PAST AND CURRENT SUBSONIC AERODYNAMIC RESEARCH

RESULTING IN REDUCED FUEL CONSUMPTION OF AIRCRAFT

It is well known that any change in the external shape of a component of an aircraft which provides a reduction in drag or allows reduction of aircraft weight ultimately provides improvement of the aircraft fuel consumption required to accomplish a given mission. For a number of years a substantial part of the experimental and analytical research effort of the HSAD of the Langley Research Center has been directed toward arriving at aircraft shapes which accomplish these objectives at subsonic speeds. The results of this research can be used to improve the fuel consumption of all types of aircraft, helicopters, general aviation airplanes, commercial and military transports, and combat aircraft.

This research has resulted in new improved shapes of the wing or helicopter blade cross sections (airfoils), wing planforms, fuselages, engine nacelles, and tail surfaces. One of the more significant improvements has been the NASA supercritical wing section developed in the HSAD wind tunnels and refined by analytic methods. For a given airplane cruise speed this wing shape provides both a reduction of wing weight and a reduction of drag. Analyses have indicated that these gains should provide a 15% reduction of fuel consumption for future transport aircraft incorporating such wing sections. The research has also resulted in new airfoil sections for helicopter blades which should result in reductions of fuel consumption for such craft although the gain will be less than for transport aircraft.

The new shapes of wing planform, fuselage and engine nacelles resulting from the research provide improvements of the three dimensional airflow around complete airplane configurations with resulting drag reductions. The reductions in fuel consumption for such changes are dependent on the particular airplane design. The effect of some has been as great as that mentioned previously for the supercritical wing section.

The shapes of the tail surfaces have been improved in a manner similar to that for the wing. However, since the tails contribute less to the total drag than the wing, the resulting reductions in fuel consumption are less than those obtained by changing the wing shape.

It should be strongly noted that any change in the shape of an aircraft component intended to improve the fuel consumption cannot adversely affect the safety of an aircraft. Therefore any new shape must provide good aerodynamic stability and landing and take off performance. Substantial research has been conducted to assure that the new shapes do provide these important aircraft characteristics.
The experimental research on the shapes of aircraft components intended to improve subsonic fuel consumption while still obtaining the characteristics required for safety is conducted in the 8' Transonic Pressure Tunnel, the 16' Transonic Tunnel, the 7x10 Tunnel, the Low Turbulence Pressure Tunnel and a new 6x28" airfoil research tunnel. The associated analytic work is conducted by several groups in HSAD particularly the Theoretical Aerodynamics Branch, and by University groups under grants funded by the Langley Research Center. A more complete description of the analytic work is attached.

During the past five years approximately 150 man years and $5 million have been devoted to the effort described by HSAD. The funding includes $.4 million to construct and instrument the 6"x28" airfoil research tunnel.
ADDENDUM: ANALYTIC RESEARCH

Since mid-1970, the center has focussed a considerable amount of research effort in theoretical analysis of transonic flow, with the aim of improving the efficiency of high subsonic flight. Prior to 1970, there was essentially zero capability in practical transonic analysis, primarily because of the inherent nonlinearity and mathematical complexity of mixed flows (i.e., those flows in which both subsonic and supersonic velocities occur); but also because most of the available theoretical talent had been concentrated in Supersonic-Hypersonic aerodynamics for problems involving missiles and other spacecraft.

The theoretical transonic aerodynamics effort has rapidly caught up with the fundamental experimental research on wings, bodies, and wing-body combinations. We now have the capability to accurately predict the characteristics of 2D airfoils and simple 3D wings and wing-bodies in transonic flight, and to study the effects of shape changes on flight efficiency. In addition to the direct fuel-saving benefits of improved aerodynamic efficiency, accurate predictive techniques allow a tighter structural margin, resulting in a saving in structural weight and hence further fuel economy for a given payload. To date, the expenditure has been approximately 30 man-years of in-house effort, $500K contract and grant research funds, and $200K computer costs.