ON THE OREGON TRAIL

ION GNSS 2010 HEADS FOR PORTLAND

ION’s GNSS international conference and exhibition — the world’s premier event for the industry — returns to the U.S. Pacific Northwest for its 23rd annual meeting, September 21–24, in Portland, Oregon.

Opening under the plenary theme, “The ‘Big Three’ Issues for GPS: Sustainment, Robustness, Interchangeability,” this year’s meeting will feature more than 260 paper presentations in 36 parallel sessions ranging from algorithms to applications, from satellite and signals to receiver design.

Participants also have their choice of six panel discussions including GNSS program updates and another commemorating the 50th anniversary of Kalman filtering. Col. Bernard Gruber, the newly installed commander of the GPS Wing, has confirmed his participation in the first panel, as have Rene Oosterlinck, director of the European Space Agency’s Galileo office, and Dr. Hiroaki Maeda, representing Japan’s Quasi-Zenith Satellite System (QZSS) program.

Keynote speaker and moderator for the opening evening’s plenary session will be Dr. Bradford Parkinson, emeritus professor from Stanford University and the founding chair of the ION’s Satellite Division. He will be joined on the panel by Dr. Paul Massatt, The Aerospace Corporation; Phil Ward, Navward GPS Consulting; David Turner, U.S. Department of State; and Dr. Mikel Miller, Air Force Research Laboratory.

New technical sessions this year include one on the GPS Block IIF satellite, the first of which is still undergoing on-orbit checkout. Other special sessions include two sets of invited papers on “Integrating System Capabilities at the GPS Wing” and “NATO Military PNT & NAVWAR.”

A reception in the exhibit hall on Wednesday night (September 22) will be hosted by approximately 60 companies and organizations exhibiting at the conference this year. The annual Johannes Kepler and Bradford W. Parkinson awards will be announced at a luncheon on Friday (September 24).

Operating under the auspices of the ION Satellite Division chaired by Dr. Pratap Misra, ION GNSS 2010 has as its general chair, Prof. Naser El-Sheimy, from the University of Calgary, Canada. Patricia Doherty, Boston College, serves as this year’s technical program chair.

Preceding the conference itself is the 50th meeting of the Civil GPS Service Interface Committee (CGSIC), an open forum organized by the U.S. Department of Transportation, which will also be held at the Oregon Convention Center on September 20–21.

Previous ION GNSS conferences held in Portland in 2002 and 2003 proved extremely popular with attendees, few of whom had visited either the city or the state before. Many participants extended their stay to take advantage of the easy

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FROM THE PRESIDENT
DR. MIKEL MILLER

From Lawn Mowers to UAVs, ION Reaches Out

As you review this issue of the ION Newsletter you will see that ION’s outreach programs continue to thrive.

The ION Satellite Division’s Robotic Lawn Mower Competition had a record 14 university teams from California to Florida and points in between participate this year. Many thanks to Don Venable, Dayton Section Chair, and the Dayton Section membership for making this competition a memorable annual event.

ION’s second Mini-Urban Challenge (MUC) co-sponsored by the Air Force Research Laboratory (AFRL), attracted twice as many high school students in 2010, with 304 young scientists-in-the-making taking part. (That’s almost triple the 103 who participated in 2009.)

We were encouraged to see more schools, teachers, community leaders, civic/non-profit organizations and volunteers giving hands-on help to the budding engineers. Volunteers participated in coordination, publicity, judging, creation of the competition course, construction of the LEGO® buildings, and mentoring of students and schools.

I am happy to report that we are already planning to double the number of regional competitions in 2011. Many thanks to the competition chairs (and MUC founders), 1Lt Caroline New (USAF) and Capt. Casey Miller (USAF), for turning their vision into a reality.

And, continuing my “expansion” theme, I would like to draw your attention to the ION’s Autonomous Weapons Summit and GNC Miniature Autonomous Systems Workshop to be held October 25-27, 2010, at the Emerald Coast Conference Center in Ft. Walton Beach, Florida. It is supported by the Air Force Research Laboratory, Munitions Directorate.

Now in its third year, the workshop and summit will bring together the leading users and developers of the next generation of autonomous weapons systems. At this fall’s event you will still find all the advantages of prior year workshops, but you will also be able to experience the expanded program made available as part of the Autonomous Weapons Summit. For more information please see www.ion.org/aws.

As a U.S. government civil servant, I found the experiences related by the active duty operators of equipment and systems developed and managed by numerous ION members, to be simply awe-inspiring.

Jim Doherty. As a U.S. government civil servant, I found the experiences related by the active duty operators of equipment and systems developed and managed by numerous ION members, to be simply awe-inspiring. Know that as PNT professionals you do make a difference to the safety and security of our troops.

ION GNSS 2010 is being held September 21-24, 2010 in Portland, Oregon. I look forward to seeing you in September in the lovely Pacific Northwest. ◆
As we saw in the first part of this series, the assisted GPS (A-GPS) technology revolution has brought us a long way. Having come this far, we can ask that most famous of all navigation questions: Are we there yet?

The assisted GPS (A-GPS) technology revolution has brought us a long way. Having come this far, we can ask that most famous of all navigation questions: Are we there yet?

The rest of this article will answer this question for the consumer segment of GNSS: Has the consumer market reached the point we expected it to be by now? And has the technology in consumer GPS reached levels we expected?

In the next few pages I will show you that:

- from a consumer perspective, we have exceeded market forecasts
- from a technology perspective, we have kept track with Moore’s law —
- chips and receivers are cheaper than expected — because, as well as Moore’s law, we have seen greatly increased volumes and competition
- from a performance perspective, low-cost chips have not come at the expense of quality, in fact the opposite — as chips have evolved, they have become less costly and better performing.

Small, cheap, antennas have also affected performance, and many would argue that it’s for the worse. However, given the same antenna, I will show you that a receiver with a single-die GPS chip that costs less than $4 can outperform a $19,000 receiver. This sounds paradoxical, even impossible, but the metrics of time-to-first-fix (TTFF), sensitivity, and urban accuracy data will prove my point.

Another implication of the chip evolution is that we are reaching plateaus of development for GPS-only systems. Many problems still remain to be solved — especially in urban canyons and indoors. But these problems may never be solved with GPS alone (or any other single system alone). So, this decade will be characterized by “GPS-plus”, and the days of GPS-only will soon be in the past.

This should not be interpreted as a failing of GPS — quite the opposite. Because GPS-only systems have worked so well that they have found their way into half a billion cell phones, and we are boldly taking GPS to places no satellite navigation has gone before — and due to this success we have begun to run into the limitations of GPS-only performance.

In the near future we will see the proliferation of “GPS-plus”: GPS+MEMS inertial, GPS+WiFi, GPS+NMR (network measurement report), and GPS+GLONASS, Compass, QZSS (Japan’s Quasi-Zenith Satellite System), and Galileo. And the winners will be those with the greatest levels of integration. So, to paraphrase Winston Churchill, this is not the end of GPS-only; it is not even the beginning of the end. But it is the end of the beginning.

GPS Consumer Market
To see how market predictions compare with actual sales, we can turn to a summary of GNSS forecasts provided in the book GNSS Application and Markets by Len Jacobson. In this summary, there is a single forecast for the 2010 consumer market: a 2006 Frost & Sullivan report estimated that the global market for portable navigation devices (PNDs) and other mobile handheld devices (not including cell phones) would be $2.7 billion, with 8.3 million units sold (for an average selling price or ASP of $325).

In fact, this market today is approximately $6 billion, with 40 million units (at an ASP of $150).

In summary: the consumer market, not including cell phones, is twice as big (in dollars) as forecast a few years ago, even though prices are less than half forecast. Unit sales are more than four times the forecast.

For the cell phone market segment let’s return to 1999 when it was anticipated that A-GPS would be adopted in fine-time networks only (such as the CDMA networks). Today A-GPS is dominant in both fine-time and coarse-time networks worldwide, including GSM in Europe and North America, and W-CDMA in Japan.

The GPS consumer market, in particular the cell phone market, has grown so rapidly that more GPS receivers have been built in cell phones in the last three years than all other GPS built ever. And today L1-only C/A code GPS accounts for over 99% of all GNSS receivers manufactured each year.

So, from a consumer market perspective, have we reached the point we expected to be by now?

YES!
Not only are we there, we have surpassed expectations of where we would be today. Next, let’s take a look at the technological developments of the last decade, and see if they have reached the point that we expected.

**GPS and Moore’s Law**

Moore’s law says that for a given number of transistors, the chip size will halve every two years. What this looks like in practice is summarized in the accompanying table, which shows a particular class of GPS chip: the A-GPS receiver with massive parallel correlation and the release dates of different generations of these chips.

<table>
<thead>
<tr>
<th>Introduced</th>
<th>Process</th>
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<tbody>
<tr>
<td>2001</td>
<td>0.18 µm (180 nm)</td>
</tr>
<tr>
<td>2004</td>
<td>0.13 µm (130 nm)</td>
</tr>
<tr>
<td>2006</td>
<td>90 nm</td>
</tr>
<tr>
<td>2008</td>
<td>65 nm</td>
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I’ve also shown the technology process, which is the linear dimension in micrometers (µm) and nanometers (nm) of a single gate on the silicon die. As this dimension reduces to 70 percent of the previous value the (2D) chip size reduces by two times.

So, you can see Moore’s law in action here in GPS, as approximately every two years the technology process changes to the next level, and the chip size reduces by 2X. Already in 2010 people are talking about 40-nm GPS chips, which is the next step in the process.

For comparison purposes, consider a GPS chip found in many cell phones measures 2.9 x 3.1 millimeters, the size of the letter B on this page. (This is a single-die, host-based GPS/satellite-based augmentation system (SBAS) receiver, including RF front end, low noise amplifier, baseband, and power management unit.)

Ten iterations of Moore’s law have passed in the last two decades years. The same chip, had it been built 20 years ago, would have been 210 times (more than a thousand times) bigger. The point is that chips were never that big. — GPS chips aren’t just getting smaller with Moore’s law, they are getting vastly more complex and more capable.

**Performance of the Lowest-Cost GPS**

At an elemental level, a GPS receiver does just three things: it starts, tracks weak signals, and computes position, velocity, and time. Strip away the obfuscating details and performance may be summed up by: how fast, how sensitive, and how accurate.

Since the 1990s, TTFF and sensitivity have improved dramatically thanks to the seven technology enablers discussed in Part 1 of this series. TTFF for assisted cold starts, or unassisted warm starts, is now as good as one second, even without fine-time (accuracy better than one millisecond) assistance.

This is a 45-time improvement on typical GPS performance of the 1990s. Sensitivity increased roughly 30 times (to –150 dBm) in 1998, then another 10 times, (to –160 dBm) by 2006, and perhaps another three times to date, for a total of almost 1,000 times extra sensitivity.

And what about accuracy?

Some perceive low-cost chips as being synonymous with low accuracy — but this is not true. It is true that small, cheap, antennas reduce accuracy, but, given the same antennas to work with, the lowest cost receivers on the market today will outperform the most expensive in typical environments where cell phones are used. The accompanying figures show data to prove this point.

First we connect one of the smallest, lowest cost, GPS receivers to one of the best antennas (a choke ring) on a roof top with a clear view of the sky. The left-hand plot in Figure 1 shows the scatter of positions. The blue circle shows the median distribution, which is 0.9 meter for this data set of 2,000 position fixes.

The adjacent plot shows the positions obtained from a $19,000 survey-grade GPS receiver connected to the same antenna.

So, the survey grade GPS shows a 60-centimeter advantage over the cell phone GPS, or maybe a 3X advantage depending on how you look at it. But don’t get too hung up about this result, because this is neither the typical consumer scenario (on a rooftop with choke ring antenna) nor the main challenge facing us today.

Next we look at the accuracy achieved with a more typical consumer antenna in a more typical environment. Figure 2 shows the positions obtained in downtown San Jose with an active patch antenna (such as found in PNDs). (With venues portrayed in Figures 2 through 5, San Jose is a fairly typical U.S. city — not the hardest place to use GPS, but not the easiest either.) The labeled street (Lightstone Alley), adjacent to tall buildings, is only five meters wide.

To evaluate accuracy we used a truth reference system combining GPS and a tactical grade inertial measurement unit (IMU) with ring laser gyro, to produce the blue dots on the figure. The white dots are the low-cost GPS positions. Most of the time the white dots appear to be on top of the blue, but occasionally you see some separation, and there the red...
lines show the horizontal error. The median horizontal error is 4.4 meters.

**Figure 3** shows the comparison of low and high-cost receivers, with the survey-grade receiver connected to the same patch antenna as the cell-phone GPS. Many position gaps appear in the survey-grade receiver data, and the position walks around when the vehicle is stationary (at the intersections, bottom left and top of the figure).

This performance results from the weak signals available in the urban environment; but don’t get too hung-up on this data either, because we have still not met the real challenge of consumer GPS: location in severe urban canyons, such as San Francisco, New York, Chicago, Shanghai, Taipei, Shinjuku (Tokyo), and similar locales. In these places, often only one or two GPS satellites can be seen directly. Other satellites may be tracked, but only by observing reflected signals.

This is not classic GPS multipath in its most often analyzed meaning, that is, the combination of a direct and reflected signal; instead, this is position calculation based on nothing but reflected signals. The direct signals are usually completely blocked by many buildings and cannot be tracked directly by a receiver at all. So, the whole premise of GPS — observing range from time of flight — breaks down, and obtaining satisfactory positioning accuracy is very difficult.

**Figure 4** compares the cell-phone GPS data side-by-side with the survey-grade GPS, connected to the same small antenna, in San Francisco’s Financial District. There are no fixes at all from the survey-grade receiver!

**Figure 5** looks deeper into the available signals to explain why. In Montgomery Street, pictured in the figure, only one satellite was directly visible, and it had a signal strength of -132 dBm. All the other satellites were at -140 dBm or weaker, and traditional GPS receivers cannot acquire signals at this level. Hence, the only receivers that work in this environment are modern high-sensitivity receivers most commonly found in cell-phones.

So, in summary, we see that the move to lower cost receivers has not come at the expense of performance. In fact the opposite: TTFF and sensitivity have improved dramatically thanks to the seven technology

**GPS REVOLUTION continued on page 6**
enablers discussed earlier. Meanwhile, accuracy has not been compromised and is, in fact, much better in urban environments than legacy receivers and even modern, multi-thousand dollar, survey-grade receivers.

But Are We There Yet?
We have seen that the consumer GPS market has surpassed expectations. From a technical perspective the answer is more nuanced. Consumer GPS technology has made tremendous leaps forward in the last decade. And, as I mentioned earlier, precisely because of these improvements we are taking GPS where it was never expected to be.

For GPS to work indoors (which it can) is no longer enough; the demand is now for it to work as well as if it were outdoors (which, presently, it cannot). Performance improvements seen with GPS-only will almost certainly not continue at the same rate as seen heretofore. For example, we do not anticipate yet another 45X improvement in TTFF, or another 30-decibels of sensitivity, for GPS-alone. However, we do expect order of magnitude performance increases with the addition of other technologies.

Figure 6 shows a commercially available example of a consumer device incorporating GPS+MEMS (micro-electro-mechanical system) inertial. The device is the TomTom 950, which contains the same chip used for the foregoing tests, along with MEMS accelerometers and MEMS rate gyros.

When tightly integrated with the GPS and tested in the same deep urban canyons of San Francisco, the effect on position is favorable —median accuracy is improved by 30 percent, worst case errors are more than halved — but the effect on heading accuracy is especially dramatic.

The bar graph in the lower right-hand corner of Figure 6 shows the worst-case heading accuracy in each of the streets in the San Francisco test. With GPS-only (red) the worst-case error is around 45 degrees, which will be a familiar result to anyone who has used any GPS-only device in a similar environment — sooner or later the map will veer erroneously. However, with the integration of the MEMS rate gyros the worst-case heading errors drop to around 3 degrees. So, we see a 15X improvement in a key metric; similar to the kind of advances we saw in the last decade for GPS-alone, but now thanks to the effect of “GPS-plus.”

In this and future years we will start to see GPS-plus in combination with many other technologies: WiFi, NMR/MRL (power measurements from GSM and 3G phones), and, of course, GPS plus GLONASS, Compass, QZSS, and Galileo.

For example, most of the recent iconic smart-phone, netbook, and similar devices contain GPS and WiFi, and many also have 3G capability. So, a natural path is emerging for the evolution of GPS technology to include WiFi and MRL measurements. A natural trend also is appearing towards the sourcing of different radios from the same chip-supplier. After all, why would you wish to undertake a do-it-yourself effort at removing co-existence issues that can crop up with different radios, when a chip supplier has already done the work for you?

As we look forward to a new decade of navigation technologies, we will very likely discover that this is the decade characterized by GPS-plus other technologies, and the winners will be those with the greatest levels of integration.◆

Dr. Frank van Diggelen is Senior Technical Director of GPS Systems and Chief Navigation Officer for Broadcom Corporation. Dr. van Diggelen is the inventor of coarse-time navigation, co-inventor of long-term orbits for A-GPS, and holds more than 50 issued U.S. patents on A-GPS. He has a Ph.D. in electrical engineering from Cambridge University and is the author of A-GPS: Assisted GPS, GNSS & SBAS, the first textbook on assisted GPS.
First-hand experiences with GPS from troops in the field provided a highlight to this year’s Joint Navigation Conference (JNC), held in Orlando, Florida, June 8-10, 2010.

Part of the classified session on June 10, the War Fighter Cross Talk Panel brought six representatives from the Army, Air Force, and Coast Guard to discuss their perspectives on the use of GPS in combat missions: operational benefits, challenges, and suggestions for improving equipment.

All panel members were recently returned from theater or between deployments: Coast Guard Lieutenant Fred Bertsch, Army Captain Travis Brunelle, Air Force Captain Todd “Punch” Campbell, Army Major E. J. Karlberg, Air Force Captain Sean Williams, and Air Force Master Sergeant Alan Yoshida. Panel moderators were ION President Dr. Mikel Miller of the Air Force Research Laboratory (AFRL) Munitions Directorate and Past ION President Jim Doherty of the Institute for Defense Analyses.

Panel members described what they do when they cannot receive GPS, types of equipment used, and changes they would like to see in their equipment. They offered specific and candid comments on user interface and intuitiveness of use (for example, “Gear should work for me, not me for it.”), power consumption (“Carrying more batteries means carrying less water.”), and accuracy (“Need more precision and need it faster.”).

Their practical comments flowed from a range of intense, real-world experience.

Lt. Bertsch commanded the Coast Guard Cutter Aquidneck, deployed in the Arabian Gulf for maritime interdiction and security operations. Capt. Brunelle is second in command of an elite Army Special Forces company, focused on unconventional warfare. Capt. Campbell is an Air Force A-10 pilot with more than 300 combat hours in over 60 combat sorties in Afghanistan, providing close air support to coalition forces.

Maj. Karlberg is deputy senior fire support trainer for the Army at Fort Irwin, having recently returned from Iraq where he was the fire brigade operations officer, otherwise known as the “battle space owner.” Capt. Williams is assistant flight commander and evaluator navigator in special operations in Air Force AC-130 gunships, who has deployed to both Iraq and Afghanistan. Master Sergeant Yoshida is currently with the Air Force Special Operations Command, responsible for special operations tactics and para-rescue operations.

GPS Under Fire

The Joint Navigation Conference is co-sponsored by the ION and the Joint Services Data Exchange (JSDE). JNC 2011 will be held June 28-30, 2011, at the Crowne Plaza Hotel in Colorado Springs, Colorado, with tutorials scheduled June 27.◆
"It ain’t over ‘til it’s over.” Yogi Berra’s famous lines appeared in my 1998 ION spring newsletter article on the remarkable resilience of a navigation system that has faced being shut down since the early 1980s. That system was LORAN-C and over the past dozen years it continued to cling to life and even showed shines of rejuvenation.

But, on January 7, 2010 — notwithstanding the recommendations of an Independent Assessment Team and protestations from international organizations — the Coast Guard published a Federal Register notice to terminate transmission of the United States LORAN-C signal on February 8, 2010. The Commandant of the Coast Guard had certified that it was not needed for maritime navigation and the Secretary of the Department of Homeland Security said it was not needed to backup GPS.

A February Coast Guard announcement said the termination would not affect U.S. participation in Russian-U.S. or Canadian-U.S. LORAN-C chains until the international agreements ended, but they “strongly urged” mariners using LORAN-C for navigation to shift to a GPS navigation system and become familiar with its operation as soon as possible. Mariners can no longer rely upon LORAN-C for navigation as of February 8, 2010.”

And so U.S. Loran-C signals were duly made “unsusable and permanently discontinued.” Thus ended a 90-year history. LORAN-C has a heritage that can be traced back to the electronic radio direction finding systems of the 1920’s. Those early systems were generally restricted to distances less than 100 nautical miles, and more sophisticated radio navigation techniques were required for the longer-range missions of World War II.

**GEE and MIT**

In 1940, the British developed the GEE hyperbolic radionavigation system and used it for the first time on the night of March 8, 1942. GEE directed Royal Air Force bombers against Essen, Germany, the opening counter-punch of the British World War II attack on German cities.

The GEE transmitters in England provided navigation signals that covered the Netherlands and Germany’s Ruhr Valley industrial region. It subsequently played a major role in guiding Allied bombers during the D-Day invasion of Normandy, marking the major conclusive battle on World War II’s western European front.

GEE remained in service as a navigation aid in friendly airspace after the war; the last GEE transmitter shut down in 1970. By that time, other hyperbolic radionavigation systems such as DECCA, OMEGA and LORAN were in operation. Meanwhile, between 1940 and 1945 the Massachusetts Institute of Technology Radiation Laboratory — effectively a subdivision of the National Defense Research Council (NRDC) — began to develop a long-range navigation system for ships and aircraft.

The NRDC was the result of early concern by leading American scientists to develop better military technology as the threat of war in Europe loomed. The Radiation Laboratory researchers were not given detailed specifications for this
navigation system. They might develop improved radar, or a harbor entrance locator for convoys. At this period, they were simply searching for something, anything, that might serve the nation when war actually came.

Early in 1941 a U.S. Army colonel returned from England and told certain members of the Radiation Laboratory staff that the English had a pulse-transmitting navigational aid that operated on a very high frequency and was rumored to exceed radar’s precision range of 50 to 100 miles. He had made several attempts to discover details of its construction and operation, but the British wouldn’t disclose military secrets to a neutral during that time of great national peril. The colonel could state positively only that such a system did exist.

On the strength of those statements, Dr. Brown of the MIT Radiation Laboratory and Bell Telephone Laboratories made a hurried trip to England. Through his widespread commercial and scientific connections, he managed to gather a few salient facts about the British GEE System.

Back in Cambridge, the Rad Lab carried the British idea further. Their work would result in the “Long Range Navigation (LORAN)” system. It was designed to provide longer range than GEE at the expense of accuracy, primarily for naval navigation. The LORAN team was led by Dr. John A. Pierce of Bell Labs.

The first five operational LORAN transmitters were put into service in June 1943, and operated from sites on the coasts of Nova Scotia, Newfoundland, Labrador, and Greenland. The radio and television pioneer, Philco, built LORAN receivers for aircraft, and New York’s FADA Radio & Electric Company built LORAN receivers for ships.

Inside LORAN
Like GEE, LORAN used a master-slave transmitter network to allow an aircraft or ship to determine its position from a pair of hyperbolas traced out on a map. Early experiments used transmitters operating at 10 meters (30 MHz). It turned out, however, that radio waves with longer wavelength could propagate farther through the atmosphere, particularly through ionospheric bounce, and the operational system used wavelengths of 171, 162, 158, and 154 meters (1.75, 1.85, 1.9, and 1.95 MHz).

LORAN was the only Rad Lab invention that used long wavelength signals. They gave LORAN a range of about 800 nautical miles compared to GEE’s 400 nautical miles, particularly at night when signals bounced off the ionosphere. LORAN was not as accurate as GEE and, like Decca, LORAN was intended mainly for transoceanic navigation for aircraft and ships, not for targeting.

Although LORAN could in principle have used the same “one master/two slaves” arrangement as GEE, in practice LORAN ended up with one master and four to six “secondaries”, forming a LORAN “chain”.

The LORAN pulses had a width of 40 microseconds, and were repeated about 25 times per second. The delay between master and secondary was variable, and was changed on a regular basis to prevent the enemy from making use of the system. Authorized users were given tables indicating which delays would be in effect at which time.

LORAN signals could be disrupted by severe electrical storms, but otherwise LORAN worked in any weather, day or night. Accuracy was about 1% of the distance of the LORAN receiver from a transmitting station, which was roughly equivalent to the accuracy obtained by celestial navigation. Range was about 1,100 kilometers (700 miles) from transmitting stations during the day. At night, radio...
signals bounced off the ionosphere, doubling the range, though multipath interference degraded the signal.

Due to diffraction effects, radio waves can actually propagate close over the surface of the Earth, though such “ground waves” tend to fade out at higher frequencies and longer range. The original LORAN scheme used the ground wave instead of the sky wave to synchronize the master and secondary stations, but with experience the designers learned that the sky wave could be used to provide acceptable synchronization, at least at night.

This allowed the master and secondary stations to be situated up to 2,000 kilometers (1,080 nautical miles) apart, which increased the range of the system and provided a more accurate grid, since the two sets of hyperbolas were more distinct. The result was “skywave synchronized LORAN (SS-LORAN)”. In 1944 and 1945, the RAF used SS-LORAN transmitters sited in England and the Shetland Islands to guide bombers on missions as far east as Warsaw.

By the end of the war, 70 LORAN transmitters had been installed in sites as remote as Assam, India, and Kumming, China, with the network providing navigational coverage over 30 percent of the Earth’s surface. Some 75,000 LORAN receivers were in operation, and millions of LORAN charts had been printed and distributed. LORAN was particularly useful for finding islands in the broad expanses of the Pacific Ocean.

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Autonomous Weapons Summit and GNC Challenges for Miniature Autonomous Systems Workshop

October 25-27, 2010

Emerald Coast Conference Center • Fort Walton Beach, FL

SESSIO N TOPICS
FOUO U.S. ONLY
- GNC Challenges for Miniature Autonomous Systems (multiple sessions)
- Combatant Command Perspective
- Processing and Algorithms
- Navigation
- Networking
- Seeker Sensors
- DoD & Service Perspective
- Dynamics and Controls
- Simulation and Test Technology

PUBLIC ACCESS SESSIONS
- Alternatives to GPS
- Avionics and Control
- Precision Navigation in Challenging Environments
- Operator Interfaces
- GNC Test Technology
- Networking
- Seeker Concepts and Technologies
- Small Weapons and Systems Concepts

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Certainly, Cold War rivalry served as a catalyst for jump-starting the race, and President Kennedy’s challenge to put a man on the moon before the end of the 1960s galvanized American popular opinion. But, as we continue what has become a marathon with many competing national and commercial rivals, we must not lose sight of the consequences of losing the race. U.S. national security and commercial prowess depend on an advantage in space.

The new policy goes on to state, “… we find ourselves in a world where the benefits of space permeate almost every facet of our lives.” I agree, and in my view the policy falls short of providing the necessary national motivation to succeed. Our nation greatly needs to motivate young Americans to become the engineers and scientists required to maintain a U.S. lead in space-based technology and applications. The policy is right about the importance of space. Space systems and the technology that results from space exploration will continue to affect our everyday lives in ever-expanding ways — including our national security.

Faced with the budget realities of the current economic downturn, it comes as no surprise that the new policy places a significant emphasis on the role of the commercial sector in achieving the administration’s policy vision. The first goal is dedicated to “Energize competitive domestic industries to participate in global markets and advance the development of: satellite manufacturing; satellite-based services; space launch; terrestrial applications; and increased entrepreneurship.”

The opportunities for gaining access to space through the commercial marketplace present an interesting number of prospects. However, we are unlikely to realize those prospects without more emphasis on growing a new generation of young Americans interested in pursuing engineering and science. This seems essential if we as a nation are to meet the challenges inherent in greater commercialization of the space race.

Under the Intersector Guidelines, the new space policy tasks departments and agencies to promote and expand public-private partnerships that foster educational achievement in science, technology, engineering, and mathematics (STEM) programs and to target investments in these areas.

Will this general mandate motivate our nation’s workforce now and into the future to develop the cutting edge technology required to remain the world’s leader in space? Or, do words like “international cooperation” and “multilateral transparency” found elsewhere in the policy statement signal a willingness to allow engineers and scientists from other nations to pick up where our own education system is unable to compete?

As quoted in the introduction to the new policy, President Eisenhower captured the essence of why I chose to pursue an engineering degree when he stated, “More than by any other imaginative concept, the mind of man is aroused by the thought of exploring the mysteries of outer space.” The current policy missed an opportunity to motivate this nation’s young people to pursue careers in science and engineering. Without that, the United States is unlikely to successfully meet challenges as our commercial sector forges ahead into the new frontiers of space.

This is the first installment of a regular column on navigation topics related to defense and security.

Doug Taggart is president of Overlook Systems Technologies, Inc. In addition to his day job, he is currently serving as the IEEE-USA Chairman for the Committee on Transportation and Aerospace Policy, which identifies as one of its key mission areas a commitment to support the careers and public policy interests of IEEE’s U.S. members in appropriate professional areas of economic, ethical, legislative, social, and technology policies in the United States. He was an ION Congressional Fellow in 2005/2006 and is currently serving on the ION Council.
During the first week of June this year, 14 teams from the U.S. and Canada converged on Siebenthaler’s Garden Center near Dayton, Ohio, for the Seventh Annual ION Robotic Lawn Mower Competition. In the advanced competition, last year’s champion Case Western Reserve University took first once again, winning the $15,000 grand prize.

The 2010 event was sponsored by the Air Force Research Laboratory (AFRL) Sensors Directorate, The Institute of Navigation’s Satellite Division, Rockwell Collins, Honeywell, John Deere and Siebenthaler’s Garden Center.

It took place over three days, beginning Thursday, June 3, with paper and presentation judging and qualifying rounds preceding the actual mowing of lawns.

The competition was stiff this year, as more teams — both experienced and new to the event — tried to “cut the green stuff” remotely than any year to date. Students drove across the country from California, Florida, and Canada — attempting to take home some “green” as well — more than $35,000 in sponsored prize money that was up for grabs.

They came up with a variety of mower designs, most of which used a fusion of GPS, laser scanners, cameras, inertial measurement units, odometers, and touch sensors feeding custom designed navigation algorithms.

Qualification judging took place on Friday, June 4, during which all but two teams were able to qualify. This major milestone challenges teams to demonstrate that their mower is fit to compete by passing various safety and operational tests.

In what is quickly becoming a tradition leading up to the competition, many of the teams worked late into the night — with some through the night — tweaking their equipment in preparation for the big day.

Mow-by-Mow Description
By 8 a.m. on the morning of the final event, as volunteers arrived and the dew rose from the grass, it looked like a beautiful day to do some mowing.

But it didn’t come easy.

This year, thunder and lightning closed down the competition’s headquarters tent shortly after qualifications were over, a recurring pattern during the weekend. Rain held off while the mowers were in the field, but a round of thunderstorms moved in while the judges were calculating the scores.

The wild weather and grass that was thicker than most teams had expected made the mowing more difficult. Teams adapted by adjusting mower blade heights, motor controller gains, and navigation strategies.
to deal with adverse conditions. But it was
tough — none of the other five winning
teams took home 100 percent of “the
purse” because they didn’t manage to cut at
least half of the grass.

Final scores included a combina-
tion of points from the teams’ technical
papers, presentations, and the mowing
competition. Seven teams competed in the
advanced division — a field with fences,
flowerbeds, and The Institute of Navigation
robotic poodle, Pierre, showing up here
and there in their path.

University of Florida took home third-place
garnering $800 of a $1,000 prize.

The Cast
Teams that entered the basic competition
were California State Fullerton, The Univer-
sity of Cincinnati, Georgia Southern Univer-
sity, The University of Florida, The University
of Michigan, University of New Haven, and
The University of North Florida, with The
University of Cincinnati being the only team
to return in the category from 2009.
The advanced competition included

Dr. Brian Kent, AFRL’s chief scientist,
kicked off the session with a talk
outlining the importance of science,
technology, engineering and math (STEM)
education to the health of the United States
and Defense Department infrastructure
as well as the critical role of positioning,
navigation, and timing technology.

Don Venable, the current competition
chair, and Dr. Jacob Campbell, a previous
chair, briefed the competitors and an-
swered questions about logistics, schedule,
and safety.

The grand prize winner was followed by
Cedarville University taking home $8,000
of the $10,000 second-place prize in the
advanced division, and Auburn University
receiving $4,000 out of a possible $5,000
third-place award.

Seven more teams attempted the basic
competition, a defined field with a randomly
placed static object. The University of North
Florida took first place, winning $2,000 of
the $2,500 prize. Second place went to the
University of New Haven, winning $1,250 of
the $1,500 prize. And last but not least, the

last year’s champion Case Western Reserve
University, along with returning teams from
The University of Evansville, team CAPRA
from École de Technologie Superieure, and
Wright State University. Teams from Auburn
and Cedarville Universities have competed
in the past, but both brought new teams and
mowers to try the advanced field this year.

And finally, a new team from California
State Long Beach decided to trek across the
country with their mower “Roy” disassem-
bled, and checked in their airline luggage
to compete.

The teams then presented the work
and designs they had completed over the
past year before a panel of guest judges
from the Air Force Institute of Technology
(AFIT) and AFRL and an audience of
students and faculty from competing
schools. It was a great time for the teams
to discuss different design strategies and
network with each other.

Several distinguished visitors were
spotted in the crowd, including senior
leaders Dr. David Jerome, director of the
AFRL Sensors Directorate, and Joseph
Sciabica, AFRL executive director, along
with Dr. Steve Butler, executive director of
the Air Force Material Command.

ION President Dr. Mikel Miller closed
out the session with a short presentation,
and stayed after the paper judging to
interact with the students and faculty at a
reception hosted at the Wright Brothers
Institute Tec^Edge Innovation and
Collaboration Center.
Excitement was high last month as seven high school regional winners from high schools across the eastern United States competed in the second ION Mini-Urban Challenge at Wright State University in Dayton, Ohio, for a grand prize of $2,500.

After eight hours of intense competition, the winning team, “Catastrophic” of Pace High School in Pace, Florida, emerged victorious at the national competition on June 4. Parkway High School of Bossier City, Louisiana, finished a close second and a second Pace High School team, “Navigators,” took third.

Encouraging high schools and teenagers, who may never have had a chance to engineer a complex project and compete, is a top goal of the two-year-old ION event.

The 2010 contest doubled in size from last year, with 40 high schools and 304 students participating in regional contests in Shalimar, Florida; Washington, D.C.; Dayton, Ohio; and Bossier City, Louisiana.

The Challenge invites high school teams of three to five students each to enter the contest. They spend the entire school year designing and programming robotic autonomous vehicles using competition provided LEGO® Mindstorms® NXT kits. The robots must navigate accurately through an 18-foot square Lego city, obeying street signs and speed limits and stopping at locations designated by the judges on the day of the race.

Each kit includes a 32-bit microprocessor, interactive servomotors, built-in rotation sensors to align speed for precise control, and a variety of optional sensors, including a color light sensor, black and white light sensor, sonar sensor, touch sensor, and sound sensor. The teams get to keep their LEGO® kits after the competition.

The competition challenges students in the areas of problem solving, optimization theory, code writing, path planning, technical speaking, vehicle design, efficient programming, and test and evaluation planning. The students work with their own teachers as well as engineers from the local communities who serve as team mentors.

America’s top technologists at the best universities and companies are trying to solve the problem of autonomous traffic navigation. ION’s Mini-Urban Challenge encourages high school students to explore the same challenge. It is further motivated by President Obama, who told a meeting of the National Academy of Sciences and the National Academy of Engineering last year, “Think about new and creative ways to engage young people in science and engineering, like science festivals, robotics competitions, and fairs that encourage young people to create, build, and invent – to be makers of things.”

This fall, the Mini-Urban Challenge will expand again. The organizers are considering new regional contests in Boston and Los Angeles, Utah and Southern Colorado. Teams may enter the contest beginning this September. The 2011 national competition will take place at the Smithsonian’s National Museum of American History on May 21.

“I loved going into the schools, working side-by-side with the students, and watching their interest in science and engineering grow throughout the year. The Mini-Urban Challenge is a great thing for our nation’s high school students!”

— Lt Tan Van, Air Force Research Laboratory, Munitions Directorate, and one of the competition’s numerous mentors
Florida High School Uses Lego® Mindstorms® Kit to Build a Robot and Win $2,500

Pictured top to bottom:
Second Place: Parkway High School (Bossier City, LA), $1,500
Third Place: Pace High School (Pace, FL), “Navigators”, $500
Best in Show: Robert Montgomery High School (Rockville, MD)

Congratulations to our 2010 National Champions!

The National Competition of the 2010 Mini-Urban Challenge was held June 4, 2010 at the Erwin J. Nutter Center, Wright State University, Dayton, Ohio. The top teams from each region participated in 3 days of competition, activities and learning.

Complete List of Participating Teams:
• Archbishop McNicholas High School, Cincinnati, OH
• Benton High School, Benton, LA
• Pace High School, Team: Catastrophic, Pace, FL
• Pace High School, Team: Navigators, Pace, FL
• Parkway High School, Bossier City, LA
• Richard Montgomery High School, Rockville, MD
• Talawanda High School, Oxford, OH

SPONSORS

The generous support of our sponsors makes this contest possible. If your company, university, or agency would like to help the 2011 high school teams, e-mail Lisa Beaty at Lbeaty@ion.org.

Track the 2011 competition all year at www.MiniUrbanChallenge.com

Follow us on Facebook – ION Mini-Urban Challenge

CALENDAR

SEPTEMBER 2010
21-24: ION GNSS 2010, Portland Convention Center, Portland, Oregon
Contact: The ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

OCTOBER 2010
Contact: German Institute of Navigation
Tel: +49-228-20197.0
Fax: +49-228-20197.19
Web: www.dgon.de

22-22: 16th Ka and Broadband Communications Navigation and Earth Observation Conference, Grand Visconti Palace Hotel, Milan, Italy
Contact: Ms. Clotilde Canepa Fertini
Tel: +39 338-700-1650
Web: www.kaconf.org

25-27: ION’s Autonomous Weapons Summit & GNC Challenges for Miniature Autonomous Systems Workshop, Emerald Coast Convention Center, Fort Walton Beach, Florida
Contact: ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org/aws

26-28: International Symposium on GPS/GNSS, Taipei, Taiwan
Contact: NCKU
Tel: +886-6-2345482
Web: www.gnss2010.ncku.edu.tw

JANUARY 2011
24-26: ION International Technical Meeting (ITM) 2011, Catamaran Resort Hotel, San Diego, California
Contact: ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

JUNE 2011
28-30: ISDE/ION JNC 2011, Crowne Plaza Hotel, Colorado Springs, Colorado
Contact: The ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

SEPTEMBER 2011
20-23: ION GNSS 2011, Portland Convention Center, Portland, Oregon
Contact: The ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org
All of the world’s GNSS systems showed signs of progress in recent months, with launches, certification of augmentation systems, and a new operational signal — the GPS L5 — beginning transmissions.

**GPS**

On the fourth launch attempt, the first GPS Block IIF (follow-on) generation satellite was launched May 27 from Cape Canaveral Air Force Station, Florida.

In July, Air Force officials at the GPS Wing confirmed that higher-than-expected range residuals detected by researchers at the German Aerospace Center (DLR) are appearing in signals transmitted by the first GPS IIF satellite, designated SVN/62/PRN25.

But the Air Force and Boeing Space and Intelligence Systems, which built the spacecraft, point out SVN62 is currently performing within specifications, and the signal phenomenon does not appear likely to have any significant effect on GPS positioning when the satellite is declared operational.

The 2nd Space Operations Squadron (2SOPS) and the Boeing team at Schriever Air Force Base, Colorado, are well along in the 90-day on-orbit testing and validation process.

The IIFs have a design life of 12.5 years, weigh 1,545 kilograms (3,406 pounds), and carry a span of 13.11 meters (43.01 feet) with solar panels producing an average of 2.40 kilowatts. The satellites’ navigation payload must generate and transmit seven signals: the L1 C/A-code (1575.42 MHz) and civil L2 (L2C) signal at 1227.60 MHz, the legacy P(Y)-code signals along with the new military M-code at both L1 and L2, and a new civil safety-of-life signal at L5 (1176.45 MHz).

Meanwhile, work on the next generation of GPS satellites is progressing well.

Earlier this year, Lockheed Martin successfully completed a key GPS IIB System Requirements Review (SRR) under the U.S. Air Force’s GPS III Space Segment program. Currently, the Air Force and Lockheed Martin expect to conduct the GPS IIIA Critical Design Review (CDR) in August — two months ahead of schedule.

The program is working toward a 2014 launch date for the first GPS III satellite.

A new U.S. National Space Policy announced in June by the White House gave the GPS program high visibility in an approach that reflected a more cooperative and internationalist approach to the GNSS efforts. For example, the policy stated that foreign GNSS services may be used “to augment and strengthen the resiliency of GPS.”

The new policy reaffirmed efforts in recent years “to engage with foreign GNSS providers to encourage compatibility and interoperability, promote transparency in civil service provision, and enable market access for U.S. industry.”

**GLONASS**

Three GLONASS-M satellites are scheduled for launch from the Baikonur space center in Kazakhstan on September 2, according to the Russian Space Agency.

As of August 1, the GLONASS constellation had 23 satellites, with
two in reserve as spares and one offline for maintenance. Officials plan to launch a total of seven GLONASS satellites this year, including the first test-flight version of the GLONASS-K spacecraft.

In June, Russian Prime Minister Vladimir Putin, said that 2.5 billion rubles ($85.24 million) were spent on GLONASS in 2009, and another 3.7 billion rubles ($122.6 million) have been allocated for 2010–11.

A provisional specification for the planned GLONASS CDMA signal has been defined and is available to receiver manufacturers interested in experimenting with the demonstration CDMA signal that will be broadcast from the GLONASS-K satellite.

A representative of the Russian Space Systems (RSS), extended the offer in June during the Asia Pacific Economic Cooperation GNSS Implementation Team (APEC-GIT) meeting in Seattle, Washington. While cautioning that a final GLONASS-K interface control document (ICD) has not been approved, the official said that specification could allow manufacturers a head start in designing receivers that will be able to process the CDMA signals.

RSS is an amalgamation of 10 former Russian federal state unitary enterprises — that is, government corporations — and other Russian institutes and agencies established last year, with the former Russian Institute of Space Device Engineering (RISDE) serving as the lead.

In May, RSS and Trimble announced a 50/50 joint venture, Rusnavegoset, that will develop and market GNSS equipment and geodetic network infrastructure systems for the regional governments within the Russian Federation and Commonwealth of Independent States or CIS, former members of the Soviet Union.

Galileo

On August 2 the European Satellite Services Provider (ESSP) will be able to remove the message 0 (Do Not Use in aviation) from the European Geostationary Navigation Overlay Service (EGNOS) signal, representing the first step toward use of EGNOS for enroute and lateral guidance approaches (LNAV) in civil aviation.

The action follows approval of a certificate of “Air Navigation Service Provider” issued to ESSP in July by the French National Supervisory Authority (NSA). The certification confirms that ESSP complies with safety criteria for operations and is a prerequisite for the company to provide navigation services to airspace users.

Similar to the U.S. Wide Area Augmentation System (WAAS), EGNOS provides integrity alerts and real-time differential corrections to GPS signals. After a successful operational period of three months, the European Commission will be able to declare the safety-of-life service available to the aviation community, enabling the publication of precision approach procedures with vertical and lateral navigation guidance (APV) based on EGNOS.

Meanwhile, the European Commission has asked for additional funding of Galileo-related research and development to support an Action Plan on GNSS Applications.

Described in a “communication” to the European Council and European Parliament, the plan seeks an additional €362 million in the 7th Framework Program for R&D (FP7) to support €100 million annual expenditures for GNSS user equipment and application market development over the next four years. Currently, only €38 million in FP7 funds have been allocated for disbursement in 2011.

In 2008 the EC reprogrammed €400 million from the FP7 budget to finance development of Europe’s GNSS infrastructure following abandonment of a public-private partnership (PPP) model in favor of a purely public implementation of Galileo. That left the commission without resources for promoting commercial development and downstream markets for Galileo and EGNOS.

Compass

China successfully launched the fifth Compass (Beidou-2) satellite — the system’s first inclined geostationary orbit (IGSO) spacecraft — on August 1 from Xichang Satellite Launch Center in southwestern Sichuan Province. It was the third successful Compass satellite launch this year.

That gives the current Compass/Beidou-2 constellation a complement of three geostationary orbit (GSO) satellites, and one each in middle Earth (MEO) and IGSO orbits.

In early June, China began transmitting signals on three frequencies from the Compass G3 GSO satellite launched on June 2. G3 is the third Compass (Beidou-2) GSO and the second such launch this year following a GSO launch on January 17.

Chinese officials announced that the Compass G3 had reached its geostationary position at 84.6° E longitude on June 7. According to current plans, primarily Compass Phase II (CPII) signals will be used in the regional system, transmitting on three frequencies using quadrature phase shift keying (QPSK).

The full 35-satellite GNSS Compass system planned to be in place by 2020 would use mainly binary offset carrier (BOC) waveforms, with the signals moving on two of the frequencies during Compass Phase III: 1561.098 MHz shifting to 1575.42 MHz, where GPS and Galileo L1 signals are centered, and 1207.14 MHz moving to 1191.795 MHz. “Authorized” signals will be transmitted from 1268.52 MHz in both phases.
Arthur C. Clarke's GPS Letter
Periodically, science fiction icon Arthur C. Clarke's prescience on telecommunications satellites and other technology wonders hits the news.

This month, the blogosphere has picked up a letter Clarke wrote in 1956 predicting satellite-based positioning and navigation. (Luckily, he wrote this down before e-mail and texting; so, the typed note has been preserved.)

In response to a letter from his friend Andrew G. Haley of the American Rocket Society, Clarke — who was an RAF radar instructor during WWII — wrote that in 30 years an “orbital relay system” could take over all existing surface [communication] networks:

“...three stations in the 24-hour orbit could... make possible a position-finding grid whereby anyone on earth could locate himself by means of a couple of dials on an instrument about the size of a watch. . . no one on the planet need ever get lost.

Imagine if Arthur C. Clark had written his vision of satellite positioning into 2001: A Space Odyssey. “Hal! Turn on the GPS receiver, Hal!”

GPS Action Cameras Get It All
So, you are leaping across a crevasse in a snowstorm and you absolutely must capture every microsecond of the action, plus the screams of your teammates as they fall.

What do you need? An extreme sports camera, of course. It's a wildly competitive niche for smaller, sharper, lighter, easier. And the innovations keep on coming.

Meet Oregon Scientific's HD all-terrain video camera. It's a brand-new, shock-resistant, waterproof to 20 meters item with a G-sensor that can measure the force of gravity during acceleration. It can be strapped to your helmet, snowboard, go Kart, powerboat . . . or UAV, we imagine.

Starting in October, they'll also sell a GPS plug-in that lets you map your location, altitude, speed, and distance traveled on your computer during playback.

But wait, Munich-based Go Bandit already has integrated GPS on its HD video camera released in June. “Record your adrenaline!” the website says, with your location, speed and altitude recorded in 3D plus software to transform your data into a “thrilling action film.”

Wow. How to decide? Better toss that HD GPS cam into the pool and let the kids take underwater movies of their cousins while you decide which extreme sport to do next. ◆

HMS Bounty: Dead Reckoning to Duluth
The most popular ship at the Duluth, Minnesota, Tall Ships festival in July was HMS Bounty, a replica of the British ship that hosted the infamous 1789 clash between Fletcher Christian's mutineers and Royal Navy Captain William Bligh.

Built in Nova Scotia for Marlon Brando's star turn in the 1962 movie, “Mutiny on the Bounty,” it cost $750,000 — at the time the most expensive movie prop ever built.

It's bigger than the real ship (412 Registered Gross Tons compared to 215 tons) but otherwise is a “good example of a sixth-rate frigate of the time,” said Captain Robin Walbridge in a July 31 interview in the Duluth Tribune. Over the past 16 years, he's taken the ship to five of the seven continents.

The original Bounty carried one of the world’s master navigators and one of the world’s most famous risk-takers.
access to the region’s spectacular natural environments including the Oregon Coast, Cascade Mountains (including nearby Mount Hood) and the Columbia River Gorge.

The city of Portland itself is regularly named among the most livable in the United States and features a wealth of cultural, recreational, and sightseeing activities, as well as its own claim to a measure of GNSS fame. (See the accompanying sidebar, “GNSS in Oregon.”) And, of course, Portland is the site of what is reputedly the world’s largest independent used and new bookstore, Powell’s Books.

GNSS IN OREGON

Few would mistake Portland, Oregon for the beating heart of GNSS. Still, modesty aside, for a medium-sized U.S. city in the Pacific Northwest, the region has enough relevant involvement with the industry to justify hosting the ION GNSS 2010 event.

Geocaching, for one thing. Love it or hate it — the GPS-guided treasure-hunting craze started here. The first cache (called by those in the know the “original GPS stash”) was hidden on a tree farm right outside of Portland, the day after selective availability was turned off in 2000.

Oregon has a lot of technophiles, and a lot of outdoors. Put them together and you’ve got geocaching heaven.

And then there is world-famous Oregon Pinot Noir and Oregon draft beers. Nothing to do with GNSS, you say — but they have a lot to do with elevating the delights of an engineering conference.

Yes, yes, you know Portland is fun — culturally hip, energetic, and innovative, but what about business and technology? Does anyone actually do anything GNSS-related here except check traffic on their smartphones?

Well, there’s FLIR Systems, makers of infrared and thermal-imaging systems that keep company with GPS on autonomous unmanned aerial vehicles (UAVs). They’re an S&P 500 company based in Wilsonville, just south of Portland.

And speaking of UAVs, Cloud Cap Technology, a Goodrich company that develops autopilots, GPS/INS payloads, flight management systems, and miniaturized cameras for UAV and other autonomous platforms, is 60 miles away from Portland in Hood River, Oregon — home to Columbia River windsurfers.

Although not based in Oregon, Intel Corporation has a large presence in the state’s so-called Silicon Forest west of Portland. Facilities there include a significant research center with about 475 staff members as well as semiconductor manufacturing plants. Intel has a long history developing products and applications that work in concert with GPS and other location technologies.

TriQuint Semiconductor, another hi-tech company, manufacturers some of those little, tiny electronic components that go into GPS receivers and other mobile devices, such as RM front-end modules that incorporate a low noise amplifier and filter at the GPS L1 frequency. Celebrating its 25th anniversary this year, TriQuint reported first-quarter revenue of $180.8 million — up 52 percent from the year-earlier period.

Finally, the GNSS industry’s leading trade journals, Inside GNSS and GPS World, both got their start 110 miles south of Portland in Eugene, Oregon.

The Tall Ship Bounty, a replica of the 1789 home of the most famous mutiny in history. Photo: courtesy of HMS Bounty Organization LLC.


Nominations for ION Satellite Division Officers were submitted by the Satellite Division’s 2010 Nominating Committee, which was chaired by Dr. A.J. Van Dierendonck. The nominees are as follows:

**Chair:** Dr. John Raquet, *Air Force Institute of Technology*; **Vice Chair:** Dr. Gary McGraw, *Rockwell Collins* and Dr. Jade Morton, *Miami University (Ohio)*; **Secretary:** Dr. Anthea Coster, *MIT Haystack Observatory* and Mr. Tim Murphy, *Boeing*; **Treasurer:** Dr. Paul Kline, *Honeywell* and Dr. Sherman Lo, *Stanford University*.

**Online Voting.** Voting for the ION Satellite Division Officers will be done on-line through the ION website. On-line ballots are available through August 23. Any ballot received after August 23 will not be counted.

To access the on-line ballot, follow these simple instructions:

1. Go to www.ion.org.
2. Click on the voting button.
3. Enter your User I.D. and password. The default User I.D. is your six-digit member number (printed on the address label of this postcard), and the default password is your last name. If you have previously changed your default User I.D. or password, use those instead.
4. Mark your selections, and submit your ballot!

Election results will be announced during the 23rd International Technical Meeting of the ION® Satellite Division being held Sept. 21-24, 2010 in Portland, OR. The newly elected officers will take office on Sept. 24, 2010 at the conclusion of the meeting and will serve for two years. Election results will be reported in the ION Newsletter.
Section News and Notes

GREATER PHILADELPHIA SECTION NEWS

On April 16, 2010, members of the Greater Philadelphia Section of the ION met at the Johnsville Centrifuge & Science Museum in Warminster, PA. The museum is located on the former Naval Air Development (NADC) site in Warminster. The centrifuge is the largest human centrifuge ever built and where the Mercury, Gemini and Apollo astronauts trained to understand the effects of high G-forces on the human body. The members were provided a tour of the centrifuge and museum by museum staff.

An executive board meeting was held to discuss reinvigorating section activities and enrollment of new members. Since the closure of NADC in 1996, there have been few section meetings held.

Mr. Neil Weinman has become the newest Section Chair. Mr. Demetri James has joined the board as Vice Chair. Dr. Ray Filler stepped down as Section Chair and has graciously taken on the duties of Section Treasurer and Mr. Louis Pelosi continues in his role as Section Secretary. Other volunteers have stepped up to maintain the section navigation library and to help reestablish regular section activities. The board discussed ideas to improve student participation in section activities. Representatives from the Section will be contacting the local universities to establish opportunities for student participation in section activities.

DAYTON SECTION NEWS

The Dayton Section recently held its annual dinner at the Wright Patterson Club located at Wright Patterson Air Force Base, Oh. This event included a catered dinner, a golf putting competition, door prize giveaways and officer elections for the 2010-2011 term. The election results are as follows:

- Vice Chair: Mark Smearcheck, a research engineer with the AFIT’s Advanced Navigation Technology (ANT) Center
- Executive Secretary: Mr. Jared Kresge, Air Force Institute of Technology Advance Navigation Technology (ANT) Center
- Treasurer: Mr. Boyd Holsapple of General Dynamics Information Technology

The section is currently on break until September, at which time monthly meetings will resume. Monthly meetings typically include a lunch with guest speaker discussing navigation related topics or tour of schools within the Dayton Section.

WASHINGTON DC SECTION NEWS

On May 15, 2010, the Washington DC Section helped host and support the DC Regional Competition of the Mini-Urban Challenge (MUC) in Lorton, VA. Eight teams from six schools from Fairfax, Lorton, and Virginia Beach, Virginia and from Rockville and Silver Spring, Maryland participated in the event.

Members of the DC Section - Karen Barker, Jim Doherty, Doug Taggert and Larry Hothem - were judges. Chuck Schue, the Section Chair, opened the event with a short speech about the MUC and its importance in helping students engage in science, technology, engineering and math careers. He also had the pleasure of introducing Congressman Gerald E. “Gerry” Connolly, who is serving his first term in the U.S. House of Representatives from Virginia’s 11th District. Because Chuck’s company – UrsaNav, Inc. – is a MUC sponsor as well as a team sponsor, he recused himself from judging.

A special thanks to Chuck’s son Ian, who competed throughout high school in the MIT Robotics Challenges, volunteered to take pictures and video during the event.
Several millennia ago, while European sailors avoided venturing out of sight of land for fear of getting lost, Polynesian explorers were finding their way across thousands of miles of open ocean without benefit of navigational instruments.

Long before the invention of such familiar tools as John Harrison’s clock, the sextant, or even the astrolabe, these intrepid navigators charted their courses using only observations of stars, moon, wind, currents, and wildlife and a mental map based on training and experience to cross the ocean.

In order to locate directions at various times of day and year, Pacific Island navigators memorized such details and signs as the motion of specific stars and where they would rise and set on the horizon of the ocean, weather patterns, floating plant debris, the behavior of wildlife species (which congregate at particular locations and times), directions of swells on the ocean, colors of sea and sky, and even the clustering of clouds over some islands.

On July 12, Mau Piailug (pronounced “pee-EYE-lug”) — a leading figure in the revival of these skills — died on his native island of Satawal in the Federated States of Micronesia. He was 78.

Perhaps Piailug’s most notable feat took place in 1976 when he served as navigator aboard the double-hulled sailing canoe Hokule‘a on its maiden voyage of more than 3,000 miles from Hawaii to Tahiti. The journey was supported by the Polynesian Voyaging Society in Hawaii, which recruited Piailug because the traditional navigation skills that led the first settlers to the island chain had died out there.

Piailug reportedly began studying at the age of five as an apprentice navigator with his grandfather, first setting out to sea the following year with his father. He trained for the next 12 years, becoming a master navigator after going through the sacred initiation ritual at the Weriyeng School of Navigation in the central Caroline Islands, one of two such schools of traditional navigation remaining in Micronesia.

According to the 1994 text on the subject, *We, the Navigators*, by David Lewis, boys were historically taught navigation skills in the men’s house with pebbles, shells, or pieces of coral representing stars in what is known as the Carolinian star compass. The points of the compass, laid out in a circle in the sand, represented the horizon, with a canoe at its center and the eastern and western halves of the circle representing, respectively, the rising and setting points of the stars.
Rincon Research Corporation is a leading provider of advanced digital signal processing solutions and technologies for government clients. As a small business headquartered in Tucson, Arizona, Rincon has a 21-year history marked by steady growth in revenue and customer base.

Founded in 1983, Rincon began as a small research company. Today their business is drawn from a variety of government clients. They have diversified through the efforts of their talented staffs of scientists, engineers, programmers, writers, and support staff who continue to develop new and different types of signal processing products and services. Within these areas, they design, integrate, maintain, and upgrade state-of-the-art systems for intelligence and other high-priority government missions.

For more information, please see www.rincon.com

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.

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 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, fax: 703-366-2724; e-mail: mlewis@ion.org.

The Institute of Navigation is pleased to welcome these new ION corporate members:

- **STMicroelectronics**
  www.st.com/stonline

- **Rincon Research Corporation**
  www.rincon.com

For more information on corporate membership in The Institute of Navigation, please contact Kenneth P. Esthus at 703-366-2723, ext 104, or visit us at www.ion.org.
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