NASA SBIR 2016 Phase I Solicitation

A1.05   Physics-Based Computational Tools - Stability and Control/High Lift Design Tools

Lead Center: LaRC

Participating Center(s): GRC

NASA continues to investigate the potential of advanced, innovative propulsion and airframe concepts to improve fuel efficiency and reduce the environmental footprint of future generations of commercial transports across the breadth of the flight speed regimes. Advanced concepts are viewed as potential options for helping to meet aggressive, long range (i.e., 'N+3' timeframe) fuel burn, noise, and emission reduction targets. Conceptual design and analysis of unconventional airframe and propulsion concepts and technologies is used within NASA for technology portfolio investment planning, development of advanced concepts to provide technology pull, and independent technical assessment of new concepts, so the agency's systems analysts need the best conceptual design and analysis tools possible to support these efforts.

Historically, only empirical and semi-empirical analysis methods have been used during the conceptual design phase. These techniques work well for the conceptual design of conventional systems with parameters that reside within the historical databases used to develop the methodologies. However, these methods are not well suited for unconventional concepts, or even conventional concepts which reside outside of the database. Substantial progress has been made recently in incorporating more physics-based analysis tools in the conceptual design process, and NASA has developed a capability that integrates several analysis tools and models in engineering frameworks, such as ModelCenter and OpenMDAO, with a geometry-centric approach built around tools such as OpenVSP and GeoMACH. However, modeling gaps still remain in many disciplines.

Developing higher-order, more-accurate tools suitable for conceptual design is a difficult challenge. To perform the configuration trades and optimization typical in conceptual design, runtimes measured in seconds or minutes, instead of hours or days, are required. Additionally, because it is not possible to model every detail of the design and account for all the underlying physics in the problem formulation, it is difficult to predict the 'as-built' characteristics with physics-based methods alone. Finally, the gap between the analysis capability and the maturity of the design being analyzed currently limits the usefulness of high order analysis in conceptual design. Physics-based tools for conceptual design are needed which can rapidly and accurately predict the as-built characteristics of unconventional aircraft designs, while remaining consistent with the amount of design knowledge that is available at the conceptual design stage.

Sizing of an aircraft design can be strongly affected by its takeoff and landing characteristics, yet for both conventional and unconventional aircraft concepts it can be difficult to accurately estimate the aerodynamic performance in the high-lift configuration. In addition, many traditional methods of sizing aircraft controls surfaces and assuring acceptable handling qualities have lost their validity as more unconventional aircraft are being studied, and additional dynamic modes might become unstable. For FY2016, specific capabilities are being sought in the following areas:

- Methods for aerodynamic analysis, weight estimation, and design of aircraft high-lift systems.
  - Analysis of the aerodynamic performance of externally-blown flaps.
  - Robust prediction of maximum lift coefficient with flaps and slats extended.
  - Estimation of high-lift system weight as a function of design parameters.
  - Optimization of high-lift component design, trading aerodynamic performance and weight/complexity to minimize overall aircraft system weight, fuel burn and cost as an objective function.
- Methods for analysis of aircraft static and dynamic stability characteristics suitable for unconventional aircraft.
  - Physics-based sizing of tails and control surfaces that is more sensitive to aircraft design parameters than traditional tail volume coefficients.
  - Calculation of mass moments of inertia for the complete aircraft system throughout the full mission.
  - Simulation of the dynamics of unconventional aircraft configurations with tight coupling of propulsion and aerodynamics characteristics, including evaluation of active control systems.
  - Definition of handling qualities for unmanned aerial systems.

The desired capabilities are physics-based methods that are of higher order than traditional empirical methods, but can be applied in the conceptual design phase with limited requirements on the availability of detailed design information. Newly-developed methods and methods integration activities should include verification and validation of results, and will ideally address quantification of uncertainty and calculation of sensitivity derivatives for use in adjoint design.