The upper atmospheric environment of the supersonic transport: a bibliography

Alden McLellan

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I. INTRODUCTION

THE DEMAND FOR THIS PUBLICATION HAS FAR EXCEEDED OUR EXPECTATIONS. WITH THE INCREASING NUMBER OF RESEARCH PAPERS ON THE UPPER ATMOSPHERE, WE HAVE UPDATED OUR BIBLIOGRAPHY TO INCLUDE THE LATEST REPORTS FOR THIS SECOND EDITION.

SUPERSONIC TRANSPORTS (SST) ARE PRESENTLY BEING BUILT TO TRAVEL IN THE 20-30 KM REGION IN THE LOWER STRATOSPHERE. IN THE NEAR FUTURE, IT IS CERTAIN THAT A LARGE NUMBER OF SUPERSONIC TRANSPORTS WILL BE OPERATING IN THIS UPPER ATMOSPHERIC ENVIRONMENT. IT IS POSSIBLE THAT THE IMPACT OF EXHAUST OUTPUT OF CONTAMINANTS IN THIS REGION WILL CAUSE A STRATOSPHERIC ENVIRONMENTAL CHANGE. THIS BIBLIOGRAPHY IS PRESENTED IN ORDER TO OBTAIN A BACKGROUND FOR WHAT IS KNOWN ABOUT THE PHYSICAL AND CHEMICAL PROPERTIES OF THE LOWER STRATOSPHERE SO THAT FURTHER RESEARCH CAN BE DONE ON THE CHANGES THAT WILL TAKE PLACE UPON THE INTRODUCTION OF THE EXPECTED CONTAMINANTS FROM A TRAFFIC PATTERN OF SUPERSONIC TRANSPORTS.

TOWARD THIS END, THIS PAPER HAS BEEN DIVIDED INTO SIX SECTIONS. THE FIRST SECTION IS A LISTING OF SOME GENERAL REFERENCES PERTAINING TO THE STRUCTURE, COMPOSITION AND PHYSICAL DYNAMICS OF THE STRATOSPHERE. SECTION II CONCERNS THE CONSTITUENTS THAT MAKE UP THE COMPOSITION OF THE AMBIENT CASES
Available to undergo chemical reactions with the pollutants. References on ozone and water vapor will be considered as well as particulate matter, trace gases and radiation absorption. The temperature of the stratosphere, which governs the rate of most chemical reactions, and heat flux variations, which control tropospheric and stratospheric mixing rates, are considered in a separate section, Section IV. Section III concerns the vertical and horizontal winds and transport properties of the upper and lower stratosphere. Even though the stratosphere is a relatively quiescent region within the atmosphere, there are mechanisms for the vertical transport of material into the stratosphere from the troposphere (e.g., volcanic eruptions) and from the mesosphere (e.g., meteoric dust). The characteristics of the uppermost part of the stratosphere and the properties of the mesosphere are considered in Section V. Reference to papers on the circulation, synoptic dynamics, and energetics of the stratosphere are contained in Section VI.

II. THE LOWER STRATOSPHERE

Since the ozone layer of the earth's atmosphere is situated in the lower stratosphere, the observations of this layer became one of the first methods of getting a handle on air flow within the region. Although the details of the meteorological processes that lead to large-scale ozone variations are not known, it is well known that the total ozone content of the northern hemisphere increases by a large factor during the winter months (November through March) which is not due to photochemical processes. This increase in ozone, which is lost during the remainder of the year, is either moved into the upper stratosphere or is mixed down into the troposphere. The meridional transport of atmospheric quantities at this level can be accomplished by either meridional cells or by quasi-horizontal, large-scale
EDDY PROCESSES. THE UNCERTAINTY ABOUT TRANSPORT MECHANISMS CENTERS AROUND THE RELATIVE IMPORTANCE OF THESE TWO MECHANISMS.

NUCLEAR BOMB EXPLOSIONS AND VOLCANIC ERUPTIONS ON THE EARTH'S SURFACE AND IN THE TROPOSPHERE HAS RESULTED IN THE DEPOSITION OF A SIGNIFICANT AMOUNT OF RADIOACTIVE MATERIAL AND PARTICULATE MATTER INTO THE STRATOSPHERE WHICH HAS REMAINED THERE WHILE SPREADING QUASI-HORIZONTALLY UNTIL IT IS TRANSPORTED DOWN AND THROUGH THE TROPOPAUSE. ONCE IN THE TROPOSPHERE IT CAN REACH THE EARTH'S SURFACE RELATIVELY QUICKLY, JUST AS MATERIAL WHICH WAS ORIGINALLY DEPOSITED IN THE TROPOSPHERE. OF IMPORTANCE TO THE POLLUTION IN THE STRATOSPHERE FROM SUPersonic TRANSPORTS ARE THE QUESTIONS OF HOW LONG THE MATERIAL CAN BE EXPECTED TO REMAIN IN THE STRATOSPHERE AND WHETHER ITS TRANSPORT INTO THE TROPOSPHERE, AFTER INJECTION AT SOME POINT IN THE STRATOSPHERE, SHOWS ANY PREFERENTIAL VARIATION WITH LATITUDE AND SEASON. THESE QUESTIONS ARE FAR FROM ANSWERED, BUT FROM OBSERVATIONAL STUDIES OF THE VERTICAL DISTRIBUTION OF RADIOACTIVE MATERIAL, VOLCANIC DEBRIS AND OZONE CONCENTRATION HAVE TENDED TO SHOW LARGE DEPOSITION RATES IN THE LATE SPRING IN THE MIDDLE LATITUDES, MORE ESPECIALLY IN THE NORTHERN HEMISPHERE.

GENERALLY, ONE CAN TENTATIVELY CONCLUDE THAT SUPersonic TRANSPORT POLLUTION MAY BE TRANSPORTED FROM MIDDLE-LATITUDE OR LOW-LATITUDE UPPER STRATOSPHERE TO THE HIGH-LATITUDE LOWER STRATOSPHERE DURING THE WINTER MONTHS. SUCH TRANSPORT WOULD BE MUCH WEAKENED DURING THE REST OF THE YEAR. THIS TRANSPORT COULD BE ACCOMPLISHED BY EITHER A MERIDIONAL CIRCULATION OR EDDY PROCESS. LARGE AMOUNTS OF OZONE SEEM TO APPEAR IN THE HIGH-LATITUDE LOWER STRATOSPHERE AT THE SAME TIME AS STRATOSPHERIC WARMINGS; INDICATING A POSSIBLE RELATIONSHIP BETWEEN LARGE-SCALE DISTURBANCES, OZONE TRANSPORT, AND FUTURE POLLUTION TRANSPORT FROM THE SST. STUDIES FROM RADIOACTIVE TRACER OBSERVATIONS TAKEN BY U-2 AIRCRAFT TEND TO CONFIRM A MECHANISM OF EDDY TRANSFER
RATHER THAN A LARGE-SCALE MERIDIONAL CIRCULATION.

MUCH WORK STILL NEEDS TO BE DONE ON THE DISTRIBUTION OF WATER VAPOR IN THE STRATOSPHERE. THE RESULTS WHICH ARE PRESENTLY AVAILABLE FOR WATER VAPOR CONTENT IN THE LOWER STRATOSPHERE GIVE AN AMBIGUOUS PICTURE OF EXACTLY WHAT DOES HAVE TO BE EXPLAINED BY ATMOSPHERIC TRANSPORT PROCESSES. AT PRESENT, THERE IS NO EVIDENCE THAT THE MOISTURE STRUCTURE OF THE STRATOSPHERIC REGION IS SIGNIFICANTLY MORE VARIABLE THAN THAT OBSERVED IN THE TROPOSPHERE. CLOUDS (Nacreous and Mother-of-Pearl) HAVE BEEN OBSERVED IN THE UPPER REGIONS OF THE LOWER STRATOSPHERE, APPARENTLY IN RELATION TO STRONG WAVE MOTIONS (INTERNAL GRAVITY WAVES) GENERATED BY OROGRAPHIC EFFECTS IN THE TROPOSPHERE. THESE OBSERVATIONS INDICATE SATURATION AND WITH A KNOWLEDGE OF THE TEMPERATURE AND PRESSURES PROVIDE EVIDENCE OF A WIDE RANGE IN RELATIVE HUMIDITY FROM A FEW PERCENT MEASURED IMMEDIATELY ABOVE THE TROPOPAUSE TO THE SATURATION OF THESE CLOUD REGIONS.

III. THE UPPER STRATOSPHERE


ALTHOUGH AT THIS TIME THE LOWER STRATOSPHERE IS MARKED BY AN ABSENCE OF DIRECT CONSTANT SOURCES OF PARTICULATE CONTAMINATION; IT DOES HAVE AN INFLUX
OF PARTICULATE MATTER THROUGH SEDIMENTATION OF NEARBY MATERIAL FROM THE
HIGHER ATMOSPHERE AND CONVECTIVE INJECTION ACROSS THE LOWER BOUNDARY FROM THE
TROPOSPHERE. THE LATTER PROCESS HAS A FAR GREATER POTENTIAL OWING TO GROSS
CONTAMINATION WHICH EXISTS IN CERTAIN TROPOSPHERIC REGIONS, BUT IS LIMITED IN
EFFICIENCY BECAUSE OF THE CONSIDERABLE STABILITY OF THE LOWER STRATOSPHERIC
TEMPERATURE STRUCTURE. Thus, IN THIS MANNER, THIS VARIABLE PARTICULATE
CONCENTRATION IS HIGHLY DEPENDENT UPON SUDDEN STRATOSPHERIC TEMPERATURE
CHANGES. A SEPARATE SECTION IN THIS BIBLIOGRAPHY IS DEVOTED TO THE
TEMPERATURE AND HEATING OF THE LOWER STRATOSPHERE.

IV. SUPersonic ENVIRONMENT PROTECTION ACT

IN MAY 1971 A BILL WAS INTRODUCED IN THE UNITED STATES SENATE BY
SENATOR GAYLORD NELSON TO AMEND THE FEDERAL AVIATION ACT OF 1958 IN ORDER TO:
1) PROVIDE FOR INDEPENDENT SCIENTIFIC STUDIES OF THE IMPACT OF CIVIL
SUPersonic AIRCRAFT UPON THE ENVIRONMENT,
2) PROHIBIT THE OPERATION OF ANY CIVIL SUPersonic AIRCRAFT WITHIN THE
TERRITORIAL JURISDICTION OF THE UNITED STATES UNTIL AND UNLESS THE
CONGRESS DETERMINES FROM INDEPENDENT SCIENTIFIC STUDIES THAT THE
OPERATION OF CIVIL SUPersonic AIRCRAFT WILL NOT HAVE IMMEDIATE OR LONG-
RANGE ADVERSE EFFECTS UPON THE ENVIRONMENT.

IN THE BIBLIOGRAPHY THIS BILL (S. 1881) IS QUOTED IN FULL.

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PROGRAM, AND DEBBIE RENNDT, PHILI NEUSTCH, DONNA HAMILTON, MARCIE SEAVERNS,
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JANUARY 1973
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WOODBRIDGE, N.D.

IONOSPHERIC WINDS

S. 1881
92D CONGRESS 1ST SESSION

A BILL

TO AMEND THE FEDERAL AVIATION ACT OF 1958 TO PROVIDE FOR INDEPENDENT SCIENTIFIC STUDIES OF THE IMPACT OF CIVIL SUPersonic AIRCRAFT UPON THE ENVIRONMENT; TO PROHIBIT THE OPERATION OF ANY CIVIL SUPersonic AIRCRAFT WITHIN THE TERRITORIAL JURISDICTION OF THE UNITED STATES UNTIL AND UNLESS THE CONGRESS DETERMINES FROM INDEPENDENT SCIENTIFIC STUDIES THAT THE OPERATION OF CIVIL SUPersonic AIRCRAFT WILL NOT HAVE IMMEDIATE OR LONG-RANGE ADVERSE EFFECTS UPON THE ENVIRONMENT AND FOR OTHER PURPOSES;

BE IT ENACTED BY THE SENATE AND HOUSE OF REPRESENTATIVES OF THE UNITED STATES OF AMERICA IN CONGRESS ASSEMBLED:

SHORT TITLE

SECTION 1. THIS ACT MAY BE CITED AS THE 'SUPersonic ENVIRONMENTAL PROTECTION ACT'.

DECLARATION OF POLICY AND PURPOSE

SEC. 2. THE CONGRESS FINDS AND DECLARES THAT-

(A) INTERNATIONAL AIR CARRIERS OF THE WORLD ARE AT VARIOUS STAGES OF PLANNING THE PURCHASE OF CIVIL SUPersonic AIRCRAFT WHICH WILL OPERATE IN INTERNATIONAL COMMERCE AT STRATOSPHERIC LEVELS AND SUPersonic SPEEDS AND WILL FLY WITHIN THE TERRITORIAL JURISDICTION OF THE UNITED STATES;

(B) THE OPERATION OF CIVIL SUPersonic AIRCRAFT WILL INJECT INTO THE STRATOSPHERE QUANTITIES OF WATER VAPOR, SULFUR DIOXIDE, HYDROCARBONS,
AND OTHER SOLID OR GASEOUS SUBSTANCES WHICH MAY COMPROMISE THE STABILITY AND INTEGRITY OF THE STRATOSPHERE AND HAVE A DELETERIOUS EFFECT UPON THE EARTH’S CLIMATE;


(D) THE OPERATION OF CIVIL SUPersonic AIRCRAFT WOULD PRODUCE INCREASED LEVELS OF NOISE IN AREAS ADJACENT TO RUNWAYS OF LANDING AND TAKEOFF;

(E) THE FULL NATURE AND EXTENT OF THE ENVIRONMENTAL IMPACT AND THE ECOLOGICAL CONSEQUENCES WHICH MAY RESULT FROM THE OPERATION OF CIVIL SUPersonic AIRCRAFT IN INTERNATIONAL COMMERCE AND WITHIN THE TERRITORIAL JURISDICTION OF THE UNITED STATES ARE UNRESOLVED;

(F) THE ENVIRONMENTAL IMPACT AND ECOLOGICAL CONSEQUENCES WHICH MAY RESULT FROM THE OPERATION OF CIVIL SUPersonic AIRCRAFT ARE OF A NATIONAL AND GLOBAL DIMENSION;

(G) THE PRESERVATION AND IMPROVEMENT OF NATIONAL AND GLOBAL ENVIRONMENTAL QUALITY ARE OF THE HIGHEST ORDER OF PRIORITY AND NECESSITY;

(H) THE UNITED STATES SHOULD PROMOTE COOPERATIVE INTERNATIONAL EFFORTS TO RESOLVE ALL ISSUES PERTAINING TO THE OPERATION OF CIVIL SUPersonic AIRCRAFT IN INTERNATIONAL COMMERCE AND, IN PARTICULAR, SHOULD PROVIDE INTERNATIONAL LEADERSHIP TO PRESERVE THE WORLD ENVIRONMENT FROM UNFORESEEN OR IGNORED CONSEQUENCES OF THE OPERATION OF CIVIL SUPersonic AIRCRAFT;
(I) Congress should create a commission of qualified independent scientists to conduct full and comprehensive studies of the environmental and ecological impact—both immediate and long-range; global as well as national—of the operation of civil supersonic aircraft in international commerce; and

(J) the operation of any civil supersonic aircraft within the territorial jurisdiction of the United States should be prohibited until and unless the Congress determines from the report(s) of the commission of qualified independent scientists that the operation of civil supersonic aircraft will not have immediate or long-range adverse effects upon the national or global environment.

Sec. 3. (A) Title VI of the Federal Aviation Act of 1958, as amended (49 U.S.C. 1421-1431), is amended by adding at the end thereof the following new sections:

'ENVIRONMENTAL QUALIFICATIONS FOR OPERATION OF CIVIL SUPersonic AIRCRAFT

'DEFINITIONS

'Sec. 612. (A) For purposes of this section and section 613—

'(1) The term 'civil supersonic aircraft' means any aircraft designed and intended for operation in civil aviation at supersonic speeds;

'(2) The term 'supersonic speed' means a speed in excess of the speed of sound at the altitude at which an aircraft is operating;

'(3) The term 'stratosphere' means the upper portion of the atmosphere, above seven miles, more or less (depending on latitude, season, and weather), in which temperature changes with little with altitude and clouds of water never form naturally:
'(4) THE TERM 'SONIC BOOM' MEANS THE SHOCKWAVE PRODUCED AND APPARENT AT THE SURFACE OF THE EARTH, CONSISTING OF A WAVE OF SHORT, SHARP INCREASES IN ATMOSPHERIC PRESSURE (KNOWN AS 'OVERPRESSURE' AND USUALLY MEASURED IN THE UNITED STATES IN POUNDS PER SQUARE FOOT) AT A GIVEN POINT, CREATED BY THE OPERATION OF AN AIRCRAFT AT SUPersonic SPEED;

'(5) THE TERM 'STRATOSPHERIC POLLUTION' MEANS THE EMISSION INTO THE STRATOSPHERE BY A CIVIL SUPersonic AIRCRAFT, IN ANY QUANTITY WHATEVER, OF WATER VAPOR, SULFUR DIOXIDE, HYDROCARBONS, OR OTHER SOLID OR GASEOUS SUBSTANCES NOT FOUND OR OCCURRING IN THE STRATOSPHERE IN NATURE, OR THE EMISSION INTO THE STRATOSPHERE OF SUBSTANCES FOUND OR OCCURRING THERE IN NATURE IN QUANTITIES, QUALITIES, OR MIXTURES DETERMINATELY LARGER THAN OR DIFFERENT FROM THOSE WHICH ARE FOUND OR OCCUR IN NATURE.

'PROHIBITION

'(B) NO CIVIL SUPersonic AIRCRAFT SHALL BE OPERATED WITHIN THE TERRITORIAL JURISDICTION OF THE UNITED STATES UNTIL AND UNLESS THE CONGRESS DETERMINES FROM INDEPENDENT SCIENTIFIC STUDIES, AND UPON RECEIPT OF THE FINAL REPORT OF THE CIVIL SUPersonic ENVIRONMENTAL STUDY COMMISSION, AS PROVIDED FOR IN SECTION 613, THAT THE OPERATION OF CIVIL SUPersonic AIRCRAFT WILL NOT HAVE IMMEDIATE OR LONG-RANGE ADVERSE EFFECTS UPON THE ENVIRONMENT.

S. 1881---2

'CIVIL SUPersonic ENVIRONMENTAL STUDY COMMISSION

'SEC. 614. (A) THERE IS HEREBY ESTABLISHED A COMMISSION TO BE KNOWN AS THE 'CIVIL SUPersonic ENVIRONMENTAL COMMISSION' (HEREINAFTER REFERRED TO AS THE 'COMMISSION').
(B) (1) The Commission shall consist of nine members, appointed by the President from a list of individuals submitted to the Council on Environmental Quality by the National Academy of Science, and the American Association for the Advancement of Science. The individual members shall be scientifically qualified, preferably with expertise in the fields of aeronautics or the environment, or both, and shall not have had any previous major involvement in the civil supersonic program.

(2) The President shall, at the time of appointment, designate one member of the Commission as Chairman and one member of the Commission as Vice Chairman.

(3) A majority of the members of the Commission shall constitute a quorum, but a lesser number may conduct hearings.

(4) A vacancy in the Commission shall not affect its powers, but shall be filled by appointment of the President.

(C) (1) Members of the Commission shall each receive $100 per diem when engaged in the actual performance of duties vested in the Commission.

(2) All members of the Commission shall be allowed travel expenses, including per diem in lieu of subsistence, as authorized by Section 5703 of Title 5, United States Code, for persons in the Government service employed intermittently.

(D) (1) The Commission shall conduct a comprehensive study of the probable and actual impact of the operation of civil supersonic aircraft upon the environment, with particular attention being given to the possible long-range global effects, and shall make recommendations to the Congress for the protection of the environment from any possible adverse consequences of the operation of civil supersonic aircraft.
(2) Within three years after the date of enactment of this act, unless Congress decides that more time is required, the commission shall report to the Congress its findings, conclusions, and recommendations; the commission is also directed to make annual interim reports to the Congress; and all reports of the commission shall be made public. The commission shall terminate thirty days after the date on which it submits its final report to the Congress.

(3) The commission shall meet at the call of the chairman or at the call of a majority of the members serving on the commission.

(4) In order to carry out the purposes of this section, the commission is authorized--

(1) To appoint and fix the compensation of such personnel as may be necessary, without regard to the provisions of Title 5, United States Code, governing appointments in the competitive service; and without regard to the provisions of Chapter 51 and Subchapter III of Chapter 53 of such title relating to classification and general schedule pay rates, at rates not in excess of the maximum rate for GS-18 of the general schedule under section 5332 of such title; and

(2) To obtain the services of experts and consultants, in accordance with the provisions of section 3109 of Title 5, United States Code, at rates for individuals not to exceed $75 per day for each day (including travel time) during which they are engaged in the actual performance of their duties for the commission. While traveling on official business in the performance of duties for the commission such persons so employed shall be allowed expenses of travel, including per diem instead of subsistence, in accordance with section 5703 of Title 5, United States Code.

(6) The commission is authorized to request from any federal department or agency any information and assistance it deems necessary to carry out its
FUNCTIONS; AND SUCH DEPARTMENT OR AGENCY SHALL COOPERATE WITH THE COMMISSION
AND, TO THE EXTENT PERMITTED BY LAW, FURNISH SUCH INFORMATION AND ASSISTANCE TO
THE COMMISSION UPON REQUEST MADE BY THE CHAIRMAN OR ANY OTHER MEMBER WHEN
ACTING AS CHAIRMAN.

'(H) THE GENERAL SERVICES ADMINISTRATION SHALL PROVIDE ADMINISTRATIVE
SERVICES FOR THE COMMISSION ON A REIMBURSABLE BASIS;

'(I) THERE ARE AUTHORIZED TO BE APPROPRIATED TO THE COMMISSION SUCH SUMS,
NOT IN EXCESS OF $27,000,000 FOR ANY FISCAL YEAR, AS MAY BE NECESSARY TO CARRY
OUT THE PROVISIONS OF THIS SECTION.'

(B) THAT PORTION OF THE TABLE OF CONTENTS OF THE FEDERAL AVIATION ACT OF
1958 RELATING TO TITLE VI IS AMENDED BY INSERTING AT THE END THEREOF THE
FOLLOWING:

'SEC. 612. ENVIRONMENTAL QUALIFICATIONS FOR OPERATION OF CIVIL SUPERSONIC
AIRCRAFT.

SEC. 613. CIVIL SUPERSONIC ENVIRONMENTAL STUDY COMMISSION.'

REQUIREMENT FOR SPECIFIC AUTHORIZATION FOR APPROPRIATIONS FOR THE DEVELOPMENT
OF CIVIL SUPERSONIC AIRCRAFT

SEC. 4 EFFECTIVE FOR FISCAL YEARS BEGINNING AFTER JUNE 30, 1971, NO
APPROPRIATION SHALL BE MADE FOR ANY FISCAL YEAR FOR THE DEVELOPMENT OF ANY
CIVIL SUPERSONIC AIRCRAFT UNLESS SPECIFICALLY AUTHORIZED FOR SUCH PURPOSE AND
FOR SUCH YEAR BY ACT OF CONGRESS.