

PROGRAM *(as of 10/14/08)*

www.ion.org/mas

GNC Challenges for Miniature Autonomous Systems Workshop

October 20-22, 2008

Holiday Inn Sunspree Resort
Fort Walton Beach, FL



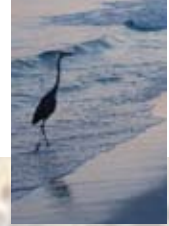
Sponsored By:
The Air Force Research Lab, Munitions Directorate



Facilitated By:
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Workshop Co-Chairs, Planning Committee & Description



Workshop Co-Chairs:

Mr. Fred Davis, *AFRL/RWA*



Dr. Mikel Miller, *AFRL/RWG*



Planning Committee:

Dr. Gregg Abate, *AFRL/RWGN*

Dr. Jacob Campbell, *AFRL/RYRN*

Dr. William Humbert, *AFRL/RWGS*

Dr. Robert Murphey, *AFRL/RWGN*

2Lt Caroline New, *AFRL/RWGN*

Dr. John Raquet, *AFIT*

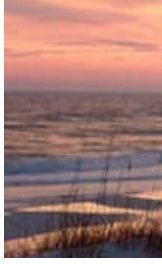
Workshop Description:

This workshop is intended to bring the DoD technical and user community, academia, and industry together to review and discuss advances in guidance, navigation, and control (GNC) for Miniature Autonomous Systems. Current trends show that future systems will be miniature (less than 20 lbs total system weight) for a number of reasons. First, they will be much cheaper to develop and build than current systems. Second, their smaller size will allow them to be carried in large numbers and be compatible with small UAVs for air-launched systems. Also, Miniature Autonomous Systems have the potential to fill the capability gap that is necessary for access to difficult targets such as hardened command and control facilities.

Miniature autonomous systems capable of agile locomotion or flight in urban, forested, and indoor (including transitions from outdoor to indoor) environments present many unique technical challenges to the controls and systems engineer. It is envisioned that the military use of miniature systems will include acquiring, tracking, and engaging non-traditional targets. Such miniature systems will use economies of scale and synergies in time-space trajectories to compensate for individual small payloads with subsequent small chemical and kinetic energies. There are many fundamental technical gaps that prevent building these systems today. Miniature systems imply small sensor apertures with subsequent poor resolution making the system less observable and therefore harder to control. Miniature systems, either airborne or ground-based have built-in plant nonlinearities and instabilities stemming from the fact that some physical forces (e.g., viscous and friction) become comparable in magnitude to inertial forces. Miniature systems will also face fundamental challenges with insufficient actuation and will need to exploit small but dense power systems and (perhaps distributed) computational resources with limited performance.

A benefit of miniature weapon systems is the potential to greatly limit collateral damage in urban scenarios. However, very precise engagement is required to achieve the desired effects in defeating targets. Urban environments and scenarios offer unique GNC challenges for Miniature Autonomous Systems as well. Since small, agile vehicles will be required to traverse the complex flight environment in so-called "urban canyons" and the possibility exists that such systems will both outdoor and indoor applications. "Tight" operating environments, clutter, obstacles, and RF interference can create situations where extremely agile GNC techniques are required. All of these applications will challenge GNC technologies for miniature autonomous systems. This workshop offers a review of active programs in the field, a window on significant trends, and the opportunity to present new technology to the community.

The workshop will feature presentations from leaders in the DoD technical and user communities, academia, and industry. The first day of the workshop will feature perspectives from the operations community, and GNC research challenge talks from senior research representatives of the Air Force, Navy, Army, and DARPA. The afternoon of the first day will feature For Official Use Only presentations. The second and third days of the workshop will feature public forum presentations and discussions centered around a variety of topics including Multi-use Miniature Seekers/Sensors; Advanced Navigation Sensors and Techniques; System Integration Challenges; and Multi-vehicle Cooperative Operations.



GNC Challenges for Miniature Autonomous Systems Workshop

Schedule: See www.ion.org/mas for Program Updates

Monday, October 20, 2008: FOUO Sessions

Operators Perspectives (FOUO):

8:00 a.m. – 9:00 a.m.

Moderator: Mr. Fred Davis, *Air Force Research Laboratory*

Operational Perspective: Col. James Geurts, *USSOCOM/SOAL/PEO-FW*

Predator Pilot Experience: Lt. Col. Dean Bushey, *USAF*

Break: 9:00 a.m. – 9:15 a.m.

Vision Challenges from the R&D Community (FOUO): 9:15 a.m. – 11:30 a.m.

Moderator: Dr. Mikel Miller, *Air Force Research Laboratory*

Navigation for Future Micro Munitions: Col. Kirk Kloeppel, *Director, AFRL/RW*

AFRL's Micro Air Vehicle Vision and GNC Challenges: Dr. Doug Blake, *Deputy Director AFRL/RB*

Micro-Inertial Navigation Technology (MINT) and Hybrid Insect MEMS (HIMEMS): Dr. Amit Lal, *DARPA*

Guidance and Control Issues and Opportunities for DARPA Nano Air Vehicle: Christopher Martin, *DARPA*

The Continuing Role of Bio-Inspiration in Miniature Autonomous Systems: Dr. Morley Stone, *Senior Technologist, AFMC 711 HPW/RH*

Box Lunch Provided: 11:30 a.m. – 1:00 p.m.

Special Presentation (FOUO):

12:35 p.m. – 12:55 p.m.

Micro UAS Autonomous Air Launch/Target Prosecution: 2Lt. Joseph Czabaraneck, *AFRL/RWAV*

FOUO Multi-Sensor GNC: 1:00 p.m. – 2:25 p.m.

Presentations in this session will review and/or discuss advances in guidance, navigation, and control (GNC) for Miniature Autonomous Systems which must be presented in an FOUO environment.

Co-chairs: Fred Davis, *Air Force Research Laboratory* and Dr. Mikel Miller, *Air Force Research Laboratory*

1. **Advanced GN&C for Nano-sized UAVs:** P. DeBietto, S. George, E. Ranger, G. Andrews, *Draper Laboratory*
2. **Guidance and Control of Airborne-Deployed Micro Air Vehicles:** K.J. Shortelle, W.R. Graham, *System Dynamics*
3. **Intelligent Navigation and Sensing for Cooperative Tasks (INSeCT)-Connecting Behaviors with Navigation Accuracy:** J.L. Campbell, D.T. Venable, *AFRL/RYRN*; J.T. Kresge, *AFIT ANT Center*
4. **LADAR EO GPS/INS Atomic Clock Navigation Demonstration (LEGAND):** R. Hartman, W. Hawkinson, P. Lommel, *Honeywell*

Discussion: 2:25 p.m. – 2:55 p.m.

FOUO Miniature Navigation Systems: 2:55 p.m. – 4:55 p.m.

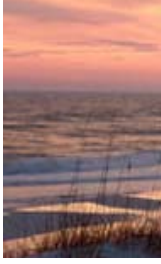
Co-chairs: Dr. Mikel Miller, *Air Force Research Laboratory* and Fred Davis, *Air Force Research Laboratory*

1. **DARPA Positioning, Navigation and Timing (PNT) Related MEMS Technologies: Transition Experience and Future Transition Opportunities:** J.T. Doherty, H. Last, *Institute for Defense Analyses*
2. **MEMS-based Inertial Technologies in the Present and Challenges for Inertial Technologies of the Future:** V. LeFevre, *US Army Aviation and Missile Command*
3. **Common Inertial Measurement Unit (CIMU) for Missile Defense Guidance Systems:** D.J. Weber, *Kearfott Corp., Guidance & Navigation Division*
4. **Stable MEMS IMU for Autonomous GNC:** D. Cardarelli, *MilliSensor Systems & Actuators, Inc.*
5. **A Single-Aperture Anti-Jam GPS-based Attitude Sensor and Inertial Navigation System:** K. Ezal, T. Mujahed, G. Johnson, C. Stankevitz, *Toyon Research Corporation*
6. **Miniature Navigation Unit for GPS EP and ES:** L. Haas, M. Clark, *Argon ST*; W. Soehren, L. Vallot, *Honeywell Aerospace Advanced Technology*

Alternates

1. **AFRL Sensors Directorate Miniature Inertial Sensor Developments:** M. Berarducci, *Air Force Research Laboratory*
2. **Robust Surface Navigation Phase 1 Program Update:** L. Haas, *Argon ST*

Discussion: 4:55 p.m. – 6:25 p.m.



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Tuesday, October 21, 2008: Public Access Sessions Day 1

Miniature Multi-Function Sensors: 8:30 a.m. – 10:30 a.m.

Capability gaps are often highlighted during conflicts, and the scientific community is tasked to develop technical solutions to fill these gaps. Given the proliferation of UAVs, we have an opportunity to capitalize on these platforms to perform more than just the typical ISR function. Adding a precision strike capability against challenging target sets in confined urban environments requires smaller, more maneuverable UAVs. Additionally, miniature systems may have increased seeker/sensor requirements at the small scale. This will place strict requirements on the development of miniature, multi-function sensors/seekers enabling this capability. This Session will highlight sensor/seeker technologies, and requirements which support this capability.

Chair: Dr. Bill Humbert, *Air Force Research Laboratory*

1. **Autonomous Sensory-Response Sciences Inspired by Nature:** J. Evers, *AFRL/RWGI*
2. **Progress on Bio-Inspired Visual Navigation:** P. Shoemaker, *Tanner Research, Inc.*; S. Humbert, *University of Maryland*
3. **Context-Dependent Adaptation of Orientation and Navigation to Chemical Plumes:** M.A. Willis, J.L. Talley, H. Chiel, R.D. Quinn, *Case Western Reserve University*; E.B. White, *Texas A&M University*
4. **Odor Tracking in the Natural World - A Model for Sensor Fused Guidance and Navigation:** A.J. Rutkowski, *Air Force Research Laboratory*; R.D. Quinn, M.A. Willis, *Case Western Reserve University*; M. Miller, *Air Force Research Laboratory*
5. **Prototype Ubiquitous Geospatial Intelligence (UGSI) Integrated Navigation and Communication System for Urban Applications:** K.M. Betts, B.K. DeKock, *SAIC, Space Development Division*; D.L. Reed, J. Gewehr, D. Bezanson, *SAIC, Space Systems Division*

Discussion: 10:30 a.m. – 11:30 a.m.

Lunch On Own: 11:30 a.m. – 1:30 p.m.

Advanced Navigation Techniques: 1:30 p.m. – 4:00 p.m.

This session focuses on advanced navigation techniques and methods for Miniature Autonomous Systems. In order to obtain robust position, navigation, and time (PNT) knowledge for a variety of Miniature Autonomous Systems, it is necessary to take advantage of new types of sensors and/or use existing sensors in innovative ways. This session will describe techniques and methods (vision-based navigation, gravity field navigation, magnetic field navigation, etc.) that exploit data from various sensors (i.e., cameras, laser-based systems, millimeter-wave radar, magnetometers, RF-based navigation sensors, combined communication/navigation systems, MEMS-based inertial systems, high sensitivity GPS, etc.). Of particular interest are PNT systems that can work in situations where standard GPS is not available or is only partially available. Included in the concept of PNT are position, velocity, attitude, and precise time information.

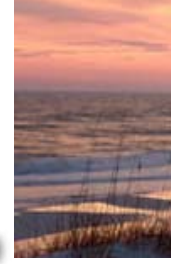
Chair: Dr. John Raquet, *Air Force Institute of Technology*

1. **A Sub 1 Cubic Inch Inertial Measurement Unit Development:** S. Hills, M. Durrant, J. Gingrich, *Atlantic Inertial Systems*
2. **Accurate Inertial Measurement by Application and Processing of Arrays of MEMS Inertial Sensors:** M. Tanenhaus, *JayMart Sensors*; D. Carhoun, *Consultant*; Ti. Geis, *Consultant*; A. Holland, *Eminent MicroSystems*
3. **A Differential RTK System for Small UAV:** T. Arthur, *Ohio University*
4. **Position Location with Periodic Codes in Broadcast Digital Transmissions:** C. Yang, *Sigtem Technology, Inc.*; T. Nguyen, *AFRL/RYRN*
5. **On GPS Signal Multi-Path Modeling in High Dynamics Environments:** S. Nedic, *Nedics Associates*

Discussion: 4:00 p.m. – 5:00 p.m.

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Wednesday, October 22, 2008: Public Access Sessions Day 2

System Integration Challenges – Multi Sensor Navigation: 8:30 a.m. – 10:30 a.m.

Future GNC challenges for miniature autonomous systems will require novel integration approaches. This session focuses on the issues and challenges facing current and future GNC hardware and software algorithms for multi-sensor fusion in miniature systems. This session will feature innovative solutions used to integrate the hardware and software into a miniature “system of systems.” That is, the system is highly multidisciplinary. Additionally, in order to meet size, weight, and power restrictions associated with miniature systems, sensors will need to be multi-functional. For example, a Ladar could serve as a sensor and a line-of-sight communication signal. Presentations discussing new ways of integrating traditional or innovative sensors will be offered.

Chair: Dr. T.J. Klausutis, *Air Force Research Laboratory*

- 1. Integrated Sensing and Processing for Miniature Systems:**
T. Klausutis, *AFRL/RWGI*
 - 2. Distributed MultiSensor Fusion for Improved Collaborative GPS-denied UAS Swarm Navigation:** J. Kaba, S. Wu, S.-C. Mau, T. Zhao, *Sarnoff Corporation*
 - 3. Exploitation of Pre-registered Imagery for Precision Geolocation:** M. Veth, F. Webber, *Air Force Institute of Technology*; M. Nielsen, *Air Force Test Pilot School*
 - 4. Multi-Sensor Integration Techniques for Navigation in Challenging Environments:** A. Soloviev, *University of Florida*
 - 5. Sensor Performance Analysis for Navigation of Miniature Autonomous Systems:** Dr. D. Grejner-Brzezinska, C.K. Toth, H. Sun, S. Moafipoor, N. Markiel, *The Ohio State University*
- Alternate**
- 1. A New Method for Electronic Compass Magnetometer Calibration for Improving Azimuth Calculation in Magnetometer/GPS Integrated System:** H. Guo, *Nanchang University, China/University of New Brunswick, Canada*; D. Kim, R. Langley, *University of New Brunswick, Canada*; M. Yu, C. Zou, W. Huang, *Jiangxi Normal University, China*

Discussion: 10:30 a.m. – 11:30 a.m.

Lunch On Own: 11:30 a.m. – 1:30 p.m.

Controlling Miniature Autonomous Systems: 1:30 p.m. – 4:00 p.m.

Miniature systems, either airborne or ground-based, have built-in plant nonlinearities and instabilities stemming from the fact that physical properties do not scale linearly nor proportionally (e.g., viscous and friction forces may become comparable in magnitude to inertial forces at this scale). This session will focus on current research activities to meet the needs of plant observability controllability, and stability for small autonomous systems, including robust, distributed sensing and actuation architectures that exploit low quality sensors and low power effectors, adaptive control strategies that take advantage of environmental features whenever possible, and cooperative or networked approaches that use synergies of multiple entities to achieve a greater effect. Papers that illustrate modeling and application of control methodologies to micro systems will be offered.

Chair: Dr. Rob Murphey, *Air Force Research Laboratory*

- 1. Autonomous Control of Micro Autonomous Systems in Complex Environments:** G. Abate, *AFRL/RWGN*
 - 2. Challenges for Autonomous Control at the Small/Mini/Micro Scale:** M. Costello, *Georgia Tech*
 - 3. Small Mobile Robots Autonomously Navigating with Low Power Microcontrollers:** W.A. Lewinger, C.M. Harley, R.E. Ritzmann, M.S. Branicky, R.D. Quinn, *Case Western Reserve University*
 - 4. Cooperative Navigation:** R. Allen, C. Xu, *Lone Star Aerospace*
 - 5. Multiple Unmanned Vehicle Cooperative Engagement Software:** J. Carbone, Jim Carter, *Proxy Aviation Systems*
- Alternate**
- 1. Human Supervision of Cooperative Time Critical Miniature Autonomous Systems:** R. Murphey, *AFRL/RWGN*

Discussion: 4:00 p.m. – 5:00 p.m.



LOCATION & HOTEL RESERVATIONS:

All workshop sessions will be held at the Holiday Inn Sunspree Resort, 573 Santa Rosa Blvd., Fort Walton Beach, Florida, 32548.

Reservations: A limited number of sleeping rooms are available at the government per diem rate (currently \$118.00 per night) and include wireless internet, self parking, refrigerator and microwave. For reservations please contact the reservations department at 1-800-238-8686 and ask for the "Navigation Group". Pre-paid, non-refundable, discounted hotel reservations may also be available by booking on-line at www.hifwb.com. Further details and pictures of the hotel can be found at www.hifwb.com.

REGISTRATION INFORMATION: REGISTER ONLINE!

Go to www.ion.org and follow the GNC Challenges for Miniature Autonomous Systems Workshop links to guide you through the registration process. Registration includes all sessions, refreshment breaks and on-line access to public release presentations that have been submitted by the author. Lunch is on your own.

Registration Received and Paid by October 1: \$300

Registration Received or Paid after October 1: \$380

FOUO SESSION REQUIREMENTS (FOR MONDAY'S SESSIONS):

Attendance Requirements:

Must meet all of the following:

- 1) U.S. Citizen
- 2) Visit Request/Authorization Request and Need-to-Know Statement
- 3) Photo ID
- 4) Workshop Participation Badge and payment of registration fees

Security Clearance:

The FOUO sessions will be limited to U.S. citizens, DoD personnel and support contractors whose attendance is related to their position or program.

All visit requests must be received by October 1, 2008, and be approved by the AFRL/RW Security Office. For your convenience, a FOUO Visit Request Form can be found at www.ion.org under the GNC Challenges for Miniature Autonomous Systems Workshop icon.

All non-government personnel must also complete a form DD 2345 which can also be www.ion.org under the GNC Challenges for Miniature Autonomous Systems Workshop icon.

Fax All Visit Request and Need-to-Know Statements to:

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GNC Challenges for Miniature Autonomous Systems Workshop

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REGISTRATION FORM

REGISTRATION INCLUDES all sessions, refreshment breaks and on-line access to public release presentations that have been submitted by the presenter. Lunch is on your own.

Go to www.ion.org and follow the GNC Challenges for Miniature Autonomous Systems Workshop links to guide you through the registration process (available August 2008). **Expect confirmation within two weeks.** Please call the ION® if you do not receive confirmation within 2 weeks.

Registration Received and Postmarked **BY** October 1: **\$300** _____

Registration Received or Postmarked **AFTER** October 1: **\$380** _____

Table Top Exhibitors – Electricity Required Yes No **\$780** _____
(One Complimentary Full Registration Included)

REGISTRANT INFORMATION (Please Type or Print)

Name: _____ Company: _____

Mailing Address: _____

City: _____ State: _____ Country: _____ Zip/Postal Code: _____

Phone: _____ Fax: _____ E-mail: _____

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METHOD OF PAYMENT – Payment must be received by the ION by October 1 to receive the early rate.

Check For Full Amount Enclosed—Please mail registration form with payment to the ION®, 3975 University Drive, Suite 390, Fairfax, VA 22030, USA. Make checks payable to the ION®. (U.S. dollars drawn on U.S. bank only)

I would like to pay by credit card—If paying by credit card, you may send your registration form by fax, Dedicated fax #: 703-383-9689, or mail. Do not mail a duplicate form if form has been faxed.

Circle One: Visa / MasterCard / American Express

Account #: _____ Exp. Date (required): _____

Credit Card Security Code: _____

Signature of cardholder: _____

CANCELLATION/REFUND POLICY: All cancellations/substitutions must be received *in writing or by fax at the ION® National Office*. Fees for written cancellations received on or prior to Oct. 1 are fully refundable. Written cancellations received Oct. 1 – Oct. 10 are refundable less a \$100 cancellation fee. This fee covers obligations incurred by the ION® in making registration arrangements and does not entitle the registrant to any conference materials. **Refunds will not be given for "no shows" or for cancellations received after Oct. 10;** however, full attendee substitutions for persons from the same organization that can assume the fees paid by the original registrant may be made through Oct. 22 at on-site registration. We regret that individual registration benefits are not transferable. Send cancellations and substitutions to the ION® National Office at: e-mail: membership@ion.org; fax: 1-703-383-9689.