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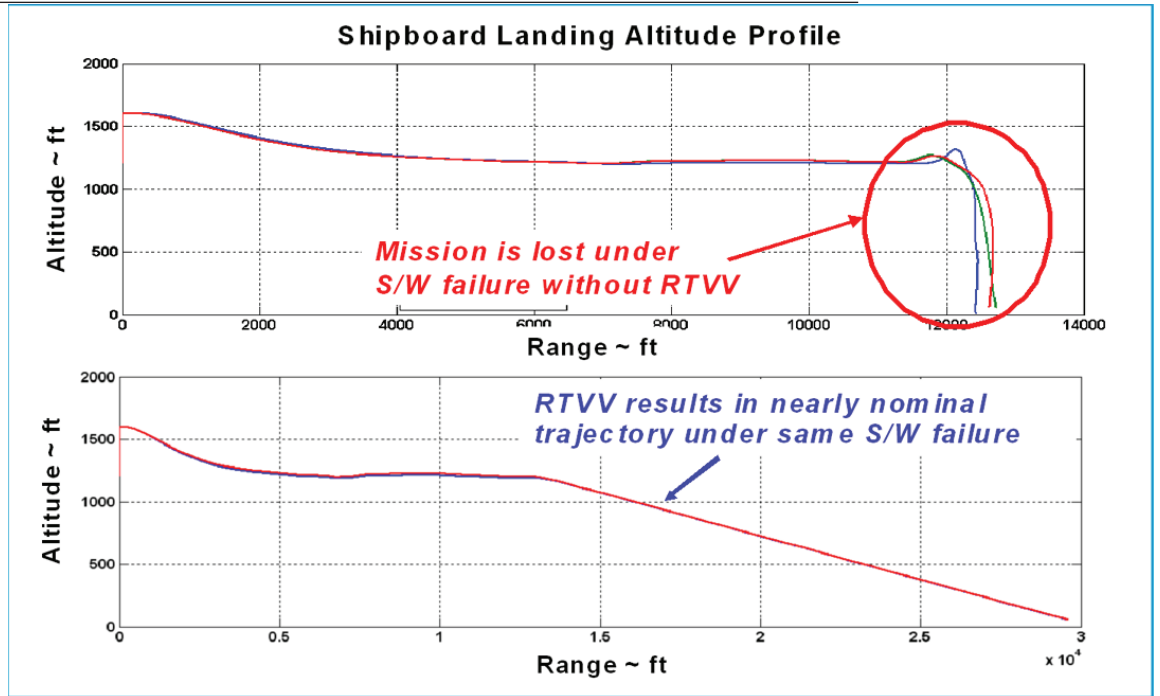
SBIR Title:
Technology for Affordable Validation and Verification (V&V) Software Design Processes and Safe Flight-Critical Software

Contract Number:
FA8650-05-C-3504

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.



Effect of Run-Time V&V on sea-based surveillance/endurance UAV mission

Run-Time Verification and Validation for Safety-Critical Flight Control Systems

- The Air Force has a requirement for new, affordable verification and validation (V&V) techniques to enable the integration and fielding of complex, advanced flight control systems for their aircraft.
- Other potential applications include UAVs operating in FAA designated airspace, automated aerial refueling of swarms of UAVs, and automated ground and collision avoidance systems.
- The safety-assurance RTVV system continually monitors advanced components and, if necessary, switches to a simpler, reversionary mode to provide a “graceful degradation” capability.
- This SBIR led to several teaming opportunities between Barron Associates and Lockheed Martin in support of AFRL’s overarching Flight Critical System Software Initiative (FCSSI).

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Air Force Requirement

New and emerging mission and operational capabilities, such as micro air vehicles, morphing wings, cooperative flight, and automated aerial refueling, require ever-increasing levels of complexity and autonomy. While fundamental flight control research has made great progress in addressing these needs, advances in software verification and validation (V&V) practices have failed to keep pace. As a result, many compelling flight control solutions cannot be implemented, thus producing a widening gap between realized and desired system capability. There is clear, pressing need for new V&V techniques that can provide strong safety guarantees for advanced systems while controlling V&V costs.

SBIR Technology

This problem is being addressed by AFRL's Flight Critical System Software Initiative (FCSSI) under which this SBIR program was funded. During Phase I, Barron Associates developed a prototype Run-Time V&V (RTVV) concept in which advanced algorithms, intelligent/adaptive control laws, or other complex subsystems, not certifiable with today's V&V technologies, were continually monitored. If observed behavior was not as expected, then the advanced system was shut down and operation was switched to a reversionary mode made up of simpler, pre-certified code. This reversionary mode gave the air vehicle "return-to-base" capability so the problem could be analyzed, thus saving the vehicle if not the mission. The Phase II program focused on advancing "performance" RTVV systems, in which individual subsystems, components, or particular algorithms within the overall feedback system were monitored. If such subsystems operated outside of expected behavior, they were terminated and reversionary, simpler components were used to replace the functionality of the higher-risk components. This architecture allowed for incremental switching or "graceful degradation" so some of the advanced, higher risk features could still operate after problems were detected in other advanced components. Under certain situations this may allow the mission to continue, thus increasing overall system robustness. During the two-year Enhancement program, a safety assurance framework was developed that covered the complete flight software system. This framework continually monitors the critical states of the system to determine whether an unsafe or non-certified state is imminent. In this event, reversion and recovery are commanded before the unsafe state is reached. This enables current flight certification standards to be relaxed for systems "protected"

by a safety-assurance RTVV system, thus allowing V&V cost savings to be realized and advanced flight control systems, not certifiable by today's methods, to be implemented.

During this SBIR program, Barron Associates worked with Lockheed Martin to explore implementation of the RTVV technologies. Lockheed performed real-time testing in their hardware-in-the-loop laboratory. They also provided a high fidelity model of a sea-based surveillance/ endurance UAV as a demonstration platform for experimental testing/analysis (see page 1). Simulations proved the benefits of RTVV in assuring vehicle safety during operation with an advanced control system.

Potential Air Force Application

This SBIR developed technology has the potential to dramatically reduce the development costs associated with a flight-critical system. The RTVV framework and technologies enable the use of advanced software to significantly improve the performance and safety of next-generation Air Force systems. Potential applications include single and multiple UAVs operating in FAA designated airspace; automated aerial refueling of swarms of UAVs; automated ground and collision avoidance systems; and advanced guidance and control systems.

Company Impact

This SBIR has led to these related opportunities for Barron Associates in support of the overarching FCSSI program:

1. Certification Techniques for Advanced Flight Critical Systems (CerTA FCS): Teaming arrangement with Lockheed Martin led to substantial involvement.
2. Challenge Problem Initiative (CPI): Follow-on to CerTA FCS. As sub to Lockheed, worked with Rockwell Collins in developing advanced design-time V&V approaches for certifying RTVV software.
3. Challenge Problem Demonstration (CPD): Follow-on to CPI; as a sub to Lockheed, will be demonstrating RTVV technologies prototyped in CPI.
4. Mixed Critical Architecture Requirements (MCAR): As sub to Lockheed, developed mixed critical architecture prototype for future flight control software systems.

Barron Associates is expanding their R&D capability in order to continue developing advanced V&V techniques for guidance, control and mission flight software.



SBIR/STTR

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