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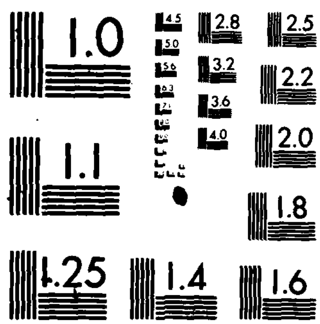

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NATIONAL BUREAU OF STANDARDS-1963-A

Technical Report Documentation Page

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Federal Aviation Administration: High Altitude Pollution Program - Third Biennial Report Prepared in Accordance With the Stratospheric Ozone Protection Provision, Section 153(g), of the Clean Air Act Amendments of 1977.	December 1981
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15. Supplementary Notes

16. Abstract

This is the third biennial Federal Aviation Administration (FAA) report prepared in accordance with the Stratospheric Ozone Protection provisions of Public Law 95-95, the Clean Air Act Amendments of 1977.

The impact of high altitude aviation on stratospheric ozone is now believed to be a decrease in total columnar ozone for flights above 15 km (about 49,000 feet). The model calculations also show that the current subsonic fleet (and the fleet foreseeable to 1990) will result in a net ozone increase of about 1 percent, considering normal flight altitudes.

Whatever the net change in total column ozone, increases or depletions will occur at different altitudes. These are expected to have subtle influences on atmospheric circulation, the effects of which are only beginning to be understood.

As a formal program, the High Altitude Pollution Program will be terminated in 1982 with the issuance of a final report. The FAA will continue to maintain and update, as appropriate, its capability to make quantitative assessments of the environmental effects of cruise-altitude emissions, and will monitor and assist, as possible, other research programs, both here and abroad.

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1. INTRODUCTION

This report, the third in the biennial series (1,2) prepared by the Federal Aviation Administration in accordance with the stratospheric ozone protection provision of the Clean Air Act Amendments (1977) contains a summary of the current scientific understanding of the possible effects of cruise-altitude aircraft emissions on atmospheric ozone. The summary is based upon an exhaustive review of recent advances in stratospheric studies conducted during May 18-22, 1981, by the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the World Meteorological Organization (WMO). The review was attended by 109 scientists from 13 countries. The result of the review is contained in "The Stratosphere 1981: Theory and Measurements," published by NASA.

The FAA receives review and advice on the conduct of its High Altitude Pollution Program (HAPP) from a scientific advisory committee. The membership and charter of this committee, and a list of studies supported by the FAA under HAPP are to be found in Appendices A and B, respectively.

2. BACKGROUND

Possible threat to the stratospheric ozone layer from engine exhaust emissions of supersonic transports (SST's) became a matter of concern in the early 1970's (3). In response, the Department of Transportation undertook a comprehensive research program on the environmental effects of SST's. The program, known as the Climatic Impact Assessment Program (CIAP), was concluded in 1975.

Based upon its scientific conclusions, the CIAP Report of Findings (4) suggested the following among its courses of action: "Develop, within the next year, a plan for a proper program for international regulation of aircraft emissions and fuel characteristics for whatever stratospheric flight operations may evolve in the future." Such a program, however, was not feasible at that time, due to the rather large uncertainties (ranging from a factor of 10 to a factor of 2) associated with the CIAP calculations of ozone depletion. In an attempt to reduce such uncertainties, the FAA, directed by the Secretary of Transportation, initiated HAPP "to quantitatively determine the requirements for reduced cruise-altitude emissions and, in conjunction with the Environmental Protection Agency and the International Civil Aviation Organization, to ensure that, if necessary, appropriate regulatory action is taken to avoid environmental degradation" (5).

3. CURRENT UNDERSTANDING OF THE EFFECTS OF CRUISE-ALTITUDE AIRCRAFT EMISSIONS

The nitrogen oxides (collectively referred to as NO_x, and composed of nitric oxide, NO, and nitrogen dioxide, NO_2) in aircraft engine exhaust have the potential to destroy ozone molecules through the well-known catalytic chemical reaction cycle:

$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$
$$\text{Net: } O_3 + O \rightarrow 2O_2$$

On the other hand, in the unpolluted atmosphere, the natural chemical processes involving oxidation of methane cause ozone production, provided NO is present simultaneously.*

Thus, NO which is the predominant ($\sim$90%) NO_x-component in aircraft engine exhaust has two distinct effects:

(1) generation of ozone through methane oxidation process, and
(2) destruction of ozone through the catalytic cycle.

Depending upon the available concentrations of reacting chemical species and the speed of the chemical reactions themselves (i.e., the rate constants), ozone production may predominate over ozone destruction and vice-versa. In the troposphere, ozone production predominates while in the middle and upper stratosphere, ozone destruction prevails. The altitude region in between, which is becoming increasingly important for flight operations in the face of the current demand for greater fuel efficiency, is an uncertain region as far as ozone change is concerned, and contains the "critical altitude" where generation and destruction of ozone balance each other. Depending upon the precise location of this "critical altitude," the effect calculated could be a net decrease, a net increase or no change. For example, the higher the average fleet flight level above the "critical altitude," the larger would be the calculated net ozone decrease. Apart from the above-mentioned chemical processes, atmospheric circulation may also affect the location of the "critical altitude". There is still much uncertainty in determining this altitude.

4. RESULTS OF MODEL CALCULATIONS

CIAP calculations showed that the "critical altitude" was situated very low in the atmosphere. The conclusion was that all aircraft flights, supersonic and subsonic, led to ozone depletion. For example, the subsonic fleet was projected then (i.e., 1974) to decrease the global burden of ozone by 0.05%, while the projected higher-flying supersonic transports would lead to ozone decreases of as much as 15 percent, by the year 2000.

*In a polluted, urban atmosphere, the presence of NO, generated for example in the automobile exhaust, gives rise to ozone production through the "smog" reactions. The "smog" reactions, however, are different form methane oxidation reactions.

Under HAPP, the critical chemical reactions were systematically identified and reevaluated. Also, the ability to model atmospheric circulation processes was improved. These actions, together with the results of ongoing research efforts at NASA and NOAA, have tended to modify the calculated effects of aircraft emissions.

Table 1 shows the net calculated ozone changes for the times when new data on rate constants were obtained. For comparison purposes, the net calculated ozone changes for aircraft emissions as well as for chlorofluoromethanes* (CFMs) releases are shown.

The model used for both calculations is the Lawrence Livermore National Laboratory (LLNL) one-dimensional (1-D) model.

The model calculations now indicate the "critical altitude" to be located near 15 km; in the middle latitudes this will be in the lower stratosphere for the most part.

The aircraft injection altitude of 17 km (~55,000 feet) was chosen because this is the typical flight altitude of the existing civil supersonic transport (Concorde). Future supersonic transports, if designed to fly higher, will show larger effects. (In fact, the table shows the calculated changes for a hypothetical fleet assumed to fly at 20 km.) The aircraft injection rate of 10^8 molecules (as NO) cm^{-2} s^{-1} can be translated to various fleet sizes depending upon fuel burn rate, engine emission index for NO_x, and aircraft utilization. This emission rate is equivalent to, for example, about 4000 "747-like" aircraft flying 5.5 hours a day consuming about 10,220 kg of fuel per hour, emitting 15 grams of NO_x as NO_2 per kg fuel burned; or a fleet of about 2200 CIAP "Concorde-like" aircraft flying 4.4 hours per day consuming 19,100 kg of fuel per hour, emitting 18 grams of NO_x as NO_2 per kg of fuel burned. More hours of flight per day per aircraft would reduce the equivalent fleet size and increasing fuel efficiency would increase it. Obviously, these are unrealistically large fleets, and the associated ozone changes are larger than actually expected.

The model calculations also show that the current subsonic fleet (and the fleet foreseeable to 1990) will result in a net ozone increase of about 1 percent, considering normal flight altitudes. It would appear that aircraft operations exclusively below the "critical altitude," resulting in ozone increase, will tend to partially offset ozone depletions due to other causes (e.g., CFM release). However, such offsetting would be only true of the total column ozone, and increases or depletions will occur at different altitudes. The attendant changes in ozone altitude profiles are expected to have subtle influences on atmospheric circulation, the effects of which are only beginning to be understood.

*Chlorofluoromethanes are chlorine-containing organic substances having wide industrial applications; particularly two compounds, F-11 and F-12, (the so-called "Freons") have been used as propellants in aerosol spray cans, as refrigerants, etc.

TABLE 1

LLNL 1-D MODEL RESULTS OF NET OZONE CHANGE

EVALUATION DATE	NET OZONE CHANGE, PERCENT			NEW DATA ON RATE CONSTANTS FOR	COMMENTS
	Aircraft Emissions Equivalent to 1×10^8 Molecules (as NO) cm^{-2} s^{-1} Injected at		Continued CFM Release at Steady Rate at Ground Level		
	17 km	20 km			
Early 1975 (CIAP)	-2.6	-5.6	-	-	No CFMs
Mid 1976	-0.6	-2.1	- 7.5	-	CFM chemistry included; 1973 release rate.
Late 1977	+1.0	+0.2	-14.2	HO_2 + NO	CFMs at 1975 release rate
December 1980	-0.3	-2.6	- 9.1	HO + HNO_3	CFMs at 1976 release rate
May 1981	-1.1	-3.6	- 5.0	HO + HNO_4; HO + HO_2	CFMs at 1976 release rate

5. FUTURE STUDIES

As a formal program, HAPP will be terminated in 1982 with the issuance of a final report. The FAA will continue to maintain and update, as appropriate, its capability to make quantitative assessments of the environmental effects of cruise-altitude emissions, and will monitor and assist, as possible, other research programs, both here and abroad.

6. REFERENCES

(1) Federal Aviation Administration, "High Altitude Pollution Program - A Status Report prepared in accordance with P.L. 95-95", Report No. FAA-AEQ-77-16, U.S. Department of Transportation, Federal Aviation Administration, Office of Environmental Quality, High Altitude Pollution Program, Washington, D.C. 20591, December 1977.

(2) Federal Aviation Administration, "Second Biennial Report prepared in accordance with the Ozone Protection Provision Section 153(g), of the Clean Air Act Amendments of 1977", Report No. FAA-EE-79-24, U.S. Department of Transportation, Federal Aviation Administration, Office of Environment and Energy, Washington, D.C. 20591, December 1979.

(3) McDonald, J., Presentation before the Department of Commerce Technical Advisory Board on Environmental Aspects of Supersonic Transport, Boulder, Colorado, March 17-19, 1971.

(4) Grobecker, A. J., Coroniti, S. C., and Cannon, R. H., Jr., "The Effects of Stratospheric Pollution by Aircraft", Report No. DOT-TST-75-50, Report of Findings, Climatic Impact Assessment Program, U.S. Department of Transportation, Washington, D.C. 20590, 1974.

(5) High Altitude Pollution Program, Initial Planning Documentation, U.S. Department of Transportation, Federal Aviation Administration, Office of Environmental Quality, Washington, D.C. 20591, June 16, 1975.

APPENDIX A

HIGH ALTITUDE POLLUTION PROGRAM

SCIENTIFIC ADVISORY COMMITTEE

MEMBERSHIP OF THE COMMITTEE

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CHARTER OF THE COMMITTEE

ORDER **DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION

1110.83B

7/1/80

SUBJ: HIGH ALTITUDE POLLUTION PROGRAM SCIENTIFIC ADVISORY COMMITTEE

1. PURPOSE. This order reestablishes the charter for the HIGH ALTITUDE POLLUTION PROGRAM SCIENTIFIC ADVISORY COMMITTEE as required under the provisions of the Federal Advisory Committee Act (P.L. 92-463, Title 5, U.S. Code, Appendix I).

2. DISTRIBUTION. This order is distributed to division level in Washington and centers and director level in the regions.

3. CANCELLATION. Order 1110.83A, High Altitude Pollution Program Scientific Advisory Committee, is cancelled.

4. BACKGROUND. The Office of Environment and Energy, Federal Aviation Administration (FAA), has established the High Altitude Pollution Program (HAPP) to determine quantitatively the effects of exhaust emissions by high altitude aircraft and to determine what regulatory action, if any, is needed to avoid environmental degradation from those emissions. Accordingly, HAPP must pursue programs related to aircraft engine emissions improvement, aircraft operations, computer modeling of stratospheric processes, and laboratory measurements related to stratospheric phenomena, and coordinate its program requirements regarding stratospheric measurements and monitoring with those of the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration. HAPP has the lead role for the Department of Transportation in carrying out U.S. responsibilities defined in the May 1976 Tripartite Agreement Regarding Monitoring of the Stratosphere, which was signed as a result of one of the actions directed by the Secretary in his February 4, 1976, decision on Concorde. In addition, the HAPP programs are in support of the requirements of the Ozone Protection provisions of the Clean Air Act Amendments of 1977 (P.L. 95-95). The program must draw upon FAA-sponsored research and on the work of other U.S. and international organizations. It has implications for the aviation manufacturers, airlines, and the general public, both in the United States and internationally. For these reasons, it has been determined necessary to have a Scientific Advisory Committee to serve the manager of HAPP in assessing and advising on elements of HAPP.

5. OBJECTIVE AND SCOPE OF ACTIVITIES. The objective of the Committee is to review the scope, adequacy, and priorities of HAPP, advise on areas of

Distribution: A-WYZ-2; A-X-1 **Initiated By:** AEE-300 research that may contribute to the analyses conducted by HAPP, appraise analyses conducted, advise of relevant results in related fields of investigation, and assist in coordinating the relevant programs of other Government agencies with those of HAPP.

6. DESCRIPTION OF DUTIES. The Committee's activity is limited to program review and submission of recommendations and advice to the HAPP manager.

7. ORGANIZATION AND ADMINISTRATION

a. The HAPP Scientific Advisory Committee is composed of up to twenty-five members consisting of representatives of the aviation industry and scientists and engineers from Government, specifically including, but not limited to, representatives of the Department of Defense, the Environmental Protection Agency, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration, industry, and universities. Persons chosen for membership on the Committee are selected on the basis of their recognized expertise and ability to contribute significant advice to the FAA in technical areas, such as aircraft engine emissions measurement or improvement; aircraft operations; computer modeling of stratospheric processes; laboratory measurements related to stratospheric phenomena; stratospheric measurements; and monitoring of stratospheric phenomena. Committee participation by non-Government members does not make them special Government employees. Selection of the non-Government members is made by the Associate Administrator for Policy and International Aviation Affairs, with the approval of the Administrator and the Secretary of Transportation; such membership will continue to be fairly balanced in terms of points of view represented and functions to be performed by the Committee.

b. The Administrator is the sponsor of the Committee and appoints the chairman. The Director of Environment and Energy is responsible for providing the administrative support for the Committee and shall provide a secretariat. The executive director shall be the FAA's Associate Administrator for Policy and International Aviation Affairs. The Committee shall not conduct any meeting in the absence of the executive director or the designated alternate. The executive director or the designated alternate, who as the designated Federal employee, shall be authorized to adjourn any advisory committee meeting whenever he determines adjournment to be in the public interest.

c. The chairman shall be responsible for:

(1) Determining, with approval of the executive director, when a meeting is required.

(2) Formulating an agenda for each meeting, which will be approved for any meeting.

(3) Providing for notice to all members of the time, place, and agenda for any meeting.

(4) Conducting the meeting.

(5) Providing for the taking of minutes at each meeting and certifying the accuracy of the minutes.

d. The number of meetings is expected to be one, possibly two, per year.

e. Detailed minutes shall be kept of each Committee meeting. The minutes shall include the time and place of the meeting; a list of Committee members and staff and agency employees present at the meeting; a complete summary of matters discussed and conclusions reached; copies of all reports received, issued, or approved by the Committee; a description of public participation, including a list of members of the public who presented oral or written statements; and an estimate of the number of members of the public who attended the meeting.

f. The Committee meetings shall be open to the public, and timely notice of such meetings shall be published in the Federal Register at least 15 days before the meeting. The proposed agenda, as well as the time and place of the meeting and information that the meeting will be open to the public, shall be included in the notice which shall be forwarded to the Chief Counsel, Attention: Rules Docket Section, AGC-204, approximately 30 days before the meeting. Other forms of notice, such as press releases are to be used to the extent practicable.

g. Members of the Committee who are full-time employees of the United States Government shall serve without compensation but may be allowed transportation and per diem in lieu of subsistence and other expenses, in accordance with the Department of Transportation's Civilian Travel Regulations.

8. ESTIMATED COST. The estimated annual operating cost of the Committee is $20,000 which includes the travel costs and compensation of the members and miscellaneous costs, such as the printing and issuance of reports. Approximately 0.2 employee-years will be required to support the Committee, including both professional and secretarial services.

9. COMPENSATION. Members of the Committee who are not full-time employees of the United States Government, while attending meetings of the Committee or otherwise engaged in the business of the Committee, shall be entitled to compensation of $100 per day and transportation and per diem in lieu of subsistence and other expenses in accordance with the Department of Transportation's Civilian Travel Regulations.

10. PUBLIC PARTICIPATION. Each Committee meeting shall be open to the public and interested persons shall be permitted to attend, appear before, or file written statements with the Committee, subject to the limitations contained in the exception to the Freedom of Information Act (Title 5, U.S.Code 552(b)) and also subject to limitations of space and time.

11. AVAILABILITY OF RECORDS. Subject to the limitations contained in the exceptions of the Freedom of Information Act (Title 5, U.S. Code 552(b)), records, reports, transcripts, minutes, and other documents that are made available to, or prepared for or by, the Committee shall be available for public inspection and copying at the Office of Public Affairs, 800 Independence Avenue, SW., Washington, D.C. 20591. Fees shall be charged for information furnished to the public in accordance with the fee schedule published in Part 7 of Title 49, Code of Federal Regulations.

12. PUBLIC INTEREST. The continued use and existence of the HAPP Scientific Advisory Committee is determined to be in the public interest in connection with the performance of duties imposed on FAA by law.

13. EFFECTIVE DATE AND DURATION. The charter reestablishment is effective July 1, 1980, which is the filing date of this charter. The Committee will remain in existence for two years subsequent to this date, unless sooner terminated or extended.

Langhorne Bond
Administrator

APPENDIX B

STUDIES SUPPORTED BY THE
HIGH ALTITUDE POLLUTION PROGRAM

MODELING: STUDIES COMPLETED

(1) DOT-TSC-(RA)-76-1 — Numerical simulation of Atmospheric Response
Department of Energy/
Lawrence Livermore Laboratory

F. Luther — August 1975 to June 1976

To refine the LLL one-dimensional model for the stratosphere in the areas of photochemical kinetics, transport kinetics and radiation transfer.

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(2) DOT-TSC-(RA)-76-10 — Latitude Variation in Ozone Reduction
USAF SAMSO/Aerospace Corporation

G. Widhopf — September 1975 to December 1976

To refine the transport parameterization in the Aerospace two-dimensional model using available tracer data and use the refined model to compare predictions with actual distributions of atmospheric trace species.

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(3) DOT-FATQWAI-653 — Numerical Simulation and Ozone Data Analysis
Department of Energy/
Lawrence Livermore Laboratory

F. Luther — July 1976 to September 1978

To continue model refinement started under DOT-TSC-(RA)-76-1 with improved tropospheric chemical cycles. Also, to process ozone data obtained from the USAF Block 5-D satellite and perform global data analysis.

FAA-EQ-77-6 ADA 040 627	Lawrence Livermore Laboratory First Annual Report to the High Altitude Pollution Program (June 1976)
FAA-EQ-78-09 AOA 057 139	Annual Report of Lawrence Livermore Laboratory to the High Altitude Pollution Program 1977 (May 1978)
FAA-EE-79-04 AOA 069 127	Annual Report of the Lawrence Livermore Laboratory to the FAA on the High Altitude Pollution Program 1978 (September 1978)

(4) DOT-FA77WA-4055 — Atmospheric Mechanisms
Center for Environment and Man, Inc.

G. Robinson — September 1977 to December 1979

In light of recent chemical kinetics data, to reexamine the chemistry and diffusion of aircraft exhaust trails and include interpretations of available trace species measurements and transport parameterizations.

FAA-EE-80-16 ADA 089 100	The Perturbation of Some Atmospheric Mechanisms by Emissions from Aircraft (November 1979)

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(5) DOT-FA77WA-3992 — Stratospheric-Tropospheric Exchange Processes
Oregon State University

E. Danielsen — August 1977 to April 1980

To develop, test and document an objective methodology based on routinely available synoptic meterological data for the quantitative determination of stratospheric-tropospheric mass exchange. To use this methodology to determine all relevant transport parameters for use in two-dimensional models of the stratosphere.

FAA-EE-80-32 ADA 091 732	An Objective Method for Determining the Generalized Transport Tensor for Two-Dimensional Models (August 1980)

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(6) DOT-FA78WAI-911 — Study of Aircraft Effects on Climate
National Science Foundation/ Climate Research Board.

A. Hecht — September 1978 to August 1980

Through the Climate Research Board of the National Academy of Sciences, to assess the impact of high-altitude aviation on the climate.

(7) DOT-FA77WA-4039 Colorado State University

Stratospheric Studies Using the Crutzen Two-Dimensional Model

P. Crutzen

September 1977 to August 1980

To refine the Crutzen model of the stratosphere and to use it to study trace species distributions, water vapor budget and the effects of high-altitude aviation on stratospheric ozone.

FAA-EE-81-2 Refinement and Modification of the Crutzen 2-D Photochemical Model of the Stratospheric Ozone Balance (May 1980)

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(8) DOT-FA79WA-4306 Science Applications, Inc.

Assess the Nature of Local Variability of Trace Species of Stratospheric Importance

R. Gelinas

June 1979 to November 1981

To study the local variability of trace species concentrations so that their atmospheric measurements may be used to (a) verify one- and two-dimensional stratospheric models, (b) develop an improved stratospheric measurement strategy, and (c) estimate the probable range of inaccuracies inherent in present stratospheric ozone models.

MODELING: STUDIES IN PROGRESS

(1) DOT-FA77WAI-720 — Two-Dimensional Model Studies
USAF SAMSO/Aerospace Corporation

G. Widhopf — December 1976

To continue to refine the Aerospace *two-dimensional* model to incorporate chlorine chemistry, multiple scattering, and to use the model to study the effect of high-altitude aviation on stratospheric ozone.

FAA-EE-79-07 ADA 073 566	Two-Dimensional Description of the Natural Atmosphere Including Active Water Vapor Modeling and Potential Perturbations due to NO_x and HO_x Aircraft Emissions (April 1979)
FAA-EE-81-6	Two-Dimensional Description of Potential Perturbations to the Ozone Layer Due to NO_x and H_2O Emissions (April 1980)

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(2) DOT-FA79WAI-034** — Study of Atmospheric Modeling and DMSP Satellite Ozone Data
Department of Energy/
Lawrence Livermore Laboratory

F. Luther — April 1979

To develop and maintain a state-of-the-art capability presently existing at LLL to numerically model all atmospheric phenomena relevant to HAPP requirements. Also, to receive and reduce ozone data sensed by the USAF Block 5-D satellite.

FAA-EE-79-23 ADA 085 128	Potential Environmental Effects of Aircraft Emissions (October 1979)
FAA-EE-80-39 ADA 097 564	Annual Report of LLL to the FAA on the High Altitude Pollution Program - 1979 (September 1979)

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(3) DTFA01-80-C-10101 — Research on the Climate and Ozone Perturbations Related to Aerospace Activities
Atmospheric and Environmental
Research

N. Dak Sze — September 1980

To study stratospheric ozone perturbations and possible climate effects associated with aircraft operations using the application of a specially constructed one-dimensional model which permits realistic interactions of radiative, chemical and dynamical processes.

(4) DTFA01-80-Y-10558 — Two-Dimensional Transport Parameterization
NASA/Ames Research Center

E. Danielsen — April 1980

To derive representative mean meridional velocities and the components of a diffusion tensor for two-dimensional chemical-photochemical transport models to improve their reliability and accuracy.

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(5) DTFA01-80-Y-10573 — Effects of Aircraft Emissions on Global Mean Temperature
NOAA/Climate Research Board

R. Etkins — July 1980

Through the Climate Research Board at the National Academy of Sciences, to assess the impact of high-altitude aviation on the climate.

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(6) DTFA01-81-C-10117 — Assess the Effects of Cruise Altitude Flight on Ozone Utilizing the Crutzen Model
Max-Planck Institute for Chemie

P. Crutzen — October 1981

To modify the two-dimensional model developed originally by Dr. Paul Crutzen to conduct studies of aircraft effects on ozone. The model includes rainout phenomena, and stratospheric and tropospheric chemistry.

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(7) DTFA01-81-Y-10538 — Ozone Uncertainty Analysis and Solar Flux Measurements
NASA/Goddard Space Flight Center

R. Stolarski — June 1981

To conduct an uncertainty analysis of predictions of ozone perturbations from aircraft NO_x emissions by propagating uncertainties of known chemical rate coefficients and solar flux through a one-dimensional stratospheric photochemical model by means of a Monte Carlo simulation. Solar flux irradiance measurements will also be reviewed and evaluated in order to assess the temporal variability of solar flux output as a function of wavelength.

(8) DTFA01-81-Y-10512
Naval Research Laboratory

Investigation of Sphericity on the Multiple Scattering of Solar Radiation in the Troposphere and Stratosphere

D. Anderson

January 1981

To develop an isotropic spherical code for the troposphere and stratosphere as a function of altitude and solar zenith angle and directly compare with plane parallel models.

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(9) AIA/CA-23
Memorandum of Agreement with the Royal Norwegian Council of Scientific and Industrial Research

Model Evaluations of Ozone Changes which may be caused by Aircraft Operations

B. Landmark/I. Isaksen

January 1981

To perform calculations with the Isaksen-Hesstvedt model to evaluate the local ozone change occurring in the troposphere due to cruise-altitude aircraft emissions.

ENGINES AND FUELS: STUDIES COMPLETED

(1) DOT-FA75WA-3574 — International Air Traffic Forecast
SRI International

R. Pozdena — January 1976 to September 1976

To produce a world aviation forecast for long-range, high - altitude flights for the years 1975 to 1990 (five year intervals) by aircraft equipment and fleet.

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(2) DOT-FA76WAI-603 — Stratospheric Emissions from Aircraft Operations
Environmental Protection Agency/ A.D. Little Co.

P. Athens — February 1976 to August 1976

For subsequent use in studies of stratospheric impacts and possible need for aircraft regulations, to determine emission indices for aircraft engines operating above 8 km and provide global emissions loading data.

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(3) DOT-FA77WA-3066 — Analysis of Fuel Usage
Eastern Airlines

P. Zegan — August 1977 to October 1978

For input to improve forecasts of emissions loading for use in model calculations, to compile forecasts of fuel burn by geographic location and altitude based on aircraft fleet projections through the year 2000.

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(4) DOT-FA77WAI-4081*** — Nitric Oxide Measurement Study
United Technologies Research Center

M. F. Zabielski — September 1977 to May 1980

Investigate both optical and sample-extractive methods for measuring nitric oxide in combustion systems and define and document the difference between the results from the two methods.

FAA-EE-80-28	Nitric Oxide Measurements Study: Optical Calibration - Vol. I
FAA-EE-80-29 ADA 097 545	Nitric Oxide Measurements Study: Probe Method - Vol. II
FAA-EE-80-30 ADA 097 607	Nitric Oxide Measurements Study: Comparison of Optical and Probe Methods - Vol. III

ENGINES AND FUELS: STUDIES IN PROGRESS

(1) DTFA01-82-Y-10505 — Global Aviations Emissions Forecast
ATAC Inc.

J. Bobick — December 1981

Modify Global Aviation Forecast Model to expand its capabilities to include projections of aircraft engine emissions at various altitudes and geographic grid locations.

LABORATORY MEASUREMENTS: STUDIES COMPLETED

(1) DOT-TSC-1201 — Laboratory Study of Chemical Reactions
Ford Motor Company

E. Kaiser — June 1976 to June 1977

To study the rate of the reaction of HONO + O_3 and $O(^3P)$ + N_2O_5.

FAA-EQ-77-7 ADA 046 159	The Kinetics of the Gas Phase Reaction of Nitrous Acid with Ozone (July 1977)
FAA-AEQ-77-11 ADA 046 160	The Kinetics of the Gas Phase Reaction of $O(^3P)$ with N_2O_5 (September 1977)

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(2) DOT-TSC-1200 — Measurements on $O(^1D)/N_0$ and HNO_2/O_3 Kinetics
AeroChem Research Laboratories

A. Fontijn — June 1976 to June 1977

To measure the branching ratio of $O(^1D)$ + N_2O and the products of the reaction HONO + O_3 over stratospheric temperatures.

FAA-EQ-77-10 ADA 051 427	Measurements on $O(^1D)/N_2O$ and HNO_2/O_3 Kinetics (June 1977)

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(3) DOT-TSC-1202 — Heterogeneous Decomposition of Ozone on Sulfuric Acid at Stratospheric Temperatures
Rockwell International

A. Harker — June 1976 to June 1977

To develop apparatus for generating aerosol mist and to measure the rate of ozone decomposition over the mist.

FAA-AEQ-77-12 ADA 051 504	Heterogeneous Decomposition of Ozone on Sulfuric Acid Surfaces at Stratospheric Temperatures (September 1977)

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(4) DOT-TSC-1204 — NO_2 Photolysis
SRI International

J. Davenport — June 1976 to June 1977

To measure the NO_2 photolysis cross-sections and quantum yields between wavelengths 385 to 425 nm and temperatures 200-300 K.

FAA-AEQ-78-05 ADA 056 843	Determination of NO_2 Photolysis Parameters for Stratospheric Modeling (June 1978)

(5) RA 76-13-6400223* — Department of Commerce/NBS — Reaction Rate Data, Tabular Input

D. Garvin — January 1976 to May 1978

This effort includes the following:

1. Review of Atmospheric Rate Constant Data
2. Compilation of $ClONO_2$ Kinetic Data
3. Compilation of Combustion Kinetic Data

NBS Special Publication 513	Reaction Rate and Photochemical Data for Atmospheric Chemistry (May 1978)
NBS Special Publication 478	Nitrogen Oxychlorides: A Bibliography on Data for Physical and Chemical Properties of NO, NO_2 and NO_3 (August 1977)
NBS Special Publication 449	Chemical Kinetics of the Gas Phase Combustion of Fuels

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(6) DOT-TSC-1203 — York University — Laboratory Study of Chemical Reactions

H. Schiff — June 1976 to December 1978

To determine the reaction rates and products of $O(^1D) + N_2O$ and of $O(^3P) + N_2O_5$.

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(7) DOT-FA79WA-4269 — University of California at Irvine — State-of-the-Art Assessment of Atmospheric Chemistry - A workshop

F. S. Rowland — November 1978 to April 1979

To perform a study of the state-of-the-art of the impact of all aspects of aviation on air quality by considering data and other input from all appropriate segments of government, scientific and technical communities, aviation-related industries and other interested parties.

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(8) DOT-FA78WA-4248 — University of California at Irvine — Measurement of the Photolytic Parameters for Pernitric Acid

M. Molina — September 1978 to February 1980

To determine the cross section in the UV and IR for HO_2NO_2 and to deduce quantum yields for its photolytic decomposition.

FAA-EE-80-07 ADA 084 915	Ultraviolet Absorption Cross Sections of HO_2NO_2 Vapor (April 1980)

(9) DOT-FA78WA-4262 — Measurement of the Rate of OH + ClO
Xonics, Inc.

R. A. Young — September 1978 to February 1980

To determine the rate of reaction of OH with ClO as a function of temperature and pressure.

FAA-EE-80-18 — Laboratory Measurements of the Reaction Rate of Hydroxyl Radicals (OH) with Chlorine Monoxide (ClO)

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(10) DOT-FA79WAI-005* — Evaluation of Chemical Reaction Rate Data and Photochemical Data for Atmospheric Modeling
Department of Commerce/NBS

R. Hampson — December 1978 to March 1980

To prepare detailed evaluations of NO_x and $O(^1D)$ reactions and to compile an evaluation of all other atmospheric reactions in individual data sheet form.

FAA-EE-80-17 — Chemical Kinetics and Photochemical Data Sheets for Atmospheric Reactions (April 1980)
ADA 091 631

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(11) DOT-FA78WA-4263 — Measurement of the Photolytic Parameters for O_3
SRI International

J. Davenport — September 1978 to May 1980

To determine the cross section and quantum yields for O_3 photolysis over the threshold region.

FAA-EE-80-44 — Parameters for Ozone Photolysis as a Function of Temperature at 280-330 nm (April 1980)

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(12) DOT-FA79WAI-026 — Theoretical Treatment of Pressure Dependent Reactions
Department of Commerce/NBS

W. Tsang — April 1979 to July 1980

To apply unimolecular reaction rate theory to possible complex intermediates formed in radical-radical bimolecular reactions.

FAA-EE-80-45 — Disproportionation Reactions of Small Inorganic Radicals in the Context of Intermediate Complex Formation (October 1980)

(13) DOT-FATQWAI-733 — Laboratory Chemistry Studies
NOAA/Aeronomy Laboratory

D. Kley — June 1977 to September 1980

To determine in situ J values for O_3, O_2, N_2O, and NO and measure the altitude profiles of H_2O and H_2O_2.

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(14) DOT-FA78WA-4264 — Measurment of the Photolytic Parameters for Formaldehyde
Max-Planck Institute

P. Warneck — September 1978 to November 1980

To measure the absorption cross section and quantum yields for HO_2CO as a function of temperature and pressure.

FAA-EE-80-47 / ADA 096 283 — Laboratory Measurements of Photolytic Parameters for Formaldehyde (November 1980)

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(15) DOT-FA79WA-4378 — Kinetics of the Heterogeneous Hydrolysis of Dinitrogen Pentoxide
Rockwell International

A. Harker — September 1979 to February 1981

To determine the rate of formation of nitric acid from dinitrogen pentoxide and water vapor in the presence of simulated stratospheric aerosol surfaces.

FAA-EE-81-3 — Kinetics of the Heterogenous Hydrolysis of Dinitrogen Pentoxide Over the Temperature Range 214-263K (February 1981)

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(16) DOT-FA79WAI-112 — Study of the Mechanism of Reaction of OH with HO_2
Department of Commerce/NBS

M. Kurylo — November 1979 to February 1981

To investigate the mechanisms of OH + HO_2 using isotopic labeling kinetic studies.

(17) DTFA01-80-C-10066 — State-of-the-Art Assessment (II) of Atmospheric Chemistry
University of California at Irvine

F. S. Rowland — May 1980 to April 1981

To perform an in-depth summary and analysis of the state-of-the-art concepts and experimental results in atmospheric chemistry as it pertains to the predicted environmental effects of aircraft cruise-altitude emissions.

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(18) DTFA01-80-Y-10559 — Measurement of the Rate of Reaction of Nitric Oxide (NO) with Ozone (O_3)
NASA/Goddard Space Flight Center

J. Allen — May 1980 to May 1981

To investigate the temperature dependence of the $NO + O_3$ reaction rate using three different experimental procedures.

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(19) DOT-FA78WA-4228 — Measurement of Reaction Rates for Pernitric Acid with OH and $O(^3P)$
SRI International

J. R. Barker — September 1978 to June 1981

To determine the rate of reaction of OH and $O(^3P)$ with HO_2NO_2 as a function of temperature.

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(20) DOT-FA79WA-4393 — Direct Determination of the Reaction of CH_3O_2 with NO
Pennsylvania State University

J. Heicklen — September 1979 to June 1981

To measure the rate and temperature dependence of the reaction of methyl peroxy radicals with nitric oxide.

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(21) DTFA01-80-Y-10532* — Evaluation of Kinetics and Photochemical Data for Atmospheric Modeling
Department of Commerce/NBS

R. Hampson — April 1980 to June 1981

To update and maintain an evaluation of the chemical reaction rates and photochemical parameters required as the data base for atmospheric models used for the assessment of aircraft effects on the environment.

(22) DOT-FA78WA-4259 — Georgia Tech Research Institute — Measurement of the Rate of $CH_3O_2 + NO_2$

P. H. Wine/A. R. Ravishankara — September 1978 to November 1981

To measure the rate of $CH_3O_2 + NO_2$ over the relevant range of tropospheric temperatures and pressures.

FAA-EE-80-38 ADA 091 293	A Kinetic Study of the Reaction of CH_3O_2 with NO_2

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(23) DOT-FA79WA-4362 — Smithsonian Institution Astrophysical Observatory — Direct Determination of the Rate of Reaction of Methoxy Radicals (CH_3O) with Molecular Oxygen and Ozone

H. Radford — September 1979 to December 1981

To measure the rate of reaction to methoxy radicals with oxygen and ozone by means of a laser magnetic resonance apparatus.

LABORATORY MEASUREMENTS: STUDIES IN PROGRESS

(1) DOT-FA77WA-4054 — Measurement of Perhydroxyl Reaction Rates
University of Cambridge

B. Thrush — September 1977

To measure the absolute rate and temperature dependence of the reactions of HO_2 with HO_2, OH, SO_2, Cl, NO, O_3, Br, and H.

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(2) DTFA01-80-C-10084 — Measurement of Hydroxyl Radicals' Reaction with Hydrogen Peroxide
University of California at Irvine

M. Molina — July 1980

To measure the rate of reaction of hydroxyl radicals with hydrogen peroxide using flash photolytic production of OH and showing an unequivocal determination of the concentration of hydrogen peroxide at all stages of the reaction.

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(3) DTFA01-81-C-10106 — Theoretical Calculation of Isomers of $ClONO_3$ and H_2O_4
University of California at Irvine

W. Hehre — September 1981

To determine possible isomeric forms of $ClNO_3$ and H_2O_4 by ab initio mathematical calculations.

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(4) DTFA01-81-Y-10519* — Evaluation of Kinetics and Photochemical Data for Atmospheric Modeling
Department of Commerce/NBS

R. Hampson — May 1981

To update and maintain an evaluation of the chemical reaction rates and photochemical parameters required as the data base for atmospheric models used for the assessment of aircraft effects on the environment.

(5) DTFA01-81-Y-10518 NOAA/Environmental Research Laboratories

Study of the Photochemistry and Kinetics of NO_3

C. Howard

March 1981

To construct an optical absorption system to detect NO_3 employing a tunable dye laser as the light source and a multipass absorption cell and use this system to determine the rate coefficients for the reaction of NO_3 with the stable atmospheric species H_2O_2, O_3, CO and CH_2O.

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(6) DTFA01-81-Y-10519 NASA/Jet Propulsion Laboratory

Laboratory Study of Selected Atmospheric Chemical Mechanisms

W. DeMore

June 1981

To determine the feasibility of quantifying the kinetic parameters for the interactive chemistry of odd nitrogen (NO, NO_2, HNO_3, etc.) and odd hydrogen (HO, HO_2, etc.)

FIELD MEASUREMENTS AND MONITORING: STUDIES COMPLETED

(1) W1-76-1085-1 — Analysis of Measurement Requirements

Dr. Rudolph Penndorf

R. Penndorf — November 1975 to May 1976

To analyze data obtained under DOT/CIAP and recommend specific requirements for future stratospheric measurements under HAPP.

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(2) DOT-FA76WAI-648* — Balloon Launch, Tracking, and Recovery Costs for NO Detector Flight to 45 km

Department of Defense/
Office of Naval Research

Commander W. Smith — June 1976 to October 1976

To provide flight services in connection with a balloon launch conducted by the University of Wyoming to detect nitric oxide up to an altitude of 45 km.

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(3) DOT-FA76WA-628 — Processing, Reduction, and Data Analysis of April and May 1975 CIAP/Airstream Data

Department of Energy/
Los Alamos Scientific Laboratory

P. Guthals — April 1976 to July 1977

To perform data processing of the CIAP/Airstream data and deliver to scientist in charge (Dr. D. G. Murcray of the University of Denver) to determine the HNO_3 column density and to compare the results with earlier measurements.

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(4) DOT-FATQWA-3866 — Critical Analysis of Field Measurement Data

Dr. Rudolph Penndorf

R. Penndorf — July 1976 to August 1977

To collect and analyze in a critical manner all field data from one kilometer to the tropopause and also all stratospheric data of importance to HAPP. Assemble ozone data to obtain monthly averages and trends.

(5) DOT-FA77WA-3949 — Data Interpretation of Measurements of Trace Gases
University of Denver

D. Murcray — February 1977 to August 1978

To determine the error in deducing NO and NO_2 altitude profiles from infrared solar spectra obtained at high altitudes during sunrise and sunset.

FAA-EE-78-30 On the Interpretation of Infrared Solar
ADA 069 495 Spectra for Altitude Distribution of Atmospheric Trace Constituents (August 1978)

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(6) W1-78-3745-1 — Trace Gas Analysis of Concorde Air Samples
Oregon Graduate Center for Study and Research

R. Rasmussen — April 1978 to October 1978

To participate in analysis of Concorde air samples and compare with data obtained on same species during previous high altitude flights. Also to evaluate the sampling program and describe needs to obtain the maximum scientific knowledge from the program.

FAA-EE-78-25 Concorde Air Sampling Program
ADA 064 905 Intercalibrations and Collaborative Measurements (September 1978)

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(7) W1-78-3740-1 — Analysis of Ozone and Water Vapor Field Measurement Data
Dr. Rudolph Penndorf

R. Penndorf — April 1978 to December 1978

To review and update results obtained for ozone and water vapor data under contract DOT-FATQWA-3866.

FAA-EE-78-29 Analysis of Ozone and Water Vapor Field
ADA 072 721 Measurment Data (November 1978)

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(8) DOT-FA77WA-3931 — In Situ Measurements of NO, NO_2 and N_2O_5 in the Stratosphere from Balloons
York University

H. Schiff — January 1977 to November 1979

To perform four ballon flights to make simultaneous NO, NO_2 and if obtainable N_2O_5 measurements throughout the course of a day. Also, to investigate laser diode technology for measurement of NO and NO_2 to better than 100 pptv.

(9) DOT-FA78WAI-860
Department of Energy/Los Alamos Scientific Laboratory

Investigation of a Global Transport Experiment

P. Guthals

March 1978 to February 1980

To examine possible tracers for a global transport experiment and include considerations of their chemistry and instrumentation for sample collection. Also, to review the scientific value of such an experiment.

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(10) DOT-FA77WAI-722*
NASA/Langley Research Center

Development of Advanced Instrumentation Tunable Double Heterostructure Laser Diodes

F. Allario

February 1977 to June 1980

Using molecular beam epitaxy techniques, to grow laser fibers, to fabricate lasers from these fibers and test for device characterization.

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(11) DTFA01-80-Y-10554*
NASA/Goddard Space Flight Center

Ozone and Hydroxyl Radical Measurements Using a Balloonborne Lidar System

W. Heaps

May 1980 to February 1981

To provide support for the launch of a balloon-born lidar system to measure the hydroxyl radical in the lower stratosphere.

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(12) DOT-FA78WA-4232
Harvey Mudd College

Development of H_2O_2 Measurement Instrumentation

G. Kok

September 1978 to June 1981

To develop instrumentation for the in situ measurement of gas phase hydrogen peroxide in the stratosphere and upper troposphere for concentrations from 0.1 ppbv to 100 ppbv.

(13) DOT-FA76WA-3782 — Cooperative Stratospheric Aerosol Research Program
University of Wyoming

D. Hofmann — July 1977 to July 1981

To perform a joint aerosol measurement program with the University of Leningrad consisting of simultaneous measurements by both groups in the U.S. and the U.S.S.R. In addition, prepare a joint report and provide supporting measurement to NASA's NIMBUS 7 satellite.

FAA-AEQ-78-22 ADA 060 383	University of Wyoming/Leningrad State University Cooperative Stratospheric Aerosol Research Program (July 1978)

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(14) DOT-FA79WA-4285 — Concorde Whole Air Sampling
Oregon Graduate Center for Study and Research

R. Rasmussen — February 1979 to November 1981

To conduct whole air sampling on not less than 10 Concorde flights between Dulles and Heathrow. Perform trace gas analysis on these samples and compare results with data previously obtained.

FIELD MEASUREMENTS: STUDIES IN PROGRESS

(1) DOT-FATQWAI-684
National Science Foundation/
National Center for
Atmospheric Research

Measurement to 45 Kilometers Using Cryogenic Sampling and Other Techniques

L. Heidt

October 1976

To conduct four (2 at the equator and 2 at northern latitudes) atmospheric balloon and aircraft cryogenic sampling missions and provide data analysis.

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(2) DOT-FA77WAI-748*
Naval Research Laboratory

Measurement of Stratospheric H_2O

J. Mastenbrook

June 1977

To design, develop and test a frostpoint hygrometer-type instrument to measure atmospheric water vapor. To continue periodic water vapor measurements presently conducted by NRL and compare data obtained for a period of one year with soundings in the vicinity of Boulder, Colorado.

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(3) DOT-FA77WA-4080
Perkin-Elmer Corporation

Development of Stratospheric Measurement System

N. Macoy

September 1977

To perform a feasibility study to provide a conceptual design with documentation for an instrument to simultaneously measure the odd nitrogen species in the stratosphere. To perform necessary laboratory measurements to verify the critical parts of the measurement system and fabricate a laboratory prototype measurement system to demonstrate feasibility.

FAA-EQ-78-10 ADA 059 330	High Altitude Pollution Program Stratospheric Measurement System Feasibility Study (January 1978)
FAA-EE-80-11 ADA 085 198	HAPP Stratospheric Measurement System Laboratory Performance Capability Report Chemical Conversion Techniques (February 1980)

(4) DOT-FA78WAI-850
NOAA/Environmental Research Laboratory

Analysis and Intercomparion of Ozone Measurements from Dobson Instruments

W. Komhyr

January 1978

To reprocess total ozone data collected over the past 15 years from the 15 station NOAA Dobson spectrophotometer network. To maintain the world standard calibration instrument and provide calibration for instruments at other stations.

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(5) DOT-FA78WAI-859
Department of Energy/ Brookhaven National Laboratory

Investigation of Tropospheric Rainout Process

S. Schwartz

May 1978

To review available literature addressing the chemistry of the interaction of nitrogen oxides and oxyacids with atmospheric water. As a result of the review, to perform necessary modeling, laboratory measurements, and field measurements to define the tropospheric rainout removal process.

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(6) AIA/CA-12
Memorandum of Agreement with the World Meteorological Organization

International Intercomparison of Rocketborne Ozonesondes

R. Bojkov

September 1978

To implement an international intercomparison of rocketborne ozonesondes at the NASA/Wallops Flight Center Facility in August-October 1979.

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(7) AIA/CA-13
Memorandum of Agreement with the Canadian Atmospheric Environment Service

International Development and Flight Test of a Balloon-Borne Tunable Laser Diode Spectrometer System for Stratospheric Measurements

W. Evans/H. Schiff/B. Ridley

October 1978

To develop a tunable laser diode spectrometer to measure at least NO and NO_2 in the stratosphere and perform a flight test of the instrument.

(8) AIA/CA-17
Memorandum of Understanding with the Australian Commonwealth Scientific and Industrial Research Organization

Comprehensive Set of Trace Gas Measurements in the Southern Hemispheric Stratosphere

I. Galbally

February 1979

To perform six balloon flights to obtain stratospheric measurements including latitudinal, altitudinal, and seasonal and (if possible) diurnal variations of nitrous oxide, nitric oxide, nitrogen dioxide and nitric acid along with ozone, water vapor, CFM's and air temperature in the Southern Hemisphere.

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(9) DTFA01-80-Y-10565
NOAA/Aeronomy Laboratory

NO, NO_2 and Total Odd-Nitrogen Stratospheric Balloon Flights

M. McFarland/D. Albritton/
A. Schmeltekopf

June 1980

To perform necessary laboratory studies to develop a stratospheric balloon-borne instrument using chemiluminescent/ photolytic techniques to measure NO and NO_2 and pyrolytic conversion to measure N_2O_5, HNO_3 and other odd-nitrogen species. After successful development to perform at least eight balloon flights at high, mid and low latitudes during both the summer and winter.

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(10) DTFA01-80-Y-10568
NOAA/Aeronomy Laboratory

Measurement of Atmospheric H_2O; NO_2; CO; H_2O_2 by Dissociative Flourescence and Resonance Flourescence

D. Kley

July 1980

To develop and perform balloon flight test of a daytime and nighttime ultraviolet fluorescence water vapor instrument, a resonance fluorescence CO instrument, and dissociative fluorescence NO_2 and H_2O_2 instruments.

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(11) DTFA01-80-C-10039
University of Denver

Infrared Data Analysis and N_2O_5 Balloon Flight

D. Murcray

March 1980

To use high resolution sunset solar absorption data to determine ozone line parameters for the ν_1 and ν_3 fundamental bands as well as the hot bands of ozone, and to perform a dedicated balloon flight using an emission spectrometer to detect the presence of N_2O_5 in the stratosphere.

ASSESSMENT, REGULATION, AND COORDINATION: STUDIES COMPLETED

(1) DOT-FA76WA-3757
Institute for Defense Analyses

Assessment of Stratospheric Effects and Uncertainties

R. Oliver

October 1975 to August 1976

To review the Report of Findings of the DOT/CIAP and other documents concerning stratospheric ozone depletion and to assess effects of high-altitude aircraft on the environment.

FAA-EQ-77-3 ADA 040 638	Aircraft Emissions: Potential Effects on Ozone and Climate (March 1977)

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(2) AIA/CA-18
North Atlantic Treaty Organization

Advanced Study Institute, "Atmospheric Ozone: It's Variations and Human Influences"

M. DiLullo/M. Nicolet

March 1979 to May 1980

To promote a workshop resulting in an assessment of the state-of-the-art understanding of atmospheric ozone, from an international viewpoint.

FAA-EE-80-20 ADA 088 899	Proceedings of the NATO Advanced Study Institute on Atmospheric Ozone: It's Variation and Human Influences (May 1980)

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(3) DOT-FA79WAI-096
National Science Foundation/
National Center for Atmospheric Research

Assessment of Modeling of Chemical Reactions in the Atmosphere

S. Ruttenberg

September 1979 to September 1980

To provide a current understanding of the modeling of various chemical reactions in the stratosphere that are related to the ozone distribution and chemical problems of trace constituents in the atmosphere that are related to climate problems.

(4) DOT-FA77WA-3965 — Analysis of Aircraft Effects
Institute for Defense Analyses

R. Oliver — April 1977 to August 1980

To summarize the status of research on the effects of high altitude aircraft operation in the stratosphere. To review the status of modeling efforts and the relationship between ozone amounts, ultraviolet irradiance and skin cancer. To study the atmospheric perturbations caused by atmospheric injection both natural and anthropogenic.

FAA-EQ-78-19 ADA 064 130	On the Linkage of Solar Ultraviolet Radiation to Skin Cancer (September 1978)
FAA-EQ-78-20 ADA 063 650	A Catalog of Perturbing Influences on Stratospheric Ozone, 1955-1975 (September 1978)
FAA-AEQ-78-23 ADA 065 472	The Status of Representative Two-Dimensional Photochemical Models of the Stratosphere and Troposphere as of Mid-1978 (October 1978)
FAA-AEE-78-24 ADA 063 586	Recent Developments in the Estimation of Potential Effects of High Altitude Aircraft Emissions on Ozone and Climate (October 1978)
FAA-EE-79-19 ADA 081 522	Modeling Differential Exposure and Differential Sensitivities in Non-Melonoma Skin Cancer Incidence (December 1979)
FAA-EE-80-06 ADA 092 841	A Study of Stratosphere-to-Troposphere Transfer Using Radioactive Tracer Data in a One-Dimensional Parameterization (February 1980)
FAA-EE-80-13 ADA 092 842	On the Applicability of 2- and 1-Dimensional Parameterizations of Atmospheric Tracer Transports of Prognostic Photochemical Models of the Stratosphere (March 1980)
FAA-EE-80-21 ADA 089 409	A Formula for Comparing Annual Damaging Ultraviolet (DUV) Radiation Doses at Tropical and Mid-Latitude Sites (June 1980)

ASSESSMENT, REGULATION, AND COORDINATION: STUDIES IN PROGRESS

(1) DTFA01-81-C-10011 — Analysis of Aircraft Effects on the Environment
Institute for Defense Analyses

R. Oliver — January 1981

To summarize the status of research on the effects of high altitude aircraft operations on the stratosphere. To assess the validity and utility of alternative approaches to modeling of atmospheric transport processes in two-dimensional representation. To review natural and anthropogenic sources, as projected to the Year 1990, of atmospheric oxides of nitrogen.

*Funded jointly with the Upper Atmospheric Research Program, Office of Solar and Terrestrial Applications, National Aeronautics and Space Administration (NASA).

**The DMSP Satellite Ozone Data Study was jointly funded with NASA.

***Funded jointly with NASA, Department of Defense (Department of the Air Force and Department of the Navy) and the Environmental Protection Agency.

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