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The following equipment has been procured with the subject contract funds: 2 each, Demonstrant Integrated UAV Testbed, at a cost of $182, 000 per unit.
The Integrated Demonstrant UAV Airframe and Avionics Hardware is a build-to-order system described in detail in the attached Airframe and Avionics Specification. This equipment is presently being used to support an Air Force Office of Scientific Research contracted research project in the area of controlled active vision (Guided Systems Technologies, Cornell University and the Georgia Institute of Technology Phase II STTR Award, Contract F49620-02-C-0017). Immediate potential future uses for these testbeds will include demonstrations of adaptive cooperative flight control concepts presently being developed under our AFOSR grant (Research in Neural Network Based Adaptive Control, Contract F49620-01-1-0024), and in support of a MURI effort (if awarded) in the area of vision based flight control in complex 3-D adversarial environments.

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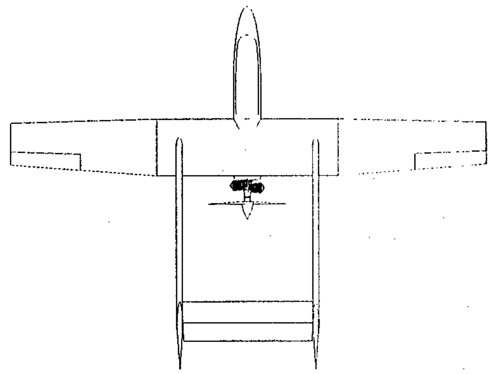
Report on Expenditure of DURIP Funds

Final Report



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Summary

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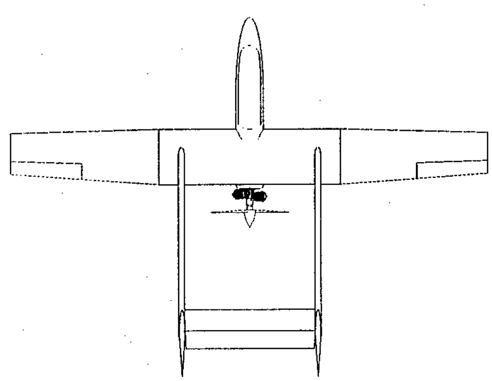
Demonstrant

A Fixed-Wing Unmanned Air Vehicle

Designed for Research In Controlled Active Vision and Cooperative Flight



Integrated *Demonstrant* UAV Airframe & Avionics Hardware Specification

Interest in the military application of Unmanned Air Vehicles (UAVs) is expanding rapidly. Funding of research and development in the area of UAVs, and UAV control systems in particular, has increased dramatically within the U.S. Air Force, Army, Navy and DARPA. "Autonomous control system development is one of the most important and challenging technologies in order for UAV's to fulfill their potential [1]."

Georgia Tech in close collaboration with Guided Systems Technologies, Inc. (GST) has a long history of successful UAV control systems research, development and demonstration to include the Association for Unmanned Vehicle Systems International's Student Aerial Robotics Competition (1992-93), flight demonstration of early neural network research (neural network adaptive control for the U.S. Army's Free Flight Rotorcraft Research Vehicle 1994-95), funded programs for demonstration of technologies for autonomous flight operations (U.S. Army ASRT program, 1996), demonstration of neural network adaptive control for DoD systems (the 1998 Air Force RESTORE program demonstration on the X-36, and the 2001 Advanced Adaptive Autopilot on the Joint Direct Attack Munition), as well as demonstration of the latest neural network output feedback adaptive control formulations on a rotary wing testbed (1998-2002).

This practical UAV expertise and experience has been exploited to design a UAV testbed to meet the anticipated need for low-cost in-flight evaluation and demonstration of developed UAV control system technologies. The testbed features a fixed-wing UAV airframe integrated with a state-of-the-art commercial-grade avionics suite. The system is fully compatible with previous generation GST UAV testbed hardware and software, is directly compatible with existing GST real-time hardware-in-the-loop simulation facilities, and is compatible with the existing GST UAV flight test range facilities and procedures.

[1] Banda, Siva, "Future Directions in Control of Unmanned Air Vehicles" to be presented at the AFOSR Workshop on Future Directions in Control, 26,27 April, 2002, Arlington, VA.

Definitions

The following definitions shall be employed wherever the associated terms are used in the remainder of this specification.

Empty Weight is defined as the weight of the flight-ready vehicle, less the typical payload of guidance and control system avionics and an imaging mission equipment package, less any required ballast, less consumables such as fuel, and less any batteries that serve as the primary source of power for electrical equipment required to perform remotely-piloted and manually-controlled flight.

Minimum Fuel and Battery Load is defined as the weight of fuel and battery required to provide 30 minutes of sustained flight by a remote pilot with manual control.

Minimum Take-Off Weight is defined as Empty Weight plus the weight of any ballast required, and the weight of the minimum fuel and primary-source battery load.

Low Speed Maneuver Set is defined as the following sequence of maneuvers: take-off from an unpaved runway of no more than A feet in length, climb to an altitude of B feet, flight in a figure eight pattern at a constant velocity of no more than C miles per hour while maintaining altitude to within plus or minus D feet, with a turn radius of no more than E feet, and landing on an upaved runway of no more than A feet in length.

The values of A, B, C, D and E are to be determined during testing of the Demonstrant UAV. Target values are as follows: A = 300 feet, B = 500 feet, C = 35 miles per hour, D = 25 feet, and E = 100 feet.

Maximum Practical Aircraft Gross Weight is defined as the maximum gross weight at which the vehicle can be safely commanded to perform the prescribed Low Speed Maneuver Set.

Useful Payload is defined as the Maximum Practical Aircraft Gross Weight less the Empty Weight of the vehicle and less the weight of the fuel and primary-source batteries required to complete a nominal 2.5-hour mission.

Specifications

The *Demonstrant* testbed, shall meet or exceed the following hardware specifications.

- A fixed-wing pusher-prop aircraft configuration is employed and is sized to allow for agile low-altitude operations at low speeds, including low-speed take-off and landing, as well as to perform the prescribed Low Speed Maneuver Set defined in Section 2.0;
- Total wing span does not exceed 15 feet, and total vehicle length does not exceed 12 feet;
- An easily removable 3-section wing, as well as easily removable tail surfaces and tail booms allows for compact storage and transportation of the UAV, as well as provide for the simple design and substitution of alternate wings.
- The system employs rugged landing gear with wheels sized to enable take-off and landing from an unpaved runway;
- The system employs a gasoline power plant with spark ignition and external electric starter;
- A high-end 72 MHz hobby-type handheld radio transmitter is employed for remote piloting, and includes battery backup and dual redundant radio receivers and actuators;
- The system features an internal payload bay, approximately 3 cubic feet in volume, with quick and easy external access.
- The system features a forward bulkhead with hard-points that support mounting of a generic mission equipment package on the aircraft nose.
- An on-board 240 Watt DC continuous power generation capability is provided with companion on-board battery for load regulation and sufficient for 1 hour primary power backup;
- Useful Payload (as defined in Section 2.0) is in the range of 40-50 pounds, depending on the specific vehicle configuration, and the Maximum Practical Aircraft Gross Weight in each case less is than or equal to 100 pounds.
- A "Controlled Active Vision" (CAV) Research and Development mission equipment package consisting of the following three (3) subassemblies is integrated into the *Demonstrant* airframe:
  - Model FCS-3 all-attitude, commercial-grade integrated telemetry, navigation and flight control avionics hardware set with high-speed

auxiliary image processing computer integrated into a single housing that is compatible with the *Demonstrant* internal payload bay. The FCS-3 is fully compatible with current generation hardware and software for interfacing with the pilot's radio control system and control surface actuators, existing software for neural network adaptive guidance and control, the existing UAV ground control station, including its associated navigation aids and communication links, existing software and equipment for real-time hardware-in-the-loop simulation, and hardware, software and procedures for conducting UAV flight operations at GST's Henry County test site;

- General purpose Model S3 external sensor mount with a 3-axis computer-controlled set of gimbals installed on the forward bulkhead at the nose of the *Demonstrant* and providing both forward and down-looking external sensor views;

- Wide field-of-view stabilized digital imaging sensor module with zoom capability fitted to the Model S3 gimbaled external sensor mount and interfaced with the auxiliary image processing computer housed in the internal payload bay;