

**RESEARCH CONSIDERATIONS TO
ASSIST IN THE DEVELOPMENT OF A COOPERATIVE AGREEMENT
FOR RESEARCH IN
PREDICTIVE TIME-ASSOCIATED GEO-LOCATION OF MOBILE TARGETS
IN THE ACADEMY CENTER FOR UNMANNED AIRCRAFT SYSTEMS RESEARCH
OF THE DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING**

DATE: January 10, 2012

1. GENERAL DESCRIPTION OF RESEARCH TO BE PERFORMED

The Academy center for unmanned aircraft systems research seeks to find research solutions to heterogeneous, autonomous unmanned systems. The overall research topics of interest are real-time technologies associated with lightweight cooperative unmanned aircraft systems used in an increasing number of military and civilian applications. Currently, the center is looking for a research team who can develop comprehensive solution methods that can (1) incorporate aperiodic sensor data obtained from multiple heterogeneous sensors to geo-locate mobile targets and (2) predict the position and orientation of targets in future time based on accumulated sensor data and physical and environmental constraints.

The results of the research will be incorporated into an experimental system for a joint force unit to test the feasibility of using multiple manned and unmanned systems to search, locate, and track ground mobile targets. Due to the distributed nature of the overall system, development of intelligent techniques to use time-delayed information is a critical portion of this project. Each manned or unmanned system has resources to process sensor data or information received by other systems. As such, any sensor-fusion tasks must be performed in multiple units with built-in redundancies to remedy any communication interruptions during an operation. To predict the location and orientation of targets, each platform must incorporate constraints of its platform dynamics, derived dynamics of targets, and mission environments in real-time as it makes control and sensing decisions. With user inputs, critical and pertinent information must then be shared among manned and unmanned systems that are working as a cooperative team.

2. OBJECTIVES AND EXPECTATIONS OF RESEARCH

- A. Provide sensor-fusion solutions that incorporate time-delayed heterogeneous sensor data from multiple sensors and physical and environmental constraints of physical mobile sensor platforms, mobile targets, and the mission areas. Perform basic and applied research to design, integrate and implement sensor-fusion solutions; derive experimental strategies; conduct field experiments; analyze performance results; report to the Academy UAS research director on the plans and progress of the investigations; present progress and findings to outside sponsors; and present results at technical, scholarly conferences and meetings.
- B. Support of cadet research associated with the project. Support of weekly cadet research activities through weekly meetings. Participation in major project reviews including System Requirements Review, Preliminary Design Review, Critical Design Review, and Final Acceptance Review.
- C. All final reports shall be submitted to the Director of Academy Center for Unmanned Aircraft Research and Defense Technical Information Center (DTIC).

The selected research team is expected to be familiar with currently available sensor fusion technologies in the related literature including filter-based and information-based methods. The research team should possess the capability to optimally (mathematically provable) incorporate time-delayed sensor data as well as an ample amount of previously demonstrated experiences on vision-based control, image processing, and state estimation techniques including Kalman filters, Sigma-Point Kalman filters, grid-based methods, particle filters, Gaussian sum filters, and non-linear filters.

3. BACKGROUND INFORMATION

The USAFA research work on cooperative systems started in 2002 with the support of AFOSR through the USAFA small grant research program. Since then, a large number of Electrical and Computer Engineering Department faculty and staff have worked with faculty from the departments of Aeronautics, Engineering Mechanics, Physics, Mathematics, and Computer Science on a number of different projects associated with cooperative ground and air unmanned systems. Outside of the Academy, we have also worked with researchers from AFRL (directorates of Munitions, Sensor, and Air Vehicles, Information, Space Vehicles), NRL (Naval Research Laboratory), AFIT, US Military Academy, US Naval Academy, Purdue University, University of Wyoming, and Raytheon Corporation, to name a few.

The particular research problem requires novel integration methods to combine existing and new sensor fusion technologies. A great deal of the knowledge developed in the field resides in a number of technical papers and journal articles developed in the community. These include: IEEE Transactions on Robotics and Automation, IEEE Conference Proceedings on Robotics and Automation, IEEE Conference Proceedings on Automatic Control, IEEE Transactions on Automatic Control, IEEE Transactions on System, Man, and Cybernetics, American Control Conference Proceedings, IEEE Conference Proceedings on Decision and Control, and IEEE Conference Proceedings on Networks, Sensing, and Control. The developed system will potentially be used by joint forces to carry out Intelligence Collection, Surveillance, and Reconnaissance (ISR) missions.

4. POSSIBLE KNOWN CONSTRAINTS

We have invested a great deal of effort into developing multiple cooperative systems technologies. As a result, we expect that the research will move forward based on the technologies we have already developed. The work requires an in-depth knowledge of unmanned aerial system auto-pilots, passive and active radio-frequency sensor design and implementation, wireless communication, sensor fusion techniques, and sensor systems. A working knowledge of simulating aircraft dynamics and incorporating the simulation with the outputs of actual sensors (optical/infrared cameras and radio frequency sensors, for example) is crucial. Ability to remove electronic noise to prevent wireless communication interference is also necessary.

Experimental efforts are to be performed in the USAFA's Unmanned Aircraft Systems Laboratory and during flight operations. These facilities must be scheduled well in advance, and offerors are advised that time available in them will be limited, subject to cancellation in support of other priorities, and constrained to the department work schedules.

Offerors' personnel must coordinate and cooperate with personnel working on other contractual efforts in support of the Department of Electrical and Computer Engineering, and with other USAFA faculty, staff, and cadets.

5. REQUIRED DELIVERABLES

Deliverables include lab notebooks, technical reports, technical papers, and journal articles for professional societies. Deliverables shall be delivered in research notebooks, graphical representations or on magnetic/optical media as appropriate. Data deliverables shall be a contemporaneous record of the experiment.

A final report is required and shall be submitted to the Technical POC and Grants Officer upon completion of the effort. Upon acceptance of the final report the recipient shall forward it to the Defense Technical Information Center (DTIC).

6. GOVERNMENT FURNISHED PROPERTY

Proficiency on the following Government Furnished Property (GFP) is required:

- Matlab software
- Multiple UAVs hardware and software system
- Linux operating systems
- Sensor decoders and encoders

The contractor shall have right-of-use to the above GFP; however, this equipment will not be assigned to the contractor.

The following GFP will be assigned to the contractor and the contractor shall bear responsibility for this equipment:

- Laptop Computer

7. REQUIRED TRAVEL

Travel will be required in support of this effort. Specific information regarding travel will be provided by the Academy Center for Unmanned Aircraft Systems Research. The Contractor shall provide the CO, through the QAP, upon request for reimbursement, a copy of all travel related receipts. The CO shall approve the travel reimbursement request and upon receipt of this approval the contractor may submit their invoice into Wide Area Work Flow (WAWF). The work defined in this contract shall be performed principally at the United States Air Force Academy, Colorado. All travel costs for lodging, meals and incidental expenses shall be based on the per diem rates noted in the JTR.

8. OPERATIONS SECURITY CONSIDERATIONS

The deliverables under this effort and any scientific or technical information obtained or provided under this project have been identified as critical information and shall not be released either formally or informally to anyone without the written consent of the USAFA Scientific and Technologic Information Officer (STINFO). The USAFA STINFO Officer is the Director of Research, 719-333-4195.

9. ORGANIZATIONAL CONFLICT OF INTEREST (OCI) CONSIDERATIONS

None anticipated.

10. DATA RIGHTS

The Government has government purpose rights to all deliverables under this effort. The U.S. Government will be given a royalty free, world-wide, nonexclusive, irrevocable license to use, modify, reproduce, release, perform, display or disclose any data for Government purposes. Appropriate markings should be affixed on any data delivered in accordance with the data rights clause in the agreement.

11. RESEARCH SCHEDULE

The contractor shall include in their proposal a proposed milestone progress schedule. The schedule shall include start, periodic review and end dates. The schedule shall also detail the types of reports (verbal or written deliverables) that will be provided at each milestone. This schedule will double as an invoicing schedule. The technical POC or Research Center Director may request additional verbal reports as deemed necessary by the pace of the work.

12. ESTIMATE OF EFFORT REQUIRED

This is estimated to be an 18 month effort and the resultant award will be issued on that basis. Continuation throughout the period of performance is contingent on the availability of funds.