Air Force SBIR/STTR

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:
AF98-180

SBIR Title:
Mission Adaptive Compliant Wing

AF Contract Number:
F33615-98-C-3205

SBIR Company Name:
FlexSys Inc.,
Ann Arbor, MI

Technical Project Office:
AFRL/VA, Wright-Patterson AFB, OH

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

A laminar-flow flight test model fitted with variable geometry trailing edge.

FlexSys' mission adaptive compliant trailing edge was designed for a high-altitude, long-endurance aircraft undergoing 10º flap deflection with a 3º twist.

Mission Adaptive Compliant Wing

A New Generation of Highly Maneuverable, Quieter, Faster and More Efficient Aircraft

- Morphing aircraft wing control surfaces in response to changing flight conditions can provide dramatic improvements for Air Force aircraft.
- The technology also offers very promising applications to variable geometry engine inlets and other surfaces to improve the performance of jet engines
- SBIR funding supported development of lightweight, low complexity and smooth variable geometry control surfaces that promise to improve aircraft maneuverability, while maximizing fuel efficiency

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Air Force Requirement

Morphing aircraft wing control surfaces in response to changing flight conditions maximizes fuel efficiency (range) and flight performance (maneuverability and stability). This enables an aircraft to operate most efficiently under all flight conditions. In the mid 1980s, the Air Force Research Laboratory, modified and flight-tested an F-111 with flexible wing control surfaces in a program called "Mission Adaptive Wing (MAW). This program proved that adaptive wing control surfaces offered significant aerodynamic superiority over conventional leading and trailing edge flaps but suffered from significant increases in weight, complexity, packaging and mechanical performance. The Air Force wants technology that enables lightweight, low power, low complexity, and smooth variable geometry control surfaces.

SBIR Technology

Through SBIR funding, FlexSys, Inc., has successfully designed and built variable geometry airfoils and tested in a subsonic wind tunnel at the Air Force Research Laboratory under realistic flight conditions. A flight test model with a variable geometry trailing edge is scheduled for performance test in October 2006 on a Scaled Composite White Knight Aircraft. By exploiting the elasticity of the underlying structure FlexSys developed variable geometry airfoils. This approach was a radical departure from conventional engineering designs typically designed to be stiff, hinged structure, and the majority of smart/adaptive structure concepts which tend to be complex or heavy. This new design paradigm, rooted in biological inspiration, offers additional benefits since the entire adaptive structure is viewed as a compliant mechanism that can move into complex predetermined positions with only minimal force and yet remain strong and stiff to withstand external air loads in any desired configurations. Sophisticated design algorithms were developed for creating an optimum compliant structure, which minimizes the force required to morph surfaces during the full flight profile while maintaining maximum stiffness to withstand all external pressure conditions.

Potential Air Force Application

The technology developed under the SBIR program is ready for transition into military vehicles including Unmanned Air Vehicles. Better performing airfoils offer a whole new generation of quieter, faster, and more reliable vehicles and systems. The fuel fraction of an unmanned surveillance and reconnaissance vehicle is very high, thereby necessitating its operation under varying lift coefficients. A smooth continuous surface with variable geometry control surfaces offers significant drag reduction and enhanced performance under varying flight conditions thereby extending the mission time or range of one of these vehicles. The variable camber compliant surface technology can also be applied to military transport aircraft for fuel efficiency, and combat aircraft for enhanced roll performance and maneuverability. The technology also offers very promising applications to variable geometry engine inlets and other surfaces to improve the performance of jet engines. Application of the Compliant Wing technology to leading and trailing edges of a helicopter rotor could also have an even greater impact as demonstrated by FlexSys through an Army subcontract and an on-going DARPA contract.

Company Impact

FlexSys Inc. was founded as a result of Air Force SBIR contract, which enabled the transformation of a biologically inspired design concept into a practical reality. The technology developed under the Air Force SBIR has direct applications to commercial aircraft, helicopters, wind turbines, and underwater surfaces. A medium range transport aircraft with variable geometry compliant wing can save about 5% in fuel consumption. Combined with FlexSys's laminar flow technology the fuel savings can be as high as 12%. To put these percentages in perspective, approximately 50% of a commercial airline's operating budget is comprised of fuel costs. During the first eight months of 2006, domestic airlines spent $25.5 billion on 12.8 billion gallons of fuel, according to the Air Transportation Association. Consuming 3% less fuel would amount to $766 million savings over that period. Morphing the leading edge of a rotor blade once per revolution, as recently demonstrated by FlexSys, offers 12-25% gain in speed and maneuverability and about 10% increase in payload. The SBIR project positioned the company as a world leader in adaptive structures technology.

The design technology developed by FlexSys under this SBIR also applies to development of shape morphing or otherwise compliant design for consumer products. One such example is a one-piece compliant windshield wiper, which costs significantly less to produce in a fully automated manner here in the US compared to the imported ones. Automotive compliant wiper blades and side view mirror actuator technologies are already in transition to commercialization. Other applications of this unique design technology, developed under the Air Force SBIR Program, include development of novel consumer products and medical devices.

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