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Part Two: Unmanned Ground Vehicles

This is the second issue in a two-part series focusing on Unmanned Ground Vehicles. In the Summer issue we concentrated exclusively on military applications in recognition of the significant military influence on technology-based development. Our focus now shifts to non-military applications pursued by the commercial sector and other government agencies such as NASA and the Department of Energy (DOE). A variety of impressive efforts are well underway, to include autonomous mobile systems for inspection, physical security, space exploration, material handling, law enforcement, and even janitorial services. Perceived paybacks are a combination of increased productivity, improved and more consistent quality control, and reduced human exposure to hazardous conditions.

In the previous issue, Doug Gage reviewed for us the long history of military ground robotics. Prominent in this history are the contributions of a recognized leader in the field, Carnegie Mellon University (CMU). Over the past few decades, CMU has made significant advances in robotic sensing, mobility, manipulation, and navigation. In Kevin Dowling's "Field of Dreams" article, the CMU Robotics Institute has developed and fielded working robotic systems for transportation, agriculture, construction, mining, remediation/cleanup, aviation, and space exploration. Dowling has been an integral part of this heritage and the end results of his expertise are readily apparent in the working systems we see today. He is also well known as the keeper of the robotics "Frequently Asked Questions" (FAQ) on the Internet, a valued resource to everyone in this growing field. As the technology continues to advance at the Robotics Institute, the public may witness in the not-so-distant future a robot walking on

Mars, automated tractors harvesting crops, or perhaps even automobiles that incorporate hands-free, foot-free driving.

Next Joe Byrd and Robert Pettus from the University of South Carolina outline relevant aspects of the Autonomous Robotic Inspection Experimental System (ARIES), a mobile robotic inspection system being developed to survey and inspect drums containing mixed and low-level radioactive waste stored in warehouses at DOE facilities. The ARIES robot must navigate down three-foot aisles between rows of stacked drums in order to execute autonomous inspection operations currently performed by humans. Real-time decisions are then made concerning the condition of individual drums, enabling automatic updating of an associated database as well as generation of relevant reports.

Due to space limitations in the previous issue, Doug Murphy and John Bott of the Naval Command Control and Ocean Surveillance Center present here one more article on military applications. The Air Mobile Ground Security and Surveillance System (AMGSSS) article describes a novel approach to providing rapid mobility for remote sensor packages. Utilization of a small vertical-take-off-and-landing air vehicle as the mobility platform to relocate a sensor suite from one ground location to the next avoids many of the challenges faced by conventional ground mobility systems. AMGSSS is somewhat of a hybrid concept in this respect, performing surveillance functions as a ground-based system, then periodically relocating to new vantage points as an airborne system.

And finally, we include in this issue the AUVS '95 Paper Award Winner, from the recent symposium in Washington, D.C., titled "Compact, Lightweight, Multifuel UAV Navy Engine and its Variants," by Frederick L. Erickson, Jeffery L. Erickson, and Rick L. Erickson.

In closing, we have very much enjoyed this opportunity to serve as guest editors for this series on Unmanned Ground Vehicles, and would like to thank all of our authors for their noteworthy contributions. Our only regret was that space limitations forced us to select only a representative handful of the many projects that were considered strong contenders. It is most encouraging, however, to note this abundance of ongoing development effort, particularly in these trying times of shrinking budgets, and to similarly note the healthy progress being made on the road to fielded hardware. Our hats are off to all of you whose dedication, hard work, and persistence have made this progress possible.

Wendell Chun
H.R. Everett

Wendell Chun received a B.S. in mechanical engineering in 1978 from the University of Hawaii. He completed the Carnegie Bosch Program in Engineering Design in 1992 in support of the Mount Erebus robot project to Antarctica, and has co-chaired the SPIE Mobile Robots conference for the past eight years. He is currently employed by Lockheed Martin as a staff engineer in the robotics and automation research group in Denver.

Commander H.R. (Bart) Everett, USN (Ret.) is the former Director of the Office of Robotics and Autonomous Systems at the Naval Sea Systems Command, Washington, D.C. Active in the field of robotics research for over 20 years, he has more than 70 technical papers published and 16 related patents issued or pending. He currently serves as Technical Director for the tri-service MDARS robotic security program under development at the Naval Command Control and Ocean Surveillance Center in San Diego, CA.

DATELINE

Annual Symposium

Countdown to AUVSI '96!

Mark your calendars now—only nine months left until AUVSI '96—the 1996 Annual Symposium and Exhibition. You're going to want to make plans early to attend this year's conference and you're going to want to bring your family.

AUVSI '96 will be held 15-19 July, 1996 at the Disney Contemporary Resort in Orlando, Florida. With this year's theme, "Innovations for the Future," AUVSI anticipates involvement from DOD, DOE, NASA, and other organizations with an emphasis on future operational concepts, technologies, and systems. Given the fact that we are now an international association, we also expect a high level of involvement from the growing international community and particularly from the members of our newly chartered European Region.

As the only conference completely dedicated to unmanned vehicle systems, AUVSI '96 will be the perfect place to network with your peers, display your products, and see the latest

developments in the unmanned vehicle field. The Convention Committee has been hard at work since just after the completion of AUVSI '95 planning for AUVSI '96 and has already mailed the Exhibitor Prospectus. The Call for Papers will be mailed in November. Anyone with ideas for possible topics should contact Mike Harper at (703) 558-0481 or via E-Mail at mharper@inter-ramp.com. Abstracts will be due at AUVSI Headquarters on 15 January. A tentative schedule has been prepared and the official AUVSI '96 Registration Brochure will be mailed in early February.

AUVSI '96 will bring two significant changes to our program. The first is the addition of four Pre-Conference Workshops on Tuesday, 16 July from 10:00 a.m. until 4:00 p.m. Topics will include Air Operations, Ground Operations, Telecommunications, and Environmental Uses of UVs. The workshops are open for all to attend; details will be forthcoming in the registration brochure.

And for the first time ever, the student robotics competitions will be held in conjunction with AUVSI '96.

Don't miss student teams competing with aerial, ground, and underwater robots on the grounds of Epcot®. The competitions will be held Monday, 15 July and Tuesday, 16 July.

As the old saying goes, "All work and no play..." The conference site in Orlando, Florida is located on the grounds of Walt Disney World®. You and your family will have access to the multitude of attractions it has to offer, which makes AUVSI '96 the ideal destination for a family vacation as well. Your family will be able to experience the wonders of the Magic Kingdom® or explore new worlds at Epcot®. Plan to join us on the links as AUVSI presents its premiere Golf Tournament on Monday, 15 July. All golfers, from amateurs to professionals, are encouraged to participate! In addition, a Family Night scheduled to be held in the Exhibit Hall on Wednesday, 17 July, will offer your children the opportunity to experience first-hand the world of unmanned vehicles.

Further details will be forthcoming in the Winter issue of *Unmanned Systems*—or you can call

AUVSI 1995 Award Winners

The Association for Unmanned Vehicle Systems International gives out four annual awards to individuals who have contributed substantially to the field. This year's awards and winners were:

- **Outstanding Contributor Award:** Captain Alan Rutherford, USN.

- **Pioneer Award:** Joseph Engelberger, Transitions Research Corporation.

- **Operations Award:** Lowell "Sonny" Haskins, Marine Corps Detachment, U.S. Army Intelligence Center.

- **Member of the Year Award:** Kimberly Schwartz, K. Services International, Inc. and Dewar Donnithorne-Tait, Royal Scottish Dragoon Guards, British Embassy, Washington, D.C.

AUVSI at (703) 524-6646 for additional information. If you have suggestions or ideas on what you would like included in the conference program, please contact Scott Myers at (410) 876-9200; E-Mail: scott@rst.com.

Don't miss out; join us for a memorable week in Orlando at AUVSI '96!

—Scott Myers, AUVSI '96 Symposium Chairman

AUVSI Welcomes a New Associate Director



AUVSI is pleased to announce the appointment of a new associate director to its headquarters staff. Lynn Goldberg joins AUVSI after returning to Washington from California, where she spent the past three years as Executive Director of the California Association of Health Underwriters and

Administrator of the Planned Giving Round Table of Southern California. A graduate of the University of Maryland and a former resident of Washington, D.C., Lynn has over eight years of association management experience, including stints with the Water Environment Federation, where she worked as conference assistant for its annual symposium and trade show, and Smith, Bucklin & Associates, a multi-management organization. Please join us in welcoming Lynn and feel free to call her with any questions or concerns you may have.

Winning Teams

AUVSI Student Competition Winners

This year, both the Aerial Robotics Competition and the Unmanned Ground Vehicle Competition went off successfully.

Several of the teams were present at AUVS '95, not only to receive their awards, but also to display their vehicles. It is hoped that the attendees of AUVS '95 had the opportunity to talk to these young minds as they tackled the world of unmanned vehicles!

The 1995 International Aerial Robotics Competition was held on July 6. Stanford University placed first after the team's helicopter flew autonomously for almost three minutes and retrieved metal disks from a bin. For finishing first, Stanford was awarded \$7,000 in prize money, the largest amount ever awarded a single school. Second place (\$1,000) went

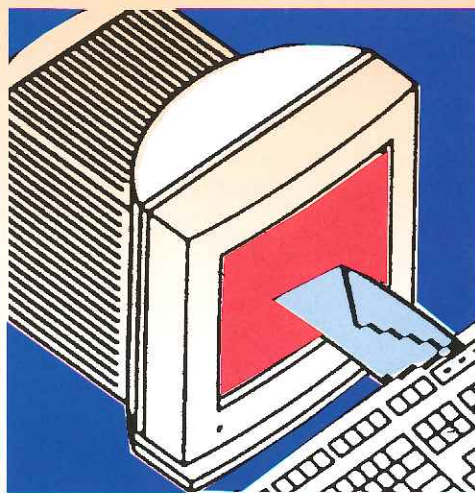
to Technische Universitat Berlin's blimp, while third place (\$500) went to the University of Texas at Arlington's tailsitter.

Six other teams participated in the event. The three judges were Commander Grant Begley, Kenneth Thurman (AUVSI Board member), and Charles Shepard.

The Unmanned Ground Robotics Competition was held in May at Oakland University in Rochester, Michigan and fared equally well. The winning team, from University of Colorado at Boulder, received \$5,000 in prize money. Second place (\$3,000) went to Ohio State University, and third place (\$2,000) went to the University of Colorado at Denver.

Editor's Note: The 1995 International Aerial Robotics Competition can be seen on Scientific American Frontiers on your PBS channel, January 17, 8 to 9pm. Check your local listings.

Surf the Net and Send E-Mail with AUVSI



AUVSI has a Homepage. To access, use this address: <http://asrt.cad.gatech.edu:80/AUVS/>. In addition, AUVSI HQ has a new E-Mail address. You may now reach us at auvs-hq@auvs.com. We look forward to hearing from you!

A Look Ahead

UAV 1995 Annual Report Summary

Major General Kenneth R. Israel, Director of the Defense Airborne Reconnaissance Office (DARO), neatly summarizes in this report not only the past year's accomplishments and challenges, but also what he and his office expect to see in the next year or so. DARO anticipates significant progress in the following key areas:

- Integration of Tactical UAVs into the Force Structure (Hunter and Predator).
- Endurance UAV Deployments and Operations [Predator, DarkStar, Conventional High Altitude Endurance (CONV HAE) UAV].
- Payloads: continued development and integration of advanced payloads for all UAVs.
- Force Mix: continued work with the Joint

Requirement Oversight Council (JROC), the Services, and other agencies to refine UAV force mixes.

- Endurance UAV Production: work with the Services to define production requirements for all endurance UAVs.

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This Just In!

As of press time, the Predator was scheduled to fly any day with a fully integrated synthetic aperture radar. The Westinghouse Synthetic Aperture Radar (SAR) gives the UAV all-weather capability. SAR provides an 800 m swath with .3 m resolution while being 4-11 km away. The Predator is built by General Atomics Aeronautical Systems, Inc.



Alan Alda and AUVSI Past President Robert Michaelson will appear on PBS.

Calendar

- 6-10 January, 1996: AIAA Aerospace Sciences Meeting & Exhibit, Reno Hilton, Reno, Nevada. Contact Gayle Armstrong at (202) 646-7400.
- 18 January, 1996: European Region of AUVSI Meeting and Press Conference. Contact AUVSI Headquarters at (703) 524-6646.
- 24-26 January, 1996: West '96, 17th Annual Western Conference & Exhibition—Technology and Tactics: Meeting the Fuzzy Threat, San Diego Convention Center, San Diego, California. Contact Valry Fetrow, U. S. Naval Institute at (410) 268-6110.
- 6-11 February, 1996: Asian Aerospace & Defense Technology Exhibition & Airshow, Changi International Exhibition & Convention Center, Singapore. Contact Dana Stratton at (203) 964-0000.
- 10-17 March, 1996: FIDAE '96, International Air & Space Fair, Santiago, Chile. Contact Avda. Pedro Aguirre Cerda in Chile at 2-558-1002.
- Spring 1996: European Region of AUVSI Board Elections. Contact AUVSI Headquarters at (703) 524-6646.
- 23-28 April, 1996: SAE Aerospace Atlantic Conference & Exposition, Sinclair Center, Sinclair Community College, Dayton, OH. Contact Karen Mong at (412) 776-4841.
- 22 June - 1 July, 1996: Indonesia Air Show '96, Soekarno-Hatta Airport, Jakarta, Indonesia. Contact Hans Hollander at (914) 698-9385.
- 16-19 July, 1996: AUVSI '96 Symposium & Exhibition—Innovations for the Future, Disney's Contemporary Resort, Orlando, Florida. Contact Lynn Goldberg at AUVSI Headquarters at (703) 524-6646.

DATELINE

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Over the longer term, DARO expects to implement its strategic plans to:

- Establish the technical architecture, migration options, and investment strategy by which to allocate airborne reconnaissance resources; implement near-term trade studies to achieve a balanced unmanned/manned force.
- Guide service investments and leverage own funds to sustain UAV development and evaluation.
- Work with the services to refine information processing/dissemination for endurance UAVs.
- Use own \$25-30 million annual Reconnaissance Technology budget to fund key platform, sensor, information processing, and communications technologies and integrate them on UAVs.

- Combine both endurance and tactical UAV/payload performance and evolving infrastructure support to improve intelligence collection management and shorten sensor-to-shooter time-cycles.
- Continue to meet chartered responsibilities to support the warfighter.

A Night Out

Pathfinder Chapter's "Membership Appreciation Night"

Continuing a longstanding tradition, the Pathfinder Chapter held its annual "Membership Appreciation Night" on August 18. The Chapter leased a large sky box at Joe David Stadium for the Southern League

baseball game between the Huntsville Stars and the Jacksonville Suns.

Just under 100 members and friends of the chapter attended. As in the past, a door prize was given. This time, Bob Nathan was the lucky winner and left the game that evening \$100 richer. The results of the election of officers were announced just prior to the game: Rick Schwartz, President; Bob Kincade, Vice President; Bob Johnson, Treasurer; and Jeanette Watson, Secretary.

It was a wonderful evening of camaraderie, shop talk, and baseball. Each year this night gets more popular. The Chapter looks forward to another active year and anticipates another appreciation night next August. US

UAV Insurance Can Protect Us in the Future

Editor's Note: The Association seeks your input on this insurance concept. Should the Association provide an insurance package service and use the numerical strength of the Association to gain the best possible price for companies and individuals? Please call, fax, or E-mail your responses to Manny Garrido, voice (703) 413-0556, fax (703) 413-8219 or E-mail America On Line (AOL) JNORRIS102 or Internet BSPC@NETRAIL.NET. Your responses will be compiled and presented to the Association's National Board for a decision on whether or not to sponsor this type of service.

Back in the 1600s in a coffee room in London, England, ship owners, cargo brokers, and underwriters came to the conclusion that the shipping business could not be profitable or even survive unless there was some way to protect their assets and businesses from catastrophic losses that were all too common in the international maritime trade. Thus the birth of the father of insurance and the entity which prevented the sun from setting on the British Empire—Lloyd's of London.

Just like the initial steps taken in that London coffee room, the owners, operators, manufacturers, and support/logistics providers doing business in the Unmanned Vehicle Systems

Scott Morrow is the Vice President of the Capital Division of Rollins Hudig Hall Aviation, one of the largest aviation/aerospace insurance brokers/consultants in the world. He has more than 22 years of aviation insurance and consulting experience with several of the largest insurance brokerage firms in the industry, possesses a high degree of technical knowledge of the aviation/aerospace marketplace, and is an experienced pilot.

industry need to protect their assets, technology, and bottom line from catastrophic loss and liability in such a fashion that would allow the industry to grow quickly and profitably.

Insurance can provide the financial protection that could make the difference between profit and loss.

Since we have to crawl before we can walk, I will address my comments in this article to one portion of your industry—Unmanned Aerial Vehicles (UAVs). The Unmanned Ground Vehicle (UGV) and the Unmanned Underwater Vehicle (UUV) areas, which have similar concerns, will be addressed at a future time.

The potential for UAVs in the world commercial and governmental marketplace is almost limitless in scope. In the next decade, the UAV commercial market will probably exceed several billion dollars, but that can only occur if commercially and economically viable insurance coverage is available at non-predatory pricing.

Currently there is no aviation insurance product that is specifically designed to address the risks and exposures unique to the emerging UAV industry. Few if any insurance underwriters and agent/brokers truly understand this industry or the soon to be realized commercial impact that it will have in the international marketplace. Lack of an effective insurance product that matches the growth of the industry will have disastrous ramifications in areas such as financing new ventures/products and contractual operational agreements.

The insurance coverages that are necessary to the industry are:

1. Aviation third party liability pertaining to:

a. The flight operations of the UAV itself including test flying—owned, nonowned, and leased.

b. Premises liability for ground operations related to flight operations.

c. Product liability for damages sought against the manufacturers and maintenance/service providers from accidents and damages allegedly caused by a defect in their product or service.

2. Aircraft (UAV) hull (physical damage) pertaining to:

a. The UAV during ground and flight operations including all equipment attached.

b. The UAV during non-flying transportation assembled or unassembled.

3. Aircraft (UAV) spare parts inventory coverage for physical damage to the parts themselves.

4. Payload coverage for expensive and unique electronics and other airborne equipment whether owned or leased.

5. Ground equipment/support/logistical physical damage coverage for ground-based related equipment.

A program such as the one outlined above would provide all coverage necessary for UAV operations and manufacturing. As of yet, such a comprehensive program does not exist.

The solution to this lack of insurance product is very possibly to design and implement a program with association support that would be available to the membership on a mass-marketed, mass-purchased basis. The members as a purchasing group would be very appealing to various insurers due to the premium volume flow and the consistency and control that this approach offers. The obvious benefit to the members would be economically affordable, state-of-the-art insurance coverage tailored to the UAV industry group.

The UAV industry has the unique opportunity of assisting in and controlling the design, implementation, and administration of their own insurance program and contributing to the financial stability necessary for profitable growth. US