Distributed Sensing, Computing, and Actuation Architecture for Aeroservoelastic Control, Phase I Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

This proposal introduces an approach to aeroservoelastic control that provides enhanced robustness to unmodeled dynamics. The core of the approach is a processing element, designed by the embedded-systems expertise at Prioria Robotics, that provides measurement and signal processing and even control commands from localized stations throughout a structure. An architecture is formulated that utilizes these distributed elements to provide information about the adverse aeroservoelastic effects, such as frequencies and damping and even mode shapes, to modify control commands and achieve desired performance characteristics. The research team has extensive expertise in the analysis, simulation, and flight testing of aircraft with novel configurations, including flexible wings, morphing aircraft, and reconfigurable designs. The proposed innovation is applicable to a wide range of aerospace applications including stratospheric UAVs and manned transport-category aircraft. The architecture enables closed-loop aeroservoelastic control or open-loop aeroelastic measurements and can be retrofit into an existing airframe and flight controller or integral to the design of a new aircraft. The Phase I objectives of the current proposal include the conceptual and initial design of a novel architecture for aeroelastic control. Initial effort involves requirements generation for the scalable architecture and dynamic simulation of a representative UAV wing. The architecture is implemented in hardware using modifications of existing electronic and airframe components.

ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: A successful outcome of the proposed research would result in a modular hardware system that can be retrofit onto existing NASA manned and unmanned aircraft to provide open-loop structural mode sensing for experimental flight tests or operational flights. The

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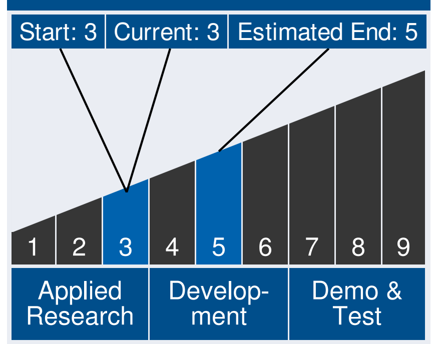
Technology Maturity



Management Team

Program Executives:

- Joseph Grant
- Laguduva Kubendran

Program Manager:

- Carlos Torrez

Continued on following page.

combination of the high-bandwidth distributed aeroservoelastic control elements with the computational capability of the central processor permit on-board modal estimation which could be telemetered to a ground control station to aid in decision-making during envelope expansion flights. In such a use case, the ACEs would be used as sensing and processing elements without an actuator component. Use of low-cost components in the design reduces overall system cost and allows the system to be used on non-recoverable aircraft. In such cases, the onboard aeroservoelastic processing alleviates need for high-bandwidth telemetry or recovery of flight logs from terminated aircraft. Instead, the system can telemeter low-bandwidth structural mode shape information in real-time to both improve situational awareness of the flight crew and for post-flight data analysis. NASA could integrate the distributed ASE control architecture into new aircraft as part of the primary flight control system. Use of the distributed control effectors could leverage the significant control authority benefits without requiring engineers to re-solve the control allocation, sensing, structural mode analysis, and communication bandwidth problems.

To the commercial space industry:

Potential Non-NASA Commercial Applications: The ASE control architecture can be licensed to aircraft manufacturers with prototype aircraft at any stage from conceptual design to final certification. Open-loop measurements on early prototype aircraft can help guide decisions on required structural stiffness versus increasing weight and lost endurance. Flight tests can yield improved data which helps prevent over-designing structures at the expense of performance. These tests are facilitated with modular instrumentation and processing that minimizes the burden of mechanical and software integration. Flight tests of unique aircraft configurations such as the high-altitude, long-endurance Global Observer are usually hindered due to structural response uncertainty. That program required extensive instrumentation in the form of individual strain gauges and accelerometers distributed throughout the wing and airframe

Management Team *(cont.)*

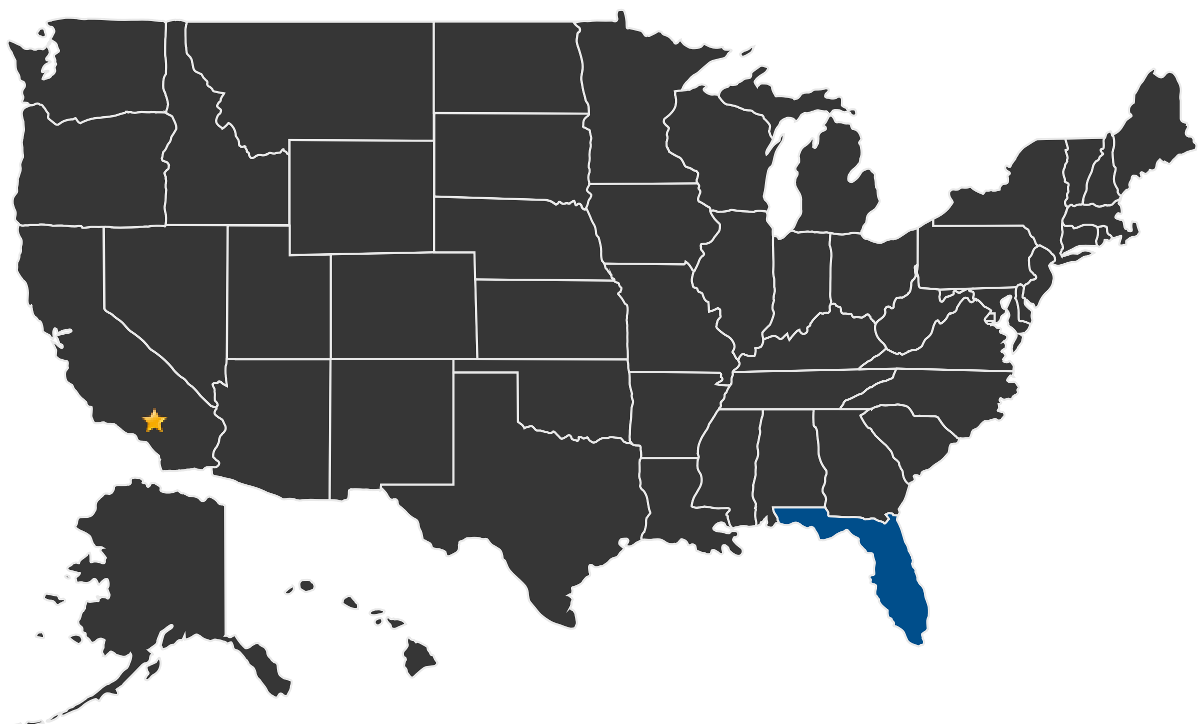
Principal Investigator:
- Mujahid Abdulrahim

Technology Areas

Primary Technology Area:
Modeling, Simulation, Information Technology and Processing (TA 11)
- Modeling (TA 11.2)
  - Frameworks, Languages, Tools, and Standards (TA 11.2.5)

structure. Wiring for these raw sensor measurements were routed through the wing and resulted in a substantial cable bundle and routing complexity in the conduits near the wing root. Additionally, the number of available sensors was limited by the interface capability and speed of the data acquisition system. A large array of sensors sampled on a single device result in temporal errors due to simultaneous sampling limitations. Large aircraft with numerous sensors may find difficulty identifying structural modes accurately due to the phase misalignment of sensors.

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Armstrong Flight Research Center

Other Organizations Performing Work:

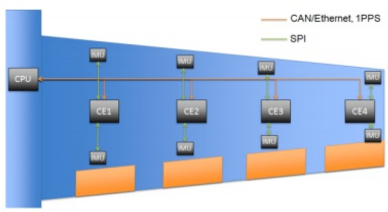
- Prioria, Inc. (Gainesville, FL)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/23321)

IMAGE GALLERY



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DETAILS FOR TECHNOLOGY 1

Technology Title

Distributed Sensing, Computing, and Actuation Architecture for Aeroservoelastic Control, Phase I

Potential Applications

A successful outcome of the proposed research would result in a modular hardware system that can be retrofit onto existing NASA manned and unmanned aircraft to provide open-loop structural mode sensing for experimental flight tests or operational flights. The combination of the high-bandwidth distributed aeroservoelastic control elements with the computational capability of the central processor permit on-board modal estimation which could be telemetered to a ground control station to aid in decision-making during envelope expansion flights. In such a use case, the ACEs would be used as sensing and processing elements without an actuator component. Use of low-cost components in the design reduces overall system cost and allows the system to be used on non-recoverable aircraft. In such cases, the onboard aeroservoelastic processing alleviates need for high-bandwidth telemetry or recovery of flight logs from terminated aircraft. Instead, the system can telemeter low-bandwidth structural mode shape information in real-time to both improve situational awareness of the flight crew and for post-flight data analysis. NASA could integrate the distributed ASE control architecture into new aircraft as part of the primary flight control system. Use of the distributed control effectors could leverage the significant control authority benefits without requiring engineers to re-solve the control allocation, sensing, structural mode analysis, and communication bandwidth problems.