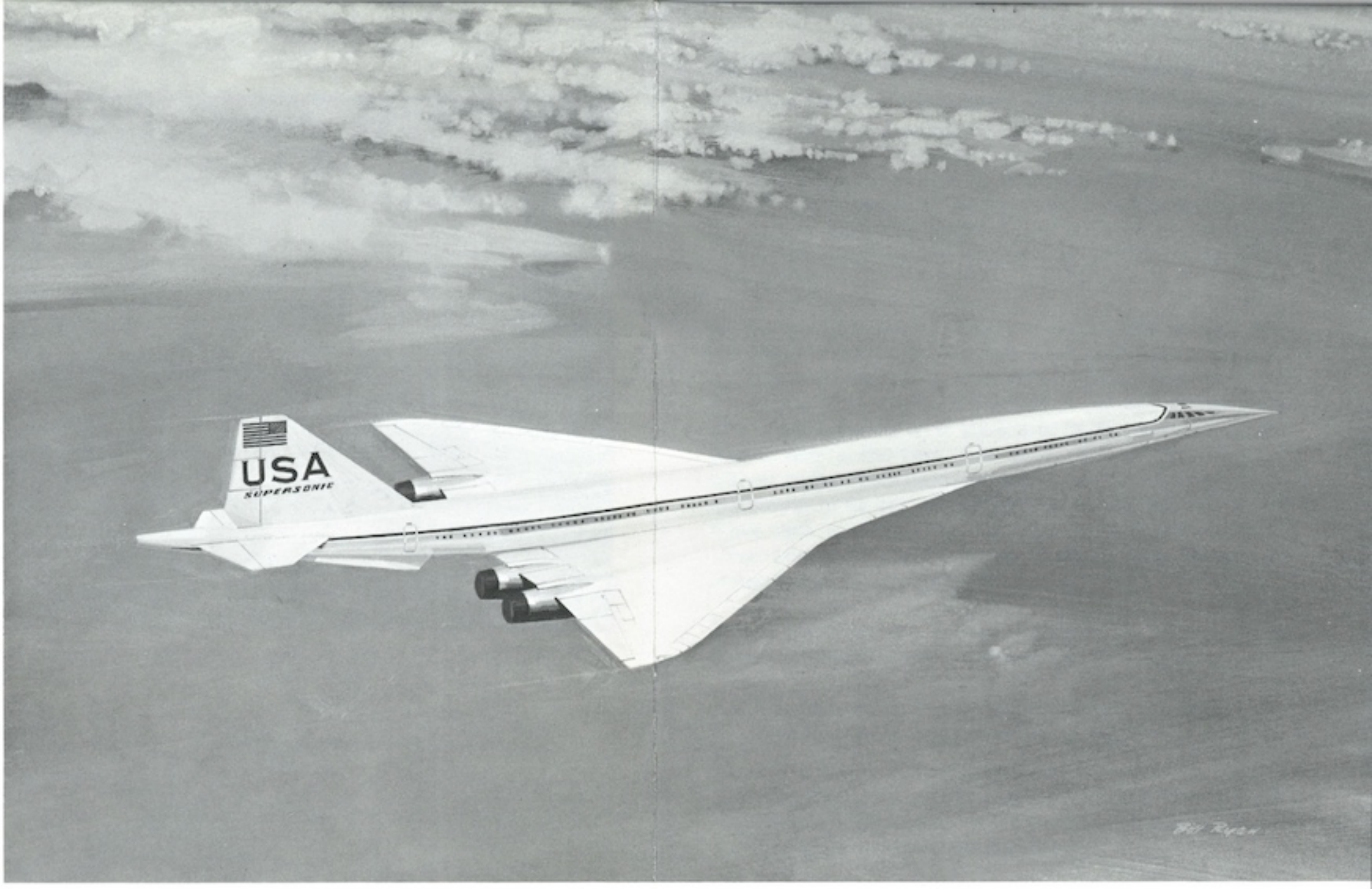


THE SUPERSONIC TRANSPORT AND THE ENVIRONMENT

JANUARY 1971
(Revised)

THE BOEING COMPANY COMMERCIAL AIRPLANE GROUP
SUPERSONIC TRANSPORT DIVISION

Introduction and Summary

The supersonic transport program will have far-reaching benefits for the future air traveler and the national economy. These beneficial aspects have been documented and are available from the Department of Transportation and The Boeing Company. This pamphlet discusses the principle environmental issues that relate to the operation of a fleet of supersonic transports.

Sincere and conscientious critics of the US SST program have questioned the SST contribution to air pollution, community noise, and the impact of sonic boom. These questions should be raised and answered with respect to any new development. The broad question is, if there is to be transportation in the future, how is this best to be accomplished? The results of current environmental studies indicate that air travel in general has proven to be not only efficient from the point of view of travel time and cost, but also *the most efficient* means of travel known to man from the point of view of minimal *impact upon the environment.*

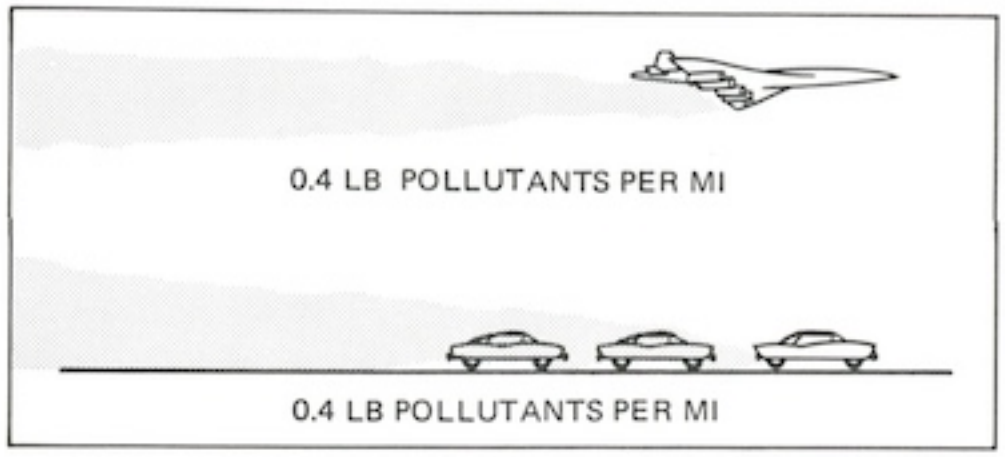
The results of specific studies relating to the SST impact on the environment are summarized below:

- The SST will generate *less pollutants* per passenger mile than most other transportation alternatives.
- There is *no known* technical basis or available data to substantiate the concern that the SST fleet operation will have an adverse effect on the weather. All indications are that there will be no detectable effect.
- Most people living in the vicinity of airports serviced by the SST will be exposed to *less community noise,* than they hear today. Sideline noise (principally noise on the airport itself) is a problem to be solved with an intensive development program.
- The supersonic transport will be prohibited from making sonic booms over populated land areas. The *sonic boom* over water will be mild and not harmful to marine life. Under these operating conditions, the SST fleet will be an economical success.

The following sections of this pamphlet discuss these issues in more depth and present some of the significant data and analysis.

Air Pollution

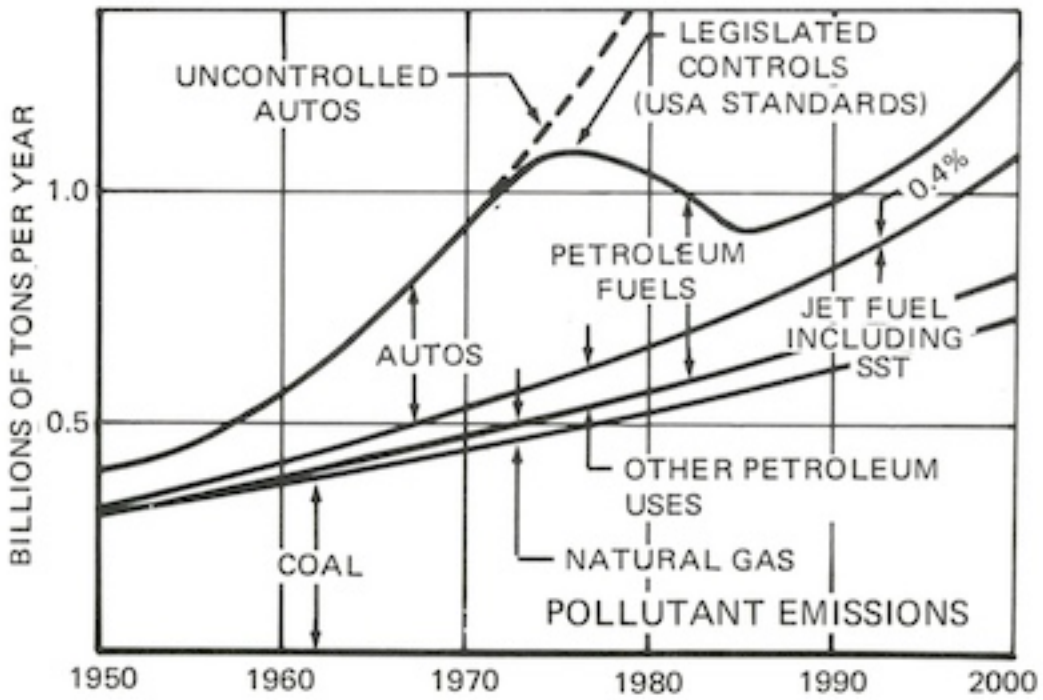
Reciprocating engines commonly used in land transportation vehicles convert 30 to 50% of the fuel consumed into air pollutants. In contrast, turbine engines convert less than 1% of fuel consumed into pollutants. One SST carrying 300 passengers at 1780 mph will emit no more pollutants per mile than three autos traveling at 60 mph.



The air transport fleet – including future SSTs – emit less pollution per 1,000 seat miles than any other known transportation means. If the comparison is restricted to vehicles capable of crossing oceans, the SST emits less pollution by an order of magnitude.

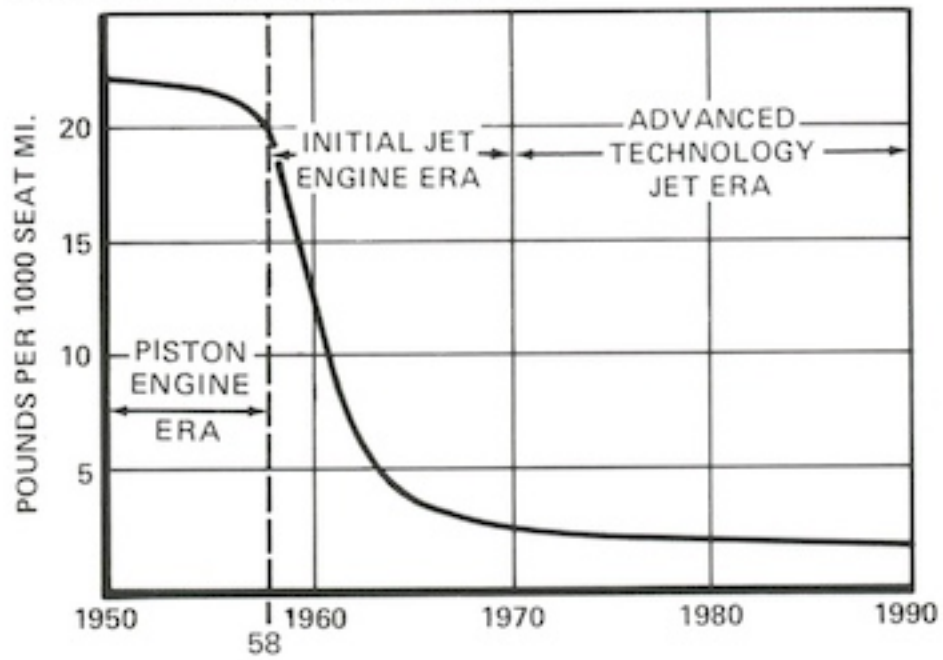
TOTAL WORLD POLLUTANT FLOW

BELOW: Compared to the total amount of pollutants emitted by all energy conversion processes, the emissions by the jet transport fleet are less than 1% of the total. Pollutants are: carbon monoxide, nitrogen oxides, sulfur oxides, hydrocarbons, particulates.



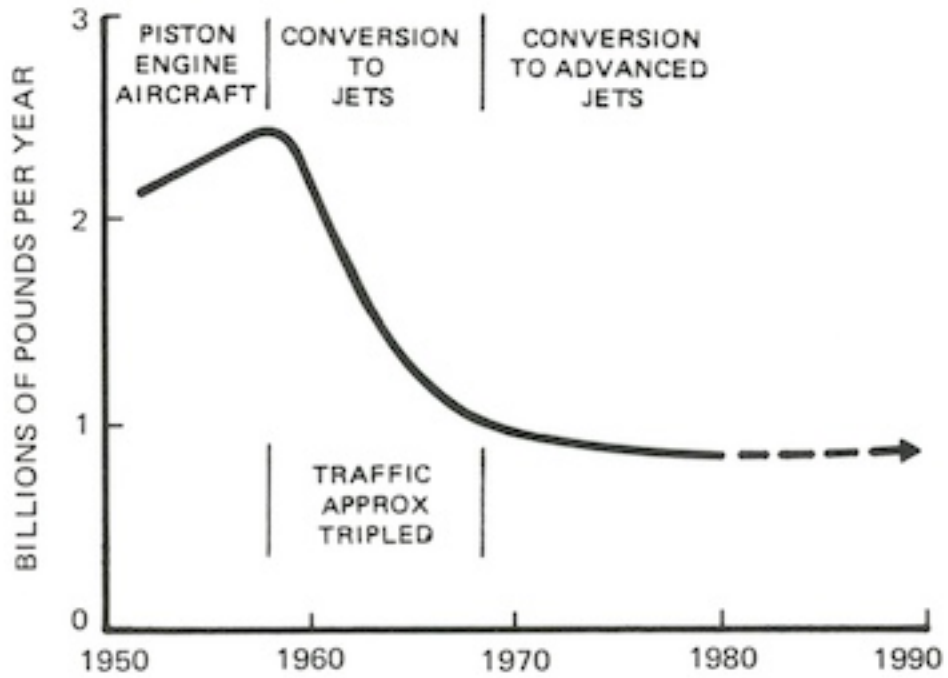
The graph below illustrates how the pollutants emitted per unit of useful work were reduced by the conversion from piston engines to jet engines. Advances in technology will provide a continuing favorable trend.

AIRCRAFT EMISSION TRENDS



As a result of the trend shown above, the total pollutants emitted by the airline fleet have been drastically reduced in the 1958-1968 decade although traffic more than tripled.

FLEET EMISSION TRENDS



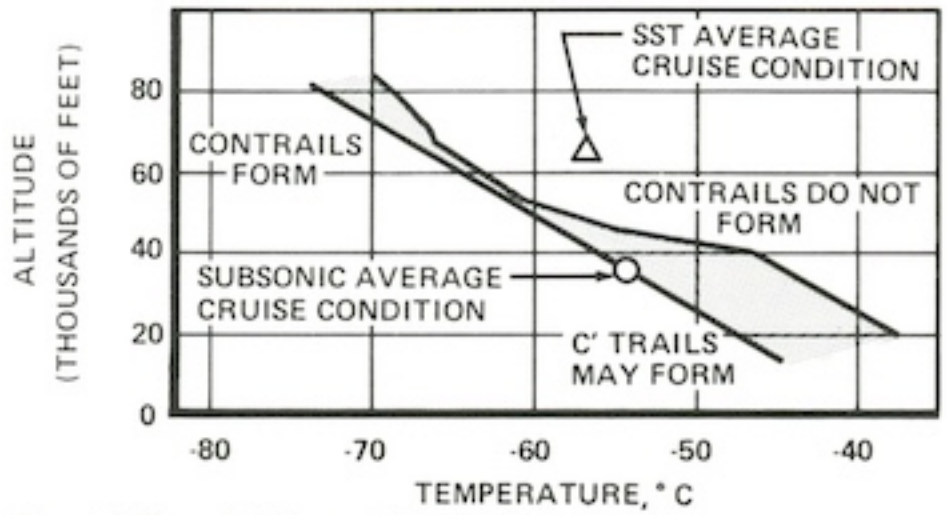
Smokeless burners are being installed on present-day aircraft engines, and they have reduced emission during ground operation by about 70% for smoke particles and by 45% for smog ingredients. The SST engines will be smokeless, and they will be equipped with emission controls at least as effective as those now being implemented.

WATER VAPOR

The following paragraphs discuss the various ways it has been suggested that water vapor from a fleet of 500 SSTs could affect the earth's climate and weather.

Condensation Trails

SSTs will not produce condensation trails at their average cruising altitude of 65,000 feet. The graph below shows that the standard atmospheric temperature at that altitude is too high for contrail formation. If SSTs were operated at an altitude of 60,000 feet on an extremely cold day (-65°C), the 500-plane fleet might add about seven hours of high-altitude cloud wisps to the 17 hours per year (8,760 hours) that now occur.



Ice Crystal Clouds (Cirrus Clouds)

A cubic mile of air at SST cruise altitude weighs about 1 billion pounds, and normally contains about 4000 pounds of water vapor. Before clouds can form at the normal stratospheric temperatures enough water must be added to increase the water content of each cubic mile to 156,000 pounds. An SST will penetrate each cubic mile of air between 60 and 70,000 feet altitude in the northern hemisphere once each 45 days on the average, and emit about 75 pounds of water as it passes through. About 250 years would be required to form clouds if there were no air movement. All available data indicate that this air is changed about every 1½ years. Based on this simple analysis, there is little possibility the SST fleet contribution to cloud cover will be significant.

In a relatively small, but heavily traveled area, horizontal winds are the dominant cleansing agent, and circulation times will be much less than the 1½ years required to change the air in the whole stratosphere. If a single cubic mile of space is considered, the air it contains will be changed several times each day. Hence, even on this small scale, an accumulation of water vapor is unlikely.

Invisible Water Vapor

Water vapor in the air is known to absorb solar radiation at certain wavelengths even though the vapor itself is invisible. In the 1966 National Academy of Sciences report on Weather and Climate Modification, Dr. S. Manabe calculated that the amounts of water vapor emitted by SST aircraft would have no appreciable effect on the earth's temperature.

Water Vapor/Ozone Interaction

Ozone in the stratosphere absorbs ultra-violet radiation, thus shielding the earth. It has been suggested that additional water vapor from SSTs might reduce the amount of ozone in the stratosphere, thus exposing the earth to increased radiation which would raise its surface temperature.

Theoretical investigations by responsible scientists indicate that this effect would be insignificant, or non-existent. Stratospheric water vapor measurements taken by the Naval Research Laboratory at Washington, D. C. show a gradual increase in the water vapor content in the upper atmosphere, but there has been no discernible effect on either ozone amount or temperature.

OTHER EXHAUST PRODUCTS

Carbon Dioxide (CO_2) and "Greenhouse Effect"

CO_2 is known to absorb radiant energy of the wavelength at which the earth's heat radiates outward to space. In theory, an increase in the CO_2 content of the atmosphere would cause more energy to be absorbed, thus raising the average temperature. Although the CO_2 content in the air has been increasing for many years, the average global temperature is apparently decreasing at present. In any case, the SST fleet will add less than 0.3% to the natural amount already in the stratosphere and less than 0.1% to that in the total atmosphere.

Trace Compounds

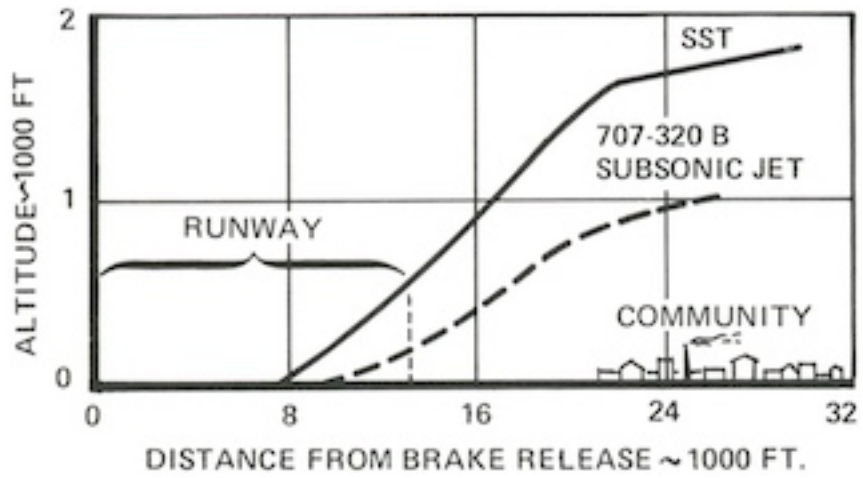
Traces of hydrocarbons, carbon monoxide, nitrogen oxides, and particles of other substances are found in the stratosphere. An investigation is in progress to determine whether or not SST exhaust products can react with natural substances in the presence of sunlight to form secondary pollutants. SST-fleet contributions to these trace compounds as well as to any possible secondary pollutants are expected to be both minute and of relatively short duration.

Dust/Smoke Particles

Smokeless engines will emit minute quantities of carbon particles. The amount of energy received on the earth may be reduced by one part in 200,000, an amount that would be completely overshadowed by ordinary variations in volcanic action or in combustion processes on the earth's surface.

Community Noise

Significant improvements in air transportation are generally associated with larger and more powerful engines. In the case of the SST, the four engines will generate about 250,000 pounds of thrust (four 707's). This large thrust would create considerable airport (side line) noise if unsuppressed. However, this large thrust also allows rapid and steep climbout (see figure) which reduces community noise.

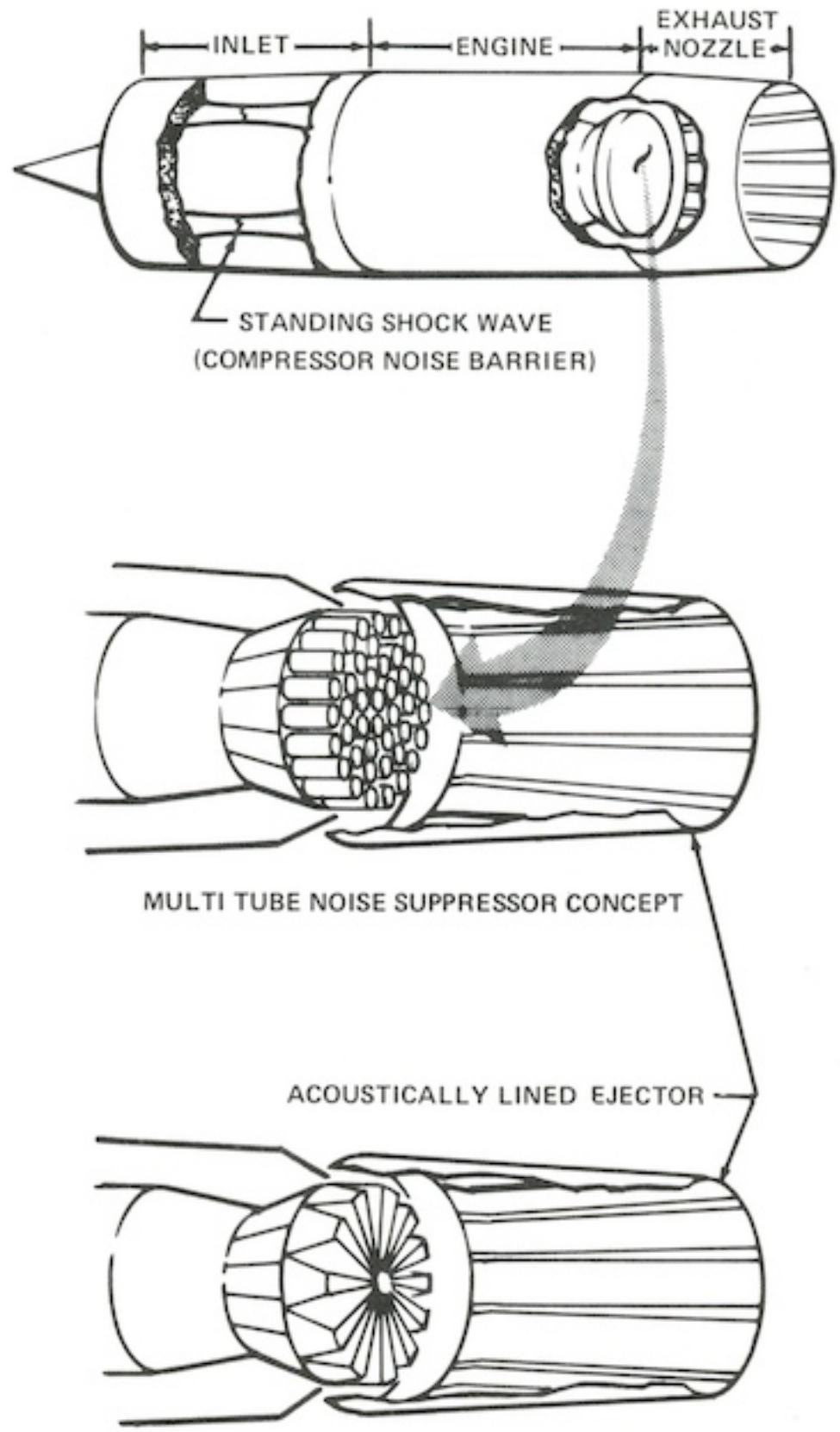


The Boeing Company is working with the engine company, members of industry and the government on a coordinated aggressive noise technology program. Recent testing has revealed three significant breakthroughs in noise improvement which have dramatically improved the SST noise posture. Actual ground tests on the prototype engine and detailed flight performance analysis have revealed significantly less effective perceived noise than was estimated initially. Wing flap tests in the NASA wind tunnel showed an improvement in lift and a marked reduction in takeoff distance, thereby improving the altitude of the airplane over the community during climb out. Recent tests of advanced suppressors are encouraging in their acoustic and performance characteristics.

The combination of these features, characteristics and suppressor developments will result in achieving a marked reduction in SST engine noise.

Prior to production commitment, the capability of the commercial SST to achieve noise levels consistent with those required for certification of new four-engined, intercontinental subsonic transport aircraft will be demonstrated.

NOISE SUPPRESSOR DEVELOPMENT



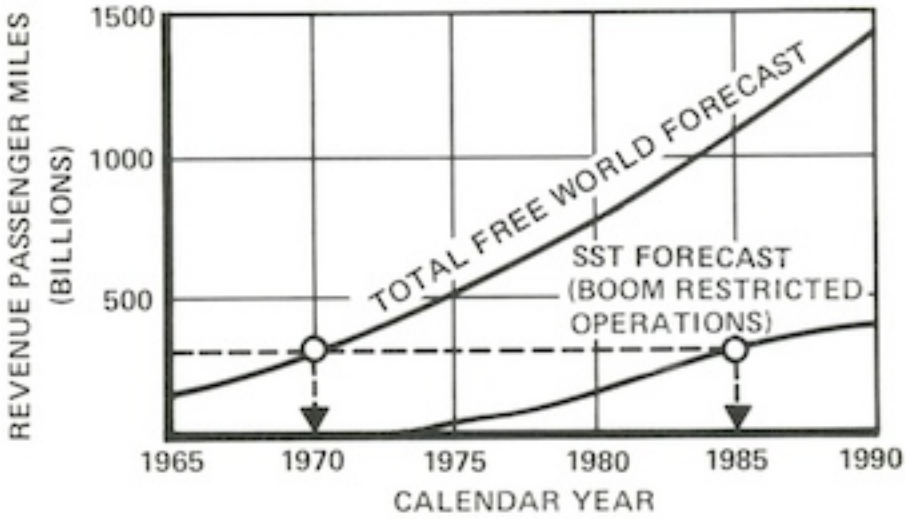
Sonic Boom

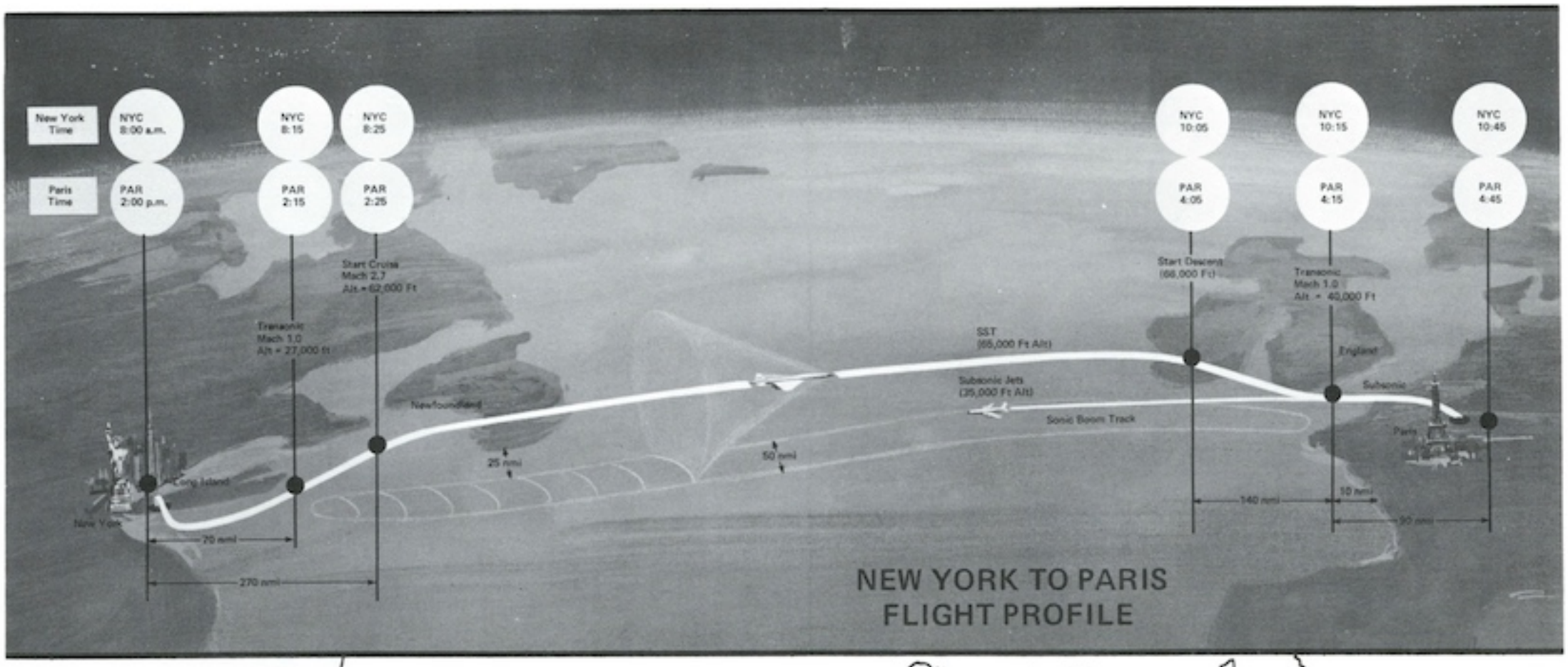
Sonic boom occurs only when the airplane flies supersonically. Although the boom is not destructive to property, it may annoy people on the ground. Consequently, the SST will fly over land at a speed (about 700 mph) that does not create a boom. Its major use will be as an over-water airplane, flying predominantly international transoceanic routes at 1,780 mph. This is known as boom-restricted operations. Operating on the long over-water routes, the productivity of the SST is great, large savings in passenger trip time are achieved, and the operation is complementary to the many subsonic airplanes flying the overland routes.

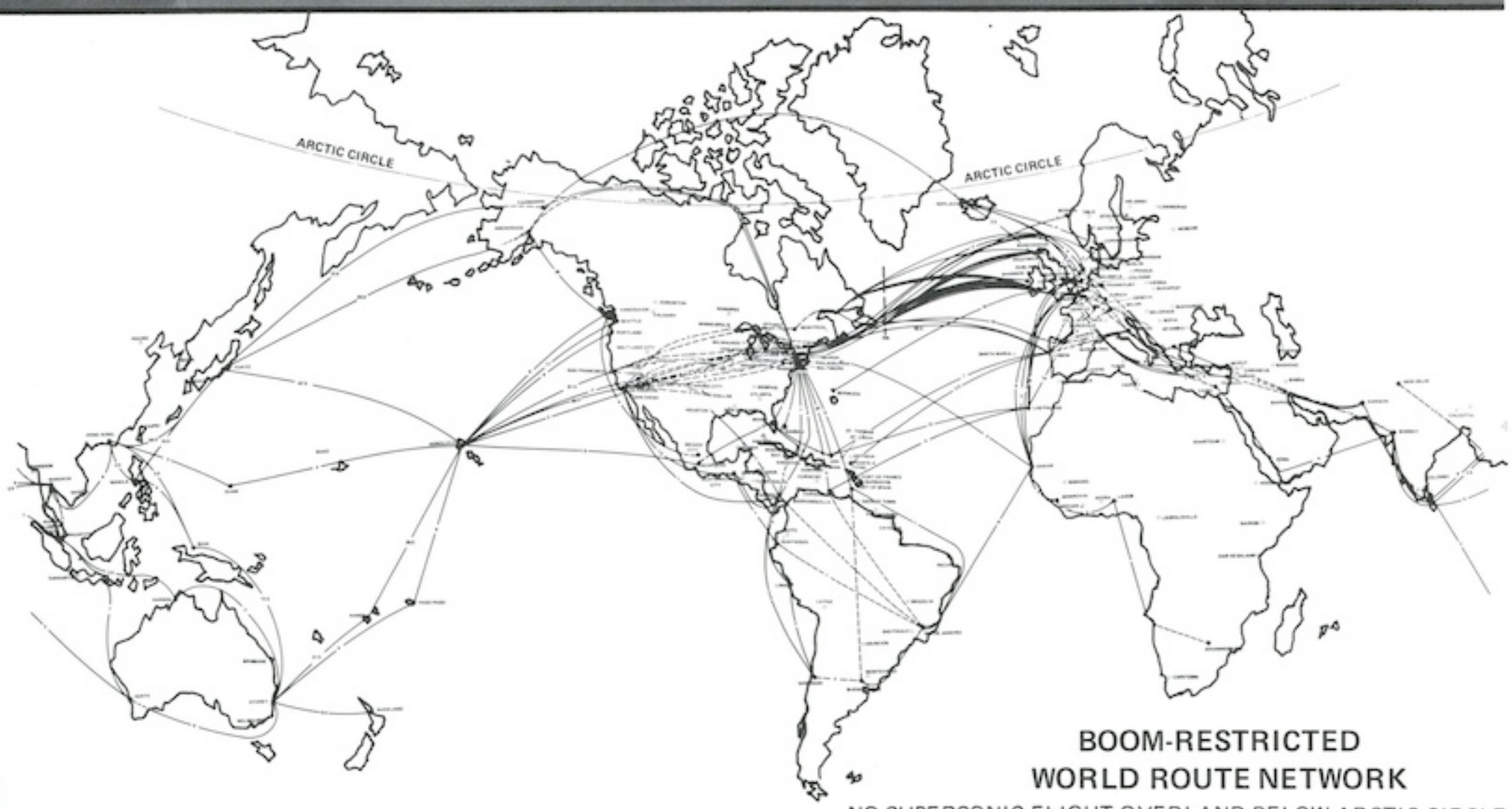
The figure below illustrates that by 1985, the passenger traffic on SST routes is projected to be equal to the total free world traffic of today.

Despite boom-restricted operation, more than 540 SST's will be required to handle the traffic in 1990.

AIR TRAVEL FORECAST

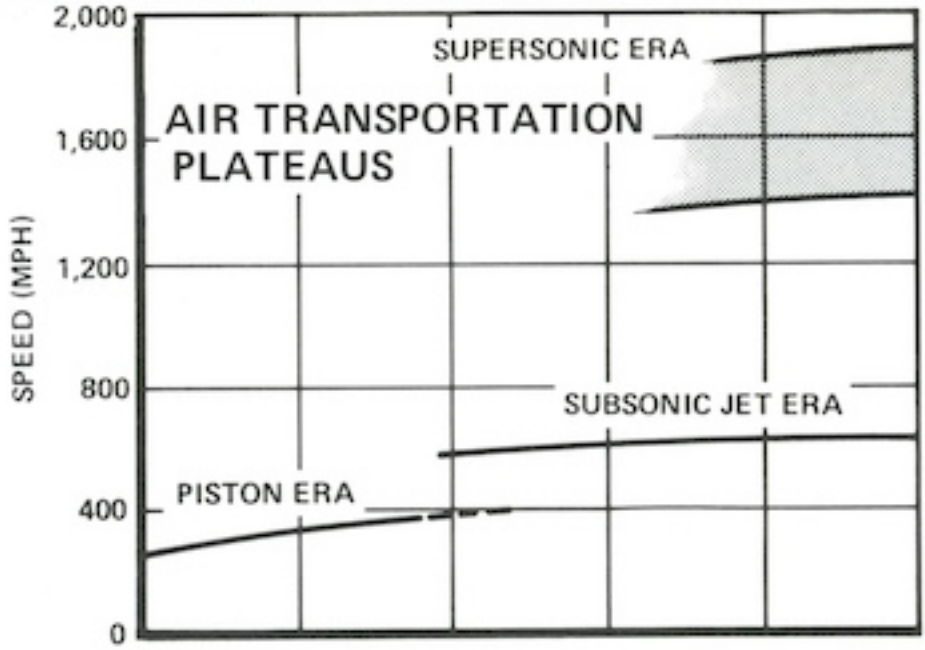


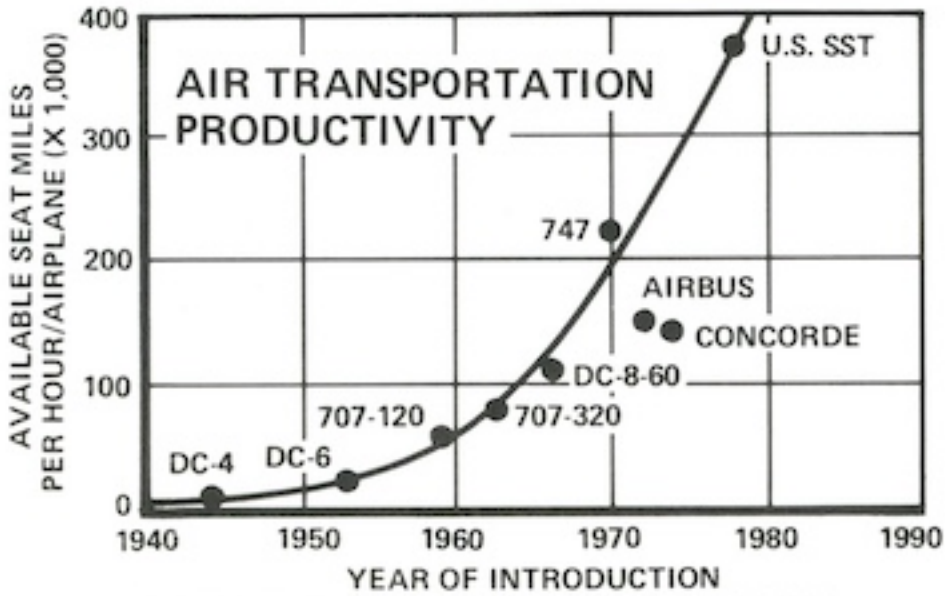




BOOM-RESTRICTED
WORLD ROUTE NETWORK

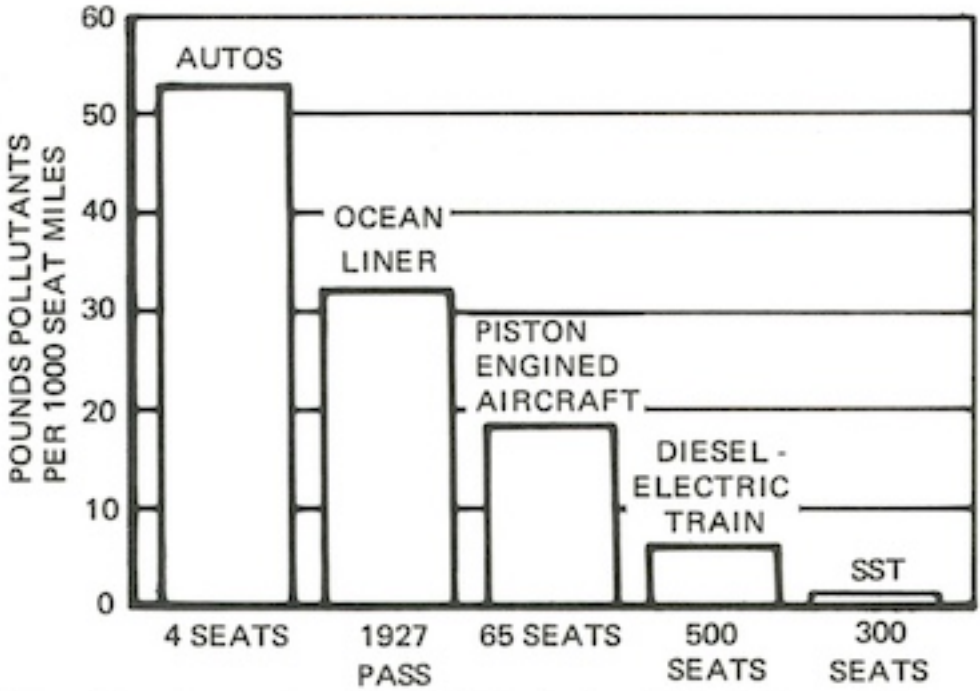
NO SUPERSONIC FLIGHT OVERLAND BELOW ARCTIC CIRCLE





TRANSPORTATION SYSTEM COMPARISON

A comparison with other modes of surface transportation is shown below.



The value shown for the SST includes all fuel burned from engine start to shutdown.