



## NASA SBIR 2011 Phase I Solicitation

### A2.05 Aerodynamics

Lead Center: LaRC

Participating Center(s): AFRC, ARC, GRC, JSC, MSFC

The challenge of flight has at its foundation the understanding, prediction, and control of fluid flow around complex geometries - aerodynamics. Aerodynamic prediction is critical throughout the flight envelope for subsonic, supersonic, and hypersonic vehicles - driving outer mold line definition, providing loads to other disciplines, and enabling environmental impact assessments in areas such as emissions, noise, and aircraft spacing.

In turn, high confidence prediction enables high confidence development and assessment of innovative aerodynamic concepts. This subtopic seeks innovative physics-based models and novel aerodynamic concepts, with an emphasis on flow control, applicable in part or over the entire speed regime from subsonic through hypersonic flight.

All vehicle classes will experience subsonic flight conditions. The most fundamental issue is the prediction of flow separation onset and progression on smooth, curved surfaces, and the control of separation. Supersonic and hypersonic vehicles will experience supersonic flight conditions. Fundamental to this flight regime is the sonic boom, which to date has been a barrier issue for a viable civil vehicle. Addressing boom alone is not a sufficient mission enabler however, as low drag is a prerequisite for an economically viable vehicle, whether only passing through the supersonic regime, or cruising there. Atmospheric entry vehicles and space access vehicles will experience hypersonic flight conditions. Reentry capsules and vehicles deploy multiple parachutes during descent and landing. Predicting the physics of unsteady flows in supersonic and subsonic speeds is important for the design of these deceleration systems. The gas-dynamic performance of decelerators for vehicles entering the atmospheres of planets in the solar system is not well understood. Reusable hypersonic vehicles will be designed such that the lower body can be used as an integrated propulsion system in cruise condition. Their performance is likely to suffer in off-design conditions, particularly acutely at transonic speeds. Advanced flow control technologies are needed to alleviate the problem.

This solicitation seeks proposals to develop and validate:

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- Turbulence models and advanced computational techniques such as detached eddy, large eddy, or direct numerical simulations that capture the physics of separation onset at Reynolds numbers relevant to flight, where relevant to flight is dependent on a targeted vehicle class and mission profile.
  - Boundary-layer transition models suitable for direct integration with state-of-the-art flow solvers.
  - Active flow control concepts targeted at separation control, shock wave manipulation, and/or viscous drag reduction with an emphasis on the development of novel, practical, lightweight, low-energy actuators.
  - Innovative aerodynamic concepts targeted at vehicle efficiency or control, including but not limited to concepts targeted at turbulent boundary skin friction drag reduction.
  - Physics-based models for simultaneous low boom/low drag prediction and design.
  - Aerodynamic concepts enabling simultaneous low boom and low drag objectives.
  - Innovative methods to validate both flow models and aerodynamic concepts with an emphasis on aft-shock effects, which are hindered by conventional wind tunnel model mounting approaches.
  - Uncertainty quantification methods suitable for use with state-of-the-art flow solvers.
  - Accurate aerodynamic analysis and multidisciplinary design tools for multi-body flexible structures in the atmospheres of planets and moons including the Earth, Mars, and Titan.
  - Advanced flow control technologies to alleviate off-design performance penalties for reusable hypersonic vehicles.