the Concorde's impact.[43]

Inaccuracies likewise permeate the two-step method for estimating the rate of increase in skin cancer incidence at the expected level of ozone depletion. First, experts calculated that the rate of increase in exposure to damaging ultraviolet radiation would be twice the amount of ozone depletion.[44] Next, they estimated that the rate of increased skin cancer incidence would equal the rate of increase in exposure to damaging ultraviolet radiation.[45] Thus, a 0.04% ozone depletion was expected to cause a 0.08% rise in skin cancer incidence; a 0.06% depletion was predicted to produce an increase of 0.12%.[46]

The experts' conclusions regarding the linkages between ozone

38. FEIS, *supra* note 7, at VI-120.
39. NAS REPORT, *supra* note 24, at 33.
40. FEIS, *supra* note 7, at VI-120.
41. CIAP REPORT, *supra* note 15, at E-13.
42. NAS REPORT, *supra* note 24, at 29.
43. *See* text accompanying note 76 *supra*.
44. CIAP REPORT, *supra* note 15, at 37; *Inadvertent Modification*, *supra* note 15, at 74-75; NAS REPORT, *supra* note 24, at 176.
45. CIAP REPORT, *supra* note 15, at 37; *Inadvertent Modification*, *supra* note 15, at 74.
46. FEIS, *supra* note 7, at VI-120.

depletion and UVR exposure, and between UVR exposure and skin cancer incidence suffered from uncertainty due to incomplete knowledge about some of the factors affecting those linkages. A preliminary problem was that the different effect of ozone depletion on each type of ultraviolet radiation made the determination of a relationship between ozone depletion and changes in ultraviolet exposure difficult.[47] Under the model for quantifying the overall change in ultraviolet exposure due to ozone depletion, scientists first quantified the present amount of ultraviolet exposure by averaging exposure to each type of ultraviolet radiation according to its skin cancer inducing ability.[48] Next, scientists determined how ozone depletion would affect each type of ultraviolet radiation.[49] A new level of ultraviolet exposure was estimated by averaging the new exposures to each type of ultraviolet radiation according to its skin cancer inducing ability. Finally, the change in ultraviolet exposure was calculated by subtracting the present amount of ultraviolet exposure from the new.[50]

To demonstrate the procedure, suppose that there are only two types of ultraviolet exposures, B and C. Assume further that ten units of B, which shows twice the ability to induce skin cancer as C, fall on a study city. Five units of C, which shows unit ability to induce skin cancer, also fall on the study city. If ozone is depleted, the study city will be exposed to fifteen units of B and fifteen units of C. UVR_2, the new level of ultraviolet exposure; UVR_1, the present amount of ultraviolet exposure; and ΔUVR, the increase in ultraviolet exposure, can be calculated as follows:

$$UVR_2 = (15 \times 2) + (15 \times 1) = 45$$

$$UVR_1 = (10 \times 2) + (5 \times 1) = 25$$

$$\Delta UVR = UVR_2 - UVR_1 = 20$$

The reliability of this research is doubtful, however, because data showing the skin cancer inducing ability of various ultraviolet radia-

47. CIAP REPORT, *supra* note 15, at G-20; NAS REPORT, *supra* note 24, at 173.

48. CLIMATIC IMPACT ASSESSMENT PROGRAM, MONOGRAPH 5: IMPACT OF CLIMATIC CHANGES ON THE BIOSPHERE, PT. 1 1-7 [hereinafter cited as CIAP MONOGRAPH 5]; *Inadvertent Modification*, *supra* note 15, at 66; NAS REPORT, *supra* note 24, at 184-91; F. Urbach, CLIMATIC IMPACT ASSESSMENT PROGRAM, U.S. DEP'T OF TRANSPORTATION, THIRD CONFERENCE OF CIAP 523-525 (1974) [hereinafter cited as URBACH STUDY].

49. CIAP MONOGRAPH 5, *supra* note 48, at 2-27 to 2-32; NAS REPORT, *supra* note 24, at 171-76.

50. URBACH STUDY, *supra* note 48, at 532.

tions have never been gathered.[51] Researchers therefore assumed that the cancer inducing ability of each type of ultraviolet radiation equalled its mean sunburning ability as measured in a number of experiments.[52] This assumption, however, was only "reasonably well established."[53] Furthermore, experiments reported different measurements for ultraviolet radiation's sunburning ability.[54] Although the CIAP study discussed these possibilities,[55] the EIS made no mention of the scientists' uncertainty, but assumed the accuracy of the underlying assumption.

The second phase of the research, predicting the causal relationship between the Concorde's effect on the ozone layer and an increase in skin cancer, was also accomplished with unreliable data.[56] In making this prediction, scientists sought a precise correlation between the rate of increase in skin cancer incidence and the rate of increase in exposure to damaging ultraviolet radiation. To determine the value of A, ultraviolet radiation's ability to induce skin cancer,[57] they set up Equation Three.

$$A = \frac{\Delta CA}{CA} \times \frac{UVR}{\Delta UVR} = \frac{CA_2 - CA_1}{CA_1} \times \frac{UVR_1}{UVR_2 - UVR_1}$$

where: $\frac{\Delta CA}{CA}$ = Rate of increase in skin cancer incidence

$$= \frac{CA_2 - CA_1}{CA_1}$$

CA_1 = Skin cancer incidence in setting 1.

CA_2 = Skin cancer incidence in setting 2.

$\frac{\Delta UVR}{UVR}$ = Rate of increase in ultraviolet exposure

$$= \frac{UVR_2 - UVR_1}{UVR_1}$$

51. CIAP MONOGRAPH 5, *supra* note 48, at 1-21.

52. CIAP REPORT, *supra* note 15, at 28; *Inadvertent Modification*, *supra* note 15, at 66; NAS REPORT, *supra* note 24, at 190.

53. CIAP MONOGRAPH 5, *supra* note 48, at 1-21.

54. CIAP REPORT, *supra* note 15, at 30; NAS REPORT, *supra* note 24, at 189.

55. CIAP MONOGRAPH 5, *supra* note 48, at 1-7 and 9-11.

56. *Id.* at 1-14; *Inadvertent Modification*, *supra* note 15, at 70; NAS REPORT, *supra* note 24, at 37.

57. URBACH STUDY, *supra* note 48, at 523; CIAP MONOGRAPH 5, *supra* note 48, at 7-54.

UVR_1 = Amount of ultraviolet exposure exceeding a safe threshold in setting 1.

UVR_2 = Amount of ultraviolet exposure exceeding a safe threshold in setting 2.

Equation Three

The occurrence of ozone in the atmosphere provided the means for appraising A.[58] Since the amount of atmospheric ozone declines nearer the equator, causing Americans living in the South to be exposed to more ultraviolet radiation than Northerners,[59] A was determined by comparing the exposures and cancer incidence for people living in Iowa, San Francisco, Dallas and Minneapolis.[60] The results noted at the outset of this section were obtained.[61]

Then, scientists calculated the rate of increase in skin cancer incidence for any change in the rate of ultraviolet exposure by rearranging Equation Three to obtain Equation Four.

$$\frac{\Delta CA}{CA} = \frac{\Delta UVR}{UVR}$$

Equation Four

CIAP scientists doubted the accuracy[62] of these predictions for three reasons. First, the experts ignored the fact that fairer skinned people were more susceptible to skin cancer,[63] and failed to account for the skin color differences between the populations of the study cities.[64] Thus, they probably underestimated the Concorde's impact on the incidence of skin cancer.

Second, the equation is unreliable because of the unproved assumption employed by scientists to determine the value of A; sci-

58. Laboratory experiments inducing human skin cancer, the most efficacious means of appraising A, were impossible to perform. CIAP REPORT, *supra* note 15, at G-37; NAS REPORT, *supra* note 24, at 41.

59. CIAP REPORT, *supra* note 15, at 24; *Inadvertent Modification*, *supra* note 15, at 70; NAS REPORT, *supra* note 24, at 187.

60. CIAP MONOGRAPH 5, *supra* note 48, at 7-55 to 7-56, 9-8.

61. *See* text accompanying note 46 *supra*.

62. "[U]ntil much better data are available, all the numerical estimates (of changes in skin cancer incidence) must be treated as very preliminary and open to significant corrections as new information accumulates." CIAP MONOGRAPH 5, *supra* note 48, at 7-59.

63. NAS REPORT, *supra* note 24, at 175.

64. CIAP MONOGRAPH 5, *supra* note 48, at 9-11.

entists assumed again that the skin cancer inducing ability of UVR equals its sunburning ability.[65] Moreover, the equation presumed without sufficient support that the actual exposure of study area residents to UVR is a proportionately varying function of the UVR falling on the city.[66] This fails to take into account the diminishing effect that clothing and time spent indoors have on UVR exposure.[67]

The fourth step of the model, estimating the additional number of skin cancer cases suffered by Americans should the Concorde be permitted to operate, was accomplished by multiplying the anticipated rate of increase in skin cancer incidence by present skin cancer incidence.[68] Secretary Coleman reported that skin cancer incidence in the United States totalled 250,000 cases per year.[69] The EIS thus expected Americans to suffer 200 additional cases of skin cancer if the rate of increase in skin cancer incidence turned out to be 0.08%[70] or 300 additional cases if it were 0.12%, although the Secretary neglected to discuss this latter possibility.

Failure to ascertain accurately the present skin cancer incidence, however, resulted in an improbably low appraisal of Concorde-caused damages. To measure skin cancer incidence, scientists asked all doctors in a given study area to report how many skin cancers they diagnosed.[71] Since not every physician cooperated, experts agreed that the incidence of skin cancer in the United States was much greater than was reported by Secretary Coleman.[72] Esti-

65. NAS REPORT, *supra* note 24, at 183.

66. CIAP MONOGRAPH 5, *supra* note 48, at 7-54, 9-11.

67. *Id.* at 9-11; NAS REPORT, *supra* note 24, at 195; *Inadvertent Modification of the Upper Atmosphere: Research and Development Relating to Halocarbons and Ozone Depletion; Hearings Before the Subcomm. on the Environment and the Atmosphere of the House Comm. on Science and Technology*, 94th Cong., 1st Sess 34 (1975) (statement of Dr. Richard Setlow).

68. These calculations and hence, the predictions they yield, reflect the number of Concorde-induced cancers that would be contracted during any year when, after many years of continuous operations, the Concorde's impact became constant. FEIS, *supra* note 7, at VI-124. Actually, Secretary Coleman wanted to know how many skin cancers would result from the first year's operations. Since the former is much easier to calculate than the latter, *id.* at VI-130, however, and the two are ostensibly equal, EIS ADDENDUM, *supra* note 12, at 35, the EIS and CIAP focused on calculating the former.

69. SECRETARY'S DECISION, *supra* note 6, at 37.

70. *Id.*

71. *See* Scotto, *Non-melanoma Skin Cancer Among Caucasians in Four Areas of the United States*, 34 CANCER 1333 (1974).

72. NAS REPORT, *supra* note 24, at 192; Scotto, *Non-melanoma Skin Cancer Among Caucasians in Four Area of the United States*, 34 CANCER 1333, 1337 (1974).

mates of the actual figures range from 300,000[73] to 600,000 cases of skin cancer each year.[74] The EIS neither included these higher estimates nor explained the uncertainties inherent in the estimates it proferred.[75]

The insufficiencies of EIS research hindered Coleman's decisionmaking. They prevented Coleman from learning the number of additional skin cancers that should have been factored into his decision as a cost of permitting the flights.[76] He did not learn that the EIS assumed the lowest possible values for three unknown variables: the Concorde's emission index, ultraviolet radiation's ability to induce skin cancer, and the incidence of skin cancer in the United States. Had the EIS listed the probabilities that higher values for these variables might be accurate, Secretary Coleman may have considered that the actual damages would be greater than those posited by the EIS.

2. Noise Damage

A second negative consequence of the Concorde is noise pollution. Annoying airport neighbors with its loud noise level is one aspect of this pollution; hearing damage is another. In assessing the annoyance impact, the EIS first measured the noise level to which airport community residents were exposed as well as the noise level to which they would be exposed if Concorde flights were instituted. These measurements were expressed in terms of the units of a well known noise exposure index, the Noise Exposure Forecast (NEF).[77] Next, the EIS counted the number of

73. *Inadvertent Modification of the Upper Atmosphere: Research and Development Relating to Halocarbons and Ozone Depletion: Hearings Before the Subcomm. on the Environment and the Atmosphere of the House Comm. on Science and Technology*, 94th Cong., 1st Sess. 237 (1975) (statement of Frederick Urbach).

74. *Fluorocarbons—Impact on Health and Environment: Hearings Before the Subcomm. on Public Health and Environment of the House Comm. on Interstate and Foreign Commerce*, 93d Cong., 2d Sess. 16 (1974) (statement of T.M. Donahue).

75. FEIS, *supra* note 7, at VI-124.

76. NAS REPORT, *supra* note 24, at 301, 308.

77. Scientists calculate NEF as follows:

$$NEF = 10 \log_{10} \frac{N_d + 16.7\, N_n}{N} \sum_{i=1}^{N} \frac{10^{LOUD_i}}{10} - 88$$

Equation 7

where: Nd = Number of airplanes heard only during the interval 7:00 A.M.-10:00 P.M.

people exposed to two levels of unacceptably high noise exposure, NEF thirty and forty, and determined the increase in this number should the Concorde operate.[78] This technique of measurement was represented as the "method . . . in general use for assess[ing] the impact of airport noise,"[79] and most decisional participants relied solely upon this difference in measuring the Concorde's noise impact.[80] The results displayed in Table Two indicated that the Concorde's noise annoyance impact might be very slight. Three EIS failings, however, obscured the fact that the Concorde's impact on noise annoyance could be very serious.

One such failing was the deficient standard of noise annoyance employed be EIS researchers. The EIS assumption that only those people exposed to NEF thirty and forty by the Concorde's noise for the first time would be hurt contradicts studies correlating annoyance and noise exposure. These studies show that annoyance increases not only when people are exposed to NEF thirty and forty for the first time, but also when they experience any increase in noise exposure beyond the threshold of noise annoyance.[81] EIS predictions of how many more people would be harmed by the Concorde's operation were therefore too low because they did not

Nn = Number of airplanes heard daily during the interval 10:00 P.M.-7:00 A.M.
$LOUD_i$ = Loudness of the ith aircraft heard in units of EPNdB.

W. BURNS, NOISE AND MAN 404-413 (2d ed. 1973); 1 C. BARTELL, AIRPORT NOISE REDUCTION FORECAST, SUMMARY FOR 23 AIRPORTS 2-13 (1974).

78. The Concorde's noise may also induce building vibrations. FEIS, *supra* note 7, at VI-76; OFFICE OF NOISE ABATEMENT, U.S. DEP'T OF TRANSPORTATION, SOUND AND VIBRATION MEASUREMENTS FOR CONCORDE SUPERSONIC TRANSPORT AND SUBSONIC JET AIRCRAFT (1974); TRANSPORTATION SYSTEMS CENTER, NOISE EMISSIONS AND BUILDING STRUCTURAL VIBRATION LEVELS FROM THE SUPERSONIC CONCORDE AND SUBSONIC TURBOJET AIRCRAFT (1975). While the Concorde induced several times more building vibrations than most other commercial planes, FEIS, *supra* note 7, at VI-29, it was not expected to cause structural damage. SECRETARY'S DECISION, *supra* note 6, at 43. It was expected, however, to cause minimal annoyance when hanging pictures and other objects rattled against vibrating walls. *Id.*

79. FEIS, *supra* note 7, at VI-154. The EIS also discussed the annoyance impact of enlarging the Concorde fleet to forty planes. *Id.* at VI-185, VI-188.

80. *Id.* at VI-154, VI-171.

81. W. BURNS, NOISE AND MAN 310 (2d ed. 1973); W. CONNOR, COMMUNITY REACTION TO AIRPORT NOISE (1971); W. CONNOR, COMMUNITY REACTION TO AIRPORT NOISE AROUND SMALLER CITY AIRPORTS (1972); Stevens. *A Community's Reaction to Noise: Can It Be Forecast?* 1 NOISE CONTROL 63 (1955); *see* FEIS, *supra* note 7, at VI-50 to VI-61.

consider those people already exposed to NEF thirty and forty who would experience an incremental increase in noise annoyance.

Table Two:
Number of People Exposed to NEF 30 and 40
With and Without the Proposed Concorde Operations

	Airport			
	JFK Airport		Dulles Airport	
	NEF 30	NEF 40	NEF 30	NEF 40
Without Concorde	485,000	112,000	0-1,000	0
With Concorde	487,000	114,000	0-1,000	0

EIS noise annoyance analysis was further deficient in failing to calculate the Concorde's impact on people exposed to less than NEF thirty daily noise. Depending on the method they employ to measure community annoyance, scientists disagree on whether NEF twenty or thirty[82] constitutes the threshold below which people can experience additional noise exposure without becoming increasingly annoyed. Rather than reporting these divergent opinions, however, the EIS selected NEF thirty as the threshold of noise annoyance. It thus failed to predict that the Concorde might harm about two million New Yorkers and a few thousand Virginians suffering daily airport noise exposure between NEF twenty and thirty.[83]

The EIS ostensibly excluded predictions based on lower

82. Community annoyance may be measured by observing the intensity of actions taken by airport neighbors to reduce airport noise. These actions include complaining to responsible authorities and commencing litigation. Community annoyance may also be measured by surveying airport neighbors to determine the extent to which the noise disturbs such activities as sleeping, television viewing, and talking. For an account detailing the development of these correlations, see BOLT, BERANAK & NEWMAN, INC., NOISE EXPOSURE FORECASTS: EVOLUTION, EVALUATION, EXTENSION AND LAND USE INTERPRETATIONS (1970). *See also* W. BURNS, NOISE AND MAN (2d ed. 1973); K. KRYTER, THE EFFECTS OF NOISE ON MAN (1970).

83. The population exposed to NEF was calculated by assuming that the area exposed to NEF 20 or more was as densely populated as the area exposed to NEF 30 or more. Generally, the area exposed to NEF 20 was 5.44 times as large as the area exposed to NEF 30. *See* FEIS, *supra* note 7, at VI-142.

threshold estimates, despite a suggestion by the Council on Environmental Quality (CEQ) that such an omission be corrected, because it feared that errors would be generated in "calculating NEF at greater distances" from an airport.[84] Thus, the CEQ's claim that people could be harmed by noise at exposures lower than NEF thirty was discounted, although the EIS failed to disclose the nature and size of the potential errors, or explain why such calculations would lack utility.

A third shortcoming of the EIS was the absence of information concerning property value diminution caused by the expected increase in noise exposure. An FAA study[85] available to EIS experts demonstrated that house values are reduced by about 0.5% for each additional NEF unit of exposure beyond NEF twenty.[86] The damage or costs attributable to the Concorde could be calculated using Equation Five.

$$\text{Damages} = \frac{\text{DIM} \times \text{N} \times \text{HV} \times \text{AE}}{100}$$

where: DIM: = Diminution in housing value with increasing NEF, percent/NEF unit

N = Number of houses impacted

HV = Average house value, dollars

AE = Additional noise exposure, NEF

Equation Five

Table Three shows the Concorde noise annoyance cost calculated for various property values and diminutions to Kennedy Airport neighbors already exposed to NEF twenty and thirty. The figures demonstrate that the cost of Concorde's flights to Kennedy Airport

84. FEIS, *supra* note 7, at VI-142.

85. J. NELSON, THE EFFECTS OF MOBILE SOURCE AIR AND NOISE POLLUTION ON RESIDENTIAL PROPERTY VALUES (1975).

86. *Id.* at 2-11. This result closely approximated those reported in other studies which estimated reductions in house values ranging between 0.4% and 2.0% per NEF unit increase in noise exposure.

could be very large. Similar calculations for Dulles Airport were not attempted since, unlike Kennedy Airport, the average change in noise exposure resulting from the proposed Concorde operations has never been reported.

Table Three: Estimated Property Value Diminution (Millions of Dollars) Caused by Concorde Operations at Kennedy Airport[a]

	Threshold of Noise Damage					
	NEF 30			NEF 20		
	Average House Value (HV)					
DIM	$20,000	$40,000	$60,000	$20,000	$40,000	$60,000
0.5%	3.84	7.68	11.5	20.8	41.6	62.4
1.0%	7.68	15.30	23.0	41.6	83.2	125.0
1.5%	11.50	23.00	34.5	62.4	125.0	187.0
2.0%	15.30	30.70	46.0	83.2	166.0	250.0

[a]In these calculations, the number of houses impacted was calculated by dividing the number of people presently exposed to NEF 20 and 30 by 3.8, by the average number of people residing in each household. W. SPERRY, NOISE SOURCE ABATEMENT TECHNOLOGY AND COST ANALYSIS INCLUDING RETROFITTING 4-5 (1973). Additional noise exposure for people exposed to NEF 20 was assumed to be 0.3 units, the same amount of additional exposure suffered by Kennedy Airport neighbors exposed to NEF 30. SECRETARY'S DECISION, *supra* note 6, at 47. The average property value for homes near Kennedy Airport was not investigated in the preparation of this study and remains only the subject of conjecture.

No clear explanation for the EIS failure to supplement its predictions with property value diminution information has been given. During the January 5, 1976 hearing, Secretary Coleman received a detailed submission recommending the use of property value information to assess the Concorde's noise annoyance costs.[87] In response to this, the EIS Addendum averred that "to date there has been no scientific research which correlates changes in NEF units, as distinguished from people or land area impacted within the NEF 40 and 30 contours, to 'environmental impact'."[88] This statement is ambiguous at best. It may mean that property value diminution is an unacceptable proxy for "environmental damage." Alternatively,

87. The Impact of the Concorde SST on Residential Property Values in the Vicinity of Dulles International Airport, Memorandum Submitted for the Record by the Urban Institute of Washington (Jan. 5, 1976).

88. EIS ADDENDUM, *supra* note 12, at 5.

it may mean that the studies cited above are not "scientific." Finally, it may mean that the EIS authors were unaware of these studies; this is an unlikely possibility since many of these studies, including the one by the FAA, were cited in the submission received by Secretary Coleman. In any event, the failure of the EIS to take into account several of the factors contributing to the potential cost of increased noise annoyance severely reduced its contribution to the rationality of the decision making process.

In addition to annoyance, a second aspect of noise pollution generated by the Concorde is permanent hearing damage. The final EIS discounted this potential harm as insignificant.[89] The EIS analysis, however, was misleading in that it assumed that the Concorde would be the only loud noise heard by airport neighbors.

The risk of hearing damage is measured by summing the impact of different sounds heard in a day.[90] Although the Concorde's noise alone does not exceed safe thresholds, many Americans are already exposed to dangerous levels of noise from other sources,[91] including non-Concorde airport operations.[92] Any of these people may suffer hearing damage when exposed to the Concorde's noise. Why the EIS neglected to consider the Concorde's impact on these susceptible people is unknown.

The EIS noise research would have been more complete and accurate had decision analysis been employed. Decision analysis would have forced scientists to analyze the reliability of available information, as well as report on the seriousness and likelihood of various impacts. Thus, the possibility that the Concorde would cause greater annoyance and hearing damage than was predicted, as well as property value diminution, would have been revealed to the decisionmakers.

89. FEIS, *supra* note 7, at VI-71 to VI-73.

90. U.S. ENVIRONMENTAL PROTECTION AGENCY, INFORMATION ON LEVELS OF ENVIRONMENTAL NOISE REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY C-11 (1974) [hereinafter cited as EPA LEVELS DOCUMENT]; *Damage-risk Criteria for Hearing*, in NOISE AND VIBRATION CONTROL 543 (L. Beranak ed. 1971) [hereinafter cited as *Damage-risk Criteria for Hearing*].

91. NATIONAL BUREAU OF STANDARDS, THE SOCIAL IMPACT OF NOISE 7 (1971). *See also* EPA LEVELS DOCUMENT, *supra* note 90, at B-9.

92. W. BURNS, NOISE AND MAN 335 (2d ed. 1973); EPA LEVELS DOCUMENT, *supra* note 90, at B-2; NATIONAL BUREAU OF STANDARDS, THE SOCIAL IMPACT OF NOISE 8 (1971). The effects of aircraft noise upon hearing have been investigated in only one very limited study, which provided no information about the impact on people exposed to high levels of noise by non-aircraft sounds. J. PARNELL, EVALUATION OF HEARING LEVELS OF RESIDENTS LIVING NEAR A MAJOR AIRPORT (1972).

D. *Benefits of a Decision Allowing the Concorde to Land*

To be balanced against the costs described above are the diverse benefits which accrue from allowing the Concorde to land in the United States. For example, a favorable decision would avoid British and French antipathy towards the United States. Banning the Concorde from the lucrative North Atlantic routes would have sparked such resentment,[93] for the two governments had invested prestige and three billion dollars[94] in the Concorde design project.[95] Secretary of State Kissinger assessed the benefits of avoiding international resentment in a two-page letter to Coleman,[96] who subsequently relied on this assessment in his decisionmaking.[97]

A second benefit derived from the Concorde is reduced travel time. The Concorde saves four hours[98] en route between Europe and the United States, thereby shortening the flight for travelers[99] as well as reducing the jet lag caused by longer flight times.[100] As shown by Table Four, Concorde passengers pay increased costs for this service, which reduces the net utility of their travel time savings. Unfortunately, no decisionmaking record estimating the value of the time travel reduction exists. The absence of this documentation prevented Secretary Coleman from balancing the range and probability of possible benefit levels,[101] although he did consider

93. SECRETARY'S DECISION, *supra* note 6, at 54. Coleman also suggested that the United States, by permitting the Concorde to land, would obey its treaty obligations and thus avoid the cost of becoming an international outlaw. *Id.* at 9. Apparently, however, the United States was not obligated to permit Concorde landings. Memorandum on Legal Issues, Monroe Leigh, Dep't of State (Jan. 13, 1976).

94. SECRETARY'S DECISION, *supra* note 6, at 54.

95. The Concorde design project was conceived to aid British and French aircraft manufacturers to achieve parity with their American competitors. The Concorde effort has proven abortive in this respect. To date, only nine have been sold, five to British Airways and four to Air France. A. WILSON, THE CONCORDE FIASCO 9 (1973). Much has been written about the Concorde's history. *See* J. COSTELLO & T. HUGHES, THE CONCORDE CONSPIRACY (1976); J. DAVIS, THE CONCORDE AFFAIR (1969); G. KNIGHT, CONCORDE: THE INSIDE STORY (1976); Gillman, *Supersonic Bust*, THE ATLANTIC MONTHLY, Jan. 1977, at 72.

96. *See FAA Certification*, *supra* note 17, at 375 (statement of William Randall).

97. SECRETARY'S DECISION, *supra* note 6, at 59.

98. AIR FRANCE, CONCORDE: A NEW WORLD OF FLYING (1976).

99. SECRETARY'S DECISION, *supra* note 6, at 51; *U.S. Dep't of Transportation, Public Hearings on Applications of Air France and British Airways to Operate Concorde Aircraft in Limited Commercial Service to New York and Washington* 43 (1976).

100. Gerathewohl, *Simple Calculator for Determining the Physiological Rest Period after Jet Flights Involving Time Zone Shifts*, 45 AEROSPACE MEDICINE 449 (1974).

101. SECRETARY'S DECISION, *supra* note 6, at 59.

the increased trade, commerce and cultural exchange which would result from supersonic flights.[102] Consideration of these remote time-savings benefits, however, was inconsistent with the decisional approach used for evaluating environmental harm, since the Secretary ignored remote costs which might ensue from the ozone depletion or noise pollution caused by the Concorde.

Table Four: Concorde and Other Roundtrip Fares

	Routes			
Ticket Type	New York-London[a]	New York-Paris[b]	Washington-London[c]	Washington-Paris[d]
Concorde	$1694	$1796	$1788	$1890
First Class	$1406	$1508	$1484	$1586
Coach	$626	650	$680	$704
Excursion	$309-$499	$310-$546	$524-$543	$565-$590
Standby	$279		$283	

[a] THE REUBEN H. DONNELLY CORPORATION, OFFICIAL AIRLINE GUIDELINES, WORLD WIDE EDITION 734 (Dec. 1978).
[b] *Id.* at 1025.
[c] *Id.* at 744.
[d] *Id.* at 1030.

A further benefit expected from the sixteen-month testing program approved by Coleman was new data on the demand for supersonic airplanes and the environmental threat they would pose.[103] This information would aid the final decisionmakers. Secretary Coleman was unaware, however, that due to the inadequacy of the tests, the value of the testing program might be much less than was anticipated.

The first goal of the testing program was to measure the demand among American consumers for supersonic airplanes; this task was frustrated due to insufficient data.[104] Economic theory indicates that this information should have been gathered by determining how many Americans would pay at varying rates for Concorde services,[105] yet no reports on the number of Americans flying the Con-

102. *Id.* at 51.
103. SECRETARY'S DECISION, *supra* note 6, at 60-61.
104. *Id.* at 52.
105. The benefit offered to American consumers by supersonic flight would then

corde have been made. Moreover, the Concorde's fares have remained nearly constant during the testing program.[106]

Likewise, the testing program's efforts to gather information on the effect of continuing Concorde operations on noise pollution are seriously incomplete.[107] Scientists installed noise measuring equipment near Dulles[108] and Kennedy Airports,[109] and they also established centers for receiving complaints about the Concorde's noise.[110] The measurements are of limited utility, however, because no experiments have been performed to determine the extent of Concorde-caused hearing damage either to airport neighborhood or more remote residents. Moreover, the standards by which the Concorde's noise impact have been measured are not accurate. Scientists judging the impact of the Concorde by the number of complaints received during the first year of operations at Dulles Airport[111] failed to consider that airport neighbors were temporarily sensitized to the Concorde's noise due to publicity.[112]

The program's efforts to test the Concorde's impact on the ozone proved to be shortlived and therefore unhelpful.[113] Secretary Coleman at first strove towards international cooperation in the compilation of information and asked the President of the United States

be calculated by totalling the prices Americans riding the SST were willing to pay less the cost of their fares. *See* UNCERTAIN SEARCH, *supra* note 1, at 103-09.

106. Since initiating Concorde service, the operators have only raised fares from their original prices which were as follows: Washington-London, $1602, THE REUBEN H. DONNELLY CORPORATION, OFFICIAL AIRLINE GUIDELINES, WORLD WIDE EDITION 569 (1976); Washington-Paris, $1654, *id.* at 784; New York-London, $1586, THE REUBEN H. DONNELLY CORPORATION, OFFICIAL AIRLINE GUIDELINES, WORLD WIDE EDITION 1287 (Mar. 1978); New York-Paris, $1642, *id.* at 926.

107. SECRETARY'S DECISION, *supra* note 6, at 58.

108. *See* FEDERAL AVIATION ADMINISTRATION, DEP'T OF TRANSPORTATION, CONCORDE MONITORING SUMMARY REPORT: DULLES INTERNATIONAL AIRPORT 15 (1977) [hereinafter cited as DULLES TESTING SUMMARY].

109. *See* FEDERAL AVIATION ADMINISTRATION, DEP'T OF TRANSPORTATION, CONCORDE MONITORING SUMMARY REPORT: DULLES INTERNATIONAL AIRPORT 15 (1977).

110. *Id.* at 32. DULLES TESTING SUMMARY, *supra* note 108, at 98.

111. During the first year of Concorde operations at Dulles, twenty times as many complaints were received concerning Concorde's noise as had previously been received about *all* aircraft noise in any typical year. *See* DULLES TESTING SUMMARY, *supra* note 108, at 100; FEDERAL AVIATION ADMINISTRATION, DEP'T OF TRANSPORTATION, CONCORDE MONITORING: SIX MONTHS' SUMMARY REPORT 27 (1976).

112. A similar comparison for Kennedy Airport is impossible because of the unavailability of data regarding complaints previously received. FEIS, *supra* note 7, at X-37.

113. SECRETARY'S DECISION, *supra* note 6, at 58.

to instruct the Secretary of State to "enter into immediate negotiations with France and Great Britain so that an agreement that [would] establish a monitoring system for measuring ozone levels in the [atmosphere could] be concluded among the three countries in three months."[114] Data obtained from this monitoring effort were to be made public every six months.[115]

The impossibility of measuring the Concorde's impact on the ozone,[116] coupled with failure to implement the proposed ozone monitoring system, has thwarted this goal. The agreement which was concluded between Britain, France and the United States provided only that the parties would "cooperate towards the establishment of a strengthened global ozone monitoring capability."[117] Thus far, the semiannual reports have outlined only actions towards gaining greater understanding of the ozone depletion problem[118] and have failed to provide the monitoring data desired by Secretary Coleman.

Decision analysis would have avoided two shortcomings of the present benefits analysis. First, decision analysis would have yielded estimates of the benefits of the Concorde's travel time savings. If such estimates were premised upon bases that were inconsistent with those used in assessing the Concorde's impact, the rigorous format of decision analysis would have permitted one of the Concorde's critics to discover and report this fact to the Secretary. Second, scientists could have submitted a more accurate presentation of the benefits of operating the testing program if they had used the decision analysis procedures demonstrated at the outset of this article.[119] Notably, however, decision analysis would not have helped Coleman better assess the foreign relations benefit, which escapes precise quantification.[120]

114. *Id.* at 5.

115. *Id.*

116. *See* text accompanying notes 29-32 *supra.*

117. W. Long, U.S. Dep't of State, Press Release No. 222, United States, Great Britain and France Sign Stratospheric Monitoring Agreement (May 5, 1976).

118. *See* U.S. DEP'T OF STATE, ACTIONS IN THE UNITED STATES OF AMERICA RELATED TO STRATOSPHERIC MONITORING, FIRST SEMIANNUAL REPORT TO THE SECRETARY OF TRANSPORTATION (1976); U.S. DEP'T OF STATE, ACTIONS IN THE UNITED STATES OF AMERICA RELATED TO STRATOSPHERIC MONITORING, SECOND SEMIANNUAL REPORT TO THE SECRETARY OF TRANSPORATION (1978).

119. *See* text pages 157-62 *supra.*

120. SECRETARY'S DECISION, *supra* note 6, at 59.

IV. Implementation of Decision Analysis

The National Environmental Policy Act of 1969 (NEPA)[121] mandates that each governmental agency assess the impact of its major actions "significantly affecting the quality of the human environment."[122] Council on Envirnmental Quality guidelines[123] suggest that this process be initiated with the preparation of a draft EIS discussing the environmental impact of the proposed action, responsible opposing views,[124] and available alternatives to the proposed action.[125] Other agencies and the public are then afforded an opportunity to comment on the draft EIS,[126] after which the final EIS is prepared. Only after a decision is made may federal courts enjoin proposed agency action pending preparation of a more detailed EIS.[127]

Decision analysis could be applied to the present decision-making process with only slight modification of these procedures. In the revised system, agency experts would be required to prepare a decision analysis for inclusion in the draft EIS. The agency would then hear comments about the accuracy of the analysis, which would be revised and incorporated into the final EIS. Should the final EIS be found inadequate, a federal court could enjoin further agency action pending the preparation of a sufficiently detailed decision analysis.

Specific criteria should govern the court's decision on the adequacy of a decision analysis. Each EIS should include results compiled for effective future use by the ultimate decision makers. Requiring the EIS to depict the decision tree and list the relationships therein considered will encourage thoroughness. In addition, an EIS should identify the analysis participants, their qualifications, and the estimates that each expert prepares. The court should hear evidence concerning the exclusion from decision analysis of important considerations or experts.

121. 42 U.S.C. §§ 4331-4347 (1970).

122. National Environmental Policy Act of 1969, § 102(2)(c), 42 U.S.C. § 4332(2)(c) (1970).

123. Preparation of Environmental Impact Statements: Guidelines, 40 C.F.R. §§ 1500.1-14 (1977).

124. *Id.* § 1500.7.

125. *Id.* § 1500.8 (4).

126. *Id.* § 1500.7.

127. F. Anderson, N.E.P.A. in the Courts: A Legal Analysis of the National Environmental Policy Act 239 (1973).

Implementation of this proposal would not be prohibitively expensive. Extensive additional research is not required; rather, scientists need simply review present knowledge, as they currently do in preparing the EIS,[128] and then summarize its import using decision analysis. The additional expense is small when compared with either the value of avoiding incorrect decisions, or the present environmental assessment costs, which total about one-percent of some agency budgets.[129] Judges should be aware of this expense, however, and vary their adequacy standards according to the importance of the decision, as they usually do in judging the sufficiency of an EIS.[130]

C. *NEPA's Possible Mandate for Implementing Decision Analysis*

Having just outlined the contention that decision analysis could be adapted to present decisionmaking procedures, this article will now examine the suggestion that sections 102(2) (A) and 102(2) (B) of the National Environmental Policy Act of 1969 (NEPA) can be interpreted to *require* agencies to implement decision analysis. These provisions:

> [A]uthorize and direct that: to the fullest extent possible . . . all agencies of the Federal Government shall:
> (A) Utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment;
> (B) Identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by Title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decision making along with economic and technical consideration.[131]

128. *See* text accompanying notes 121-26 *supra.*

129. *Council on Environmental Quality, Environmental Quality, Sixth Annual Report* 637 (1975).

130. *Id.* at 210, 219; Natural Resources Defense Council, Inc. v. Morton, 458 F.2d 827, 837 (D.C. Cir. 1972);nvironmental Defense Fund, Inc. v. Corps of Engineers, 325 F. Supp. 728, 758 (E.D. Ark. 1970-71). Thus, the "rule[s] of reason" that currently allow agencies to avoid discussing alternatives or impacts that are merely remote and speculative possiblities, F. ANDERSON, N.E.P.A. IN THE COURTS 221 (1973), would be extended to permit agencies to avoid preparing decision analyses that analyze the impact of environmental harms that are only remotely possible.

131. National Environmental Policy Act of 1969, § 102(2), 42 U.S.C. § 4322 (2)(c) (1970).

The legislative history of NEPA and subsequent case law development support the contention that these provisions require the use of decision analysis. Participants in the hearings preceding NEPA's passage acknowledged that future environmental decisionmaking entailed balancing environmental considerations against other concerns.[132] Many witnesses advocated the use of systems analysis for this balancing process,[133] a decisionmaking methodology that comprehends decision analysis techniques.[134] In response, several Congressmen endorsed the use of systems analysis,[135] and one 1966 committee report recommended its implementation.[136]

Hearing participants recognized, however, that widespread use

132. *Joint House-Senate Colloquium to Discuss a National Policy for the Environment: Hearings Before the Senate Comm. on Interior and Insular Affairs and the House Comm. on Science and Astronautics*, 90th Cong., 2d Sess. 16 (1968) [hereinafter cited as *Joint Committee Hearings*] (statement of U.S. Secy. of the Interior Stewart Udall); *id.* at 20 (statement of U.S. Secy. of Housing and Urban Development Robert C. Weaver); *id.* at 46 (statement of Dr. Donald F. Hornig); *id.* at 49 (statement of Laurance S. Rockefeller); *id.* at 152 (communication from Harvey Brooks); *National Environmental Policy, Hearings on S. 1075, S. 237 and S. 1752 Before the Senate Comm. on Interior and Insular Affairs*, 91st Cong., 1st Sess. 32 (1969) [hereinafter cited as *Senate Committee Hearings*] (statement of Sen. Henry Jackson); *Environmental Quality, Hearings on H.R. 6750, H.R. 11886, H.R. 11942, H.R. 12077, H.R. 12180, H.R. 12207, H.R. 12209, H.R. 12228, H.R. 12264, H.R. 12409 Before the Subcomm. on Fisheries and Wildlife Conservation of the House Comm. on Merchant Marine and Fisheries*, 91st Cong., 1st Sess. 18 (1969) [hereinafter cited as *House Committee Hearings*] (statement of Stewart L. Udall); *id.* at 26 (statement of Rep. John D. Dingell). *See also Subcomm. on Science, Research and Development of the House Comm. on Science and Astronautics*, 90th Cong., 2d Sess., *Managing the Environment* (Comm. Print 1969) [hereinafter cited as *House Committee Report*].

133. THE ADEQUACY OF TECHNOLOGY FOR POLLUTION ABATEMENT, 89th Cong., 2d Sess. 106 (1966) (statement of John W. Tukey); *id.* at 241 (statement of William E. Warne); *id.* at 269 (statement of Dr. Walter R. Hibbard, Jr.); *id.* at 395 (statement of John O. Logan); *id.* at 832 (communication from Ray K. Linsley); *Joint Committee Hearings, supra* note 138, at 25 (statement of Ass't U.S. Secy. of Agriculture John A. Baker); *id.* at 52 (statement of U.S. Secy. of Housing and Urban Development Robert C. Weaver); *id.* at 188 (communication from John S. Lagarius); *House Committee Hearings, supra* note 138, at 45, 472 (statement of Dr. John Cairns, Jr.); *id.* at 187 (statement of Carlos Fellerolf, Jr.); *id.* at 328 (statement of David M. Gates); *id.* at 417 (statement of Harold P. Konig).

134. G. FISHER, COST CONSIDERATIONS IN SYSTEMS ANALYSIS (1971); A. Madansky, UNCERTAINTY IN SYSTEMS ANALYSIS AND POLICY PLANNING, 81-96 (W. Boucher & E. Quade eds. 1968). For additional descriptions of systems analysis techniques, see H.A. HOVEY, THE PLANNING-PROGRAMMING-BUDGETING APPROACH TO GOVERNMENT DECISIONMAKING (1968); PROGRAM BUDGETING (2d ed. D. Novick 1967).

135. *House Committee Hearings, supra* note 132, at 57 (statement of Rep. John Dingell); *id.* at 329 (statement of Rep. Thomas M. Pelley).

136. *House Committee Report, supra* note 132, at 7, 49.

of systems analysis techniques was a long range goal.[137] Most such techniques require a great deal of data which was unavailable. For the present, therefore, hearing participants recommended expanded research by many professional groups, such as mathematicians, economists and social scientists.[138] They argued for the implementation of techniques which were highly reminiscent of decision analysis by proposing that scientists articulate their "best estimates about what is likely to result from decisionmaking,"[139] "the margin of error"[140] in estimated environmental impacts and "probabilities for success[ful]"[141] environmental protection.

Senator Henry Jackson's instrumental Senate Committee Report on Interior and Insular Affairs evidences Congressional intent that sections 102(2) (A) and 102(2) (B) be broadly interpreted. The report states:

> Wherever planning is done or decisions are made which may have an impact on the quality of man's environment, the responsible agency or agencies are directed to utilize to the fullest extent possible a systematic, interdisciplinary team approach . . . draw[ing] upon the broadest possible range of social and natural scientific knowledge and design arts. . . .
> . . . [I]n the past, environmental factors have frequently been ignored . . . because of the difficulty of evaluating them in comparison with economic and technical factors. . . . A vital requisite of environmental management is the development of

137. *Joint Committee Hearings, supra* note 132, at 36 (statement of U.S. Secy. of Health, Education and Welfare Wilbur J. Cohen); *id.* at 51 (statement of Dr. Donald F. Hornig); *id.* at 52 (statement of U.S. Sec. of Housing and Urban Development Robert C. Weaver); *id.* at 68 (statement of Don K. Price); *House Committee Hearings, supra* note 132, at 101 (statement of C. R. Guttermuth); *id.* at 328 (statement of David M. Gates). *See also House Committee Report, supra* note 132, at 5.

138. *Joint Committee Hearings, supra* note 132, at 25 (statement of Ass't U.S. Secy. of Agriculture John A. Baker); *id.* at 37 (statement of Secy. of Health, Education and Welfare Wilbur J. Cohen); *id.* at 110; *id.* at 166 (communication from Jack W. Carlson); *Senate Committee Hearings, supra* note 132, at 36 (statement of Sen. Henry Jackson); *House Committee Hearings, supra* note 132, at 24 (Rep. Paul N. McCloskey, Jr.); *id.* at 50 (statement of Dr. John Cairns); *id.* at 267 (statement of Dr. Serge Korff); *id.* at 330 (statement of David M. Gates). *See also House Committee Report, supra* note 132, at 7.

139. *Joint Committee Hearings, supra* note 132, at 221 (statement of Gerald R. Tape).

140. *House Committee Hearings, supra* note 132, at 120 (statement of Lloyd Tupling).

141. SECRETARY'S DECISION, *supra* note 6, at 52.

adequate methodology for evaluating the full environmental impacts and full costs of Federal action.[142]

Courts have interpreted NEPA as requiring the adoption of these proposals of the hearing participants. Sections 102(2) (A) and 102(2) (B) have been read to mandate a "systematic and finely tuned balancing,"[143] a process in which agency decision makers must consult a wide variety of professionals.[144] Recognizing that much relevant data may be uncertain or unavailable, however,[145] courts have not expected agencies to produce perfect knowledge. On the other hand, courts have required agencies to report all reasonably available information and, where possible, to quantify impacts.[146]

Should courts read NEPA to require decision analysis, they would effect a compromise between the ultimate goal of implementing systems analysis and the present lack of knowledge, which

142. S. REP. NO. 296, 91st Cong., 1st Sess. 20 (1969) (Report accompanying S. 1075).

143. Calvert Cliffs' Coordinating Comm. v. Atomic Energy Comm'n, 449 F.2d 1109, 1113 (D.C. Cir. 1971); Daly v. Volpe, 376 F. Supp. 987, 995 (W.D. Wash. 1974); First Nat'l. Bank v. Watson, 363 F. Supp. 466 (D.D.C. 1973); Movement Against Destruction v. Volpe, 361 F. Supp. 1360, 1388 (D. Md. 1973), *aff'd*, 500 F.2d 29 (4th Cir. 1974).

144. Hanley v. Kleindienst, 471 F.2d 823 (2d Cir. 1972), *cert. den.*, 412 U.S. 908 (1973); Simmans v. Grant, 370 F. Supp. 5, 17-18 (S.D. Tex. 1974); Environmental Defense Fund, Inc. v. Corps of Engineers, 348 F. Supp. 916, 928 (N.D. Miss. 1972), *aff'd*, 492 F.2d 1123 (5th Cir. 1974).

145. Robinson v. Knebel, 550 F.2d 422 (8th Cir. 1977); Environmental Defense Fund, Inc. v. Corps of Engineers, 492 F.2d 1123, 1133 (5th Cir. 1974); Jicarella Apache Tribe v. Morton, 471 F.2d 1275, 1280 (9th Cir. 1973); State v. Corps of Engineers, 411 F. Supp. 1261, 1268 (N.D. Ala. 1976); Natural Resources Defense Council, Inc. v. Callaway, 389 F. Supp. 1263 (D. Conn. 1974), *modified*, 524 F.2d 79 (2d Cir. 1975); Environmental Defense Fund v. Tennessee Valley Authority, 371 F. Supp. 1004 (E.D. Tenn. 1973), *aff'd*, 492 F.2d 466 (6th Cir. 1974); Environmental Defense Fund, Inc. v. Corps of Engineers, 348 F. Supp. 916, 928 (N.D. Miss. 1972), *aff'd*, 492 F.2d 1123 (5th Cir. 1974).

146. Robinson v. Knebel, 550 F.2d 422, 426 (8th Cir. 1977); Hanley v. Kleindienst, 471 F.2d 823 (2d Cir. 1972), *cert. den.*, 412 U.S. 908 (1973); State v. Corps of Engineers, 411 F. Supp. 1261, 1268 (N.D. Ala. 1976); Daly v. Volpe, 376 F. Supp. 987, 955 (W.D. Wash. 1974), *aff'd*, 514 F.2d 1106 (9th Cir. 1975); Simmans v. Grant, 370 F. Supp. 5, 17-18 (S.D. Tex. 1974); Sierra Club v. Froehlke, 359 F. Supp. 1289, 1356 (S.D. Tex. 1973), *modified*, 499 F.2d 982 (5th Cir. 1974); Brooks v. Volpe, 350 F. Supp. 269, 278 (W.D. Wash. 1972), *aff'd*, 487 F.2d 1344 (9th Cir. 1973); City of New York v. United States, 337 F. Supp. 150 (E.D.N.Y. 1972); Environmental Defense Fund v. Hardin, 325 F. Supp. 1401 (D.D.C. 1971); Environmental Defense Fund v. Corps of Engineers, 325 F. Supp. 749, 757 (E.D. Ark. 1971).

prevents the widespread use of other systems techniques. In addition, the courts would thereby realize Congress's intention that diverse professions contribute information to the environmental assessment process. Decision analysis is, after all, within the professional province of mathematicians, economists, and business administrators.[147]

V. CONCLUSION

The process leading to the Concorde decision was exceptional, but was hampered by uncertainties and inaccuracies withheld from and ignored by decisionmakers. To improve the transfer of this important information, agencies should employ decision analysis, a technique for using available knowledge to estimate the likelihood and seriousness of possible impacts of an environmental decision. Without this innovation, decisionmakers will continue to evaluate available information for themselves. There is no reason to believe they will better Secretary Coleman's effort, which ultimately failed to develop, disclose and analyze data essential to rational decisionmaking.

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147. *Preface* to C. EMORY & P. NILAND, MAKING MANAGEMENT DECISIONS at v (1968); *Preface* to S. HYMANS, PROBABILITY THEORY at ix (1967); *Preface* to H. RAIFFA, R. SCHLAIFER, APPLIED STATISTICAL DECISION THEORY at vii (1961); *Preface* to R. SCHLAIFER, ANALYSIS OF DECISIONS UNDER UNCERTAINTY at v (1969); MANAGEMENT DECISION MAKING 7 (L. Welsch & R. Cyert eds. 1970).