

PROGRAM

(as of 10/15/09)

GNC Challenges for Miniature Autonomous Systems Workshop

October 26-28, 2009

www.ion.org/mas



Sponsored By: The Air Force Research Lab, Munitions Directorate

Facilitated By: The Institute of Navigation



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www.ion.org



Emerald Coast Conference Center
Fort Walton Beach, FL



Workshop Co-Chairs, Planning Committee & Description

Workshop Co-Chairs:

Mr. Fred Davis, *AFRL/RW*

Dr. Mikel Miller, *ION President*

Dr. Gregg Abate, *AIAA NWF Section Chair*



Planning Committee:

Mr. Fred Davis, *AFRL Munitions Directorate*

Dr. Mikel Miller, *ION President*

Dr. Gregg Abate, *AIAA Northwest Florida Section Chair*

Dr. Tom Doligalski, *ARL/ARO*

Dr. Leslie Perkins, *AFRL Air Vehicles Directorate*

1Lt Caroline New, *AFRL Munitions Directorate*

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 (i.e., 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 must be bridged so that we can build these systems. Today's small sensor apertures have poor resolution, making a MAS system that can be built today less observable and 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 include 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 (FOUO) presentations. The second and third days of the workshop will feature public forum presentations and discussions on 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 26, 2009: FOUO Sessions

8:30 a.m. – 11:30 a.m.

PLENARY SESSION

Technical Speakers:

Dr. John Wilcox, *AFRL/RW*

Dr. Leslie Perkins, *AFRL/RB*

Dr. Tom Doligalski, *ARL/ARO*

Dr. Azar Ali, *AFRL/RWA* – **Navigation Challenges in Insect Cyborgs**

Invited Operational Speakers:

Pete Chmelir, *NAVAIR-Weapons Division*

Mike Bata, *ACC/A8ZW*

Maj Travis Woodworth, *SOCOM*

Col (ret) Hondo Geurts, *USSOCOM/SOAL/REO-FW*

Marty Drake, *CENTCOM*

1:00 p.m. – 3:00 p.m.

Navigation-Grade Integrated Micro Gyroscopes (NGIMG) Development & Potential Uses - Panel Discussion

Panel Moderators: Mr. James Doherty, Dr. Howard Last, *Institute for Defense Analyses*

This panel discussion will provide information on the various NGIMG technologies being developed under the Defense Advanced Research Projects Agency Microsystems Technology Office (DARPA MTO) program and on potential military uses for these technologies. The panel members will consist of the NGIMG technology developers and DoD personnel active in the research and development of future host systems requiring advancements in GNC technologies. Currently, three different NGIMG technologies being developed to meet challenging DARPA performance goals and size, weight, and power (SWaP) restrictions. At this phase of development, the NGIMG developers will be considering user system needs in order to determine engineering trades needed to position each technology for manufacture and use. The potential host system users will be assessing host system architectures needed to take advantage of the emerging NGIMG technologies. This panel discussion is intended to enable dialog between NGIMG technology developers and host system users that will facilitate transition of these technologies into military host systems. In addition, this discussion will provide workshop participants, interested in future GNC technologies and systems, the opportunity to interact with NGIMG technology developers and with DoD personnel who have considered possible GNC advancements for future systems through the use of this technology.

The panel will be held at the FOUO / ITAR restricted level.

3:45 p.m. – 5:30 p.m.

A1: FOUO Program Addresses

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: Dr. Mikel Miller, *ION President*; Mr. Fred Davis, *AFRL Munitions Directorate*

- 1. An Extreme SWAP Budget, Navigation-Grade 5-DOF IMU for Broad DoD Application:** B. Dillard, M. Greene, V. Trent, D. Sellers, B. Hill, M. Anderson, D. He, B. Recktenwald, *Archangel Systems, Inc.*
- 2. Bias Stabilized MEMs IMU for Miniature Autonomous Systems GNC:** D. Cardarelli, M.D. Fontanella, *Milli Sensor Systems & Actuators, Inc.*
- 3. LADAR EO GPS/INS Atomic Clock Navigation Demonstration (LEGAND):** P. Lommel, R. Hartman, S. Susca, B. Mohr, *Honeywell*
- 4. Micro NMR Gyro for DARPA MTO MGIMG Program:** H. Abbink, M. Bulatowicz, A. Choi, R. Griffith, M. Larsen, D. Sakaida, *Navigation Systems Division, Northrop Grumman Corporation*; R. Boye, K. Neely, D. Serkland, P. Schwindt, *Sandia National Laboratories*



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Tuesday, October 27, 2009: Public Access Sessions Day 1

8:30 a.m. – 11:30 a.m.

B1: Miniature Multi-Function Seekers/Sensors

Co-chairs: Capt. John Tatar, *AFRL/RWGS*; Bryce Schumm, *AFRL/RYJM*

Keynote Speaker: Prof. Rob Wood, *Harvard Microbotics Laboratory*

- 1. Micro-Beacon Tracking of Autonomous Systems (MTAS):** J.D. Cyganski, R.J. Duckworth, *Worcester Polytechnic Institute*; D. Baughman, *Honeywell Aerospace*
- 2. Accurate Real Time Inertial Navigation Measurement by Application and Processing of Arrays of MEMS Inertial Sensors:** M. Tanenhaus, *Tanenhaus and Associates*; D. Carhoun, *Consultant*; T. Geis, *Tanenhaus and Associates*; A. Holland, *Eminent MicroSystems-Consultant*
- 3. Flight Test Results of a Miniature GPS/Inertial Camera Payload:** R. Tredway, *NAVSYS Corporation*; T. Lippmann, *Dugout Consulting, LLC NAVSYS Corporation*

Discussion

1:30 p.m. – 4:30 p.m.

C1: Advanced Navigation Techniques

Co-chairs: Dr. TJ Klausutis, *AFRL/RWGI*; Dr. John Raquet, *AFIT*

- 1. Indoor Navigation Using a Three-Axis Magnetometer:** W. Storms, J. Raquet, M. Veth, *Air Force Institute of Technology*
- 2. Lightweight Laser-Vision-Inertial Navigation System for Small Indoor UAVs:** D.J. Yates, M.J. Veth, *Air Force Institute of Technology*
- 3. Robust Geotags for Positioning:** D. Qiu, D. De Lorenzo, S. Lo, D. Boneh, P. Enge, *Stanford University*
- 4. Challenges and Solutions for Indoor Mapping and Geolocation:** C. Yang, *Sigtem Technology, Inc.*; P. Norris, *AFRL/RWGN*; A. Soloviev, *University of Florida*
- 5. Direct Orientation and Position Measurements via Magnetometers for Miniature Autonomous Systems:** I.A.G. Laureyns, G. Sharma, K.B. Ariyur, *Purdue University*
- 6. Chip Scale Atomic Clock (CSAC):** S. DeVilbiss, *AFRL/RYRN*

Discussion



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Wednesday, October 28, 2009: Public Access Sessions Day 2

8:30 a.m. – 12:00 p.m.

D1: System Integration Challenges

Co-chairs: Johnny Evers, *AFRL/RWAV*; Harris Edge, *ARL*

- 1. Low Cost Guidance Navigation and Control Solutions for an Indoor MAV Based Only on Range Sensors:** G. Chowdhary, E.N. Johnson, *Georgia Institute of Technology*
- 2. The Challenges of Integrating a Generic GNSS/INS Hardware Platform into a Legacy System:** S. Kennedy, *NovAtel Inc., Canada*; W.H. Spires III, *Eglin AFB*; J. Hamilton, *NovAtel Inc., Canada*
- 3. Feasibility Exploration on a Common and Reconfigurable Chipset for UAS/MAS GNC:** B. Dillard, M. Greene, *Archangel Systems, Inc.*; K. Stern, *Intrinsic Corp.*
- 4. Real Time Implementation of a MEMS Based INS/GPS System Using Matlab/Simulink:** J.A. Franca, Jr., J.A. Morgado, R.C. Durao, *Centro Tecnológico do Exercito, Brazil*
- 5. Development of Quadrotor Vehicles for Sensing and Navigation:** M. Stepaniak, *Air Force Institute of Technology*
- 6. A Hardware in the Loop Simulator for MAV Flight:** J. Shumaker, I. Walker, K. Ali, *Jackson State University*

Discussion

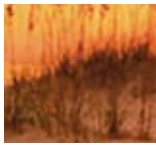
2:00 p.m. – 4:30 p.m.

E1: Controlling Miniature Autonomous Systems

Co-chairs: Dr. Rob Murphey, *AFRL/RWGN*; Sean Regisford, *AFRL RBCA*

- 1. Technical Challenges for Autonomous Systems:** J. Evers, *AFRL/RWAV*
- 2. Actuation Devices for Aerodynamic Control of Micro Air Vehicles and Weapons:** K.J. Shortelle, *System Dynamics*
- 3. Integrated Estimation and Control for GPS-denied Navigation of Autonomous Systems:** A. Soloviev, *University of Florida*; A. Rutkowski, *Air Force Research Laboratory*; K. Brink, *Texas A&M University*; T. Klausutis, *Air Force Research Laboratory*
- 4. Using Multi-agent Approaches for Enabling GPS-denied Navigation:** R. Sharma, C.N. Taylor, *Brigham Young University*
- 5. Forward Operator Control Unmanned Systems (FOCUS):** A. Judy, L. Branthoover, *Defense Technologies Inc.*
- 6. Old Architectures/Mechanizations for New Miniature Autonomous Systems:** T.H. Kerr, III, *TeK Associates*

Discussion



LOCATION:

All workshop sessions will be held at the Emerald Coast Conference Center, 1250 Miracle Strip Parkway, SE, Fort Walton Beach, Florida, 32548.

Hotel Reservations: There are numerous hotels available in the area that provide government rated rooms.

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.

	<u>ION Member Rates</u>	<u>Non-member Rates</u>
Registration Received and Paid by October 5	\$325	\$395
Registration Received or Paid after October 5	\$415	\$485

FOUO SESSION REQUIREMENTS:

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 5, 2009, 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 found at 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.

Go to www.ion.org and follow the GNC Challenges for Miniature Autonomous Systems Workshop links to guide you through the registration process.

Expect confirmation within two weeks. Please call the ION® if you do not receive confirmation within 2 weeks.

	ION Member Rate	Non-member Rate
Registration Received and Postmarked BY October 5:	\$325 _____	\$395 _____
Registration Received or Postmarked AFTER October 5:.....	\$415 _____	\$485 _____

Table Top Exhibitors – Electricity Required Yes No **\$900** _____
(One Complimentary Full Registration Included)

ION® MEMBERSHIP DUES: Purchase a membership now and qualify for the ION® full-member registration rate

Domestic: (mailing address inside the U.S.)..... **\$75** _____

International: (mailing address outside the U.S.) **\$95** _____

REGISTRANT INFORMATION (Please Type or Print)

Name: _____ Company: _____

Mailing Address: _____

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

Phone: _____ Fax: _____ E-mail: _____

LOCATION & HOTEL RESERVATIONS:

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Hotel Reservations: There are numerous hotels available in the area that provide government rated rooms.

METHOD OF PAYMENT – Payment must be received by the ION by October 5 to receive the early rate.

Check For Full Amount Enclosed–Please mail registration form with payment to the ION®, 8551 Rixlew Lane, Suite 360, Manassas, VA 20109 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:

1. FAX: Send your registration form by fax, Dedicated fax #: 703-366-2724.

2. ONLINE: Go to www.ion.org and follow the GNC Challenges for Miniature Autonomous Systems Workshop links to registration.

3. MAIL: The Institute of Navigation, 8551 Rixlew Lane, Suite 360, Manassas, VA 20109. 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. 5 are fully refundable. Written cancellations received Oct. 5 – Oct. 13 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. 13; 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. 28 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: 1-703-366-2724.