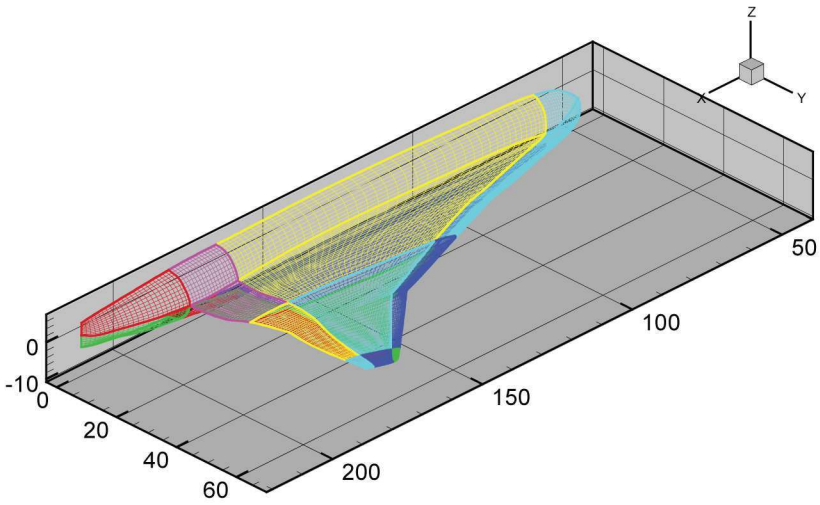


National Aeronautics and Space Administration

Information Technology and Software

Reduced-Order Models for Efficient Computational Analysis of Complex Systems

Innovative software for aeroelastic analysis at a fraction of the time and cost of traditional CFD methods

NASA's Langley Research Center has developed unsteady aerodynamic Reduced-Order Models (ROMs) that significantly improve the computational efficiency compared to traditional analyses of aeroelastic and other complex and unsteady systems. Traditional methods rely on the repetitive use of aeroelastic computational fluid dynamics (CFD) codes and the iteration between the structural and nonlinear aerodynamic models of the aeroelastic CFD code for predicting the aeroelastic response of flight vehicles very time consuming and computationally expensive. The new ROMs are quite different from the traditional aeroelastic analysis tools and enable the computational aeroelastic analysis of flight vehicles at a fraction of the time and cost.

BENEFITS

- Reduced computational costs through the ability to:

  -- Calculate both the dynamic and static aeroelastic responses using the same ROM

  -- Analyze all of the structural modes in one CFD run

- Simplified model in a form shared by other engineering disciplines such as controls and safety

APPLICATIONS

- Aerospace - aerodynamic flutter of rotorcraft
- Civil structures - dynamic behavioral models of large buildings and other civil structures such as bridges, dams, and towers

technology solution

THE TECHNOLOGY

As shown in Figure 1, traditional computational aeroelastic analysis using CFD codes requires the coupled interaction of the linear structural model and the nonlinear aerodynamic model (both within the aeroelastic CFD code). The structural model provides displacements due to aerodynamic forces, and the nonlinear aerodynamic model computes the aerodynamic forces induced by the structural displacements. The computed aerodynamic force is passed back to the structural model, and the resource-intensive process is repeated at each time step.

Starting with an aeroelastic model consisting of a CFD grid and structural mode shapes, NASA Langleys new analysis procedure, shown in Figure 2, occurs as follows:

1. The unsteady aerodynamic responses of all of the structural modes are computed by exciting all of the modes simultaneously in just one execution of the CFD code.

2. The responses obtained in Step 1 are processed through a NASA Langley-developed set of algorithms, yielding a simplified mathematical model in state-space form.

3. The state-space forms of the aeroelastic and structural models are combined, and:

-- A new method computes matched-point solutions.

-- Another new method enables simultaneous computation of the static and dynamic responses.

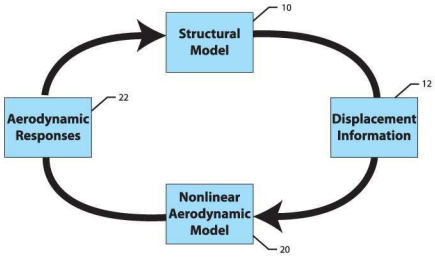


FIGURE 1 Traditional computational aeroelastic analysis

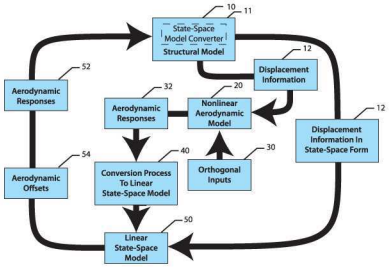
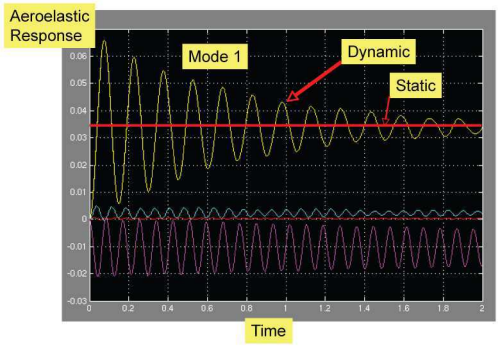


FIGURE 2 Novel computational aeroelastic analysis using ROMs



Static and dynamic aeroelastic analysis results using ROMs

PUBLICATIONS

Patent No: 8,060,350

More Information

National Aeronautics and Space Administration

The Technology Gateway

Langley Research Center

Mail Stop 151
Hampton, VA 23681
757.864.1178
LARC-DL-technologygateway@mail.nasa.gov

http://technology.nasa.gov/

www.nasa.gov

NP-2014-09-1229-HQ

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

LAR-17325-1