African university researchers and U.S. GNSS experts meet in Trieste at the first Satellite Navigation and Technology for Africa Workshop

GNSS can help the countries of Africa achieve their science and technology plan of action for problems of hunger, poverty, environmental devastation, and natural disasters and integrate fully into the world economy. That’s the hope of 50 African scientists and engineers who participated in the first Satellite Navigation and Technology for Africa Workshop held in March in Trieste, Italy.

“The scientists wanted to learn as much about GNSS as we could provide,” said organizer Pat Doherty. “We worked from 8 a.m. to 5 p.m. each day, and we were often in the laboratory well into the evening.

The U.S. lecturers were particularly delighted with the keen interest level of their African colleagues, and many said this was the most enriching teaching experience of their career.”

The two and a half week long workshop, sponsored by Boston College and the Abdus Salam International Centre for Theoretical Physics (ICTP), was the brainchild of ION executive committee member Pat Doherty and Sandro Radicella, head of the ICTP Radiopropagation Laboratory.

The two scientists have worked together on several projects involving ionospheric

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Outreach

Outreach has become central to the goals and objectives of the institute. We do this by promoting public awareness, achieving and sustaining an international presence, promoting young people’s interest in navigation and promoting the ION as a center of PNT excellence and technical credibility. This Spring we participated in several new and exciting events that targeted these goals.

First, twenty ION members, including myself, participated in the first Satellite Navigation and Technology for Africa 3-week Workshop held in Trieste, Italy. The ION sponsored several of the instructors’ travel and expenses and members volunteered their time and expertise to teach classes, lead lab projects and consult individually with African academics who came from eighteen universities in twelve countries. This was a truly amazing, inspiring and yet humbling experience. The opportunity to teach a subject we are all passionate about to a group of very appreciative students is an experience that I will not soon forget. You just start to realize all the potential opportunities to make a difference in the world by educating people about navigation technologies and their applications. The workshop will be held again between April 6 - April 23, 2010 in Trieste, Italy. Please see the article by Patricia Doherty for more details about this amazing workshop.

Second, the ION flew the institute’s flag at The European GNSS conference in Naples, Italy in early May. Rick Buongiovanni of the national staff manned the ION membership booth promoting the institute and Carl Andren and myself served on the ENC technical committee and as session chairs during the conference. It was a great opportunity to see the latest European based GNSS activities and to also meet with several of the European Countries’ Navigation Institutes’ Presidents and Vice-Presidents.

Third, in our effort to get young people interested and excited about choosing a science and engineering education the ION conducted the First Annual Mini-Urban Challenge which was supported by 14 sponsors. Thanks to Carrie New’s and Casey Miller’s leadership, we held very successful regional competitions in Florida and Ohio. The regional competitions were followed by a National Competition that was held at the end of May in Dayton, OH. It was held in conjunction with the highly successful 6th Annual Autonomous Lawn Mower competition, led by Dr. Jacob Campbell. Please see upcoming articles concerning both of these competitions in our next newsletter.

Finally, mark your calendars for the September GNSS 2009 meeting in Savannah, Georgia – register and make your hotel reservations soon. The technical program is now available on the ION website www.ion.org/meetings/gnss2009program.cfm. In addition to the great technical papers, checkout the several new discussion panel topics. Also, abstracts will soon be due for the AFRL Co-Sponsored GNC Workshop for Miniature Autonomous Systems to be held in Fort Walton Beach, Florida from October 26 – 28, 2010. In addition, abstracts for the 2010 International Technical Meeting, which will be held on January 25 – 27, 2010 at the Catamaran Resort Hotel in San Diego, California, will be due on October 2, 2009. I really hope to see as many of you as possible at one of these upcoming events!
Life in Washington, D.C., is never boring; there is always something in the air.

The second half of my fellowship is with the Space Communications and Navigation (SCaN) office at NASA Headquarters. Program elements at SCaN include the space networks, the Tracking and Data Relay Satellite System, national/international data standards, and systems planning for a communications and navigation architecture to support exploration and science programs.

The office interacts with other government agencies as well as international space agencies, which provides for great opportunities to see a variety of government processes at work. My assignment at NASA is primarily on the use of GNSS technologies in the space program.

Washington provides a wealth of information on numerous interesting topics and many ways to learn about the details. On April 28, 2009, I attended a hearing of the House Committee on Science and Technology’s Space and Aeronautics Subcommittee on the subject of “Keeping the Space Environment Safe for Civil and Commercial Users.”

According to one witness at the hearing, Nicholas L. Johnson, chief scientist for orbital debris at Johnson Space Center, the number of pieces of debris as small as a half-inch traveling in or near satellite orbital planes exceeds 300,000. Each piece is large enough to disable a spacecraft.

Space debris increasingly affects space operations such as the recent Hubble repair mission, where the probability of a catastrophic debris hit was estimated at 1-in-221 http://www.space.com/missionlaunches/090423-sts125-hubble-update.html. However, existing technology can only track pieces of debris that are larger than 10 centimeters.

A total of 19,000 objects are currently being tracked, including 1,300 active payloads, Lt. Gen. Larry James, Commander of the Joint Functional Component Command for Space, told the subcommittee. However, accurate conjunction analyses are only performed on a subset of these 19,000 objects.

The recent collision of an active Iridium satellite and an out-of-service Russian COSMOS satellite, which in turn greatly increased the number of objects to be tracked and the potential for additional collisions, illustrated the enormous challenge facing operators of space systems.

Much activity also followed the release on May 7 of the U.S. Government Accountability Office (GAO) report on “Global Positioning System: Significant Challenges in Sustaining and Upgrading Widely Used Capabilities.” In fact, that same day, the House Committee on Oversight and Government Reform’s Subcommittee on National Security and Foreign Affairs held a hearing on this topic.

Between the report’s warning that the GPS constellation faced a risk of sizable reduction in operational satellites and the high profile of the hearing, the popular press started to report on “GPS satellites falling out of the sky.” The same topic also received attention at the National Space-Based PNT Advisory Board on May 14.

Although a substantial risk does exist that the constellation will not perform as well in the future as it was with 30 healthy satellites on May 7, the probability of falling below one of the service guarantees of 24 satellites 95 percent of the time is smaller, but not negligible. To fully understand this issue, the best source of information is the GAO report itself (available at http://www.gao.gov/new.items/d09325.pdf).

The ION D.C. Section is doing very well. Section Chair Chuck Schue invited me to present at the April 7 Spring Meeting about the ION Government Fellows Program as well as the hunt for GPS anomalies. The meeting took place at the National Air and Space Museum and included a light dinner and a brief tour of the museum with a focus on navigation-related exhibits.

I’m looking forward to the remainder of my fellowship year at NASA — the educational and professional opportunities provided by this program are unique and highly recommended to all ION members.◆
Climate change was a high priority concern for Congressman Rohrabacher, and I wrote two papers on the issue during my fellowship year.

Although he supports measures to promote clean air and clean water, cap-and-trade and carbon dioxide sequestration were different matters. Present or near-term threats from fossil fuels and the buildup of CO₂ gas in the atmosphere were not so clear to him. He feared that efforts to reduce it could hurt industry severely, with economic impacts distributed unequally across the world.

However, Rep. Rohrabacher was very interested in two alternatives to fossil fuels: nuclear power and space-based solar power.

**HTGR.** The congressman supports the high temperature gas-cooled reactor (HTGR). A few U.S. nuclear plants used this technology about 40 years ago. But power needs grew, technologies advanced, regulations changed, and water-cooled reactors became the dominant source of nuclear power.

Interest in HTGR has slowly grown again in recent years and South Africa, Japan, the United States and Russia are working on development programs. A few years ago, HTGR attracted attention for its unique ability to produce hydrogen for the “hydrogen economy.”

HTGRs are modular, not dependent on water, drive turbines directly without steam, leave fewer residuals and are often described as less costly, more efficient, and safer. Rep. Rohrabacher sought more details on the validity of these claimed HTGR advantages.

**Space-Based Solar.** Space solar power was a more complicated issue. Ground-based solar power, of course, is already generated in the United States by rooftop collectors and in open areas of the Southwest. The technology is limited to daylight hours and suitably sunny weather.

Large arrays of solar cells in geosynchronous orbit could, in theory, provide abundant regional electrical power via fixed spots on Earth.

Serious technical challenges exist, however, including limitations on space launch capability and power downlink design. At this point, such an energy option may not be feasible for many years. However, meetings with a few entrepreneurs indicated some small trial implementations might be forthcoming.

**Gravity.** Launch limitations prompted a request to look into the status of locally reducing the force of gravity — a kind of Holy Grail. Rep. Rohrabacher suggested the study include an assessment of writings on “concealed” Nazi World War II technology. None of these writings nor any other claims of anti-gravity or gravity-reduction schemes appear to have much scientific credibility.

**When Worlds Collide**

As I mentioned earlier, Rep. Rohrabacher is dedicated to protecting the Earth from collisions with asteroids or comets, such as the one believed to have caused the extinction of the dinosaurs about 65 million years ago.
I drafted a point paper for him to present at the 2009 Asteroid, Comet, Meteor (ACM) Conference. It was sponsored by the Johns Hopkins Applied Physics Laboratory and held in Baltimore, Maryland last July.

I also developed a media conference for the 100th anniversary of the 1908 Tunguska event that flattened an area in Siberia the size of Los Angeles.

The congressman wanted to include Bruce Willis, star of the 1988 movie thriller, *Armageddon*. When that effort failed, we arranged a successful joint conference in Pasadena, California with the Planetary Society, the space exploration advocacy group cofounded by Carl Sagan.

**Constituents in Space**

Part of my job involved meeting with a fairly steady stream of lobbyists, constituents, and proponents of various causes. Their issues ranged from increasing support of aerospace R&D to arranging a hearing on 9/11 conspiracies.

Most of the time, I couldn’t do much for them because of time and resource constraints and the level of Congressional support that would have been required.

In some cases, though, the payoff was great enough and the scope within my capacity to follow up.

**Gyros.** One constituent wanted to make sure that sufficient spare control moment gyros (CMGS) were brought onto the International Space Station (ISS) before the Shuttle is retired in 2010. After that, comparably large cargo delivery capability would not be available until about 2015. NASA assured us that his concern would be adequately addressed.

**TIR.** In another case, the Western Water Management Association and the Western Governors Association objected to NASA’s decision to drop the thermal infrared (TIR) sensor from the follow-on Landsat satellite.

Thermal imaging is used to map water-usage patterns, and leaders of the two organizations were concerned that its absence from the next-generation Landsat spacecraft would make it very difficult to manage the scarce water resources of the Western states. A joint effort finally succeeded in getting the sensor added to the spacecraft design.

**SOYUZ.** In addition to helping constituents, I had a chance to initiate some of my own projects. One concerned re-entry problems with Russia’s Soyuz space vehicle.

On April 24, 2008 the House Space and Technology subcommittee held a hearing on the International Space Station. William Gerstenmaier, NASA’s associate administrator for space operations, was the senior witness.

Problems with the Soyuz was a top concern — particularly because the United States will have to use the vehicle to ferry U.S. astronauts to and from the ISS after the shuttle is retired next year. Its two most recent flights had been intensely turbulent during re-entry and slightly injured a South Korean passenger.

First, Mr. Gerstenmaier assured the members of the committee that Russia was working on the problem. But, given the safety-of-life issue, I contacted colleagues outside Congress to get an independent assessment of progress in resolving the anomalous re-entry experiences.

When Mr. Gerstenmaier learned of this, he came to Rep. Rohrabacher’s office and spent nearly an hour detailing the technical analyses under way and the means to verify that the fix was successful.

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On the Hill continued from page 5

INKSNA. The second issue raised in the subcommittee hearing was the matter of extending the Iran-North Korea-Syria Non-proliferation Act waiver that allows the United States to purchase Soyuz and other ISS-related services from Russia until our own crew transfer systems are ready in a few years. (INKSNA was intended to dissuade Russia from supporting nuclear-related interests of the three countries.)

The current exception ends in 2011, but our need for access to the Soyuz will continue through 2015. NASA requested an extension through the planned resumption of manned space-flight (around 10 years from now). Although I supported NASA’s request, Congress was willing only to extend it to 2016.

I also tested several science and technology topics to see if they might lead to Congressional hearings. As a result, three presentations were given by Smithsonian Fellows in the Congressman’s office: Dr. Lynn Carter on general utility of the Arecibo radar, Professor John Logsdon on manned vs. robotic space exploration, and Dr. Richard Hallion on hypersonics R&D. Unfortunately, they were not well attended. The broad interest in space navigation and export control doesn’t appear to have found its focus.

Away from the Beltway
Meanwhile, the scope of my job was not limited to inside the Washington Beltway. I worked with the American embassies in Berlin and Moscow to put together an arrangement for German FGAN and Russian RT-70 radars to augment Arecibo’s radar. (I called on MIT and Defense Department colleagues as advisors.)

And I traveled to three conferences, generally at my own expense. In early March, I attended a Heartland Institute conference in New York City to listen to those who doubt that climate change is man-made.

In late March, I traveled to the Congressman’s district office where local staff kindly arranged a visit to Space Exploration Technologies Corporation (SpaceX) in Hawthorne, California. There, CEO Elon Musk gave me a personal tour. In 2006, SpaceX won the NASA competition to demonstrate transport of cargo and, optionally, crew to and from the International Space Station.

On the same trip, I also visited two Boeing plants, explored HTGR nuclear reactor technology at General Atomics, and learned about asteroids at JPL.

In late May, I accompanied Rep. Rohrabacher to Berlin and Moscow where we met with a number of government and corporate leaders and scientists, including Lt. Gen. Anatoliy Perminov, the director of Roscosmos, the Russian Federal Space Agency; Yuri Izrael, climate change expert and winner of the 2007 Nobel Peace Prize, and a long list of other notable figures.

In addition to the drafting of legislation, the briefings and staff work, constituent services, research and conferences, I also attended some remarkable events. Perhaps the most memorable were a California Winegrowers Association gathering in the Grand Hall of the Library of Congress and the reception hosted by the Ambassador of France at his residence.

Lasting Impressions
It has been a wonderful year! I believe I owe a short list of Washington, D.C., impressions to the next fortunate ION Fellow:

1. Shepherding a bill through Congress can be a daunting task.
2. Operations in Congress tend to place the minority party at more disadvantages than just sheer numbers.
3. Members of Congress have limited time to themselves and are seemingly “on-call” seven days a week.
4. The number of phone calls, letters, and visitors with suggestions or requests for support can become overwhelming, often leaving little choice but to simply pay attention and express appreciation.

Thank you!
This extraordinary experience could not have taken place without the kindness of the Institute of Navigation and its members, leaders, and staff, including Clark Cohen, Jim Doherty, John Lavrakas, Chris Hegarty, Carl Andren, and Lisa Beaty. Many thanks as well to Emily MacGillivray, Paget Graham, and Cynthia Robinson of the AAAS.
September 22-25

The modern world doesn’t work without GNSS. And this is only the beginning.

GNSS is interwoven into everything we do — that’s the remarkable achievement of the past 10 years. At the ION GNSS 2009 plenary session on Tuesday, September 22, a panel of industry, military, and academic experts will discuss sensor integration and increased signal power and sensitivity that are making GNSS-enabled tools — smart phones and, soon, robotic vehicles — normal tools of today’s urban environments.

Discuss these issues with your colleagues at the world’s first and largest GNSS conference: ION GNSS 2009 takes place at the Savannah International Convention Center in Savannah, Georgia USA from Tuesday evening, September 22 through Friday afternoon, September 25.

In between sessions, enjoy the ambience of old Savannah and the Southern low country (and check out some of the dining, historical, and entertainment attractions you may have missed last year.)

FIND OUT MORE:

www.ion.org/meetings/gnss2009program.cfm
Register online, or send your information and fees to our new address:

The Institute of Navigation
8551 Rixlew Lane, Suite 360
Manassas, VA 20109-3701

PROGRAM HIGHLIGHTS

Out of 587 abstracts — a record number — we accepted 288 on of the most cutting-edge papers (and 154 alternates) for presentations in Savannah. Just a few of the technical session topics:

- The systems: GPS, GLONASS, Galileo, Compass, IRNSS, QZSS
- Deep Indoor Navigation
- New Products
- Space Applications
- Space Weather
- Integrity and jamming
- Scientific applications
- Backup systems and more...
effects on GNSS. In organizing the workshop, their goal was to bring GNSS science and technology to African universities — the key to dispersing such critical information throughout the continent.

Twenty-five GNSS experts, 20 of whom were ION members, taught classes, led laboratory projects, and consulted individually with the African academics. Participants came from 18 universities in 12 countries.

One of the ION participants, Mike Miller of the Air Force Research Laboratory, characterized his experience there as “a truly amazing, inspiring, yet very humbling day.”

Networking
But it took a while for the university researchers, mainly from sub-Saharan Africa, and the GNSS experts, mainly from the United States, to establish the easy give-and-take that would make the workshop a success.

Doherty said people clustered in national and university groups at the opening dinner. “By the end, all kinds of collaborations were made. Scientists from Uganda, Kenya and Zambia are even planning to establish a regional network for scientific studies using GNSS, and I was delighted when they asked me to be an advisor.”

This groundbreaking event pointed the way to another collaborative possibility. Many research programs use GPS ground- and space-based measurements. But studies over the African region have not been possible due to the lack of dependable, long-term measurements. The workshop and the discussions may lead toward establishing a foundation of measurements for joint studies between American, European, and African colleagues.

What is a LEGO®?
The workshop wasn’t all talk. Lecturers integrated formal presentations with hands-on practice in GNSS architecture, signal structure, hardware design, state of the art applications, and scientific exploration using GNSS.

They devoted the first week to GNSS basics, the second to cutting-edge technologies, and the third to scientific exploration, including space weather and atmospheric monitoring.

Lecturers also spent a good deal of time on individual consultations, which the participants especially liked.

An on-site computer laboratory gave participants ample opportunities to perform positioning calculations, use mapping and surveying soft-
ware, plan a precision farming procedure, and analyze atmospheric and ionospheric data — all from GNSS measurements.

In one of the laboratories, participants built LEGO® Mindstorm® robots to demonstrate the concept of autonomous navigation. The Mindstorm® kits — which include a 32-bit ARM7 microcontroller with picture programming, USB and Bluetooth communications, sensor and motor ports — were donated by The Institute of Navigation.

The Mindstorm® kits are the same as those being used in the ION Mini-Urban Challenge organized with the AFRL Munitions Directorate, and each university team that participated in the Triest workshop received one.

In groups of four or five, participants followed instructions to build a robot out of the plastic LEGO® building blocks and Mindstorm package that automatically followed an oval track.

This was no simple task.

“Our participants never gave up,” Doherty said. “Many stayed in the lab late into the evening to finish their robots. But they had never heard of or seen LEGOs before. When I told one group that LEGOS are common toys for U.S. children, they were surprised. Something as simple as LEGOs reminded me that we came from different worlds.”

“They absolutely loved the Mindstorms,” said Miller, who taught the class with his son, Air Force Lt. Casey Miller, co-organizer of the Mini-Urban Challenge. “They were probably a highlight for them. In fact, the students — senior professors, junior professors and graduate students — worked through their afternoon break, past the scheduled stop time (5:30) until 7:15 p.m., building and writing software to get their robots to work autonomously. We finally had to ‘kick’ them out of the lab.”

And then there was the geocaching exercise.

Teams of four or five members used single-frequency GPS receivers in a treasure hunt cunningly planned by the instructors. Teams took off at 10-minute intervals to navigate a course that spanned the ICTP campus. The winning team returned in just over an hour. Everyone else took a lot longer — perhaps they stopped at local ice cream stands to buy gelatos, Doherty said.

At the end of the workshop, participants received GNSS textbooks and certificates. But the best gifts were Boston College baseball caps for everyone.

Finding Common Ground

The scientists came from very different countries and cultures — from Cote d’Ivoire, Egypt, Ethiopia, Ghana, Kenya, Morocco, Nigeria, Uganda and Zambia, with presenters mainly from the United States as well as the UK, South Africa, and Italy.

But yet another subgroup found common ground in the three-week symposium. All 10 of the women who participated ate dinner together one night at a nearby restaurant. The African scientists, who told the Americans that marriage at 12 or 13 was still common in rural villages, seemed to have had strong mothers and supportive fathers who valued their daughters’ education, said Doherty.

“They were interested as well in our stories of first- and second-generation American families, how we interact with our husbands and children, and how we came to our current professional status.”

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she said. “By the end of the dinner, we regarded each other as friends. We even swapped a recipe or two.”

**What’s at Stake**

In November 2003, UNESCO (the United Nations Educational, Scientific, and Cultural Organization) developed a structure for transformation of the African continent. The Trieste workshop took place within that context.

The Science and Technology Plan of Action clearly states Africa’s commitment to develop and use science and technology for socio-economic transformation and full integration into the world economy. The leading problems that continue to cripple much of Africa include hunger, extreme poverty, erosion of natural resources and natural disasters.

GNSS can help address these problems. Specifically, GNSS applications can be used to increase food security, manage natural resources, provide efficient emergency location services, improve surveying and mapping, and provide greater precision and safety in land, water and air navigation systems. It also has applications in numerous fields of scientific study including space weather, geophysics, geography, geology, ecology and biology.

Dozie Ezighalike, a visitor from the UN Economic Commission of Africa who presented to the ION International Technical Meeting last January, addressed participants at the end of the workshop. Ezighalike talked about the need for GNSS in Africa, and the necessity for the African academics to use it in their classrooms and in their research.

In a private conversation, Ezighalike told Doherty that the Trieste event was tailor-made for the needs of Africa, and he commended the organizers on the project.

For his part, Mike Miller noted that several African faculty had approach him “with questions and projects they are working on — from simple robot ‘walking’ plow equipment to a Kenyan university’s current effort to build a small satellite.”

Another workshop participant, Herb Carlson, with the Air Force Office of Scientific Research/European Office of Aerospace Research & Development, summed up the event in this way: “Bright motivated talent was found and collected, the instruction is stellar, the commitment from every direction is tangible, and bonds are reaching across traditional boundaries.”

**Same time next year**

Doherty said plans have already been approved by Boston College and ICTP to repeat the workshop in Trieste in March or April of next year. They also plan regional workshops in Egypt, Nigeria, and Kenya.

“No I just have to find the money,” she added.

The prime sponsors for this workshop include the ICTP, Boston College, The Institute of Navigation, the Federal Aviation Administration, the Air Force Research Laboratory and the United Nations Office for Outer Space Affairs.

These sponsors together with the lecturers and African participants represent a diverse collection of people who are committed to provide GNSS technology for socio-economic benefits and scientific exploration in Africa.

ION Eastern Region Vice President Patricia Doherty designed and led the GNSS Africa workshop. She directs the Institute for Scientific Research at Boston College. Co-organizer Sandro Radicella is head of the Radiopropagation Laboratory at the Abdus Salam International Centre for Theoretical Physics. ICTP fosters advanced studies and research in developing countries.
Special Committee 159
Minimum Operational Performance Standards (MOPS) for Airborne Navigation Equipment Using the Global Positioning System (GPS)


Both documents will be forwarded to the RTCA Program Management Committee (PMC) for approval at its December 16 meeting. The stand-alone GPS MOPS, a GPS L1-only standard that will replace DO-208, is expected to be ready for final review and comment (FRAC) in mid-December with plenary review/approval at the February 2009 meeting.

Current Working Group (WG) activities:

- **WG-2**, GPS/Wide Area Augmentation System (WAAS), proposed a plan to develop three documents: a signal-in-space document for space-based augmentation system (SBAS), a L1/L5 receiver/sensor MOPS, and a flight deck MOPS. The committee discussed the WG-2 proposal and requested that a revised proposal be presented at the next meeting.
- **WG-2A**, GPS/Global Orbiting Navigation Satellite System (GLONASS), reported that the Russian government increased the funding for the GLONASS program very significantly. A status briefing is planned for the next plenary meeting.
- **WG-2C**, GPS/Inertial, addressed two major items: inertial integration with ground based augmentation system (GBAS) approach type (GAST) D and inertial integration with WAAS. A position paper on GAST D integration was presented, which covered three areas: integration methods, threat model (signal-in-space fault modes) and test methods. For WAAS integration, the working group is trying to develop a WAAS (post-correction) error model for nominal conditions.
- **WG-4**, GPS/Local Area Augmentation System (LAAS), presented the revised LAAS MOPS and the LAAS ICD document for approval. Status presentations were received from LAAS-relevant groups: FAA LAAS program status update, status of the joint precision approach and landing system (JPALS) program, International Civil Aviation Organization Navigation Systems Panel, and the European Organization for Civil Aviation Equipment (EUROCAE) WG-28 and WG-62.
- **WG-6**, GPS/Interference, is working with SC-135 to develop DO-160 radiated emission test procedures and limits for installed avionics equipment that assure compatibility with onboard Global Navigation Satellite System (GNSS) operation.

Co-Chairmen:
Christopher Hegarty, MITRE/CAASD
George Ligler, PMEI

RTCA Program Director:
Harold Moses

CALL FOR ABSTRACTS: ABSTRACTS DUE JULY 31, 2009

October 26-28, 2009
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Emerald Coast Conference Center
Fort Walton Beach, FL
The world’s GNSS programs have lived exciting lives recently, with launches, critical audit reports, technical difficulties, and broadcast of a new civil signal.

**GPS**

U.S. program leaders breathed a deep sigh of relief on March 24 and April 10, respectively, when a GPS Block IIR-M satellite was launched and began broadcast the new civil L5 signal. But sighs turned into bated breath, when an anomaly was detected in the same satellite’s L1 transmissions.

The L5 broadcast ensures that GPS has met an International Telecommunications Union (ITU) deadline for securing the right of primacy to use of the frequency.

Described by the GPS Wing’s chief engineer, Col. (Select) David Goldstein, as larger than expected, elevation-dependent pseudoranging errors, the L1 anomaly appears likely to keep the spacecraft in on-orbit checkout mode for an extended period of time. The Air Force has launched an intense investigation of the technical problems drawing on satellite experts inside and outside the Department of Defense (DoD).

Meanwhile, the frustrating journey through prelaunch testing of the first follow-on generation of satellites, Block IIF, continued. Discovery of a power anomaly in the signal generator of the first GPS Block IIF space vehicle (SV) late last year has been resolved and the spacecraft passed the crucial milestone of thermo-vac testing in May.

In an Air Force/Boeing effort to expedite launch of the first IIF, now expected early next year, the second satellite was shipped to the Cape on May 6 to perform system-level compatibility tests and “serve as a risk-reduction pathfinder for SV1 processing later this year,” according to Boeing officials.

A report by the Government Accountability Office (GAO) released May 7 kindled a flurry of news reports worldwide about potentially sharp decline in the number of satellites in the GPS constellation. One scenario run by the GAO suggested that a two-year delay in the production and launch of the first and all subsequent GPS III satellites “would reduce the probability of maintaining a 24-satellite constellation to about 10 percent by around fiscal year 2018.”

Twenty-four SVs would be fewer than the minimum number of satellites to which the U.S. government has committed for national and international user communities. It would also surely diminish the quality of GPS service, particularly for military, safety-critical, and urban applications. The GAO used an Air Force methodology developed by the Aerospace Corporation and managed by James Womack, who presented a paper on the technique at ION’s 1998 National Technical Meeting (see accompanying article).

However, in response to a congressional hearing on the subject and alarming public reaction, U.S. Air Force, DoD, and industry officials issued strong reassurances that a calamity would not occur, that any deterioration in GPS service would be gradual and slight, and that the Air Force had plans in place for managing the constellation as well as the development and launch program for the next generation of satellites, GPS III.

The GAO report also criticized the Air Force and DoD for not “synchronizing” development of the GPS space and user segments with the timely fielding of military user equipment that can take advantage of the new M-code signal, which became available with the modernized Block IIR satellites.

Meanwhile, in mid-May the Lockheed Martin team developing the next-generation GPS III satellites successfully completed a major program milestone, the preliminary design review (PDR) conducted by the U.S. Air Force’s GPS Wing. The GPS IIIA Spacecraft PDR follows successful completion of 69 separate subsystem and element PDRs and keeps the program on track to meet a 2014 target for first launch of the new generation of satellites.

The GPS IIIA program will deliver all baseline signals delivered on current on-orbit GPS IIRM satellites, plus enhanced earth coverage M-code signal power, an L5 civil signal, and a new L1C civil signal compatible with the European Galileo program. Lockheed’s $3 billion contract...
includes design and development of the first two space vehicles (SV-1 and SV-2), options for up to 10 additional production vehicles, and a “capability insertion program” that matures technology for future increments.

President Obama’s first budget proposal — for Fiscal Year 2010 (FY10) — would provide more than $1 billion for GPS and related U.S. space-based positioning, navigation, and timing (PNT) programs.

Most of the funding — $927.8 million — would go to DoD, including $815.095 million for GPS IIIA satellites and Next-Generation Operational Control Segment (OCX) development through the Air Force RDT&E program, $52 million for GPS IIF and Operational Control Segment (OCS) development, and $60.7 million via Air Force Procurement for “Other Support, Space Programs.”

A June 18 meeting of the National Space-Based Positioning, Navigation, and Timing (PNT) Executive Committee (ExCom) brought together leaders of the Obama administration in the key interagency setting for GPS issues for the first time.

Established under a 2004 National Presidential Security Directive, the ExCom advises and coordinates federal departments and agencies on matters concerning the Global Positioning System and related systems. The deputy secretaries of defense and transportation and co-chair the committee, which includes equivalent-level members from seven other federal agencies.

The June gathering will also mark the final ExCom meeting for Mike Shaw, who served as the NCO’s executive director since its founding. Shaw has joined Lockheed Martin’s Crystal City, Virginia, operations, where he will work on GPS and other satellite programs, with Lockheed’s international business development office.

**GLONASS**

The Russian GNSS system is on track to have 24 modernized satellites (GLONASS-M) operating by the end of 2010 and 30 SVs by the end of 2011. Following a successful launch December 25, 2008, the constellation has 20 operational satellites, including 17 broadcasting open civil signals on two frequencies.

GLONASS performance has improved markedly in recent years. The signal-in-space ranging errors now averages about 1.8 meters, producing typical stand-alone positioning accuracy of about 5 meters. An increasing number of users with requirements for high GNSS availability have begun using the system.

In February, Netherlands-based Fugro N.V. began broadcasting its new G2 service, a carrier phase–based precise point positioning (PPP) providing decimeter level accuracy using GLONASS as well as GPS signals.

The GLONASS program has approved implementation of a new CDMA signal at L3, centered at 1201.74 MHz, with a demonstration payload planned on the first GLONASS-K spacecraft scheduled for launch in late 2010. Additional CDMA signals have been proposed at L1 (BOC 2,2) and L5 (BOC 4,4).

In February, the Federation Council of Russia approved the Federal law “On navigation activities,” which is intended to support and develop the GLONASS system and its applications for aid the nation’s economic growth. The GLONASS law establishes a legal framework for navigation activities, defines the powers of federal, regional and municipal bodies, and the legal rights of navigation users.

So far, Russia has spent more than 100 billion rubles (nearly $3 billion) in funding for its 2002–2011 GLONASS modernization effort.

**Galileo**

The European GNSS program is in the middle of contracting out the fully operational capability (FOC) system development for Galileo. European Commission (EC) and European Space Agency (ESA) officials say that agreements with companies winning the lead contracts for six work packages should be signed between September and the end of this year.

However, European industry and ESA sources indicate that the initial bids for the work came in several hundred million euros over the the 3.4-billion limit agreed by the European Council of the European Union and the European Parliament.

A proposal now before the parliament and Council would complete the transformation of the European GNSS Supervisory Authority (GSA)...

Galello continued on page 14
from the leading executive agency for the Galileo program into essentially an EC subsidiary.

That loss of the GSA’s once pre-eminent role envisioned under the strategy of a public-private partnership (PPP) reflects the abandonment of PPP efforts more than two years ago. Now, under the terms of EC Communication 139 released March 24, the GSA would be renamed the GNSS Agency with the EC holding veto power over its administrative board and the agency’s primary mission reduced to market research and promotion of Galileo as well as conducting security audits.

On April 1, ownership of the European Geostationary Navigation Overlay Service (EGNOS) infrastructure was transferred to the EC. A Brussels-based company, the European Satellite Services Provider (ESSP SaS), will operate the system under contract.

Meanwhile, negotiations with China have not resolved the conflict about a frequency overlay of Compass signals on Galileo’s security-oriented Public Regulated Service.

As if those troubles were not enough, a report by the European Court of Auditors (ECA) criticizes the Galileo program for “poor public-sector governance.”

Although the audit covers the program from its origins in the early 1990s up to the end of 2008, it focuses on the EU’s satellite navigation programs — Galileo and the European Geostationary Navigation Overlay Service (EGNOS) — during the years 2003 to 2006 when it was primarily managed by the Galileo Joint Undertaking.

The ECA is an official organization based in Luxembourg and given powers under various European Union (EU) treaties to carry out independent audits of programs and their use of EU finances.

On another bureaucratic front, the Office of the U.S. Trade Representative (USTR) solicited public comment on American industry’s access to the Galileo program and related markets.

An invitation published in the April 15 issue of the Federal Register sought comments on six questions regarding U.S. equipment manufacturers’ ability to participate in Europe’s GNSS program. The notice cited three specific sections — Articles 5, 6, and 8 — of the 2004 Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications between the European Community (EC) and the United States.

Prompted by a congressional footnote in the 2009 Omnibus Appropriations Act, the USTR’s inquiry reflects concerns that Galileo program management is placing U.S. GNSS receiver manufacturers at a disadvantage vis-a-vis European firms.

**Compass**

China launched a second modernized Compass (Beidou-2) satellite on April 14 — this one a geostationary spacecraft — two years after the program’s first launch.

Designated Compass G2 — reflecting the geostationary nature of its intended orbital position about 22,300 miles above the equator, the satellite is the first of 10 that China has previously announced it plans to launch over the next year and a half. The second “Compass” satellite was developed by the China Academy of Space Technology, which is part of the China Aerospace Science and Technology Corporation.

April 17, an Xinhua news report by Cao Chong, chief engineer of the China Electronics Technology Group Corporation, estimated that the first phase of Compass, scheduled to complete a regional capability by the end next year, would cost more than 10 billion renminbi (US$1.463 billion).

Reflecting the growing interest of receiver manufacturers in Compass, U.S. GPS pioneer company Trimble and the China Aerospace Science & Industry Academy of Information Technology (CASIC-IT) have announced plans to form a 50/50 joint venture in China to develop manufacture, and distribute Compass GNSS receivers and systems in China.

The new enterprise will be based in Beijing and focus on equipment to be used for civil applications in commercial positioning, navigation, and timing markets. The JV is expected to begin operations after regulatory approval from the Chinese government.

Although a “regional” capability is expected once the first 10 Compass satellites are in place, a global Compass service would not arrive until between 2015 and 2020, according to Yin Jun, director of the European Affairs Division of China’s Ministry of Science and Technology.

China has applied to the International Telecommunications Union (ITU) for priority use of several bands in which Europe’s Galileo program has planned to transmit its encrypted Public Regulated Service (PRS) signals for potential use in public safety, security, and military applications.

As currently proposed, Compass signals would occupy/oracle part or all of intended PRS frequencies, including Compass B1 at 1559-1563 MHz (overlaying lower part of Galileo E1A), Compass B1-2 at 1587–1591 (overlaying part of upper Galileo E1), and B3, a 24 MHz bandwidth centered at 1268.52 (overlaying a portion of Galileo E6).

This could complicate the ability of European forces to prevent use of GNSS services by adversaries in an area of conflict because it would not be able to jam signals from other systems on the PRS frequency without jamming its own signals. ◆
A report on GPS released May 7 by the Government Accountability Office (GAO) and a congressional hearing the same day have produced a flurry of news coverage — much of it seizing on a doomsday perspective about the satellite constellation.

At the heart of the excitement were a couple of computer scenarios run by the GAO that predicted the risk of a decline in the constellation to fewer than 24 satellites — the minimum level specified by the U.S. government as being available 95 percent of the time.

Behind the alarms lies a methodology developed by The Aerospace Corporation, a federally funded research and development center (FFRDC) with headquarters in El Segundo, California, that provides independent technical and scientific research to the GPS Wing among others.

The GAO used that methodology to run some simulations that suggested the constellation faced a risk — at the 10–20 percent level — of falling below 24 satellites. Another scenario, which assumed a two-year delay in the first launch of the GPS Block IIIA spacecraft, “would reduce the probability of maintaining a 24-satellite constellation to about 10 percent by around fiscal year 2018.”

At Aerospace, the forecasting activity has been managed for nearly 20 years by Jim Womack, who holds a Ph.D. in statistics from the University of California at Santa Barbara.

More than 11 years ago, Womack laid out that methodology — the Generalized Availability Program (GAP) — in a paper he presented at the 1998 ION National Technical Meeting, “Revised Block II/IIA Lifetime Predictions and the Impact on Block IIR/IIF Replenishment Planning.”

The GAP seeks to calculate the reliability expectations of on-orbit and unlaunched space vehicles (SVs) and help the Air Force match those expectations with development, manufacturing, and launch of new GPS satellites.

The methodology evaluates and tracks the performance of subsystems and critical components on the satellites. Of particular importance are the satellite’s reaction wheels, atomic clocks, and solar panels — all items crucial for the spacecraft’s operation and all of which eventually wear out. A fourth factor, random electronic failures, is also modeled in the analysis.

In predicting the longevity of the various satellites and their subsystems, the GAP analysis considers different factors at various points in a satellite’s development and operation. In a satellite’s initial design phase, reliability models are usually based on lifetime specifications. As subsystems designs mature, detailed “piece part” models are developed based on failure rates specified in a DoD handbook MIL HDBK 217.

The final stage of reliability modeling is the incorporation of subsystem failure models that use on-orbit failure data from operating satellites.

Of course, such analyses track moving targets as new generations of satellites come on line and operational satellites provide an ever greater body of data on which to predict future performance.

For instance, in his ION paper, Womack assumed a 33-satellite acquisition for the Block IIFs, which subsequently was reduced to the 12 IIFs that the Air Force will actually buy. And based on a production and launch schedule as of September 1, 1997, the first IIF would have gone up in October 2002, whereas the current schedule for launching a IIF spacecraft is in the first half of 2010.

The difference is largely explained by the actual experience with Block IIR satellites, only two of which had been launched at the time Womack wrote his paper. The IIRs have far outlived their anticipated lifetimes.
Somewhere in the collections of the National Museum of American History, listed in “Surveying and Geodesy-Miscellaneous” between “Abneys” and the “Rhodes Reducing Arc,” is a GPS Receiver. It's the Texas Instruments 4100 NAVSTAR Navigator Multiplex, the world's first commercial production GPS receiver, and Phil Ward and his team designed and developed it.

In Part I of this story, Phil Ward, lead navigator for the 1959 bathymetric survey of Crater Lake, helped create a revealing map that formed the basis for understanding the geomorphology of this natural wonder. By 1976, he was working for Texas Instruments, where he and his team developed the Missile Borne Receiver Set (MBRS). In 1979, he started work on the TI 4100.

The TI 4100 was first offered for sale in 1981 when only a small, test constellation of GPS Block I space vehicles (SVs) existed. The TI 4100 was a third generation GPS receiver. The design was based on custom large-scale integrated (LSI) components that were originally intended for military applications.

The LSI technology was integrated injection logic or I2L, the highest speed low-power bipolar digital technology of that time period.

The basic TI 4100 included an antenna/preamp assembly, the receiver, and a control display unit (CDU) with an optional dual-drive cassette recorder. Another option supported customer reprogrammable navigation.

A geodetic version evolved from a contract funded by the Defense Mapping Agency, National Geodetic Survey, and U.S. Geological Survey and administered by the University of Texas Applied Research Laboratory. This version was delivered in pairs with phase-matched antennas plus calibrated receiver characteristics.

The navigation error (typical four-SV solution) was: 14 meters, P-code; 47 meters, C/A-code; 0.015 meters/second, velocity.

Originally, GPS was developed to provide an all-weather, worldwide, continuous navigation system for absolute, three-dimensional, real-time navigation with 10-meter accuracy. But the TI 4100 eventually achieved a contemporary mile-
stone relative navigation precision using carrier interferometric techniques as well as precise time transfer.

Prior to the TI 4100, pseudorange was — and continues to be — described as the GPS receiver code ranging observable. Very little had been published about this observable, when the carrier tracking loop is in phase lock, or the intrinsic precision time transfer capability of GPS.

The TI 4100 was built with military-grade, custom application specific integrated circuits (ASICs). Only the standard components were commercial grade.

Several military GPS receiver designs evolved from the TI 4100 chipset as well as a highly classified Space Navigation Receiver (SNR). The TI 4100 ASICs were built using integrated injection logic (1-squared L), a low-power bipolar silicon technology that was intrinsically radiation-hardened and highly immune to single-event upset.

So, “the building blocks of the TI 4100 worked beautifully in space,” according to Ward. The SNR was an unheralded success in space. The program, now unclassified, was called the “Looking Glass.”

Uniquely, the TI 4100 did not use counters to synthesize its measurements. Instead, it synthesized code states and carrier states as natural by-products of digital code and carrier tracking loops phase states. These were the uncorrected SV-transmit times and Doppler-induced carrier phases, respectively.

The transmit times appeared in the form of the prompt replica code phase—offset measurements with respect to the GPS start-of-week time epoch.

The Doppler-induced carrier phase was actually the uncorrected, ambiguous integer count and exact fraction of carrier wavelengths between the antenna phase centers of the SV and the TI 4100. The challenge of solving these GNSS SV-receiver differential integer ambiguities continues to be the subject of many technical papers.

Accuracy: In the Receiver and in the Field
The quantization noise of the TI 4100 was effectively zero. (It measured its replica code and carrier states with quantization precisions of 2-32 P-chip and 2-32 cycle, respectively.) Design attributes like this helped the TI 4100 achieve very high GPS receiver accuracy when using relative navigation techniques to remove all common-mode errors while contributing minimal GPS receiver error to the end solutions.

Because the receiver generated these “natural” raw measurements, allowing researchers freedom to modify the way these measurements were incorporated, the TI 4100 led to many pioneering advances in ultra-high precision GPS applications using relative navigation and time transfer techniques.

Initially, positioning techniques usually incorporated correction data derived from known and fixed reference location, but some precise relative navigation methods were developed that used moving reference points.

Relative to a designated starting point, a single TI 4100 could navigate precisely for as long as the same four SVs could be tracked. For example, two TI 4100s were used simultaneously to demonstrate centimeter accuracy hover-hold techniques for helicopter applications.

That was just one example. From 1982 to 1986, industry scientists — including Ben Remondi, Clyde Goad, Bill Krabill and Ron Hatch — used the TI 4100’s raw measurements to demonstrate the precision and utility of GPS.

The baseline error for the geodetic version of the TI 4100 was less than a stack of five dimes.

A Stack of Dimes
The receiver’s geodetic version achieved the most remarkable differential GPS technology breakthroughs.

Their phase-matched conical spiral antennas contained precise indexes on the tripod-mounted preamp bases. In the field, both indexes were pointed toward magnetic north to minimize differential phase center migration. The L1 and L2 phase centers were also inscribed on the antenna radomes.

The geodetic version of the TI 4100 was designed under contract and delivered to the National Geodetic Survey, the U.S. Geological Survey, and the Naval Surface Weapons Center at Dahlgren, Virginia. In the 1980s and early ’90s, these systems were used as the GPS standard for geodetic control using the Block I SVs then in orbit.

Given the intrinsic accuracy of the receiver’s two-frequency carrier interferometry measurements, these systems exceeded previous first order geodetic surveying standards. The typical baseline error was less than five millimeter — the width of a stack of five dimes. (Use of GPS also allowed surveys with very long baselines. Previous survey technologies had limited baselines to interstation line-of-sight.)
Protecting the Homeland

The Prince of Wales, in a tie, hailed a South American leader, in feathers, at the European Google Zeitgeist conference near London in May. The South American is Almir Narayamoga Surui from Brazil’s Surui tribe, the first of his people to go to college.

College paid off — among other things, tribal leader and political organizer Surui discovered the uses of GPS. His group of Amazonian Indians had avoided the outside world until 1969. When they discovered Modern Life, it was already building a highway through their homeland. Decades of battle, disease, social and environmental degradation followed.

At the conference, Chief Surui gave a speech about how the Surui used GPS satellite technology and Google Earth maps, Almir Surui brought in scientists from Google Outreach to train people in the technology.

They have charted boundaries and their own tribal reforestation project. They also mapped the location of important plants, animal breeding areas and other resources and Surui cultural and historical events and sites.

The Surui are not alone. ACT is also helping indigenous people in Suriname and Colombia.

The U.S. Agency for International Development (USAID) has trained Ecuadorian indigenous people to use GIS and GPS mapping projects for boundary security, among other things. One group located an illegal coca-growing operation on their lands and eventually shut it down. ♦

GPS and the Expanding Digital Universe

The amount of data on the Internet is nearing 500 billion gigs. If we printed it out, it would be the size of a stack of books stretching from Earth to Pluto 10 times, says a May 2009 white paper on the expanding digital universe, “As the Economy Contracts, the Digital Universe Expands.”

Why so much? Seventy percent is due to us — our personal navigation devices, for example. (Or it is there to catch us — surveillance cameras and security systems.)

However, machine-to-machine communications are growing fast, says the Guardian newspaper: such as when a GNSS receiver (perhaps embedded in a cell phone) generates information about its location and communicates that data to a mobile location server or to other GNSS users.

The digital universe doubles every 18 months and GNSS is helping with the multiplication, said digital storage provider EMC and technology market research company IDC, who created the report. ♦
Boots on the ground take off high-tech backpacks

When you’re short of travel time and money, how do you prepare weekend warriors for the real theatre of war?

The National Guard thought it had the answer in its XCTC training program or eXportable Combat Training Capability. It’s a real-time, real-life combat environment that includes about 2,000 moving pieces — including positioning, tracking and videotaping devices, civilian role players, communications towers, special vehicles and trailers, computers and more.

The troops and the actors involved wear GPS and laser-based gear that records their location and each movement and engagement in an exercise. The troop commanders can watch and review the action to hone skills for the real combat situations they will find in Iraq and Afghanistan.

So far, so good.

Well . . . the devil is in the details, according to the Florida Times-Union in Jacksonville. A Wisconsin National Guard Unit spent a few weeks training at nearby Fort Blanding in late January before deployment to Iraq.

Participants told the reporter that the theory was excellent and the training was useful, but many of the high-tech tools failed in practice. They cited heavy, bulky equipment that got in the way, poor signal tracking back at the ops center, and a too-short instruction time for officers.

Meanwhile, SRI International, the company that makes the equipment is hard at work on an improved, second-generation version. ◆

Profile

POINT, Inc. is an international, technology company that helps SOKKIA create complete, cost-effective positioning systems in response to market needs. We develop high-quality innovative solutions by integrating diverse leading-edge electronics, hardware and software programs.

We tailor each system to meet the various market-specific requirements, and we oversee the entire process—from design to manufacturing to international certifications. Our SOKKIA integrated systems are used in more than sixty countries around the world. Our integrated solutions include:

• Rugged, high-precision GPS systems designed for a variety of applications, including: Surveying, mapping and construction.
• Handheld, Windows CE-based data collection software that communicates with multiple measuring instruments, including total stations, GPS receivers, theodolites, lasers, levels and more.
• Windows, embedded, and HTML (server) based software applications that provide networking, planning, and post-mission support for GPS projects.

What makes POINT unique?

• In-depth understanding of positioning technologies and their various applications.
• Broad mix of technology skill sets
• Experience leading both large and small projects from inception to completion.
• Ability to provide complete solutions for complex systems, including hardware, firmware, software, documentation, training, support, etc.
• Understanding of international clients, requirements and markets.
• Ability to leverage knowledge base and resources from parent companies SOKKIA Co. Ltd and NovAtel, Inc.
DAYTON SECTION
ION Dayton Section Visits The Ohio State University Campus:

On 16 April, 2009 around 30 members of the ION Dayton Section visited the campus of The Ohio State University. The colloquium was hosted by ION Fellow Dr. Jiit Gupta of the Electro Science Lab (ESL), along with Dr. Charles Toth and Prof. Dorota Grejner-Brzezinska from the Satellite Positioning and Inertial Navigation (SPIN) lab. The section members were in attendance for presentations from multiple OSU graduate students working with both labs. After the presentation sessions at Dreese labs, the section members enjoyed lunch on campus, followed by a tour of the ESL facility, and demonstration of the SPIN research data collection capabilities. The ION Dayton section has also been hosting monthly luncheons, featuring speakers in the navigation field. So far in 2009, PhD Student Andrew O’Brien from The Ohio State University, Capt. Will Storms and Capt. Jason Crosby from AFIT have presented. ION President Dr. Mikel Miller will close out the 2008-2009 Dayton section presentation session in May.

WASHINGTON SECTION

The ION DC Section met at the National Air and Space Museum on April 7 to hear a presentation by ION Executive Fellow (NASA) Dr. Frank van Graas. Prior to the presentation a tour of the museum was provided by Andrew Johnston of the Smithsonian Institution. A special thanks to Andrew and Carlene Stephens of the Smithsonian for helping with the venue.

During his sabbatical year from Ohio University, Dr. Frank van Graas is serving as The Institute of Navigation Executive Branch Science and Technology Policy Fellow. His fellowship placement is with the Space Communications and Navigation Office at NASA Headquarters in Washington DC. Dr. van Graas provided an overview of the ION’s Government Fellow program and what a unique and exciting educational experience that is provided.

The second part of the presentation covered the ongoing research at Ohio University on anomalous behavior of the GPS navigation and timing service. These anomalies include the usual clock and orbit errors, as well as more subtle anomalies such as small steps, non-standard code side effects, and brief outages due to aircraft over-flights of reception antennas. Emphasis was placed on methods to hunt down and characterize these anomalies using sampled, wide-band radio frequency data.
SOUTHERN CALIFORNIA SECTION

On February 18, 2009, the Southern California Chapter of the ION held a meeting, hosted by NavCom in Torrance, CA. The meeting included a presentation from Dr. Bob Norris of John Deere on an unmanned ground vehicle (UGV) named the R-Gator. 28 people were in attendance for the meeting.

Bob provided an update on the R-Gator program. He discussed the challenges involved in the localization and navigation of a large (1400 lb) unmanned ground vehicle and how Deere’s solutions enable the accurate localization, navigation, obstacle detection and avoidance of the R-Gator.

The primary objective of the R-Gator system is to remove the user from hazardous, non-combat related missions. The ability to perform a variety of robotic utility tasks, in hostile environments and over complex terrain, reduces the users’ exposure to hazards. The secondary objective of the R-Gator system is to serve as a host for payloads. Under its current configuration, the R-Gator provides payload space, 1400 lb carrying capacity, a limited power supply, an ethernet and CAN interface for access to vehicle network communications.

The R-Gator (Robotic Gator) is an advanced ground vehicle system, capable of robust operations in both manned and unmanned modes. The combat proven John Deere M-Gator serves as the basic mobility platform, allowing existing logistics, maintenance, and training investments to be leveraged for reduced cost and ease of deployment. The R-Gator’s capabilities include manual operation, several forms of tele-operation via joystick, map based GPS waypoint navigation and path teaching and playback.

Following the talk, Chuck Morton, NavCom’s Manager of StarFire System Operations, provided a short guided tour of the StarFire Network Data Processing and Control Center. The StarFire Network gathers information from GPS monitoring receivers around the world and constructs differential corrections and integrity monitoring of the GPS satellite system, in real time. These corrections and health data are broadcast around the world via a network of 6 INMARSAT satellites. StarFire equipped GPS receiver routinely achieve 0.1 m or better navigation performance. The Torrance Control Center is one of two completely-redundant processing centers that have allowed the StarFire Network to achieve better than 99.9% up time.

On December 16, 2008, the Southern California Chapter of the ION held a meeting, again hosted by NavCom in Torrance, CA. The meeting included a two-part presentation from Dr. Chris Bartone of Ohio University covering The ION Virtual Museum and eLoran. About 25 people were in attendance for the meeting.

Part I – The ION Virtual Navigation Museum

Dr. Chris Bartone is the Chair of the ION Outreach Committee, and Editor of the ION Virtual Navigation Museum (VNM). While the ION is a non-profit professional society dedicated to the advancement of the art and science of navigation it also recognized the importance of preserving previous art and science in navigation. The ION VNM was established in September 2006 to allow visitors to read descriptions, view photographs, and obtain detailed information on a navigation device, systems, components, and/or methods in a convenient on-line format. The ION VNM link is: www.ion.org/museum/. Chris discussed the foundation of the museum, how it is organized, and administered. He presented some of the interesting entries into the museum and the various collaboration efforts that are ongoing.

Part II – eLoran

Enhanced Long Range Navigation (eLoran) leverages many of the modernization efforts that have been pursued for the traditional Loran-C. One significant difference between eLoran and Loran-C is the addition of a data channel on the transmitted signal to convey application-specific corrections, warnings, and signal integrity information to the user’s receiver. Other modernization efforts include going to time-of-transmission (TOT) control and the implementation of new transmitter, all-in-view receiver, and antenna equipment. Dr. Bartone provided an overview of the modernization and eLoran efforts as well as the Loran research efforts ongoing at Ohio University. Chris presented details on the Loran Propagation Model development and validation for additional secondary factor predictions and measurements, Loran noise characterization, and antenna H-field characterization for Loran.

On March 11, 2009, the Southern California Chapter of the ION held a meeting, hosted by NavCom in Torrance, CA. The meeting included a presentation from GPS Space Wing Chief Engineer Col(S) David B. Goldstein on the subject of the new GPS III Space Vehicle and Modernization. 25 people were in attendance for the meeting.

Colonel (S) Goldstein provided an overview of the new GPS Block III satellite series development approach as well as a description of the modernized capabilities that will become available in the future. The talk described the spiral development approach beginning with GPS Block IIIA, and the incremental increase in capability with each new series of GPS III Block vehicles, the Block IIIB and IIIC.

South Eastern Section

Due to the wide geographic area of the South Eastern Section the meetings were virtual meetings using Telecon and Web Meeting applications. The section met on November 18 to listen to a presentation by Peter MacDoran of CyberLocator. The talk was on GPS Location-Based Authentication for Network Security. A second meeting was held March 17 with Dr. Vicki LeFevre, Aviation and Missile Research, Development and Engineering Center. The topic presented was MEMS-based Inertial Technologies in the Present and Challenges for Inertial Technologies of the Future. Slides from both presentations can be downloaded at www.ionse.org.

ALBERTA CANADA SECTION

Attendees at the February 6 meeting heard a presentation by Professor Michael Braasch, Director, Avionics Engineering Center, Ohio University titled: “Iron Stomachs and White Knuckles: Navigation Flight Testing at the Ohio University Avionics Engineering Center”

Since its founding in 1963, the Ohio University Avionics Engineering Center (AEC) has been on the cutting edge of navigation and landing system research. The AEC is somewhat unusual in that it is an academic institution with its own fleet of flight test aircraft. Over the decades, these aircraft and the crews that fly them have amassed a wealth of experience that can only be obtained ‘in the air.’ The AEC’s DC-3 served as the flight-test platform for the world’s first commercial GPS receiver back in the early 1980’s. Guidance, navigation and control packages destined for installation in military unmanned aerial vehicles are first put through their paces in the AEC’s ex-Soviet fighter-trainer, the AeroVodochody L-29 Delfin. From flying synthetic vision displays up in Juneau’s Gastineau channel to automatic dependent surveillance broadcast (ADS-B) system flights down in Miami, the AEC has been involved in taking navigation research out of the classroom and lab and making the systems work in the field and in the air.

This presentation will cover a handful of the many flight test stories in the AEC’s history. What kind of navigation engineer do you need for a flight test with 6g turns? One that’s eager, healthy and preferably has not eaten all day!
The geodetic survey version of the TI 4100 achieved the only two-frequency (L1 and L2) P-code interferometric operation in commercial GPS history because the Block I SVs did not have Y-code encryption capability. The TI 4100 achieved 5-millimeter triangulation closure accuracy across 10-kilometer surveying baselines, the best performance of any other commercial GPS surveying receiver.

Later, a version of the TI 4100 was developed that included P(Y)-code capability, but obviously this version was not used commercially. The GPS Joint Program Office called it “The Gold Standard of GPS Receivers.” The TI 4100 reverted to L1 C/A-code when the anti-spoofing module was turned on in the Block II SVs.

With careful mission scheduling and planning, the receivers provided very cost-effective first order geodetic surveying, even though the GPS Block I test constellation only provided about two hours of four-SV observations each day.

The long successful life of TI 4100 ended in 1988, when Texas Instruments retired it with honor. They also honored its maker in 1991, when Phil Ward accepted their Golden Parachute award.

In 1995, the USGS resurveyed Crater Lake: this time using established techniques of modern GPS surveying. They achieved far greater precision than the original 1958 surveys in a fraction of the time — although the new methods did not confer muscle mass and tans upon the operatives, as the 1959 survey did.

Although the original mission of GPS as stated by the GPS Joint Program Office upon its formation in 1973 was to “Drop 5 bombs in the same hole...and don’t you forget it”, it is clear that many of the early contributors, including the young ensign named Phil Ward, would recognize its potential to explore the beauty of the world.

He continues to contribute to ION and to satellite navigation as principal of Navward Consulting. Phil and his wife, Nancy, live near Dallas, home of Texas Instruments. ◆

Marvin B. May is Chief Scientist at the Navigation R&D Center of the Pennsylvania State University’s Applied Research Laboratory in Warminster, Pennsylvania.

In Memoriam

After a courageous battle with leukemia, Richard Barker, 57, died January 6, 2009. Richard was an honors graduate of California State Polytechnic University, where he received a BS in Engineering.

For the past 30 years, Richard worked for Fugro Chance Inc. in Lafayette as Manager of the IT Services and Systems Engineering & Support. During his years at Fugro he pioneered many of the software and positioning systems which led to Fugro’s success. These systems included the BUOYTRAK remote processor package which integrated LORAN and GPS for seismic streamer tracking.

Richard served over the years as Satellite Division Treasurer, Land Representative, Council Member at Large, Technical Meeting General Chair, Program Chair and Technical Chair; he authored numerous papers on the subject of satellite positioning. He was a guest speaker at the 2007 American Meteorological Society’s Environmental Science Seminar and the 2007 Space Weather Enterprise forum both in Washington DC.
Members are encouraged to submit nominations for one or more of the following annual awards given by The Institute of Navigation for excellence in navigation.

- **Early Achievement Award** — for an individual early in his or her career who has made an outstanding achievement in the art and science of navigation.
- **Norman P. Hays Award** — for outstanding encouragement, inspiration and support leading to the advancement of navigation.
- **Superior Achievement Award** — for individuals making outstanding contributions to the advancement of navigation.
- **Thomas Thurlow Award** — for outstanding contributions to the science of navigation.
- **Tycho Brahe Award** — for outstanding achievement in space navigation.
- **Captain P.V.H. Weems Award** — for continuing contributions to the art and science of navigation.

**Fellow Nominations**

Nominations for ION® fellows may be submitted by currently active Institute of Navigation members. All nominations must conform to ION® nomination guidelines as outlined on the nomination form. Nominations must include a brief biography and proposed citation.

Details of the nomination process and forms are available at www.ion.org. Nominations must be received by October 15, 2009, to qualify.

Election to Fellow membership recognizes the distinguished contribution of ION® members to the advancement of the technology, management, practice and teaching of the arts and sciences of navigation, and/or for lifetime contributions to the Institute.

Former members of the ION® who are not currently active members of the organization may be elected to non-voting Fellow membership. Election to Honorary Fellow membership is authorized for non-members of The Institute of Navigation who are qualified by their accomplishments for recognition as a non-voting Fellow member. Members of other national institutes of navigation are also considered in this category.

Kindly address any correspondence to Fellow Selection Committee, The Institute of Navigation, 8551 Rixlew Lane, Suite 360, Manassas, VA 20109, phone: 703-366-2723; fax: 703-366-2724; e-mail: mlewis@ion.org.

Ohio State University has named Jong Ki Lee as the recipient of the ION-sponsored OSU Graduate Student Award. He is a Ph.D. candidate in the geodetic science and surveying graduate program at The Ohio State University. Lee’s research efforts focus on the application of artificial intelligence to navigation and alternatives to Extended Kalman filter (EKF).
ION GNSS 2009

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