Orbital Research Inc.

AERODYNAMICS RESEARCH

The Aerodynamics Group at Orbital Research, Inc. is active in a wide variety of research and engineering efforts that are focused on the design and development of advanced Active Flow Control systems for aircraft and missiles. ORI employs state-of-the-art solutions utilizing exploratory wind tunnel experiments coupled with high-fidelity Computational Fluid Dynamics (CFD) simulations to advance through the concept-to-development stages in a very time- and cost-efficient manner. Since its inception in 1991, ORI has proven excellent track record of successful research programs funded by U.S. government agencies, including Defense Advanced Research Project Agency (DARPA), Army, Air Force, and Special Operations Command (SOCOM). ORI has also been collaborating with large aerospace corporations for specific R&D programs.

Recent Achievements

What follows is a brief synopsis of recent accomplishments of the Aerodynamics Group at ORI.

AIAA Aerospace America Recognizes ORI

Excerpts from Aerospace America Dec. 2002 Issue, page 19

"... Orbital Research is developing a phantom yaw control system for weapons at high angle of attack (AoA), where conventional control surfaces become ineffective. This system integrates active microvortex generators, dynamic pressure sensors, and real-time closed-loop controllers into isolated modules placed near the tip of the nose cone. During wind tunnel testing of a prototype system, a desired yaw moment was generated and maintained over a large range of commanded values during high- AOA pitch sweeps. A similar system is under development for autonomous aircraft wing stall control."

Deployable flow effectors, dynamic pressure sensors, and real time closed-loop controllers are integrated near the tip of the nose cone.

Closed-Loop Missile Control at High Alpha

In reference to the above recognition, a high-alpha, closed-loop flow control system for missile yaw stabilization and enhanced maneuverability was designed, developed and successfully demonstrated via wind tunnel experiments on a fin-less 3:1 tangent ogive missile model. The control system consisted of pressure sensors and deployable flow effectors (micro-vortex generators) arranged in concentric rings on the missile nose cone. The closed-loop controller used sensor information to modulate the flow effectors for manipulation of forebody flow asymmetry around the missile forebody. Dynamic experiments successfully demonstrated the ability of the closed-loop control system to generate and maintain a range of desired yawing moments during high-alpha pitch sweeps.

Reference Paper: AIAA Paper # 2002-2827

Active Transparent Stall Control System

ORI has successfully developed and demonstrated an active transparent stall control system for aerodynamic applications. The system utilizes sensors, actuators, and a closed-loop controller to enable active detection-and-control of local flow separation so as to delay wing stall. The technique is independent of control inputs from the on-board flight control system and hence termed "transparent". The method of predicting flow separation is based on the identification of characteristic shifts in the power spectrum of the pressure fluctuations upstream of flow separation. Micro-vortex generators were used for controlling flow separation. This control system can be adapted to work with a variety of flow control actuators that are effective in controlling flow separation. This system is an enabling technology for the "smart-wing" concept

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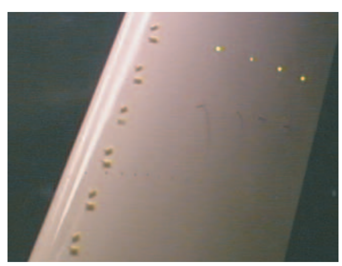

The MEMS Microvalve is placed in the airfoil and either deploys a mechanical flow effector or directly actuates air into the flow field.

Virtual AeroShaping of Air Vehicles

Orbital Research, Inc. has developed a novel, hierarchical modular control methodology - a closed-loop flow control approach, for active virtual shaping of aerodynamic surfaces. Through wind tunnel testing and numerical simulation, ORI

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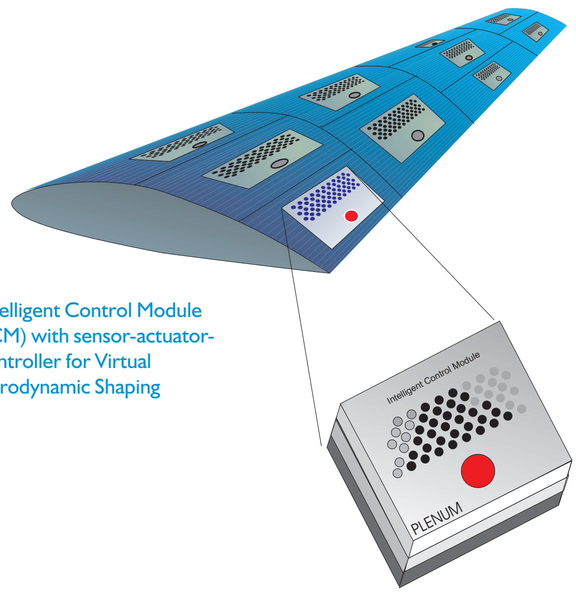
demonstrated the use of Intelligent Control Modules (miniature collocated sensor-actuator pairs) coupled with local feedback controllers for localized flow control. These ICMs are then modulated by a Global Control System (GCS), to actively track the desired rolling and pitching moment trajectories of an aircraft. A full 6 DOF numerical simulation was used to demonstrate this novel modular flow control approach for virtual shaping of air vehicles.

Reference Paper: AIAA Paper # 2003-3663



Intelligent Control Module (ICM) with sensor-actuator-controller for Virtual Aerodynamic Shaping

Reconfigurable Porosity for Flow Control

Orbital Research, Inc. has developed a new flow control technique that uniquely combines the effects of porosity and patterned-perturbations to enable active modulation of a flowfield around a surface for improved aerodynamic performance. This technique, known as Reconfigurable Porosity, generates a fundamental flow instability by allowing small amounts of mass transfer in and out of the uniquely-patterned porous surface to energize the boundary layer for flow control. Wind tunnel experiments utilizing this technique on projectile-fins and a wing model demonstrate the ability to generate control forces that can effectively be used for pitch, yaw, and roll control of various aerodynamic and hydrodynamic planforms.

Reference Paper: AIAA Paper # 2003-3665

Signature Reduction of Combatant Craft

In a recent program with the U.S. Special Operations Command (SOCOM), ORI demonstrated an effective jet vectoring technology to dissipate highly-visible wake structures that form behind military combatant watercraft, such as the 11m Rigid Inflatable Boat (RIB) and the MkV. The technology utilizes passive flow control methods to control the waterjet direction, while preserving the propulsor's thrust performance, and in some instances, improving the boat performance and handling.

Range and Controls Extension for Munitions

In another program, ORI is developing adaptive control structures and novel micro-adaptive flow control techniques to improve the range and end-game maneuvering of Future Combat Systems (FCS) projectiles. Advanced concepts such as Aero Control Fins - fins with flow control devices, and active flow control on the projectile boattail, are developed through wind tunnel testing and CFD studies. The technologies developed in this program are generic in nature and could be applied to any projectile planform for range extension and improved maneuverability.

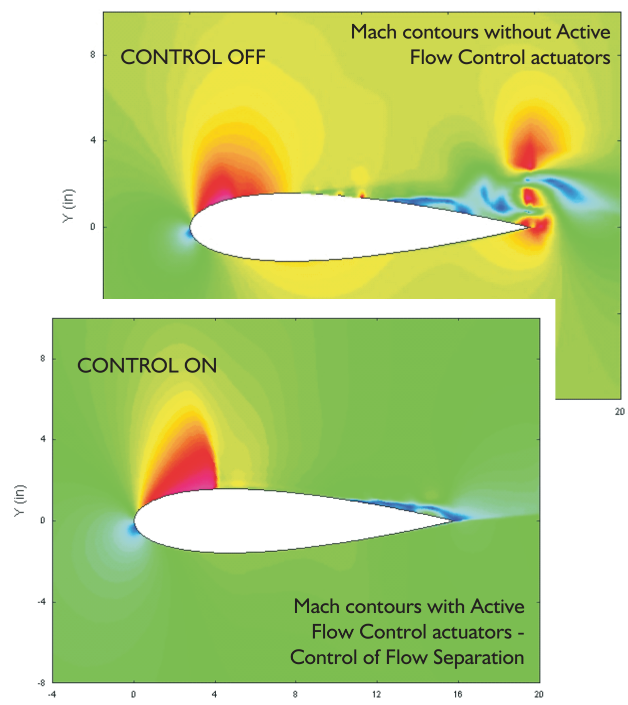
Reference Paper: AIAA Paper # 2003-3673

Computational Fluid Dynamics: Flow Control Research

ORI's flow modeling and research capabilities include a full Navier-Stokes equation solver with a flexibility to solve approximated N-S equations such as parabolized Navier-Stokes (PNS), Euler, and thin layer Navier-Stokes (TLNS). These capabilities are available though the WIND code. Pre- and post-processing tools include MADCAP - grid generation Software, GMAN - Grid Manipulation software, CFPOST and TECPLOT - post processing software.

To date, ORI has conducted CFD studies to investigate the effects of different flow control actuators such as suction, blowing, zero-net-mass synthetic jets, porosity, and discrete suction on a variety of aerodynamic models. Most recently, ORI has conducted CFD studies to understand and optimize flow through nozzles for improved stealth and thrust performance. Current CFD programs include fluidic thrust vectoring on tactical missiles and enhanced control of smart munitions through the use of advanced flow control concepts.

Reference Papers: AIAA Paper #'s 2002-0668, 2003-0547



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