

**SBIR Topic Number:**  
AF05-244

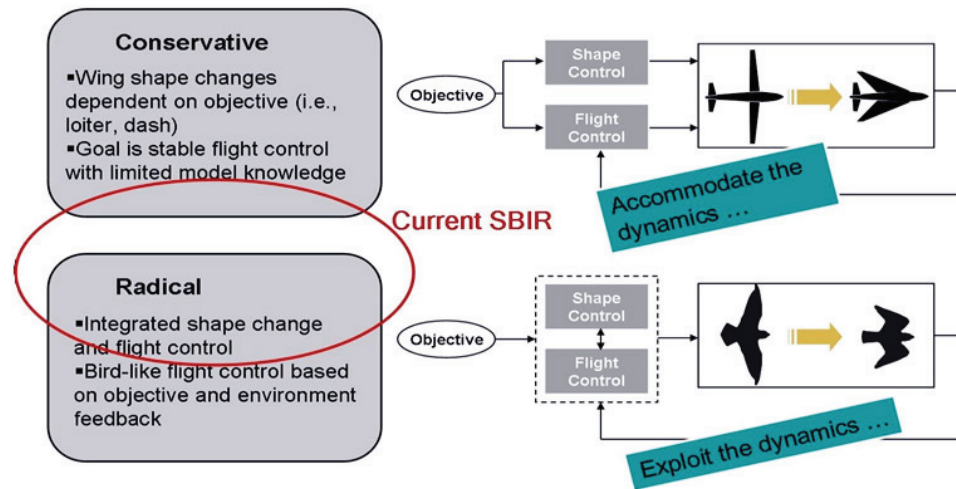
**SBIR Title:**  
Technologies for Control of Morphing Aircraft

**Contract Number:**  
FA8650-06-C-3608

**SBIR Company Name:**  
Barron Associates, Inc.,  
Charlottesville, VA

**Technical Project Office:**  
AFRL Air Vehicles  
Directorate, Wright-  
Patterson AFB, OH

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



Research Approach Employed on this SBIR

## Intelligent Control for Morphing Aircraft

- The Air Force has a requirement to utilize morphing technologies to expand aircraft flight envelopes and achieve mission-level benefits through the resulting large-scale geometrical changes.
- Barron Associates has addressed these needs by developing a control architecture consisting of (1) adaptive wing-shape control, (2) adaptive flight control, and (3) integrated command generation.
- This dual-use technology can address military performance objectives of extended range, maneuver envelope expansion, stealth, and multi-role capability from a single aircraft.
- This morphing technology can also address commercial aircraft operators' desires for extended range, improved fuel efficiency/economy, and noise/vibration dissipation.

RBO-10-116

**A**

DISTRIBUTION A:  
Approved for public  
release; distribution  
unlimited.

## Air Force Requirement

Morphing technologies have the potential to expand the flight envelope of aircraft beyond the current state-of-the-art, and early research has demonstrated that significant vehicle mission-level benefits can be achieved through these large-scale geometrical changes, especially in unmanned air vehicle (UAV) applications. To fully realize all of the capabilities of morphing aircraft, there is a need for control system research to enable active control of morphing wing structures. The primary control challenge associated with morphing aircraft structures is controlling large-scale vehicle (wing) transformations. In controlling these large-scale shape changes, the ultimate objective is to enable efficient in-flight transformation between vehicle states.

## SBIR Technology

Morphing air vehicles constitute an emerging class of aircraft capable of substantial changes in geometry during flight enabling improved performance characteristics. Advanced control technologies are required for this class of aircraft that can: (1) precisely manipulate the morphing planform adhering to physical limitations and actuator constraints; (2) guarantee vehicle stability across all possible planforms and transitions under changing aerodynamics; and (3) exploit the performance capabilities of different morphing wing configurations.

In order to address these needs, Barron Associates has developed a multi-level control architecture. This architecture consists of three components: (1) adaptive wing-shape control, (2) adaptive flight control, and (3) integrated command generation. At the lowest level, adaptive wing-shape control precisely manipulates the morphing planform in the face of variable loads and structural constraints. At an intermediate level, adaptive flight control provides consistent performance for all wing configurations and morphing transitions in the face of changing aerodynamics. At the highest level, integrated command generation harnesses the benefits of in-flight morphing to meet mission objectives.

## Potential Air Force Application

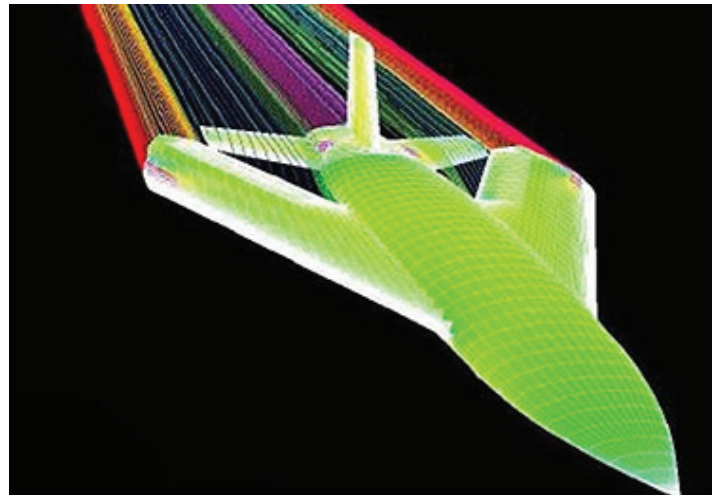
The proposed design constitutes a novel approach to achieve vehicle stability during morphing and allows for the ultimate use of morphing degrees-of-freedom to achieve mission objectives. The Air Force Hunter Killer program would be a potential transition path for this technology. Morphing

components could be utilized in these next-generation vehicles to improve fuel economy as well as performance.

The methods developed also provide dual-use technology that can address: (1) military performance objectives of extended range, maneuver envelope expansion, stealth, and multi-role capability from a single aircraft; and (2) commercial aircraft operators' desires for extended range, fuel efficiency, and noise/vibration dissipation. The proposed technology can also be transitioned to unmanned underwater vehicles and weapons (e.g., supercavitating torpedoes) to improve range, maneuverability, and speed. Another application exists in guided projectiles (e.g., the use of morphing technology to "grow" tail-fins for bullets in flight to improve accuracy).

## Company Impact

Hardware-in-the-loop demonstrations on the NextGen MFX-2 aircraft (shown below) conducted during this SBIR



**Aerodynamic Analysis of NextGen Aircraft**

enabled the efficient transition of comparatively high technology readiness level (TRL) control methods to one of the most advanced morphing-wing demonstrators developed to date. This demonstration has made Barron Associates, Inc. an ideal candidate for future work involving the modeling and control of morphing systems. One research area in which morphing technology is particularly promising is that of micro air vehicles (MAVs).



# SBIR/STTR

Air Force SBIR Program  
AFRL/XP  
1864 4th Street  
Wright-Patterson AFB OH 45433

AF SBIR/STTR Program Manager: Augustine Vu  
Website: [www.sbirsttrmail.com](http://www.sbirsttrmail.com)  
Comm: (800) 222-0336  
Fax: (937) 255-2219  
e-mail: [afrl.xppn.dl.sbir.hq@wpafb.af.mil](mailto:afrl.xppn.dl.sbir.hq@wpafb.af.mil)

