

SBIR Topic Number:
AF00-279

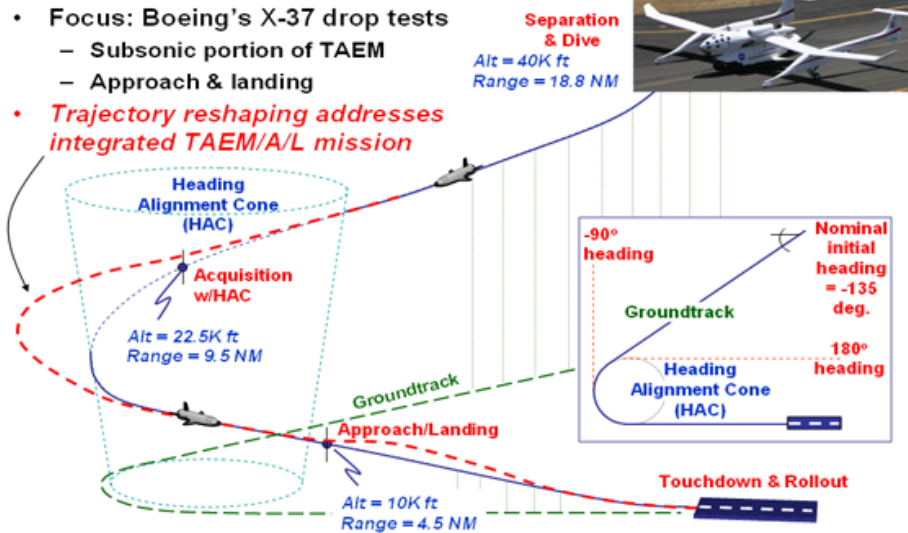
SBIR Title:
Guidance and Control
Techniques for Hypersonic
Vehicles

Contract Number:
F33615-01-C-3114

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.



Adaptive Guidance System for Hypersonic Vehicles with Reconfigurable Inner-Loop Control

- The Air Force requires time-critical access to space using highly safe and reliable launch vehicles employing reconfigurable or adaptive guidance and control technologies
- Our guidance and trajectory reshaping algorithms have been flight-tested to demonstrate their ability to recover the mission following several simulated failure scenarios
- Other potential applications include “smart” munitions, reconfigurable satellite formations, manned aircraft systems, air traffic control, and battle management and asset allocation planning
- Additional Reusable Launch Vehicle (RLV) programs include adaptive guidance and control during ascent and decent, rapid mission planning, and trajectory reshaping for the FAST vehicle

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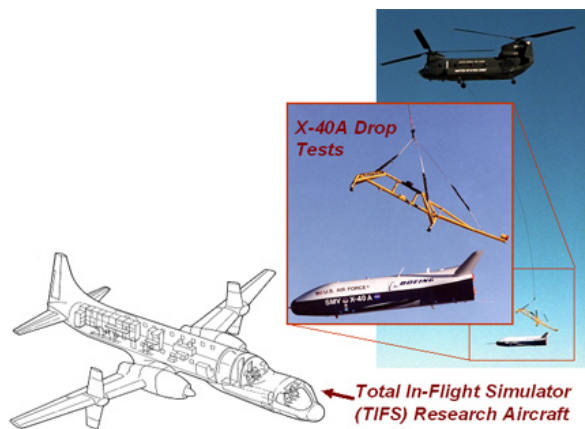
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Air Force Requirement

There is wide interest from the Air Force, NASA and other DoD agencies for responsive access to space. Rapid turnaround is needed to support time-critical missions such as emergency re-supply of space assets, satellite rendezvous, threat interception, and intercontinental munitions delivery. The long-term goal is for aircraft-like operation of launch vehicle fleets with substantially increased safety and reliability by employing reconfigurable or adaptive guidance and control technologies. This will enable autonomous response to anomalous conditions such as locked control effectors or structural damage. Since these vehicles will be unpowered as they glide back to earth, in-flight changes to the energy management plan through autonomous trajectory reshaping is critical to enable safe recovery.

SBIR Technology

The reconfigurable guidance approach for Reusable Launch Vehicles (RLVs) was first developed in Phase I for the approach/landing flight regime. Phase II was a joint venture funded by AFRL and NASA's Marshall Space Flight Center to support a related Phase III program that demonstrated our guidance and trajectory reshaping algorithms in a series of flight tests on CALSPAN's Total In-Flight Simulator (TIFS) research aircraft. The TIFS simulated Boeing's X-40A RLV dynamics in a series of "drop tests" (shown in the figure below) that demonstrated our algorithm's ability to recover the mission following several simulated failure scenarios that required control and guidance reconfiguration and trajectory reshaping. These successes led to an extension program to develop our reconfigurable control, adaptive guidance, and trajectory reshaping approaches for real-time Hardware-In-the-Loop (HIL) testing of Boeing's X-37 RLV. The HIL tests investigated subsonic Terminal Area Energy Management (TAEM) from approach



to landing, as shown on Page 1. The results successfully elevated the TRLs of these technologies. We also completed a requirements study for the Common Aero Vehicle (CAV), a technology pathfinder associated with DARPA's FALCON intercontinental munitions development program, to assess the benefits of these technologies. We teamed with Dr. Ping Lu of Iowa State University to develop a novel adaptive guidance approach that achieved very stringent targeting requirements.

Potential Air Force Application

The adaptive guidance and control, and trajectory reshaping technologies, developed under this program have potential application to a number of other related aerospace, defense, and commercial systems. These technologies have been developed for application to several unmanned UAV-type systems. They also have potential use for "smart" munitions and other delivered weapon systems, for autonomous response to varying mission requirements on reconfigurable satellite formations, and for manned aircraft systems. Also, our spin-off rapid mission planning technology has clear application for air traffic control, "smart" commercial aircraft that plan their own flight trajectories, and military battle management and asset allocation planning

Company Impact

This SBIR program has led Barron Associates to pursue the following RLV development program opportunities:

1. Integrated Adaptive Guidance and Control for RLVs During Ascent: Teamed with Northrop Grumman and Dr Ping Lu of Iowa State University.
2. Integrated Adaptive Guidance and Control for RLVs During Re-entry: Teamed with Boeing.
3. Rapid Mission Planning Using Integrated Adaptive Guidance & Control: Teamed with Lockheed Martin.
4. Trajectory Reshaping Development for the Air Force FAST Vehicle Concept: Subcontractor to Honeywell

These current and other past RLV related programs represent over \$2M in funded research. Our RLV business area is expected to employ approximately eight personnel over the next several years.



SBIR/STTR

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