NASA SBIR 2019 Phase I Solicitation

A1.01 Aerodynamic and Structural Efficiency - Integration of Flight Control with Aircraft Multidisciplinary Design Optimization

Lead Center: ARC

Participating Center(s): AFRC, LaRC

Technology Area: TA15 Aeronautics

NASA is conducting fundamental aeronautics research to develop innovative ideas that can lead to next generation aircraft design concepts with improved performance and operation. There is an increasing interest in more integrated aircraft multidisciplinary design optimization (MDO) processes that can bring flight control design into the early stage of an aircraft design cycle. By taking advantage of flight control as an additional discipline for integration with the traditional disciplines of aerodynamics, structures, and propulsion into an aircraft design process, potentially novel aircraft concepts could be identified that may provide better performance and improved safety.

Increasingly, distributed flight control designs are being investigated as future options for next-generation aircraft. A distributed flight control design can have multi-functional capabilities to accomplish multiple vehicle performance and operation objectives. For example, the aircraft industry has developed flight control technologies for drag reduction and load alleviation for modern transports such as B787 using distributed flight control surfaces. Such technologies, when fully integrated into the traditional multidisciplinary aircraft design cycle, could bring benefits to future aircraft designs, such as NASA-funded Truss-Braced Wing aircraft that could reduce interference drag at the strut juncture and lower wing weight using distributed flight control surfaces. Distributed electric propulsion (DEP) has been proposed as a technology solution for future Urban Air Mobility (UAM). The NASA X-57 vehicle utilizes wing-mounted distributed propulsion, which presents a complex aircraft design that could benefit from a more integrated design solution that would leverage DEP as flight control effectors for both operational objectives, such as cruise and roll control, as well as performance objectives, such as drag optimization by altering spanwise lift. Gradually, more advanced aircraft concepts utilize distributed flight control design such as modern Airbus A350 with adaptive drooped hinge flaps and a wide variety of UAM aircraft. The current state-of-the-art does not account for integration of flight control systems into MDO processes. Some low-level effort of addressing flight control surface integration in an MDO process has already begun; however, the investigation does not address the trade study with flight control system actuator and sensor hardware and flight control laws, nor does it address other novel flight control systems such distributed electric propulsion.

Therefore, this subtopic seeks proposals that addresses flight control integration with aircraft MDO processes. Proposed subjects may include, but are not limited to, the following:

- Novel distributed flight control design concepts that can potentially reduce size, weight, and drag relative to the existing state-of-the-art, including concepts that can improve aerodynamic performance by exploring design options with relaxed static stability.
- Flight control integration with aircraft design that results in integrated aero-structural-control optimal design and control layout for optimal L/D, noise reduction, as well as suitable handling and ride quality in all flight

phases. This should take into consideration aeroelasticity, propulsion, and flow physics, as necessary.
- Methods and tools for integrating flight control into aero-structural-propulsion design processes that include structural sizing, control layouts, interaction physics with other disciplines, flight control laws as aircraft design parameters, and trade-off between control system weight/power and aircraft performance.
- Novel aircraft design concepts that can demonstrate the benefits of integrated aircraft design solutions with flight control.

The expected Technology Readiness Level (TRL) range at completion of the project is 3 to 4.

Expected deliverables would be methods and tools on how to develop the proposed technologies. In addition, concepts of aircraft designs that demonstrate the benefit of the proposed technologies are desired.

Within the NASA Advanced Air Vehicle Program (AAVP), the Advanced Air Transport Technologies (AATT) Project is conducting research in distributed electric propulsion and adaptive wing technologies. Both of these research elements could benefit from this subtopic. Also, under the NASA AAVP, the Revolutionary Vertical Lift Technologies (RVLT) Project is conducting research in the area of UAM aircraft using distributed electric propulsion for Vertical Take-Off and Landing (VTOL). This subtopic would complement the research in the RVLT project.

References:

- Bret Stanford, "Optimization of an Aeroservoelastic Wing with Distributed Multiple Control Surfaces", 33rd AIAA Applied Aerodynamics Conference, AIAA-2015-2419, 2015.

Nhan Nguyen, Kevin Reynolds, Eric Ting, Natalia Nguyen, "Distributed Propulsion Aircraft with Aeroelastic Wing Shaping Control for Improved Aerodynamic Efficiency", AIAA Journal of Aircraft, Vol.55, pp. 1122-1140, 2018.