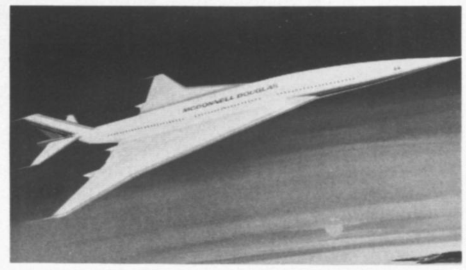
The Supersonic Question

Boeing

Will fleets of high-speed jetliners damage the fragile ozone layer?

By RICHARD MONASTERSKY



McDonnell Douglas

U.S. and foreign aircraft manufacturers are developing plans for a new breed of supersonic planes that they hope to have on the runways by 2005. According to current design scenarios, the planes would fly subsonically over land areas to avoid annoying sonic booms, although NASA is conducting research to reduce sonic booms to a level where planes could fly supersonically over land.

While the Atlantic Ocean once held center stage in world affairs, nations of the Pacific Rim are rapidly rising in prominence. The surging interest in Asia, Australia and other regions has lured waves of business people and tourists across the vast Pacific Ocean, arriving at their destinations bleary-eyed from flights that can stretch 12 hours or longer. To these weary voyagers, the prospect of supersonic planes holds an immediate appeal. Imagine eating lunch in San Francisco's Chinatown and landing in Hong Kong before you're hungry for supper.

Recognizing the potential market for such speedy transport, the National Aeronautics and Space Administration and several aircraft companies have started exploring the possibility of developing a new breed of supersonic plane. Called high-speed civil transport (HSCT), these jets would fly faster and carry more passengers than the Concorde, the only commercial airliner that currently breaks Mach 1, the speed of sound.

"We think it's the most important thing we're doing right now in civil aviation," says Howard L. Wesoky, who heads NASA's high-speed research program at the agency's Washington, D.C., headquarters.

But before civil aviation makes this jump past the sound barrier, it must first resolve the same environmental uncertainties that 20 years ago grounded U.S. plans to build supersonic passenger planes. Among those concerns, a critical question remains: Will high-speed aircraft damage the ozone layer that screens out harmful ultraviolet radiation?

Simple computer studies in the last few years have tended to confirm the dire forecasts made in the early 1970s showing that fleets of supersonic jets could indeed significantly weaken the ozone layer. But the newest computer simulation, using a more sophisticated model of atmospheric chemistry, points in the opposite direction. High-flying jets might not diminish ozone concentrations appreciably, according to work by Debra K. Weisenstein and colleagues at Atmospheric and Environmental Research, Inc., in Cambridge, Mass. Paradoxically, the pollution from such planes could cause an ozone increase under some conditions, the researchers find.

The ozone question revolves around a certain class of chemicals, called nitrogen oxides, that HSCT engines emit as exhaust. These compounds are nothing exotic; the same nitrogen oxides spew out of cars and conventional planes. The problem with supersonic jet exhaust is one of location. To achieve their extreme speeds, HSCT must fly at high altitudes where the air is thinner and creates less friction than does air at lower altitudes. So unlike other planes, which emit their exhaust in the lowest layer of the atmosphere, HSCT pollution affects the stratosphere, the region where protective ozone is most concentrated.

Concerns about the effect of nitrogen oxides on ozone first surfaced 20 years ago and helped kill an already floundering movement to build supersonic planes in the United States. In the time since then, the world has grown increasingly aware of the ozone layer's vulnerability. The dramatic discovery of the Antarctic ozone hole in 1985 demonstrated just how seriously chemical pollutants can affect this protective shield around the planet. Closer to home, researchers have detected sizable ozone loss over midlatitude regions such as the United States (SN: 4/13/91, p.231). Although scientists have yet to decipher the exact cause behind much of this ozone decrease, experts believe chemical pollutants are involved in the process.

Into this politically charged arena, NASA has now ventured with the HSCT project.

While NASA's public image most often revolves around ventures in space, the first "A" in its name stands for aeronautics; part of the agency's charter directs it to help the U.S. commercial aviation community develop new technology. Under contract from NASA, two aviation firms, the Boeing Co. and McDonnell Douglas Corp., analyzed the economic potential for HSCT.

They found that the expected market in the year 2015 could indeed support supersonic jets capable of flying across the Pacific, which the Concorde cannot. The contractors, however, remained unsure

	Concorde	Projected High-Speed Civil Transport
Range (km)	5,600	9,000–12,000
Payload (passengers)	100	250–300
Community noise standard	Exempt	Far 36, Stage 3
Fare levels	Premium	Standard
Speed	Mach 2	Mach 2.4

Adapted from NASA

whether the aviation community could produce environmentally acceptable HSCT jets by that time. To answer that question, NASA last year launched a six-year, $284 million research program.

The scientific effort addresses three primary concerns: ozone depletion, noise from sonic booms, and noise created when planes land and take off at subsonic speeds. While all three represent potential problems, the ozone question may end up playing the crucial role in determining whether the HSCT idea flies.

Much of NASA's work with ozone involves computerized replicas of the atmosphere, with which scientists can gauge the effects of HSCT exhaust. Most simulations to date have focused on two-dimensional models that mimic the chemical reactions between various gases in the stratosphere and troposphere. These models have shown serious ozone loss from high-speed traffic; some predict that a fleet of aircraft would lower ozone values substantially.

But these previous model simulations do not include a number of reactions that could dramatically alter the picture. Chief among the factors left out is heterogeneous chemistry – reactions that take place on the surfaces of liquid and solid particles in the atmosphere. Scientists have grown particularly sensitive to the importance of heterogeneous reactions in recent years because they play a critical role in creating the Antarctic ozone hole. Prior to the ozone hole's discovery, atmospheric chemists considered such reactions relatively unimportant – an oversight that prevented experts from foreseeing the hole's appearance.

When Weisenstein and her colleagues ran their model without heterogeneous chemistry, they found that 500 aircraft flying at a speed of Mach 2.4 (three times the speed of modern commercial jets) could lower ozone values by a significant 3 to 6 percent in northern midlatitudes. That weakening in the ozone layer would let some 6 to 12 percent more ultraviolet light reach Earth's surface, raising the risk of skin cancer, cataracts and damage to animals and plants.

But when the researchers included a particular heterogeneous reaction in their calculations, they found that HSCT traffic would slightly *increase* ozone concentrations by a few tenths of a percent.

The turnabout develops because heterogeneous reactions alter ozone's habits in the stratosphere, where it is continually created and destroyed by various reactions. In a model without heterogeneous chemistry, ozone is particularly sensitive to levels of nitrogen oxides because such compounds are the biggest destroyers of ozone.

When the model *includes* heterogeneous reactions, however, nitrogen oxides lose their starring role and drop to supporting players while other compounds become the biggest ozone-eaters. Thus ozone levels do not react strongly to the additional nitrogen oxides from HSCT pollution. Weisenstein's group will report their findings in an upcoming issue of GEOPHYSICAL RESEARCH LETTERS.

Far from settling the question about HSCT exhaust, the new results demonstrate the importance of making models more realistic – meaning that scientists face several more years' work before they can create a reasonable facsimile of the atmosphere to address this issue. Models must incorporate other heterogeneous reactions, as well as the effects of water vapor that the airplanes will release into the normally dry stratosphere. Especially in the polar regions, water vapor pollution could enhance ozone destruction. If so, the Antarctic ozone hole might grow wider and a new ozone hole could open over the northern pole, notes Michael J. Prather, who heads the atmospheric studies for NASA's HSCT program at the Goddard Institute for Space Studies in New York City.

"This is why I don't think the simple models [currently in use] can answer the question," Prather says.

In the end, though, scientists will not decide the fate of HSCT jets. They can only offer predictions on how much ozone destruction might result from such traffic. Government leaders must then address the question: How much ozone loss – if any – is acceptable? □