Air Force SBIR/STTR

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:
AF05-318

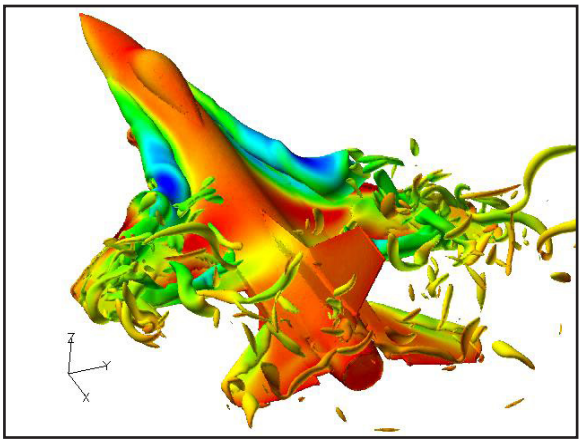
SBIR Title:
Buffet and Dynamic Loads Analysis

Contract Number:
FA9302-06-C-0015

SBIR Company Name:
CMSoft, Inc.
Palo Alto. CA

Technical Project Office:
Air Force Flight Test Center
Edwards AFB, CA

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



Improved Technology for Buffet and Dynamic Loads Analysis

- Aircraft can experience severe buffet problems which increase maintenance costs and decrease fatigue life
- CMSoft, Inc. matured the coupling of a Navier-Stokes flow solver and turbulence modeling capabilities, with a nonlinear finite element structural analyzer capable of detailed modeling and simulation of aircraft structures
- CMSoft has significantly enhanced and matured the AERO Suite of Codes deployed at Edwards AFB, which couples a high-end Arbitrary Lagrangian-Eulerian unsteady viscous flow solver with a versatile and dynamic finite element structural analyzer
- This computational technology and other variations that are built from it have led to CMSoft's involvement with the U.S. Navy and prospective commercial clients

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Air Force Requirement

Buffet and dynamic loads involve an interaction between unsteady aerodynamics and structural dynamics. These phenomena adversely affect fatigue life and maintenance costs, and in the worst case can lead to loss of aircraft and/or crew.

In order to assure safe testing in the regions of flight envelopes where these and related phenomena may occur, the Air Force Office of Scientific Research (AFOSR) sponsored Test and Evaluation (T&E) research projects that eventually led to this SBIR topic.

SBIR Technology

CMSoft, Inc. matured the coupling of a Navier-Stokes flow solver and turbulence modeling capabilities, with a nonlinear finite element structural analyzer capable of detailed modeling and simulation of aircraft structures. In the process, CMSoft overcame the challenges of representing the interface between the aerodynamics and the structural dynamics such that overall conservation is assured, and in developing mesh motion algorithms that allow the fluid mesh to conform to large motions and deformations of the structure. The result is a simulation capability that is unmatched anywhere.

High-performance aircraft, and particularly modern fighter jets, are often required to undergo maneuvers involving high angles of attack. Under these flight conditions, unsteady vortices emanate from wing leading-edge extensions and interact with vertical fins, causing vertical tail buffeting. This aeroelastic phenomenon typically increases maintenance costs and can lead to premature fatigue failure. To enable the accurate and efficient numerical simulation of this and related nonlinear dynamic aeroelastic phenomena where viscous effects and dynamic loads are important, CMSoft has elevated the state-of-the-art of computational fluid dynamics (CFD)-based nonlinear aeroelastic analysis through new computational technologies.

CMSoft has significantly enhanced and matured the AERO Suite of Codes deployed at Edwards Air Force Base which couples a high-end Arbitrary Lagrangian Eulerian unsteady viscous flow solver with a versatile and dynamic finite element structural analyzer. It has also equipped this multidisciplinary software with an innovative mesh motion solver that is both computationally efficient and robust in the boundary layer where the mesh elements tend to be very stretched, very small compared to the remaining elements of the CFD mesh, and therefore very prone to crossovers that invalidate nonlinear aeroelastic simulations.

The resulting computational capability has proved to be essential for the success of numerous commercial applications ranging from the aerodynamic optimization of a major race car to the body freedom flutter analysis of a supersonic business jet concept. It has also attracted prospective commercial clients who are interested in other fluid and fluid-structure applications.

Potential Air Force Application

There are many incidences in the past which could have been avoided if this technology had been available. Aircraft can experience severe buffet problems that increase maintenance costs and decrease fatigue life. Aircraft can suffer life threatening and expensive Category A mishaps, damaging parts such as horizontal stabilizers during abrupt maneuvers.

This innovative technology has great potential for earlier discovery and avoidance of these problems. Several aircraft platform sponsors have already shown interest in this work, and some have already exercised it for the flutter analysis of fighter aircraft and sensor aircraft. This technology will likely become a mainstay in the support of flight testing of new aircraft and for stores clearance work.

This computational technology and other variations that are built from it have led to CMSoft's involvement with the U.S. Navy, Toyota Motor Corporation, and the Goodyear Tire & Rubber Company. Toyota has consulted with CMSoft in order to refine their Formula 1 racing car and gain a competitive advantage. The Goodyear Tire & Rubber Company is interested in exploring this technology for the numerical simulation of hydroplaning.

Company Impact

The Buffet and Dynamic loads technology has been a cornerstone effort for CMSoft.

CMSoft strives to transition to practitioners the most recent advances in high-performance, high-fidelity, modeling and simulation technologies through consulting services and software development and integration.

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