Aeroelasticity and Aeroservoelastic Control

Lead Center: LaRC

Participating Center(s): AFRC

Technology Area: TA15 Aeronautics

Scope Title

Aeroelasticity and Aeroservoelasticity for Advanced Configurations

Scope Description

The technical discipline of aeroelasticity is a critical ingredient necessary in the design process of a flight vehicle for maintaining optimal performance while ensuring freedom from aeroelastic and aeroservoelastic instabilities. This discipline requires a thorough understanding of the complex interactions between a flexible structure and the steady and unsteady aerodynamic forces acting on the structure, with interactive control systems for flight vehicle performance and stability. Predicting the aeroelastic response of emerging evolutionary and revolutionary vehicle concepts, which include new vehicle configurations, new structures, and/or new materials, is not an easy task. Aeroelastic prediction and testing methods must evolve and expand together with these vehicle concepts. The use of lightweight flexible structures, the development of new airframes, and the intentional exploitation of aeroelastic response phenomena require a comprehensive understanding of the aeroelasticity involved if they are to succeed. Both enhancements to current methodologies/codes and new methodologies/codes that enable evaluation and understanding of new concepts are needed to keep pace with the state of the art in vehicle technology and to fill critical gaps in understanding these complex vehicles.

The fundamental aeronautics work for the Aeroelasticity and Aeroservoelastic Control Subtopic is focused on active/adaptive aerostructural control for lightweight flexible structures, specifically related to load distribution, flutter prediction and suppression, gust load prediction and alleviation, and aeroservoelasticity for Ultra-Efficient and Supersonic Commercial Vehicles. The program's work on aeroservoelasticity includes conduct of broad-based research and technology development to obtain a fundamental understanding of aeroelastic and unsteady-aerodynamic phenomena experienced by aerospace vehicles in subsonic, transonic, supersonic, and hypersonic speed regimes. The subtopic content includes theoretical aeroelasticity, experimental aeroelasticity, and advanced aeroservoelastic concepts. Of interest are:

- Aeroelastic, aeroservoelastic, and unsteady aerodynamic analyses at the appropriate level of fidelity for the problem at hand
- Aeroelastic, aeroservoelastic, and unsteady aerodynamic experiments to validate methodologies and to gain valuable insights available only through testing
- Development of computational-fluid-dynamic (CFD), computational-aeroelastic and computational-aeroservoelastic analysis tools that advance the state of the art in aeroservoelasticity through novel and
creative application of aeroelastic knowledge

Specific subjects to be considered include:

- Development of aerostructural control design methodologies that include CFD steady and unsteady aerodynamics, flexible structures, and active control systems
- Development of efficient methods to generate mathematical models of wind-tunnel models and flight vehicles for performing aeroservoelastic studies
- Development of CFD-based methods (reduced-order models) for aeroservoelastic models and simulation that can be used to predict gust loads, ride quality issues, flight dynamics stability, and aerostructural control issues
- Development of novel aeroservoelastic sensing and control approaches, including active/adaptive control concepts and architectures that employ smart materials embedded in the structure and aerodynamic sensing and control schemes for suppressing aeroelastic instabilities and improving performance
- Development of techniques that support simulations, ground testing, wind tunnel tests, and flight experiments for aerostructural control of aeroservoelastic phenomena

References

Links to program/project websites:

2) ARMD's Transformative Aeronautics Concepts Program (TACP): https://www.nasa.gov/aeroresearch/programs/tacp
3) ARMD's Flight Demonstrations and Capabilities (FDC) Project under the Integrated Aviation Systems Program (IASP): https://www.nasa.gov/aeroresearch/programs/iasp/fdc
4) X-56 Flight Project: https://www.nasa.gov/centers/armstrong/research/X-56/index.html

Information related to evolutionary and revolutionary flight vehicle concepts/configurations that are on the drawing board or already being tested:

2) Blended Wing Body: https://www.nasa.gov/centers/dryden/multimedia/imagegallery/X-48C/ED12-0255-51.html
3) Joined Wing: https://www.nasa.gov/centers/langley/multimedia/iotw-tdt-wing.html
4) X-57: https://www.nasa.gov/image-feature/milestone-achieved-as-x-57-mod-ii-takes-shape

Expected TRL or TRL range at completion of the project: 3 to 5