NASA Facts

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-0001

FS-1996-09-18-LaRC

High-Speed Research –– The Tu-144LL: A Supersonic Flying Laboratory

In the fall of 1996, NASA, a team of U.S. aircraft and engine manufacturers and Russia's ANTK n.a. A. N. Tupolev will begin using a Russian Tu-144 supersonic jet as a flying laboratory. Data collected by six experiments aboard the Tu-144LL, as well as two ground experiments, will be used to develop technologies for a future supersonic passenger jet.

U.S.-Russian Supersonic Flight Tests Began With Russian SST Roll-Out: *A modified Russian supersonic passenger jet was rolled out of its hangar at the Zhukovsky airfield in March 1996 to symbolize the start of a joint six-month flight research program between NASA, a U.S. industry team and the Russian aeronautics establishment.*

As part of NASA's High-Speed Research (HSR) Program, a U.S. aerospace team, led by Boeing, has contracted with Tupolev for use of a modified Tu-144 D transport aircraft to conduct supersonic experiments. The U.S. industry team for the Tu-144LL project is led by Boeing, with help from McDonnell Douglas Corp., Rockwell, Pratt & Whitney and General Electric.

Six flight and two ground experiments are scheduled to be conducted in 1996-1997. A total of 32 flights over a six-month period are planned. Using the Tu-144LL to conduct flight experiments will allow researchers to compare full-scale supersonic aircraft flight data with results from models in wind tunnels, computer-aided techniques and other flight tests. The flight experiments will provide unique aerodynamic, structural, acoustic and operating environment data on supersonic passenger aircraft. All flights will be conducted in Russia.

Tupolev Tu-144 History and Background

Andrei Nicholayvich Tupolev was born in 1888 and was responsible for the design of many Russian aircraft. He acted as the general designer for the Tu-144 and after his death in 1972 was succeeded by his son, Alexei. Both Andrei and Alexei Tupolev were present on Dec. 31, 1968 for the maiden flight of a prototype Tu-144, which became the world's first supersonic transport. The Tu-144 was originally designed as a supersonic transport for service in the Russian airline industry.

On Nov. 1, 1977, a Tu-144 flew from Moscow to Alma-Ata, Kazakhstan, making its first passenger flight. A total of 17 Tu-144's were manufactured, including a prototype and five D models.

Tu-144LL Flight Test Preparations

The Tu-144LL has undergone many upgrades and modifications, including the removal of its Koliesov engines and the installation of NK-321 augmented-turbofan engines, which were originally produced for the Tupolev Tu-160 Blackjack bomber.

A new digital data system (Damien PCM) has been installed to collect airworthiness data and data from the experiments. Thermocouples, pressure sensors, microphones and skin friction gauges have been placed on the Tu-144LL to measure the aerodynamic boundary layer – the layer where the air interacts with the surfaces of a moving aircraft.

Flight Test Experiments:

Surface/Structure Equilibrium Temperature Verification (Experiment 1.2)

Why would U.S. researchers want to take the temperature of a Russian jet? Because the results will help them design a future supersonic passenger transport, which will carry 300 passengers at more than twice the speed of sound. Speed is the key here, because the faster a plane flies, the more heat builds up on it. Researchers want to identify areas of temperature increase to help them decide what materials to use, and how to manage the heat on the next-generation supersonic passenger jet.

Engine Airflow and Heat (Experiment 1.5)

How do you build a jet engine that will hurtle a plane filled with 300 people through the skies at more than twice the speed of sound? U.S. researchers will use the Tu-144LL to help them find out, as part of an effort to develop the next-generation supersonic passenger airliner. The engines on this future aircraft will have to be unlike anything that flies today, including durable enough to withstand hours of flying at supersonic speeds. A major challenge is determining how to build engines that will stand up to the tremendous heat generated by flying at such high speeds for long periods. Experiment 1.5 will provide invaluable data on the temperatures within an engine compartment at both subsonic and supersonic speeds.

Slender Wing Ground Effects (Experiment 1.6)

When an airplane is landing, air pressure builds up between the plane and the ground. This “ground effect” pushes back at the plane, and is a factor in a pilot’s handling of the aircraft. Ground effects are fairly well understood for conventional airplanes, but little is known about how they would affect a radically different aircraft such as a future supersonic passenger jet. This new jet will have different characteristics – more slender wings, for example – and thus different ground effects. To understand more about this phenomenon, researchers will perform tests on the Tu-144LL, which has a wing shape similar to that envisioned for the future supersonic passenger jet.

Structure/Cabin Noise (Experiment 2.1)

Flying at high speeds can get noisy, but passenger peace and quiet will be critical to the success of the next-generation supersonic passenger jet. That’s why researchers are using the Tu-144LL to conduct noise-measurement experiments. Researchers hope to learn how airflow over the surface of the fuselage generates noise inside the passenger cabin and thereby design efficient means to reduce the noise level.

Handling Quality Assessment (Experiment 2.4)

Supersonic airplanes are more difficult for pilots to handle than current passenger aircraft, due to their slender wings and arrow-like shape. It’s an important consideration in the design of a future supersonic passenger jet. To make this future aircraft as easy to fly as possible, researchers will study the flight controls of the Tu-144LL.

Coefficient of Friction & Pressure – Boundary Layer Measurement (Experiment 3.3)

Aerodynamic drag is a critical factor in the design of a future supersonic passenger jet. Measurements of pressures, skin friction and other aerodynamic characteristics on the wing of the Tu-144LL will enable researchers to calibrate their computational tools to better predict and improve the performance of future supersonic passenger aircraft.

Ground Test Engine Experiments:

Engine Operation Behind Close Coupled Structures (Experiment 3.1) – COMPLETED –

Engine Face Reflection Properties (Experiment 3.2)

Future supersonic aircraft will fly at an altitude of 65,000 feet, at more than twice the speed of sound. The engines on this aircraft will be radically different from current jet engines. To understand more about the special requirements of these future engines, researchers will conduct experiments on a Tu-144 engine using a ground test stand. These experiments will provide invaluable engine airflow data for the designers of future large supersonic engines.

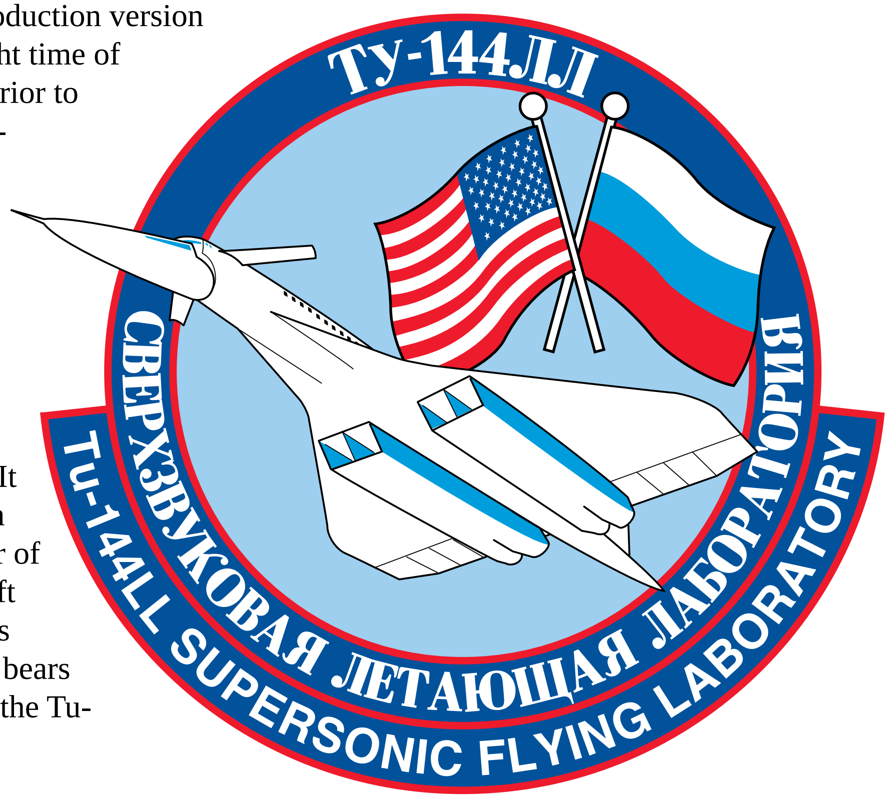
Experiment 3.1 was successfully completed on Sept. 5, 1996. Eight configurations were tested to determine the effect of aircraft inlet structures on the quality of the airflow entering the engine. The proximity of the inlet structure to the engine was varied, and future data analyses will define the optimum spacing.

U.S. Ambassador Pickering addresses Russian and American dignitaries, industry representatives and members of the press during a roll-out ceremony for the Tu-144 held in Russia in March 1996.

Aircraft Specifications

The modified Tu-144LL being used for this HSR flight program has slightly different specifications than a production model. The wing span is 88 feet and 7 inches (27.0 m) and the overall length is 196 feet and 10 inches (60 m). Typical takeoff weight of the Tu-144LL is 440,000 pounds (200,000 kg) and it holds 224,800 pounds (102,000 kg) of fuel. If used as a passenger aircraft, the Tu-144LL could carry 140 passengers 3,508 nm (4,040 miles/6,500 km), cruising at maximum speeds.

The Tu-144LL is a later production version built in 1981 that has a total flight time of only 82 hours and 40 minutes. Prior to its recent modification to the Tu-144LL, the aircraft had a maximum cruising speed of Mach 2.35 (2.35 times the speed of sound or approximately 1,600 mph), a range of 2,485 miles (4,000 km) and a maximum altitude of 62,000 feet (18,897 m). Tupolev most recently used the plane as a flying laboratory. It has an emergency escape system and mounts a significant number of research instruments. The aircraft chosen for the Tu-144 flight tests program, designated Tu-144LL, bears tail number 77114 and is one of the Tu-144D models.



The Tu-144LL is constructed mostly of VAD-23, a light aluminum alloy, with integrally stiffened panels. Titanium and stainless steel were used for the leading edges, elevons, rudder and under-surface of the rear fuselage.

HSR Team Members

HSR program team members include aircraft manufacturers Boeing and McDonnell Douglas, engine manufacturers General Electric and Pratt & Whitney, flight deck partner Honeywell, and more than 70 major subcontractors.

The High-Speed Research program is a key element of NASA's Office of Aeronautics and is managed by the NASA Langley Research Center, Hampton, Va. The NASA HSR team includes NASA Lewis Research Center, Cleveland, Ohio, NASA Ames Research Center, Mountain View, Calif., NASA Dryden Flight Research Center, Edwards, Calif., NASA Goddard Space Flight Center, Greenbelt, Md., and the Jet Propulsion Laboratory, Pasadena, Calif.

For more information, please contact:
NASA Langley Research Center, Office of Public Affairs, Mail Stop 115, Hampton, VA 23681-0001 (757) 864-6124
The Boeing Co., (206) 294-9333
McDonnell Douglas Corp., (714) 896-1302
General Electric, (513) 243-5805
Pratt & Whitney, (860) 565-9600
Honeywell, Inc., (602) 436-3644