# Aeronautics Directorate Manages Extensive Research and Development Program

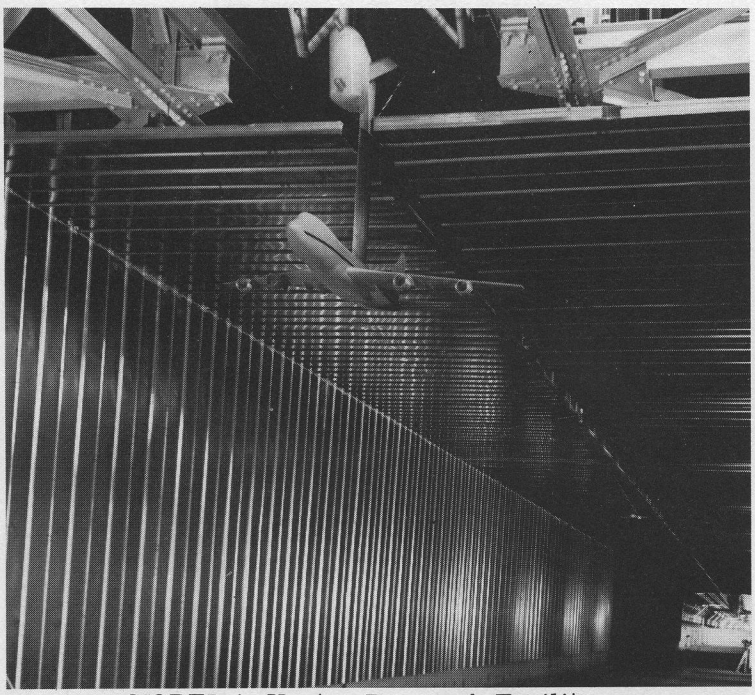
This is the first in a series of articles which will be published periodically in the Langley Researcher on the Research and Development Programs being studied in the different Langley Directorates. In this issue we feature the Aeronautics Directorate, headed by Robert E. Bower.

## VORTEX RESEARCH FACILITY

A Vortex Research Facility has recently been established in the towing tank in an effort to determine some method to reduce the lift induced wing tip vortex and its associated hazard to following aircraft.

A vehicle has been designed and built to propel a vortex generating model along the existing 1800-foot overhead track in the tank while trailing a second model at a distance of 160 feet (a scale distance of one mile) to measure the rolling moment induced by the vortex.

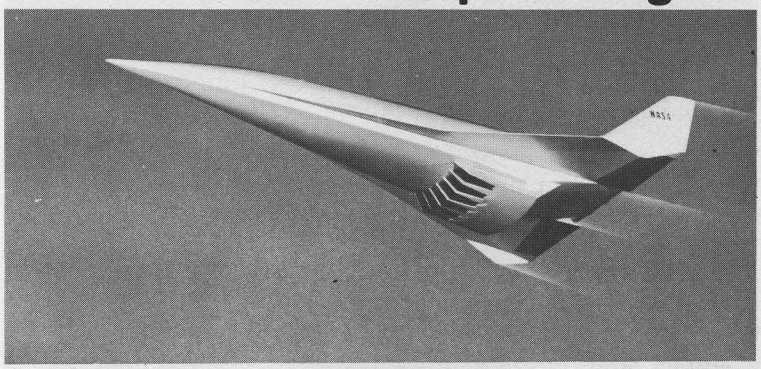
This manner of testing, plus the newly developed flow visualization method, allows a detailed cross sectional view of the continuous wake left by the model. The onboard data acquisition system records the aerodynamic forces experienced by the lead model as well as the rolling moment of the following model. A laser Doppler velocimeter will be installed in the future to measure the vortex velocity profile throughout the life span of the vortex.



MODEL in Vortex Research Facility

## TRANSONIC RESEARCH TUNNEL

Langley has been designated as the NASA lead center in the design and procurement of a high Reynolds number Transonic Research Tunnel. The proposed facility will utilize the cryogenic concept employing gaseous nitrogen to obtain high test Reynolds numbers with minimum model loads. The test-section size will be 2.5 by 3 meters (8.2 x 9.8 ft.) with a stagnation pressure range 3 to 100 psia. The proposed facility will be powered by the existing electric motors of the 4-Foot Supersonic Pressure Tunnel (70,000 hp for 10 min.; 46,000 hp continuous). Mach range will be from 0.2 to 1.2. Provision for test-section plenum suction at a later date will provide for M = 1.4 potential.



ARTIST' S drawing of High-Speed Research Airplane

## HYPERSONIC VEHICLES

The ultimate goals of hypersonic vehicles research and technology programs are the potential advanced aeronautical systems of the 1990' s and beyond - - Mach 4-6 liquid-hydrogen-fueled transports, airbreathing launch aircraft for future generation shuttles, and a variety of military systems requiring speeds up to Mach 12. A necessary predecessor of these future systems is a new airbreathing, hydrogen-fueled, high-speed research airplane, and the present HVD R&T program focuses specifically on a Langley-conceived modular scramjet engine, actively cooled structural components, and aerodynamic developments for this vehicle.

An additional one-third of the hypersonic vehicles program is in basic fluid mechanics research throughout the aeronautical speed range, centering on solution by numerical methods of general three-dimensional viscous flows, skin friction drag reduction, low sonic boom aircraft design, and quiet-tunnel development.

## ROTOR SYSTEMS RESEARCH AIRCRAFT

One of the major projects in the Aeronautical Directorate is the Rotor Systems Research Aircraft (RSRA) Project Office which is a joint Army/NASA endeavor. The purpose of the RSRA Project is to fabricate, flight test, and deliver to LRC two specially designed research vehicles with provisions for adequate instrumentation, operating over a wide range of test conditions, with capabilities to test and correlate a variety of advanced rotor systems concepts, and verification of rotorcraft supporting technology.

ROTOR System Research Aircraft

## THRUST VECTORING

For the past several years, Langley has been exploring the effects of thrust vectoring in forward flight (VIFF) on the overall maneuverability of a vectored-thrust V/STOL aircraft, the Kestrel.

A flight investigation utilizing the Kestrel to determine the effects on maneuverability of up to 95 degrees of downward thrust vectoring has recently been completed. In view of the current interest in the deceleration effects or reverse thrust and its possible application to air combat maneuvering, the Kestrel has been modified to permit up to about 130 degrees of thrust vectoring. A flight investigation is currently underway to expand the nozzle angle-speed envelope and to determine the effects of 130 degrees of thrust vectoring on aircraft maneuverability. This present effort is a joint NASA-Naval Air Systems Command program.

DE HAVILLAND DHC-6 Otter aircraft during crosswind landing tests.

### CROSSWIND LANDING

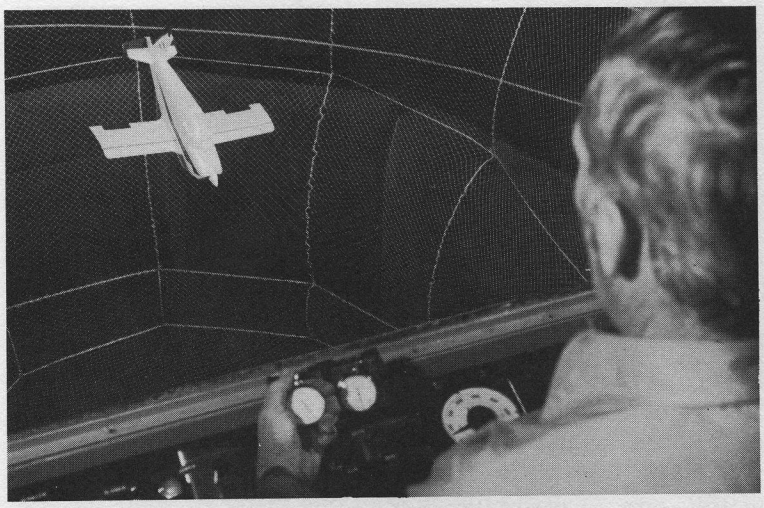
Flight tests to study the relation between pilot techniques and aircraft control and response during crosswind landings are nearing completion. The tests are being conducted by the Research Aircraft Flight Division, at Wallops, using a De Havilland DHC-6 Twin Otter aircraft. Landings have been made with direct crosswind components as large as 22 knots.

As part of this program, the Structures and Dynamics Division has completed model tests of several crosswind landing gear configurations. A contractor study is underway to evaluate the feasibility of mounting a research-type crosswind landing gear configuration on the Twin Otter. The more promising landing gear configurations of the model-test program will then be investigated in full-scale flight tests.

### AERONAUTICAL SYSTEMS OFFICE

The Aeronautical Systems Office is concentrating on energy-saving applications of aviation technology. Such developments as the Whitcomb supercritical airfoils, originally designed to increase speed, are being studied for application to lower speed aircraft to improve aerodynamic efficiency and reduce fuel consumption. For the longer term, the 1990's and later, ASO is studying hydrogen-fueled aircraft that could significantly reduce aviation requirements for petroleum. One objective of the studies is to determine the overall energy efficiency of hydrogen aircraft.

Some of the more radical concepts under consideration include tip coupling (to reduce induced drag) and glider trains.

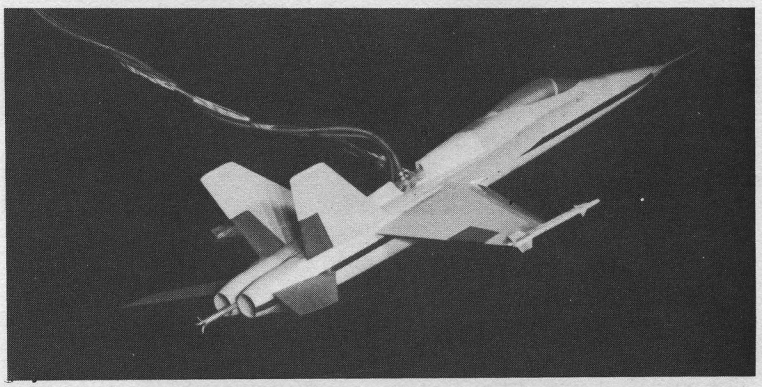


MODEL goes through spin tests in Spin Tunnel

### SPIN RESEARCH

Between 1967 and 1969, a total of 1261 stall/spin accidents of general aviation airplanes occured in the U.S. These accidents accounted for only 8 percent of the total number of accidents during this period, but resulted in 23.5 percent of the fatalities. Consequently, the Spin Research Section, LSAD, has started a program to study and improve the stall/spin characteristics of general-aviation airplanes. The program includes tests with spin-tunnel models, radio-control models, and full-scale airplanes. The models being tested are of six different basic configurations; but, with modifications to the wings and tails, they constitute about 50 different representative light general-aviation aircraft configurations.

Renewal of close-in air-to-air combat for fighter aircraft has resulted in an alarming number of stall/spin accidents The Simulation and Analysis Section, LSAD, is conducting a program to develop methods for automatic spin-prevention, for designing for inherent spin resistance, and for theoretical prediction techniques. The program involves free-flight tests of dynamically scaled models, conventional wind-tunnel tests, theoretical analysis, and piloted simulator studies.



STALL/SPIN tests are conducted by Dynamic Stability Branch, Low-Speed Aircraft Division.

### V/STOL RESEARCH

A recent V/STOL tunnel investigation by the Aerodynamics and Performance Branch, LSAD, has provided a solution to a major operational problem concerning engine exhaust flow impingement on the AH-1G helicopter, a high-performance helicopter. A flight-test program will be conduct-

VTOL aircraft during flight test

ed shortly to verify the effectiveness of the solution. Reporting of wind-tunnel data and analyses of a tilt-proprotor concept investigated in V/STOL tunnel is being concluded.

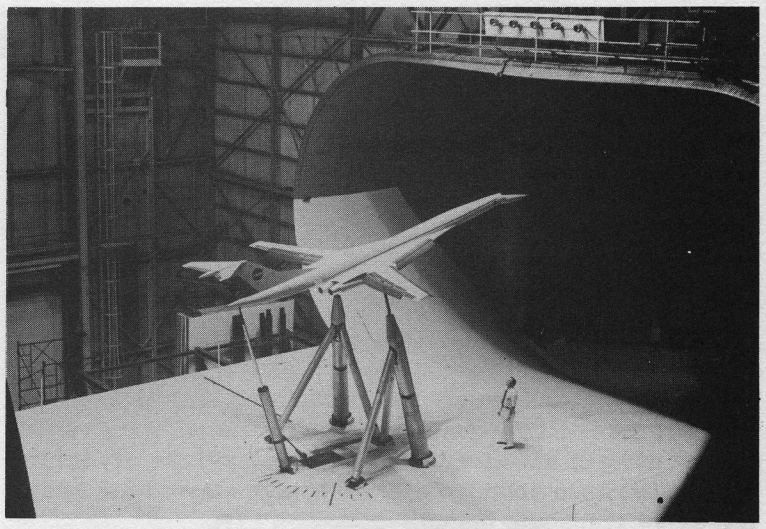
Advanced technology airfoils for rotorcraft will be flight tested on a series of new main-rotor blades of the AH-1G by the Flight Research Branch. The flight investigation will yield data for basic research analyses and for guidance in best applying developing airfoil design technologies to satisfy rotor requirements.

The acoustic signature and vibratory stresses of a helicopter are due, in part, to the tip vortex shed from each blade. The tip shape on the helicopter blade can alter the characteristics of this vortex and, thus, can potentially alleviate adverse effects of the tip vortex. The Flight Research Branch will fit the UH-1H helicopter with advanced tips and it will be flown to determine the effect of tip shape on acoustics and vibration in an operational environment.

A Civil Helicopter Program has been initiated in the V/STOL Aircraft Project Office, LSAD, to accelerate evaluation and application of advanced technology to helicopters to improve their acceptance and use for short-haul passenger transportation. As part of the program which also addresses safety, fuel saving, reliability, and maintainability, a modified CH-53 helicopter will be used in studies of passenger comfort and community noise. One phase of these studies involves flight experiments onboard a research aircraft during which ride-comfort evaluations by test passengers will be coordinated with various types and combinations of vehicle motion.

VTOL aircraft applications require improved instrument flight capability, along with the ability to operate in a manner which minimizes fuel, noise, and airspace requirements. To achieve the necessary technology advances in automation, operating procedures, and handling qualities, the VTOL Approach and Landing Technology (VALT) program, jointly sponsored by the Aeronautics and Electronics Directorates and by the Army, was developed. The flight portion of the program is conducted by Flight Research Branch, LSAD, and utilizes the SH-3A advanced display aircraft and the CH-46 in-flight simulator.

Research on powered-lift aerodynamics in the V/STOL tunnel has recently focused on the low-speed aerodynamics of upper-surface blown transport configurations which provide the opportunity for low noise aircraft. Four arrangements have been investigated by the Aerodynamics and Performance Branch.



SUPERSONIC Transport design in Full-Scale Tunnel

An extensive program of tests of the upper-surface blown (USB) jet-flap concept for powered-lift short take-off and landing (STOL) aircraft is being conducted in the Full Scale Tunnel. The objective of the program is to provide a data base for the evaluation of the concept and for accurate design of future aircraft of this type.

Deficiencies in low-speed aerodynamics for take-off and landing were a serious problem for previous supersonic transport designs. A program of large-scale low-speed tests is being conducted in the Full Scale Tunnel to improve the technology base for future designs.

## BOUNDARY LAYER SEPARATION

Research is currently underway in the Theoretical Aerodynamics Branch, HSAD, to develop computer programs for the solution of the flow field in regions of strong viscous-inviscid interaction on an airfoil. These interaction regions may occur near the leading or trailing edges, or near the foot of an embedded shock. When flow separation occurs in this interaction region, classical procedures for solving the boundary layer equations with the pressure prescribed give rise to a singularity at the separation point. Alternative procedures have been developed which yield nonsingular solutions and the results appear to be accurate from the few checks available.

## TRANSONIC FLOW ANALYSIS

Numerical and analytical techniques are now being successfully applied in the Theorectical Aerodynamics Branch to a variety of transonic flow problems. Various forms of the nonlinear governing equations have been solved for the flows about blunt and pointed axisymmetric bodies, unswept wing-body combination and slender swept wing-bodies with unswept trailing edges. Computer programs to provide solutions for more complicated wing-body geometries are being prepared for both our present computers and the interim STAR.

## SUPERSONIC FLOW INVESTIGATION

An experimental investigation of the supersonic flow over forward facing steps is in the data analysis and reporting stage by Theoretical Aerodynamics. Detailed pressure distributions have been obtained ahead of and on the step faces for step heights which range from a small fraction of the boundary layer thickness to those that exceed it. Previously unknown features of the flow have been discovered as well as a number of deficiencies.

## CRYOGENIC TRANSONIC TUNNEL

As part of NASA's study of various approaches to the design of a new transonic tunnel to provide sorely needed high Reynolds number capability, the Stability and Dynamics Branch has been investigating the application of the low temperature test medium concept by means of theoretical and experimental studies.

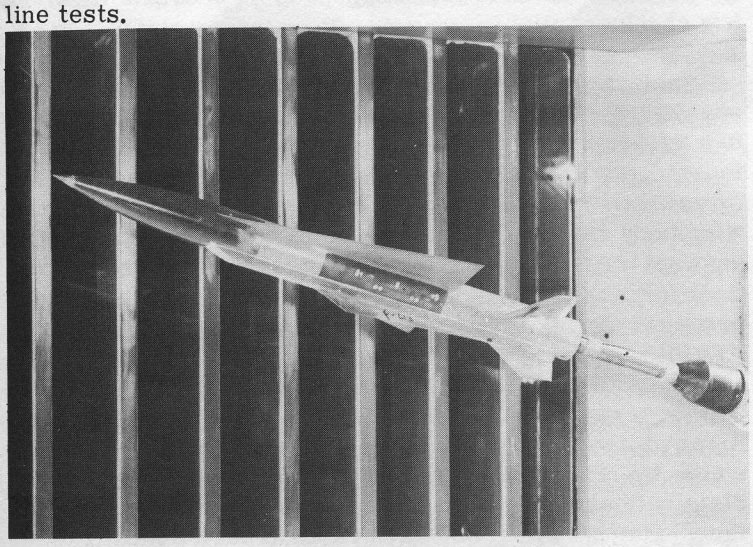
The resulting Pilot Cryogenic Transonic Tunnel which has been in operation for approximately six months has verified the use of cryogenic gaseous nitrogen as a valid transonic test medium and has demonstrated the large advantages with regard to reduced drive power, reduced aerodynamic loads and the independent control of Reynolds number, Mach number and dynamic pressure. As a result of this research and the resulting technology, the cryogenic concept has been selected and the design started for Langley's new transonic tunnel.

### 2-D WIND TUNNEL

In order to provide Langley with high Reynolds number transonic research capability in the areas of basic fluid mechanics, airfoil development and flow control devices, a new two-dimensional tunnel based on the cryogenic concept is under construction. This tunnel will utilize the drive system, return legs, and cryogenic systems of the present three-dimensional pilot cryogenic tunnel and will have an 8- by 24-inch test section. This new research facility, which will obtain Reynolds numbers in excess of 100 million per foot at transonic speeds, will provide capability consistent with the large three-dimensional facility currently being designed.

### FLEXIBLE WALLED WIND TUNNEL

Research directed towards the elimination or reduction of tunnel wall interference effects is currently underway in a joint program between the University of Southampton and the Stability and Dynamics Branch, HSAD, to investigate the self-correcting flexible wall concept. The current effort is directed towards eliminating the wall interference in low-speed two-dimensional tunnels in order to allow larger models to be used, thereby increasing the Reynolds number capability. Initial tests, in a pilot facility at the university, using a high blockage circular cylinder were very encouraging and are being extended to airfoil tests with LRC providing the pressure model and making the ''free air'' baseline tests.



MONOPLANE cruise missile technology studies for long range air-to-surface and surface-to-surface missile application are conducted by Supersonic Aerodynamics Branch.

SLOTTED wall test section of Cryogenic Transonic Pilot Tunnel with delta wing model installed.

### MAGNETIC SUSPENSION AND BALANCE

The reduced aerodynamic loads made possible by the cryogenic tunnel concept enhances the capabilities of magnetic suspension and balance systems and brings the possibility of eliminating model support interference, of providing more representative model shapes and of ''free flight'' type testing closer to reality. To accomplish this, the Stability and Dynamics Branch is continuing the research program on superconducting magnetic balance systems at the University of Virginia and is in hopes of re-establishing the in-house effort. The superconducting suspension and balance system has been successfully demonstrated at the university and the program is being extended to study scaling and design consideration for larger systems.

### NONLINEAR AERODYNAMIC THEORIES

Many of the critical aerodynamic conditions encountered in the design of advanced high-speed aircraft involve non-potential and nonlinear flows such as those associated with leading and side-edge separations with resulting vortex flows, and with local Mach number variations, and aerodynamic theories are needed to assist the designer and to provide ''real flow'' capability in newly emerging computerized design techniques. To fill this technology gap, the Stability and Dynamics Branch is engaged in both in-house and contract efforts to develop advanced theories that provide the overall forces, and detailed nonlinear surface load predictions required to predict stability, performance and wing loads for these critical conditions at subsonic and supersonic speeds.

### HIGHLY MANEUVERING AIRCRAFT

One of the major areas where NASA is providing support to DOD is the Highly Maneuverable Aircraft Technology (HIMAT) Program. Stability and Dynamics Branch is actively engaged in several aspects of this program: responsibility for overall coordination of the LRC program; experimental aerodynamic configuration studies and maneuver device research; and joint simulator studies of dynamic effects.

### SUPERSONIC CRUISE AIRCRAFT

In support of the SCAR Program, research is being conducted to provide technology in several critical subsonic areas related to the SCAT 15-F type configuration. These involve the measurement of detailed surface load distributions and correlation with theory, the development of improved load theories, experimental and analytical studies of control characteristics including aeroelastic effects, and the study of the effects of leading-edge radius and Reynolds number on the high angle stability characteristics.