Crossbow® Solutions

First Quarter 2004
Volume 1

ENVIRONMENTAL SENSING ARRAY AT JAMES RESERVE USING CROSSBOW'S MICA2 MOTES

Crossbow's MICA2 family of wireless sensors using TinyOS is an industry first in its ability to integrate the latest wireless mesh networking technology to enable distributed environmental data collection via low-cost battery-powered sensors. These capabilities are being put to the test in a deployment at James Reserve in Southern California under the auspices of the Center for Embedded Network Sensing (CENS). The James Reserve is a natural reserve run by the University of California, and it is located in the mountains east of Los Angeles.

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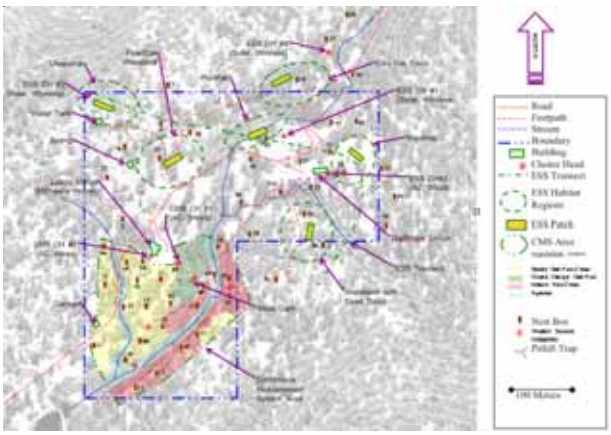

Mote Deployment at James Reserve

INSIDE THIS ISSUE

NEW PRODUCT OVERVIEW

Crossbow's line of MICA Mote products is expanding rapidly to meet the growing needs of the wireless sensing community.

You will find environmental monitoring boards, boards with GPS integration and much more.

Please also note the growing line of Inertial Systems we provide, including the first FAA-Certified MEMS AHRS System on the market.

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TECH TALK - CROSSBOW SOLID-STATE AHRS: ABOVE THE REST

AHRS stands for "Attitude and Heading Reference System." An AHRS provides, in one instrument, the information needed to drive the Attitude Indicator (Roll/Pitch) display, and a Directional Gyro (Heading) display. Since an AHRS is fully electronic and digital, it can be used with today's modern glass avionics displays that convey attitude, heading and a variety of other information. An AHRS also provides valuable three-axis rotational rate and three-axis acceleration information for auto-pilots and flight data recorders.

AHRS Flight Test Equipment

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41 Daggett Drive ♦ San Jose, CA 95134 ♦ phone: (408) 965-3300 ♦ fax: (408) 324-4840 ♦ web: www.xbow.com

TRADESHOWS

Wireless Systems Design Expo 2004
San Diego Convention Center
San Diego, CA
March 8 - 10

Aircraft Electronics Association (AEA)
Hilton's Paris Hotel
Las Vegas, NV
March 29 - April 1

Sensors Exposition
Cobo Hall- Booth #420
Detroit, MI
June 8 - 10

EAA Airventure 2004
EAA Aviation Center
Oshkosh, WI
July 27 - August 2

AUVSI Unmanned Systems
Anaheim Convention Center
Anaheim, CA
August 3 - 5

ION 2004
Long Beach Area Convention Center
Long Beach, CA
September 21 - 24

These shows will feature Crossbow and its products. We look forward to seeing you there.

Dear Friends,

As we begin the New Year, I would like to welcome you to our first quarterly newsletter. This newsletter will contain feature articles on a variety of interesting subjects including customer profiles, technical application summaries, new product announcements, and an ongoing calendar of coming events. It is my sincere hope that this newsletter will prove to be a beneficial way for us to stay in touch with your needs.

We are very excited about 2004 and the new opportunities the upcoming year will provide to continue serving our customers. For example, compared to 2003 there will be a 50% increase in dollars spent on both Research and Development. This investment will fund new product development as well as more intensive research on all of our existing products. The resulting growth will be fueled by the combined efforts of many talented engineers, and resumes are always welcomed at staffing@xbow.com.

Within the Inertial Systems group, the AHRS500 product line will expand on the FAA's existing TSO Certification and approval to install the world's first (and only) standalone MEMS-based Attitude and Heading Reference System on over 600 different aircraft by adding a certified remote magnetometer in early 2004. We have also begun the delivery of a new code base for the VG400 and AHRS400 series products that supports marine applications with better performance under constant wave motion. These are only two examples of the many new and exciting inertial product announcements that can be expected over the coming months.

Within our Smart Dust and Wireless Sensor Networking group, we are introducing a variety of new peripheral products. These peripherals include the MIB600 Ethernet Interface, the Stargate Xscale Gateway and Single-Board-Computer, the MTS400/420 Environmental Monitoring Sensor Boards, and the MDA300 Data Acquisition Board. In addition to new products, we are also increasing our emphasis on both product support and training. We have always contributed both Research and Development dollars and manpower for the benefit of the TinyOS community as a whole, and we will continue this investment with a full schedule of worldwide seminars in 2004. Finally, in response to the rapid increase in commercial deployments of TinyOS-based MICA Motes, we will also be offering new consulting and programming services designed to help our commercial customers streamline the integration of Smart Dust technology into their products.

As always, we look forward to hearing your feedback, understanding your requirements, and helping you with your new projects. We hope that our products and people can serve you in the near future

Sincerely,

Mike Horton
President & CEO

ENVIRONMENTAL SENSING ARRAY AT JAMES RESERVE

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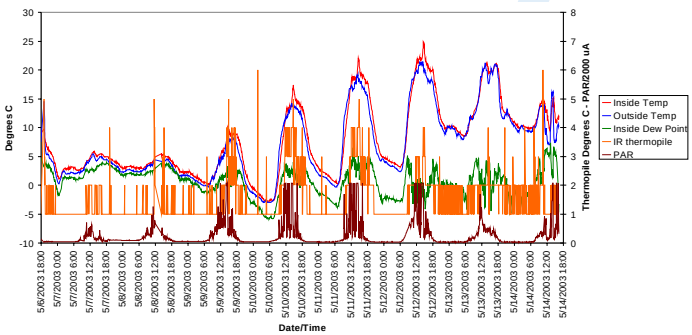
Evolving scientific needs for new types of environmental observation are the motivation behind the CENS Research Team's deployment efforts. Many phenomena cannot be observed by individual sensors and are only observable by a sensor array of adequate scale. It is necessary to make spatially and temporally dense measurements to understand terrestrial, oceanic and atmospheric material cycle interaction, ecosystems and geological processes including seismic activity, complex climate phenomena, atmosphere between ecosystems and the movement of nutrients and pollutants through groundwater. Professor Deborah Estrin at UCLA created the CENS Research Center with funding from the NSF and industrial partners to address the technology development required to make such sensor arrays practical. The CENS group has been an active leader within the growing TinyOS community, and they have developed important sensornet software and hardware building blocks being used at a number of groups outside of CENS.

For the James Reserve deployment, the CENS Research Team has developed an Extensible Sensing System (ESS) for microclimate monitoring in support of a wide range of needed ecophysiological studies. The first generation ESS system consists of MICA2 Motes with an environmental sensor board developed jointly by Crossbow and Mohammad Rahimi on the CENS Staff. Condsiderable design input and testing were provided by Mike Wimbrow of the James Reserve science team. This sensor interface board is now available from Crossbow (New Products Section (pg 7) MDA300CA Environmental Sensor and Data Acquisition Board for MICA2 Motes). As shown in the figure below, each sensor node (MICA2 and MDA300CA combination) is responsible for gathering certain climate-related sensor data such as temperature, leaf-wetness, soil moisture, wind-speed, and wind-direction. These nodes collect data through a multi-hop mesh network into multiple head nodes. Each head node is a Crossbow Stargate Gateway running a data logging and networking stack under Linux. The overall ESS data collection and aggregation software was written and tested by researchers on the CENS Team, and it is one of the very first wireless sensor networks to be deployed in the scale of hundreds of nodes.



Display of Climate Data Collected from ESS Motes

Installation of Mote inside the nest box

The MICA2 sensor nodes transmit their data to a single cluster head (Stargate node). Each node is able to choose the cluster head to which it forwards its data. The sensor node also has the ability to determine the number of hops away it is from each cluster head to make the appropriate choice. Every node sends its local adjacency list and link statistics to its selected cluster head. In addition, each node sends its battery voltage information as an indication of node health.

Both the MICA2 sensor nodes and Stargate cluster head nodes within the ESS system are powered by a combination of solar panels and deep cycle batteries. The ESS system has the ability to log and transmit core small-scale environmental data to a central facility, and utilize analog and digital data inputs for controlling micro-video cameras and proximity sensors. In fact, environmental data from the James Reserve is transmitted via the Internet back to UCLA's campus in Los Angeles.

The deployment of these sensors at the James Reserve has allowed the CENS Research Team to test and evaluate the MICA2 radio hardware and communication software, the Mote-Sensor interface hardware (MDA300CA) and software, and the cluster head hardware (Stargate) and software under real-world conditions.

In order to make the MICA2 Motes ready for environmental monitoring, the CENS Research Team

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has added housings that provide MICA2 Motes with indirect exposure to the environment (temperature, humidity…) but protect them from rain, snow and insects. The sensors (soil moisture, soil temperature, leaf wetness, etc…) are mounted at some distance from the actual mote.

Inside view of the nest box

The deployment has grown from 10 nodes to 50 nodes, and it will continue to grow in 2004.

Crossbow would like to thank Prof. Deborah Estrin, Dr. Mohammad Rahimi, Dr. Mike Wimbrow and the entire CENS Team for their help with this newsletter story and developing the MICA2 family of motes into usable remote environmental sensors.

More information on CENS is available at http://www.cens.ucla.edu.

TINYOS TECHNOLOGY EXCHANGE

The TinyOS Technology Exchange will provide a forum for researchers, developers, educators, companies and users to learn from one another about important recent developments within the TinyOS embedded network systems area and to participate in shaping paths of future development.

When: Thursday, Feb. 26, 2004, 8:30 am - 5 pm
Where: Wozniak Lounge, 4th Floor Soda Hall, University of California Berkeley.
Who: Members of the research, industry and education community actively working in the wireless embedded network space with TinyOS.

For more information please visit:
http://www.eecs.berkeley.edu/~culler/tinyos/ttx/

Last year Crossbow announced its commitment to offer "Smart-Dust-Service" for its Wireless Sensor Networking customers. There is a worldwide community in Universities, Government, and Industry that use the Motes built by Crossbow for Wireless Sensor Networking. Besides offering assistance through calls and emails, Crossbow now offers seminars that enable users to receive training on the functions available with these products.

Wireless Seminars and Tutorials

Smart-Dust Training Seminar
Boston, MA
January 15 - 16

EWSN Workshop - Free Tutorial
Berlin, Germany
January 19

Smart-Dust Training Seminar
Sydney, Australia
February 25 - 26

Smart-Dust Training Seminar
Beijing, China
March 15 - 16

These seminars include a complete hands-on lab that introduces the MICA hardware and TinyOS software. Participants bring their own laptops and Mote-Kits and walk away with loaded software and the training that they need to build and deploy wireless sensor networks using Motes.

In 2004 Crossbow will also be offering similar training sessions for our inertial line of products.

For more information on upcoming seminars and events: http://www.xbow.com/General_info/events.aspx

Seminar Tokyo, Japan 2003

CROSSBOW SOLID-STATE AHRS: ABOVE THE REST

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So why do some companies couple their AHRS to Air Data or GPS?

It is very challenging to get acceptable AHRS performance from standalone MEMS technology (the raw drift-rate error of a single MEMS rate gyro can be several degrees per second). Crossbow has worked with this technology in industrial and aerospace environments for six years and has developed a whole range of techniques in hardware, packaging, software, calibration, testing, and sensor screening that has enabled us to harness this technology into a reliable standalone AHRS. No other company has been able to accomplish this task forcing them to depend on another system such as Air Data (or in some cases GPS) for their systems to work. While we applaud their efforts, an electrical spinning gyro will be more dependable than one of these systems.

How does Crossbow's approach differ from others ?

Crossbow Solid State Gyro products consist of three MEMS rate-gyros, three MEMS accelerometers and a three-axis magnetometer compass in the AHRS. The sensor information is processed by digital electronics where detailed calibration data about each sensor is stored. This upgraded sensor information is read by Crossbow's proprietary algorithms which calculate roll, pitch and heading. The three-axis magnetometer inside the Crossbow AHRS allows it to make a true measurement of magnetic heading without an external flux valve.

How do Environmental Conditions impact performance of an AHRS or other Inertial Systems?

Environmental Conditions (temperature, vibration, shock, and other factors) play a major role in an AHRS's performance. Many systems that work under nominal conditions fail under temperature or vibration.

Crossbow addresses the environmental sensitivities of MEMS sensors in several ways. With one of the best test labs in the country, consisting of vibration tables, a Carco two-axis rate table with thermal chamber, and a variety of thermal chambers including temperature-shock capability - Crossbow has the ability to examine performance under varied conditions when designing our products. This also allows us to temperature compensate the systems in production.

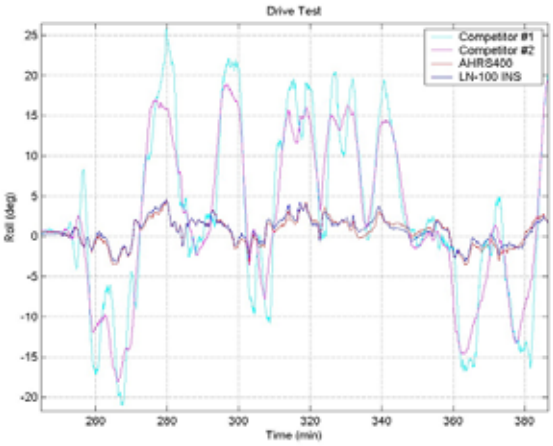
Crossbow spends a great deal of time and testing in the design of its inertial systems to systematically reduce the effect of vibration on the AHRS unit's performance. With respect to temperature, Crossbow's proprietary calibration techniques make the sensors perform "better" than their raw specification data would predict. Each AHRS unit is tested over at least three complete temperature cycles during calibration testing at Crossbow.

How does Crossbow measure the dynamic accuracy of its AHRS in flight and other real-world usage scenarios ?

Crossbow uses an LN100 Navigation Grade INS as reference for its flight testing. The LN100 is used in high performance fighter jets and incorporates 0.001 degree-per-hour ring laser gyros (RLGs) and high-performance accelerometers. Crossbow mounts its AHRS alongside the INS and flies a variety of flight profiles while recording data. Crossbow is unique in this testing approach.

How does Crossbow compare against other solid-state AHRS units ?

Crossbow has characterized its performance against two other AHRS units that advertise themselves as a MEMS-based low-cost AHRS solution. We conducted three categories of tests: dynamic accuracy, vibration and temperature.



AHRS400 vs. Solid-state Competitors (Driving Test)

CROSSBOW SOLID-STATE AHRS: ABOVE THE REST

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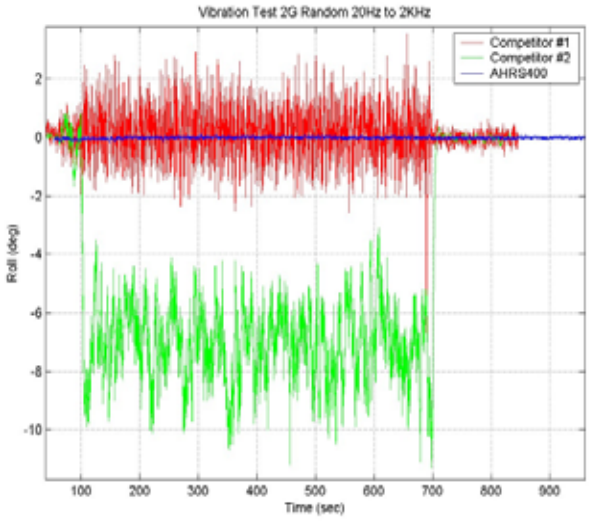
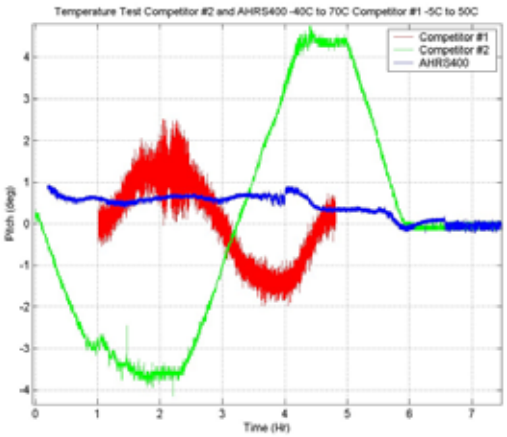
For dynamic accuracy, a driving test was conducted. In this test a standard automobile was driven in a continuous circle. Driving on a circular track generates centrifugal acceleration forces that have a tendency to bleed into roll and pitch creating false or exaggerated roll and pitch readings. Of course the exaggerated roll and pitch is not physically occurring. During the test, the INS system mentioned earlier was carried as a reference. As the results show, the two competitor units generated unacceptable errors during this simple dynamic test.

For the vibration test, the units were mounted in a level configuration on the shaker table. The vibration was perpendicular to the roll and pitch axes. This Z-axis, vertical shake, is the easiest test case because it is perpendicular to the axes of motion. As shown in the figure below, the two competitor units responded with increased noise on both roll and pitch. One unit showed a significant shift in angle that is not physically occurring. However, with the Crossbow AHRS400 unit, it is difficult to distinguish when the shaker table is turned on and vibrating.



AHRS400 vs. Solid-state Competitors (Vibration Test)

To complete the comparison a final temperature test was conducted. In this test, the three units were placed on a secure and level mounting platform inside a thermal chamber. The level mounting platform is mechanically attached to the ground via a 500 lb block of granite. The thermal chamber is mounted on stilts with a hole cut in the chamber's base in order to allow a secure, mechanically grounded, mounting platform inside the chamber. This ensures that the oven does not induce a shift in roll or pitch during the test. The results in the figure below show the performance of the Crossbow AHRS400, and its relative insensitivity to temperature change.



AHRS400 vs. Solid-state Competitors (Temperature Test)

Conclusions

In conclusion, while other solid-state MEMS AHRS products may look similar, they are not the same. In non-turbulent conditions, at benign engine power settings, at benign temperatures and in the absence of vibration, these units may do the job. Real-world conditions are not this ideal. The likelihood of receiving bad data creates a dangerous situation. As any pilot knows, when an instrument begins giving you bad data, you are much better off without it. Trying to correlate bad data with the rest of your panel in an EFIS system or trying to use bad data in an UAV autopilot, or any other application simply does not Fly !

INTRODUCING CROSSBOW'S NEWEST PRODUCT ADDITIONS

Low-Power, Small-Size, 400MHz, Linux Single Board Computer - Stargate is a powerful single board computer with enhanced communications and sensor signal processing capabilities. The Stargate uses Intel's® latest generation 400MHz X-Scale® processor (PXA255). This product was designed within Intel's Ubiquitous Computing Research Program and licensed to Crossbow for production. Stargate directly supports applications around Intel's Open-Source Robotics initiative as well as TinyOS-based Wireless Sensor Networks.

The MTS400CA and MTS420CA are Multi-Function Environmental Monitoring Boards with Temperature, Humidity, Barometric Pressure, Light, Acceleration and optional GPS sensing modalities. The MTS400CA and MTS420CA are compatible with Crossbow's MICA2 mote family of wireless sensors and dataloggers.

The MDA300CA is a Multi-Function Data Acquisition Board with an on-board Temperature and Humidity Sensor compatible with Crossbow's MICA2 mote family of wireless sensors and dataloggers.With it's multi-function direct user interface, the MDA300CA offers a convenient and flexible solution to those sensor modalities commonly found in such areas as environmental and habitat monitoring as well as many other custom sensing applications.

The MIB600CA provides Ethernet (10/100 Base-T) connectivity to the MICA2 family of motes for communication and in-system programming. The MIB600CA allows remote access to sensor network data via TCP/IP. The MIB600CA serial server connects directly to a 10 Base-T LAN like any other network device. The MIB600CA can bridge "wired" and "wireless" segments of a network. The MIB600CA is also an effective conduit for sensor data.

Crossbow has upgraded its Fiber Optic Gyro-based Inertial Systems. The new design features less than 20°/hr drift and lower noise than the previous 600 series. All the 600 series inertial systems have been replaced by improved 700 series units that are software and dimensionally compatible with the older units.

FOR MORE INFORMATION ON CROSSBOW'S LINE OF SENSOR PRODUCTS PLEASE VISIT OUR WEBSITE AT WWW.XBOW.COM OR TO SPEAK WITH A SALES REPRESENTATIVE YOU CAN REACH US AT (408) 965-3300

Other News

Crossbow is pleased to announce the introduction of our new website. Filled with features to make your search for the right product easier - you will find everything you need at the click of a button.

You will have access to your own 'My Crossbow' account which will allow you to place orders, track shipments and search your history for older orders and invoices.

The on-line ordering process provides you with current lead-times and prices so you can determine which product will meet the needs of your application requirements.

Features:
~ Order Status
~ On-line Ordering with pricing and lead-times
~ Technical Support and User's Manuals
~ Datasheets with all specifications
~ Easy Re-ordering process
~ Shipment Tracking Services available
~ Complete Product Resources in a single location

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Crossbow® TECHNOLOGY INC.

41 Daggett Drive
San Jose, CA 95134

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SAN JOSE, CA
Permit No. 03248

www.xbow.com
Phone (408) 965-3300
Fax (408) 324-4840