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FOR IMMEDIATE RELEASE

Release 64-55

Hugh W. Harris
(res: 681-9354)

CLEVELAND, Ohio, June 18--Wind tunnel tests recently completed at the Lewis Research Center here studied the aerodynamic forces which will occur when Mariner spacecraft are launched toward Mars late this year.

The boost phase, while the spacecraft is being carried into space by the launch vehicle, is the first of many critical points in Mariner's long flight. During this part of the flight, the vehicle can encounter severe structural loads that are caused by large pressure differences on the surface.

Both an over-the-nose design, which involves a new separation technique, and a back-up pyrotechnic shroud were tested in Lewis' 8x6 foot supersonic wind tunnel. In the primary design, the second stage Agena is narrower than the Mariner-C shroud. Bobby W. Sanders, Project Engineer for these tests, explained that this sudden decrease in diameter creates a region of "aerodynamic flow instability"--a region where air flowing past the shroud can separate and cause significant pressure fluctuations that could damage the shroud structures and might lead to destruction of the entire vehicle.

The tunnel tests simulated actual launch and boost environments on scale models of the shroud and the Agena second stage vehicle. The model was tested over a range of speeds from Mach 1.56 (1.56 times the

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speed of sound) to Mach 1.96. Sanders explained that the most critical portion of the Mariner boost lay between Mach 0.70 and Mach 0.90.

In the 8x6 foot tunnel, fluctuating pressures on the models were measured with dynamic pressure pickups. Static pressure profiles have been measured in wind tunnels frequently, but high frequency dynamic pressure measurements are relatively new. In the Mariner tests, frequencies between 20 and 10,000 cycles per second were measured. Because the tunnel model is a reduced scale version of the full-scale vehicle, these frequencies correspond to 2 to 1000 cycles per second in actual flight.

To identify the "aerodynamic noise" created by the tunnel itself, an empty tunnel test was made with the pressure transducers mounted on the tunnel walls. The data recorded during these tests are currently being analyzed.

In continued testing, the shroud model was tested in the 10x10 foot supersonic wind tunnel which runs from Mach 2.0 to 3.5. Thus, with both tunnels, the Mariner shroud will have "flown" several complete missions long before its actual launch date.

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64-94

Public Information Office
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FOR RELEASE: IMMEDIATE

CLEVELAND, Ohio, Oct. 16 -- The shroud for the Mariner Mars 64 spacecraft underwent extensive aerodynamic studies at the National Aeronautics and Space Administration's Lewis Research Center here earlier this year. Here, an engineer is shown making final adjustments to a 1/10 scale model of the Mariner shroud with an Agena upper-stage vehicle mounted in Lewis' 8x6-foot supersonic wind tunnel. Scale models can "fly" virtually an entire mission at Lewis with this tunnel running with environment simulation between Mach 0.1 and 2.0 and the 10x10-foot tunnel running between Mach 2.0 and 3.5. The test shown here simulated actual launch and boost environments on both the Mariner shroud and the Agena. Lewis, through its Agena Project Office, provides overall direction and management of the launch vehicle program for the Mariner missions.

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FOR RELEASE: THURSDAY A. M. 'S
October 22, 1964

Release 64-91

Hugh Harris
(res: 681-9354)

CLEVELAND, Ohio, Oct. 22 -- Preparations for dynamic stability tests of the Apollo command module and its launch escape system are observed by NASA engineer Bobby W. Sanders at the Lewis Research Center, Cleveland, Ohio. A scale model of the command module, in which three astronauts will ride during their journey to the moon, and the launch escape system are undergoing tests in Lewis' 8 x 6-foot transonic wind tunnel. The tunnel simulates conditions the spacecraft will encounter during a portion of its flight through the earth's atmosphere. The Apollo project is under the direction of NASA's Manned Spacecraft Center, Houston, Texas.

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Mach 5 Cruise Aircraft

In a joint study NASA and industry have identified an "over-under" turbojet plus ramjet as a viable propulsion system for a Mach 5 cruise aircraft. This propulsion system includes a variable-geometry, split-flow inlet and nozzle to provide airflow to the dual-flow engine system, with the turbojet being shut down at Mach numbers greater than 3.

An experimental test program on a two-dimensional inlet that represents the ramjet-only part of flight (Mach 3 to 5) is planned for the Lewis 10- by 10-Foot Supersonic Wind Tunnel (10 x 10 SWT) during 1988. This large-scale inlet incorporates a variable-geometry ramp system and remotely variable plate systems for the main and bleed flows. The model has been extensively instrumented to provide computational fluid dynamics code validation data in addition to inlet performance information.

Supporting research studies for the 10 x 10 SWT inlet test program include flowfield prediction with a three-dimensional viscous analytical code (PEPSIS) and small-scale inlet testing in the Lewis 1- by 1-Foot Supersonic Wind Tunnel (1 x 1 SWT). The analytical code results have indicated a significant boundary layer flow migration on the inlet sidewalls, from the ramp toward the inlet cowl. This low-energy boundary layer is captured by the inlet and results in a large separated flow region in the corner of the cowl, just downstream of the cowl lip. Since the separation occurs in the internal contracting section of the inlet, an unstart will occur unless some system, such as bleed, is employed to reduce the separation. As a result of the three-dimensional analysis additional bleed was added to the inlet sidewalls and to the inlet cowl.

A small-scale inlet has been tested in the 1 x 1 SWT to verify the flow migration predicted by the analytical code. This model duplicated the external compression system and was opened to a divergent passage downstream of the inlet shoulder to aid in starting. The sidewall flow migration was verified. Since the Lewis 10 x 10 SWT has a maximum Mach number of 3.5, the inlet model will be located under an expansion plate to accelerate the flow to about Mach 4.1 (the Mach number on the first inlet ramp for the flight condition of Mach 5). The small-scale model was also used in the 1 x 1 SWT to verify the use of the accelerator plate to provide the higher Mach test condition. Additional testing in the 1 x 1 SWT to study cutback sidewalls, a reduced blockage expansion plate, and bleed patterns to control high-pressure gradient–boundary layer interactions in the inlet model have been completed.

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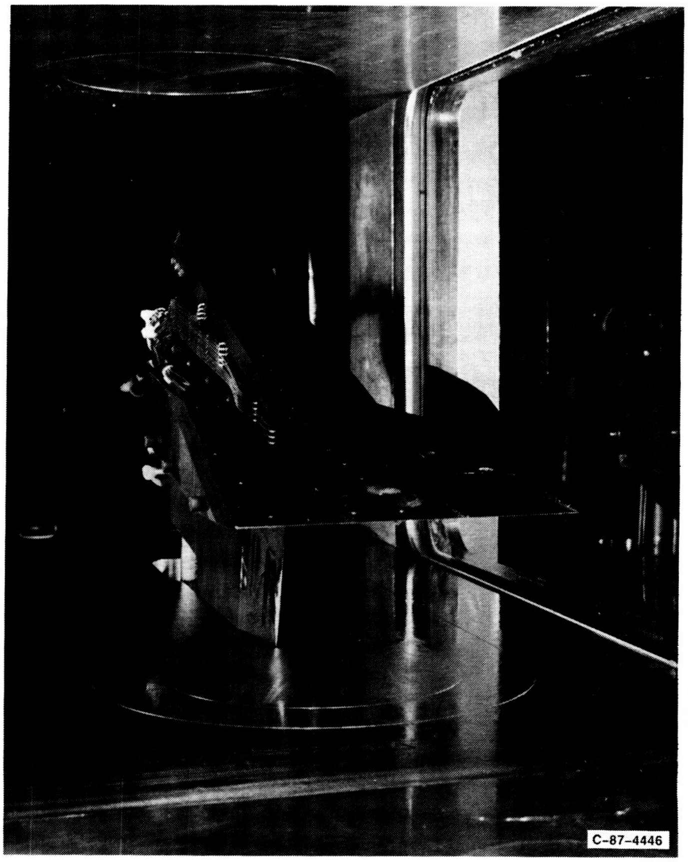
Small-scale Mach 5 inlet model (design Mach number, 2 to 5; maximum dynamic pressure, 15 psi; maximum dynamic temperature, 100 °F)



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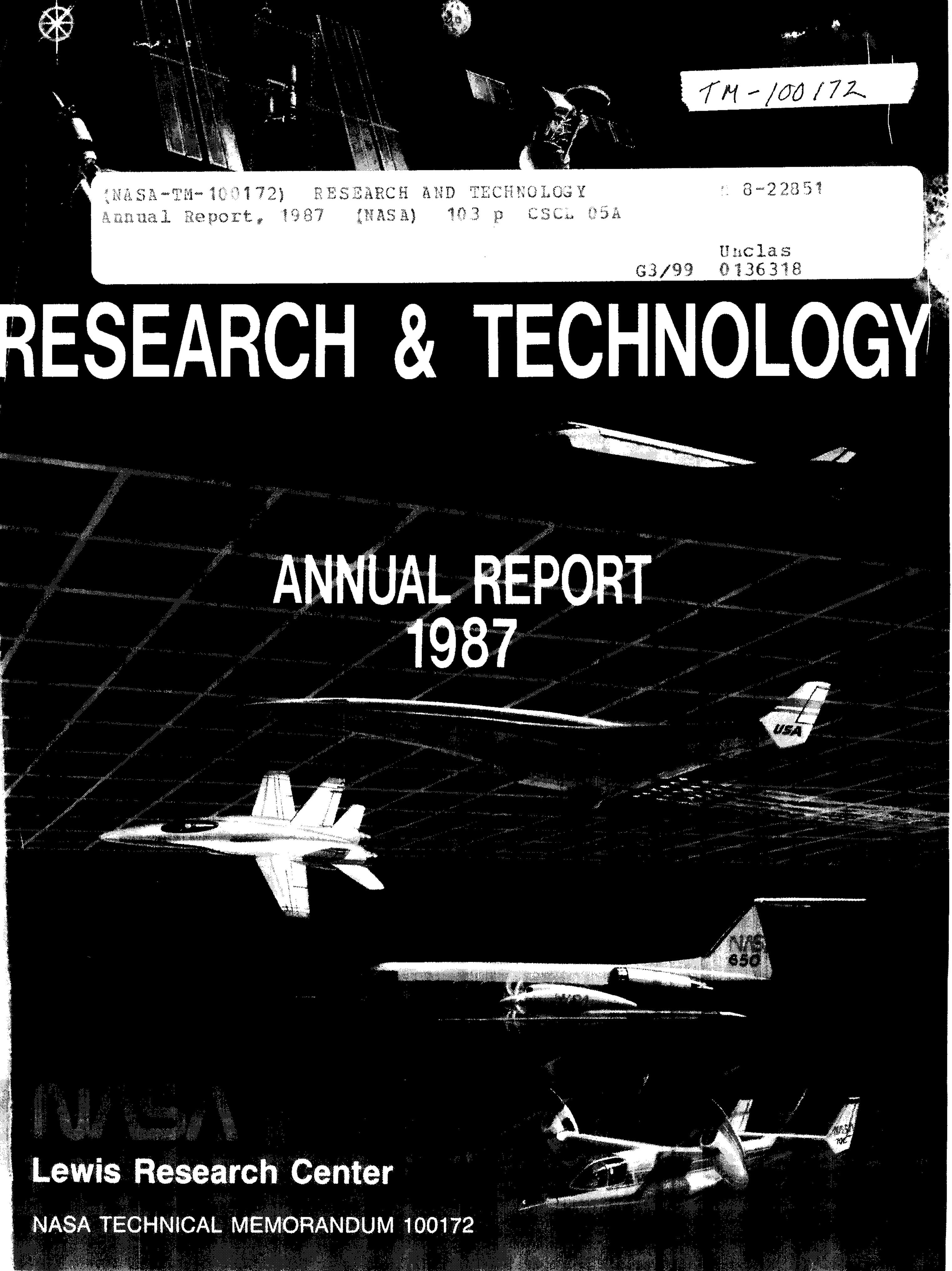

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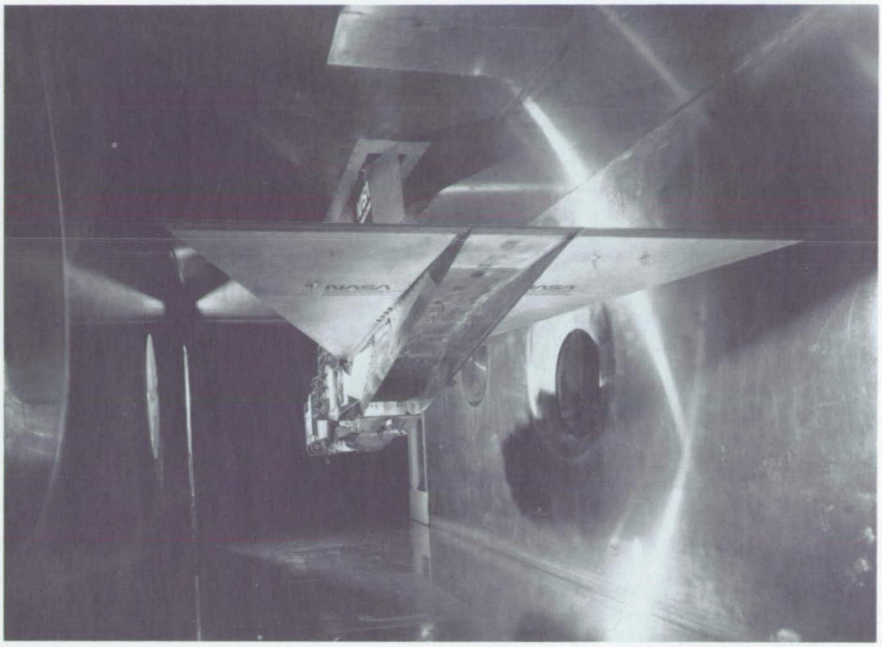
Mach 5 Inlet Research



Mach 5 inlet in wind tunnel

During a joint research study, NASA (Lewis and Langley) and industry (Lockheed and Pratt & Whitney) developed a conceptual aircraft capable of sustained cruise at Mach 5. The proposed propulsion system for the aircraft was an "over-under" turbojet plus ramjet. This dual flow system was designed to provide the required propulsion over the entire speed range from 0 to Mach 5. In addition to the airplane design and the evaluation of the performance potential for this class of aircraft, experimental evaluation of propulsion system components that appeared practical from a design viewpoint was begun. Since the data base for inlets at this high-speed cruise condition was practically nonexistent, the inlet was selected for further study.

An experimental research program has been conducted on the inlet system of the Mach 5 aircraft in the NASA Lewis 10- by 10-Foot Supersonic Wind Tunnel. Only the high-speed configuration of the inlet (ramjet), representing operation between Mach 3 and 5, was incorporated into the test model. This inlet was designed by the method of characteristics with boundary layer connection. The large inlet model incorporated a variable-geometry ramp system and remotely variable mass flow plugs for the main duct and bleed airflows. So that Mach 5 conditions could be evaluated in this test facility, which has a maximum Mach number of 3.5, the inlet model was mounted under a large plate and run at negative angle of attack. Thus, the free-stream Mach number of 3.5 was expanded to the desired first-ramp Mach number of 4.1.

Early supporting research studies, using analytical codes and small-scale basic inlet testing in the NASA Lewis 1- by 1-Foot Supersonic Wind Tunnel, indicated that the inlet would have a boundary layer flow migration on the forward sidewall that would result in flow separation just inside the cowl lip. This separation could prevent the inlet from operating in the desired started mode. Therefore, the large-scale inlet, which was instrumented for inlet performance, was also extensively instrumented for computational fluid dynamics validation data on the forward surfaces. Additional bleed was also added to the inlet on the forward sidewalls and on the cowl near the leading edge. The experimental program was to be accomplished in two phases with the first phase devoted to validation data and only limited overall inlet data. The first phase of the experimental program has been completed. The code validation part of the study was of particular interest for the National Aerospace Plane (NASP) Program, which supported this part of the overall effort.

Inlet data have been obtained for the

Mach 3 to 5 speed range. These data indicate that the expansion concept for acceleration of the tunnel flow performed as predicted. An important data base has been established for validating the complex analytical codes. The data base includes extensive surface static pressure information, along with fixed and translating total pressure probes at several locations. The data are being made available to both Government and industry upon request.

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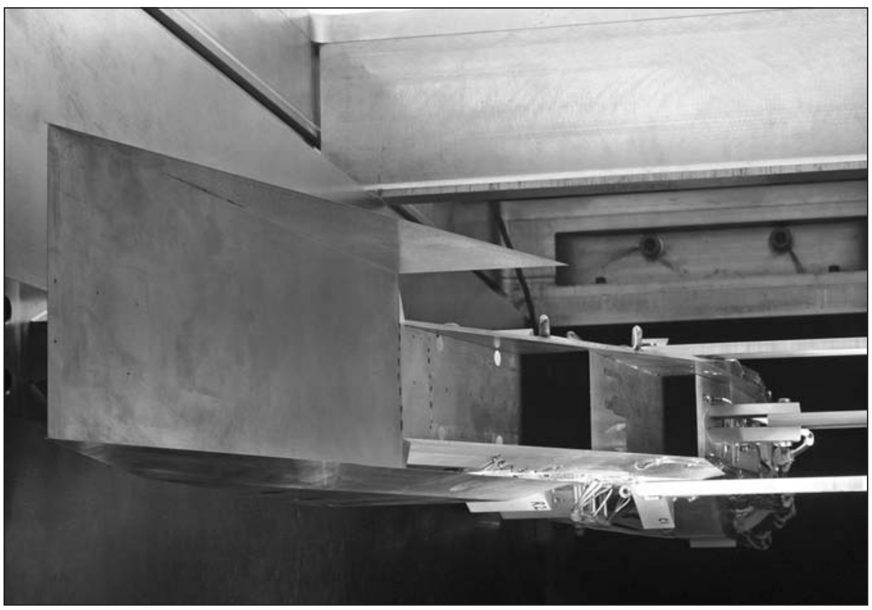
Small-Scale Inlet Mode Transition Model Tested in Glenn's 1- by 1-Foot Supersonic Wind Tunnel

A screening test of an inlet mode transition model was completed for hypersonic propulsion. The test was conducted at Mach 4 to verify the design concept for high performance and smooth transition between a low-speed turbofan to a higher speed scramjet operation. This effort ties into a need to demonstrate acceleration through intermediate supersonic Mach numbers, 2 to 4.

For hypersonic flight, air-breathing propulsion can enable new efficiencies for quick space access and global reach. Various propulsion modes have been proposed for the range of Mach numbers encountered by an accelerating hypersonic vehicle. One possible propulsion scheme is the turbine-based combined cycle (TBCC), which uses a high-Mach-capable engine to accelerate the vehicle to scramjet takeover speeds. Switching between the turbine (turbofan) cycle and the scramjet is termed mode transition. Typically, the two engines are placed one above the other and are fed by a common inlet and nozzles to save weight. The focus of this effort was to design and verify an inlet concept for TBCC that is termed the Inlet Mode Transition (IMX).

A major element of the IMX design was variable geometry based on sets of cowl and ramp contours. Hydraulic actuation, providing a smooth transition from turbofan to dual-mode ramjet operation, was used to vary the cowl geometry. The design balances high performance (low loss), engine flow demand, and mechanical feasibility. A splitter-contoured surface directs flow into the turbofan up to the transition Mach number 4 and then closes to provide added compression to improve the dual-mode ramjet operability and performance. For lower Mach number turbofan flow demands, a variable geometry ramp was also designed.

The conceptual design was conceived by TechLand Research, Inc. (North Olmsted, OH), which had received funding through NASA's Small Business Innovation Research program. The Hypersonics Project of NASA's Fundamental Aeronautics Program adopted the design and directed the high-speed flowpath design to Mach 7. The NASA Glenn Research Center in collaboration with TechLand carried this aerodynamic design through mechanical design and in-house fabrication of a screening model for testing in Glenn's 1- by 1-Foot Supersonic Wind Tunnel (1×1 SWT). Glenn researchers used computational fluid dynamics (CFD) tools for three-dimensional, turbulent flow analysis to further refine the aerodynamic design.



IMX model mounted in Glenn's 1×1 SWT.

The inlet was sized near maximum blockage limits at Mach 2.5. Main remotely variable geometry included rotating cowl lips for both the high- and low-speed inlets and an exit flow-metering plug on the low-speed inlet. The main parametric aspects of the low-speed inlet included interchangeable components for ramp contours (Mach 4 and 3) as well as bleed patterns and amounts. The IMX model was fabricated and instrumented at Glenn, and it was tested during the summer of 2007 in Glenn's 1×1 SWT, covering design and off-design conditions. The model featured nine bleed compartments in the region in the low-speed flowpath. Each of these bleeds was found to contribute to the overall high performance of the low-speed inlet. The objectives of the test were met: high performance, stability, and smooth mode transition. The experimental data are being compared with the CFD analysis methods; an effort that will help develop CFD tools for future hypersonic inlet design.

Find out more about the research of Glenn's Inlet and Nozzle Branch:
http://www.grc.nasa.gov/WWW/RTE/

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Programs/Projects:
Fundamental Aeronautics Program, Hypersonics Project

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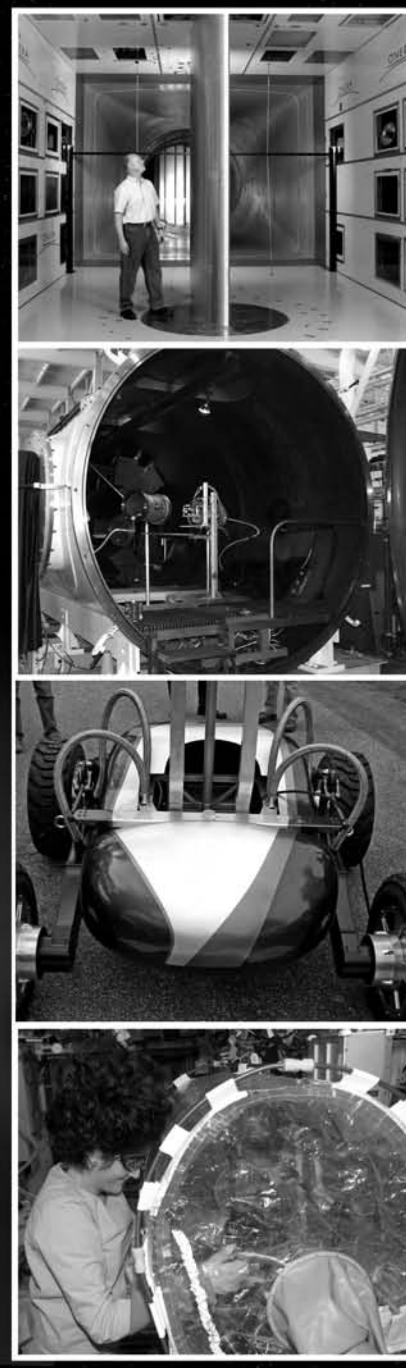

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