About 1,300 registered attendees and 76 exhibitors gathered at the convention center in Nashville, Tennessee, for this year’s ION GNSS conference and expo, September 18–21.

There, in addition to the rich technical program and associated activities of the event, they were surrounded by historical buildings, down-home cooking, locals in western boots, and strains of country music emanating from the plethora of nearby honky-tonks.

Leading with Practical Education
Before the conference even started, tutorials took off with a bang. On Monday, September 17 and Tuesday, September 18, more than 300 attendees took part in 20 pre-conference tutorials. During the two-day educational program, they had their choice of such topics as Fundamentals of GNSS, GNSS Receiver Design, GNSS Interference, and Differential GNSS, among many others.

PNT in the Information Society
On Tuesday night, September 17, Tony Thelen of John Deere’s Intelligent Solutions Group, started off the opening plenary session, “GNSS Revolution, the Catalyst of the New Information Age” with stories of GPS use in a different field — the kind of field that grows crops. Thelen described the critical role of GNSS in improving agricultural productivity, cost management, and sustainability, using such approaches as yield monitoring, precision spraying, precision planting and precision irrigation — collectively known as “precision farming.” According to Thelen, GNSS-driven farming methods produced a savings of at least $8.2 billion per year for U.S. farmers, and improved yields of $6 billion per year.

Time is at the heart of navigation, and the leap second is at the heart of a debate over GNSS system time and universal time scales.

The world’s dominant mode of timekeeping, Coordinated Universal Time (UTC), took on another leap second on Saturday, June 30, 2012, at 23:59:60 UTC.

And then the fun began.

The addition caused software handling Internet services such as LinkedIn, Pinterest, Mozilla, Reddit, StumbleUpon, Yelp, FourSquare and Gawker to behave unpredictably or even crash over the weekend.

Although most GNSS receivers and systems that depend on GNSS-based timing probably continued to operate normally with the addition, the discontinuation of leap seconds could potentially affect existing software designs of some equipment.

Such experiences have led to a growing call for the elimination of the leap second from the UTC.

Several presentations at the recent Civil GPS Service Interface Committee (CGSIC) Timing Subcommittee meeting held before the ION GNSS 2012 conference in Nashville touched on the leap second debate.
FROM THE ION PRESIDENT

DR. TODD WALTER

ION GNSS 2012: A Thriving PNT Community, Kepler Award Winner, PTTI Cooperation and Elections

This past September’s ION GNSS 2012 International Technical Meeting, hosted by the ION Satellite Division, reinforced the fact that the positioning, navigation, and timing (PNT) community continues to thrive.

Attendance remained even with last year, and the meeting saw a 13 percent increase in exhibiting companies. I want to thank the ION GNSS 2012 program committee: Dr. Dorota Grejner-Brzezinska, General Chair, and Dr. Jade Morton, Program Chair, as well as all the Satellite Division officers, technical track and session chairs, tutorial instructors, and exhibitors for making this year’s meeting such a resounding success.

I would also like to thank all of the other organizations that hosted workshops and symposiums in conjunction with ION GNSS, including the Civil GPS Service Interface Committee (CGSIC). We had a very strong technical program this year and I found the presentations and panels that I attended extremely informative.

One of my personal highlights from this year’s ION GNSS meeting was to watch Dr. John Raquet, Satellite Division Chair, present the 2012 Kepler Award to Mr. Karl Kovach, of The Aerospace Corporation. The Kepler Award is presented for sustained and significant contributions to the development of satellite navigation, and is the Satellite Division’s highest honor. Mr. Kovach was recognized with this honor for his contributions to the development of the Navstar Global Positioning System satellites, operations, signals, receivers, and standards. (See page 5 for more information.)

I know that a great many of us have worked directly with Karl over the years and found him to be an invaluable source of information on the operation of GPS. All GPS users owe him a large debt of gratitude for his work on the GPS interface specification and the performance standards among his many other contributions.

Further, I need to express my appreciation for the members of this year’s Nominating Committee, who put forth an excellent slate of candidates for election to ION Council. Electronic voting for Council representatives will take place after November 15 through the ION website. (Information on nominated candidates and voting can be found on page 23 of this newsletter.) Please do remember to vote!

I am also delighted to report that the ION and the organizers of the Precise Time and Time Interval Meeting (PTTI) have approved an agreement for ION to assume and host the PTTI meeting beginning in 2013. ION’s assumption of the PTTI conference is a good fit within a specific market segment of our existing membership and will offer ION the opportunity to expand our membership and representation in the timing community. Thanks to Francine Vannicola, PTTI Chair, and the ION’s Executive Director Lisa Beaty for all of their efforts to make this happen. As someone who started off in the timing field, I am excited to have these two very complementary organizations join forces together.

And finally, a last-minute reminder that ION’s 2013 International Technical Meeting will take place January 28–30, 2013 at the Catamaran Resort and Spa in San Diego, California. During this technical event, the ION Annual Awards will be presented and the 2013 ION Fellows will be named. I hope to see you there! ✪
Professor David Last regaled the audience with stories of his experiences working with the police in the law enforcement field, using GPS to bring criminals to justice. Shortly after he retired, Professor Last was asked by a police department to help gather evidence with which to convict four armed robbers using the contents of GPS receivers confiscated from each of the suspects.

This was a novel idea at the time, and Professor Last shared with ION GNSS attendees the challenges and obstacles that he faces while trying to educate a jury on the inner workings of a GPS unit. According to Professor Last, explaining GPS to juries in layman’s terms can be taxing, “They don’t understand when you say, ‘look, the navigation solution is simply a four-dimensional weighted least-squares minimization of an over-determined set of pseudo-ranges!’”

Stanford University Professor Mark Kasevich, a faculty member of the physics department, wrapped up with his experiences and hopes regarding atom interferometry. Although a subject new to many ION GNSS attendees, it is one in which Professor Kasevich has been immersed for more than two decades.

Atom interferometers offer access to higher frequencies (and thus accuracies) than optical interferometry. An atom is in a “near-perfect inertial frame of reference,” because of the absence of spurious external forces, Professor Kasevich pointed out, sharing his belief that AI sensors could produce profound advances in navigation in the near future.

**GNSS Workshops**

A hot topic during panel discussions on Wednesday, September 19, and Thursday, September 20 is the ramping up of Galileo, GLONASS, and BeiDou (known in English as the Compass system) to be completed by 2020.

China’s BeiDou project, named after the Big Dipper constellation and currently consisting of 13 satellites, will ultimately comprise 30 to 35 satellites — although a 35-satellite option was mentioned several times during the workshop — and provide two levels of service; one unencrypted for open use, one encrypted for authorized use only.

Speakers emphasized a desire within China’s BeiDou community to cooperate with other GNSS systems. The presenters suggested that this could take the form of development of joint standards for GNSS signals and joint efforts to provide monitoring.

The ION worked with Compass leaders during this year’s China Satellite Navigation Conference (CSNC) to assemble a high-level panel presentation for the event held in Guangdong last May. CSNC 2013 is scheduled for next May 15–17 in Wuhan.

Also advancing rapidly is the European Union’s Galileo program, which will be using the Ariane 5 rocket to lift four satellites at a time. Ariane 5 will make three such trips over the next few years, bringing Galileo to full operational capability by 2020.

European officials are hoping to make up lost ground caused by past political and technical delays. The Galileo program has signed most of its contracts with suppliers and set a schedule to have its full constellation of 30 satellites in place by 2020, said Hillar Tork, from the European Commission (EC).

“We have been criticized, of course, in the past for not reaching milestones and targets, for delays,” said Tork. “One of the things we’ll be careful of now is to ensure that we don’t promise something that we don’t believe we can achieve. . . . So, [with] the full 30-satellite constellation . . . we’re going to guarantee that’s going to be there by 2020.” Tork is head of sector for services and exploitation, EU Satellite Navigation Programs office of the EC Directorate-General for Industry.

Finally, Russia’s GLONASS program has gained approval to develop the next block of GLONASS-K2 satellites, which will have a 10-year design life and offer a new code division multiple access (CDMA) signal in addition to its existing frequency division multiple access (FDMA) signals. The program plans to have 24 K2-generation satellites in place by 2020.

GLONASS program managers are also studying a new signal in the L5 band — a development that could support the idea of another common GNSS standard on a single frequency, this one in a protected safety-of-life band, said Dr. Sergey Revnivykh of the Central Research Institute of Roscosmos, the Russian Space Agency. ◆
ION GNSS 2012 Program Committee: Dr. Thomas Pany, IFEN GmbH, Germany; Bernhard Richter, Leica Geosystems, Switzerland; Prof. Marek Ziebart, University College London, UK; Dr. Dorota Grejner-Brzezinska, The Ohio State University; Dr. John Raquet, Air Force Institute of Technology; Dr. Todd Walter, Stanford University; Dr. Jade Morton, Miami University; Patricia Doherty, Boston College; Dr. Frank van Diggelen, Broadcom; John Nielson, Rockwell Collins; not pictured: Dr. Grace Gao, Stanford University; Dr. John Betz, The MITRE Corporation

ION GNSS 2012 Student Paper Award Winners

2012 PARKINSON AWARD

The 2012 Bradford W. Parkinson Award was presented September 21 during the ION GNSS Awards Luncheon to Dr. Susmita Bhattacharyya, University of Minnesota, for Graduate Student Excellence in Global Navigation Satellite Systems in her thesis “Performance and Integrity Analysis of the Vector Tracking Architecture of GNSS Receivers.” The award was established in June 2003 and is awarded annually to an outstanding graduate student in the field of Global Navigation Satellite Systems (GNSS). This award, which honors Dr. Bradford Parkinson for his leadership in establishing both the U.S. Global Positioning System and the Satellite Division of The Institute of Navigation, includes a personalized plaque and a $2,500 honorarium.
KARL KOVACH RECEIVES KEPLER AWARD

The Institute of Navigation recognizes Karl Kovach with the prestigious Johannes Kepler Award at the ION GNSS 2012 Conference

The ION Satellite Division awarded Karl Kovach its Johannes Kepler Award on September 21, 2012 at ION GNSS 2012 in Nashville, Tennessee, for his contributions to the development of the Navstar Global Positioning System Satellites, Operations, Signals, Receivers and Standards.

Karl Kovach is a Senior Project Leader with The Aerospace Corporation, supporting the Systems Engineering branch of the Global Positioning Systems Directorate. Kovach began his involvement with GPS as an Air Force Lieutenant in 1978; and over his Air Force career developed requirements and specifications for the first generation of military GPS receivers, standardized interfaces among diverse GPS platforms, and conducted flight test of Phase I and Phase II military GPS receivers. Captain Kovach then served as commander of the GPS Control Segment at Vandenberg Air Force Base, first managing the build-up of the initial Block I GPS constellation, establishing routine operating procedures including sending the very first Notice Advisory to Navstar Users (NANU), and subsequently leading the transition of GPS operations from Vandenberg to its present location at Schriever Air Force Base in Colorado Springs.

Following his Air Force service, Kovach joined ARINC, where he focused on GPS receiver standards, Receiver Autonomous Integrity Monitoring (RAIM) algorithms, certification of military aviation receivers, Wide Area GPS Enhancement (WAGE), GPS signal development, and GPS performance standards. In 2007, Karl joined The Aerospace Corporation directly supporting the Systems Engineering Division of the GPS Directorate. In this capacity he has focused on the integrity of the current operational system, while working to improve integrity in the new modernized space and control segments and to finish modernization efforts for the GPS navigation signals.

Kovach has been an ION member since 1985. He has over two dozen ION publications and was the recipient of the ION Capt P.V.H. Weems Award in 2003. Karl holds a B.S. in Mechanical Engineering from the University of California Los Angeles. However, perhaps his proudest accomplishment is as a father to his young daughter Karlie, who he credits as one of his primary inspirations.

The Kepler Award recognizes and honors an individual for sustained and significant contributions to the development of satellite navigation. It is the highest honor bestowed by the ION Satellite Division.

Previous Kepler Award Winners at ION GNSS 2012 (front left to right) Dr. AJ Van Dierendonck (09), Thomas Stansell (03), Ronald Hatch (94), Patrick Fenton (06), Dr. Gerard Lachapelle (97), Dr. Todd Walter (10), Karl Kovach (12), Dr. Per Enge (00), Phil Ward (08), Dr. Penina Axelrad (09), Dr. Frank van Graas (96), Dr. Richard Langley (07)

THANK YOU to our sponsors!

The ION wishes to express its sincere appreciation for the support of its Show Daily advertisers, JAVAD GNSS and NovAtel, and to Inside GNSS magazine for its editorial contribution to the Show Daily.

Also, our thanks to the sponsors of the Internet kiosks — Inside GNSS magazine, Lockheed Martin and NovAtel, Inc.; RX Networks for sponsorship of the Business Center; and to Trimble for sponsorship of the ION GNSS Mobile website.
The Satellite Division of The Institute of Navigation traditionally recognizes the best presentation given in each session. Recipients are selected by the session's co-chairs. The criteria used to evaluate each presentation are as follows: 70 percent: relevance, timeliness and originality of technical work/information; 20 percent: quality of visual aids (legibility, relevance to topic, etc.); and 10 percent: quality of presentation delivery (enthusiasm, enjoyment as a speaker, etc.).

Session A1: Algorithms & Methods 1: GNSS Tracking & Multipath Amelioration

GNSS MLOs Using Multi-Constellation Mitigation Using Advanced Multi-Constellation Consistency Checking with Height Aiding: T. Jing and P.D. Graves, University College London, UK

Session B1: GNSS Simulation, Testing & Timing Applications 1

Skyclone: Realtime GNSS Signal Denial for Testing GNSS-based Automotive Applications: M. Dumville, W. Roberts, D. Lovel, B. Wales, NSL, UK; P. Pettit, S. Warner, C. Ferris, InnovITS ADVANCE, UK

Session C1: Aviation Applications 1


Session D1: Emerging GNSS (Galileo, COMPASS, QZSS, IRNSS)

Analytical Transmission Model of POCET Technique for Compass B1 and B3 Signals: K. Zhang, Y. Li, University of Defense Technology, China; H. Zhou, Beijing Institute of Tracking and Telecommunication Technology, China; F. Wang, University of Defense Technology, China

What is Achievable with Current COMPASS Constellations?: M. Ge, German Research Technology, China; K. Zhang, Wuhan University, China; X. Jia, X’An Research Institute for Surveying and Mapping, China; S. Song, Shanghai Astronomical Observatory, China; J. Wickert, German Research Center for Geosciences, Germany

Session E1: Receivers & Antennas 1

Low Power ASIC GNSS Tracking Loops Quantifying the Trade-Offs Between Area, Power and Accuracy: B.Z. Tang, S. Longfield, Jr., S.A. Bhave, R. Manohar, Cornell University

Session F1: Urban & Indoor Navigation

GNSS & Assisted-GNSS Hybrid Positioning with 3GGP-LTE and GNSS Employing Particle Filters: C. Gentner, J-M. Rawadi, E. Malouzi, M. Kihler, German Aerospace Center (DLR), Germany


Session B2: GNSS Simulation, Testing & Timing Applications 2

Experimental Evaluation of Fine-Aiding in Indoor Navigation Environments: N. Couronneau, & P.J. Duffett-Smith, University of Cambridge, UK

Session C2: Aviation Applications 2
eDME Architecture Development and Flight-Test Evaluation: W. Pelgrum, K. Li, M. Smooden, F. van Graas, Ohio University

Session D2: GPS & GLONASS Modernization


Session E2: Receivers & Antennas 2

Blind Adaptive Beamformer Based on Orthogonal Projecting for GNSS: M. Sgammini, F. Antreich, German Aerospace Center DLR, Germany; L. Kurz, RWTH Aachen University, Germany; M. Meurer, German Aerospace Center DLR, Germany; T.G. Noll, RWTH Aachen University, Germany

Session F2: Urban & Indoor Navigation Alternatives: Wireless Physical-Statistical Channel Model for Joint GNSS and Mobile Radio Based Positioning: W. Wang, T. Jost, A. Lehnert, and U-C. Fleigeb, C. Gentner, German Aerospace Center (DLR), Germany

Session A3: Geodesy, Surveying & RTK for Civil Applications

A Proposed Industry Solution to Realize Universal GLONASS Observation Interoperability for Precise Positioning: F. Takai, A. Cole, M. Carrera, Leica Geosystems, Switzerland; P. Alves, NovAtel, Canada; G. Wubbenha, Geo++v, Germany; J-M. Sleewaegen

A. Simsky, W. De Wilde, Septentrion, Belgium

Session B3: Robust Navigation in GNSS-Challenged Environments


Session C3: GNSS Space Based Augmentation Systems (SBAS)

Overbounding Missed-Detection Probability for a Chi-Square Monitor: J.H. Rife, Tufts University

Session D3: GNSS Algorithms & Methods 1: Signal Processing

Multipath Mitigation In Sol Environments Using a Combination of Squared Correlations: E. Falletti, B. Motella, M.T. Gamba, Istituto Superiore Mario Boella, Italy; C. Facchini, ASI, Agenzia Spaziale Italiana, Italy

Session E3: Land Based Applications

Comparison of State Estimation Filters for Safety Relevant Localization in Rail Applications, Based on the Milestone Based SIPS-Rail Approach: R. Rutters, M. Breuer, J. Zhang, D. Abel, D. Lüdicke, RWTH Aachen University, Germany

Session F3: MEMS Technology

Three-Axis Magnetometer Navigation in suburban Areas: J.A. Shackley & J.F. Raquet, Air Force Institute of Technology

Session A4: Remote Sensing with GNSS & Integrated Systems

Scintillation Characteristics Across the GPS Frequency Band: C.S. Carrano, K.M. Groves, F. Takai, M. Paehl, Institute for Scientific Research, Boston College

Session B4: Preserving the Availability & Integrity of GNSS in Harsh Environments

The UHARS Non-GPS Based Positioning System: D. Craig, D. Ruff, 746th Test Squadron S. Hewitson, J. Barnes, D. Amt, Locata Corporation, Australia

Session C4: GNSS Ground Based Augmentation Systems (GBAS)

Ionosphere Gradient Detection for Cat III GBAS: R. Reuter, D. Weed, M. Brenner, Honeywell International

Session D4: GNSS Algorithms & Methods 2: General Areas

Using LEO GNSS Data for Precise Calibration of Space HW Biases: J.D. Calle Calle, I. Rodriguez-Perez, M. Cueto-Santamaria, E. Saldan Pérez, GUM, Spain; F. Amariolla, ESA, The Netherlands

Session E4: Software Receivers

GPS-Based Attitude Determination for a Spinning Rocket: K.O.Z. Chiang, M.L. Piasik, S.P. Powell, R.J. Miceli, B.W. O’Hanlon, Cornell University

Session F4: Pedestrian & Indoor Location, MEMS & Vision

Integration of iPhone/iPad: Floor Plan Based Monocular Vision Navigation: B. Huang & Y. Gao, University of Calgary, Canada

Session A5: GNSS and the Atmosphere 1

High Latitude Synchronization Analysis for Marine and Aviation Applications: P. Ghafouri, S. Skone, University of Calgary, Canada

Session B5: Next Generation GNSS Integrity

RAIM Detector and Estimator Design to Minimize the Integrity Risk: R. Jonger, F-C. Chan, S. Langel, B. Pervian, Illinois Institute of Technology

Session C5: Interference & Spectrum Management 1

Civilian GPS Jammer Signal Tracking and Geolocation: R.H. Mitchel, M.I. Piasik, B.W. O’Hanlon, S.P. Powell, Cornell University; J.A. Bhatti, University of Texas at Austin

Session D5: Multi-Constellation User Receivers

Origin and Compensation of GLONASS Inter-frequency Carrier Phase Biases in GNSS Receivers: J-M. Sleewaegen, A. Simsky, W. De Wilde, F. Boom, T. Wilems, Septentrion, Belgium

Session E5: Precise Point Positioning 1

NextGeo’s Integrity Ambiguity-Resolved Precise Point Positioning System: L. Urquhart, Y. Zhang, S. Lee, J. Chen, NextGeo Navigation, Canada

Session F5: Consumer Products & Services


Session A6: GNSS & the Atmosphere 2

Slant Tropospheric Delay Estimation Using the Integration of Operational Numerical Weather Modelling and CORS Observations: L. Yang, C. Hill, C. Hilde, T. Moore, University of Nottingham, UK

Session B6a: SBAS+GBAS Integrity

EVT:SIM: A Tool Based on Extreme-Value Theory for the Assessment of SBAS Accuracy and Integrity: F. Buscarlet, Thales Alenia Space, France; J-M. Azais, S. Gadat, IMT, Institut de Mathematiques de Toulouse, France; N. Suard, UNEX, French Space Agency, France

Session B6b: Advances in Military GNSS Systems and Applications


Session C6: Integrity & Spectrum Management 3


Session D6a: GNSS Compatibility, Interoperability & Services

On the Determination of C/A Code Self-Interference with Application to RFC Analysis and Pseudolite Systems: C. D’Orselli, Fortuny-Gauch, IPSC/ClU of the European Commission, Italy

Session D6b: Marine Navigation & Applications

New Approach for Tsunami Detection Based on RTK-GNSS Using Network of Ships: R. Nakasone & N. Kubo, Tokyo University of Marine Science and Technology, Japan

Session E6c: Precise Point Positioning 2

Satellite Bias Determination with Global Station Network and Best-Integer Equivalent Estimation: Z. Wei, P. Henkel, A. Brack, Technical University Munich, Germany; C. Günther, Technical University Munich and German Aerospace Center (DLR), Germany

Session F6a: Modern Applications

Sports, Robots, Health

Laser-Guided Autonomous Snowplow Designs: S. Craig, R. Kollar, K. Li, P. Duan, W. Pelgrum, F. van Graas, M. Uijt de Haag, Ohio University

Session F6b: Alternatives to GNSS: Wide Area

Orbital Diversity for Satellite Navigation: P. Enge, Stanford University; B. Feinell, J. Bennett, S. Wehlin, The Boeing Company; G. Gutt, D. Lawrence, iKaré
This past summer the Satellite Division held its election for Satellite Division officers who took office at the conclusion of ION GNSS 2012. The following individuals were elected and will serve on the Satellite Division Executive Committee for a two-year term of office.

**Chair:** Dr. Jade Morton, *Miami University (Ohio)*

**Vice Chair:** Dr. John Betz, *The MITRE Corporation*

**Secretary:** Dr. Anthea Coster, *MIT Haystack Observatory*

**Treasurer:** Dr. Mark Petovello, *University of Calgary, Canada*

Dr. John Raquet, AFIT, will continue to serve on the Satellite Division Executive Committee for an additional two years as the Immediate Past Chair. In addition, Dr. Yuanxi Yang, *China National Administration of GNSS and Applications, China*; and Dr. José Ángel Avila Rodríguez, *ESA/ESTEC, The Netherlands* were appointed as International Technical Representatives.

The Satellite Division would like to thank Tim Murphy and Dr. Paul Kline who have served as Satellite Division Secretary and Treasurer for the past two years, Dr. Pratap Misra who has served on the Satellite Division Executive Committee for the past six years and Dr. Allison Kealy who served as an International Technical Advisor. The Institute also extends its thanks to all other volunteers that have provided counsel and guidance over the past two years.

---

**RAQUET IS RECOGNIZED**

Dr. John Raquet, out-going Satellite Division Chair, was recognized during Friday’s Awards luncheon for his visionary leadership of the Satellite Division. During the four years that Dr. Raquet has served on the Satellite Division Executive Committee (two years each as Chair and Vice Chair) he has been an avid supporter of the Satellite Division’s outreach, supporting developing technical events such as the ION’s Robotic Lawn Mower and Autonomous Snowplow Competitions, ION GNSS Student Awards, and initiatives for the sustainable development of navigation, science and technology in Africa. Additionally, he has participated in the further development of the ION GNSS conference’s organization and leadership which has included ION led pre-conference tutorials and recent updates to the Division’s bylaws and awards policy. The Institute extends its thanks.

---

Co-Sponsored by the Joint Services Data Exchange (JSDE) & The Institute of Navigation (ION)

**JNC 2013**

**Joint Navigation Conference**

June 10–13, 2013

Tutorials: June 10

Show Dates: June 11 & 12

Renaissance Orlando at SeaWorld & Shades of Green (classified sessions)

Orlando, Florida

www.ion.org/jnc
For the third year, the Civil GPS Service Interface Committee (CGSIC) symposium, historically separate from the main conference, was integrated smoothly into ION GNSS 2012.

Sponsored by the U.S. Coast Guard Navigation Center and the U.S. Department of Transportation’s Research and Innovative Technology Administration, the meeting was the occasion for several announcements from high-level officials involved with the GPS program.

GPS modernization continues apace, with plans to have 18 satellites transmitting the new L2C signal by 2017 and L2C full operational capability (FOC) with 24 satellites by 2020, Major General Jack Weinstein told attendees in a presentation titled, “Maintaining GPS as the ‘Gold Standard’ for Positioning, Navigation and Timing.”

Users, however, will not have to wait until 2020 to get a full navigation message (CNAV) on L2C, added Weinstein, director of Air, Space and Cyberspace Operations, for Air Force Space Command. Enabled by completion of work on the new OCX control segment, L2C is anticipated to become available by 2016.

Meanwhile, the GPS L5 signal should reach IOC with 18 satellites by 2020, Weinstein said, and FOC with 24 satellites by 2023 or 2024. Eleven satellites with L2C capability are now on orbit, with all both the most recently launched satellite transmitting a test signal without the navigation data message.

Col. Bernie Gruber, head of the USAF GPS Directorate, provided new details on an analysis of a dual-launch proposal for GPS, long advocated by some as a cost-cutting measure.

Gruber told the CGSIC that the Air Force is considering launching some next-generation GPS III satellites two at a time. Air Force GPS and launch directorates are coordinating on final requirements for a GPS-specific dual payload adapter and mission profile requirements, he said. Initial studies indicate that only minor changes would be needed to support this capability, with minimal changes in the production line of GPS III beginning with the ninth satellite.

The current generation of GPS spacecraft, the Block II Follow-On (IIF) satellites, can’t be sent up together because each is configured for direct insertion into a specific orbit. The modernized satellites are scheduled to go up beginning in 2014.

Other CGSIC reports included Patriot Watch, a Department of Homeland Security (DHS) effort to address concerns about GPS jamming and interference. John Merrill, manager of the DHS PNT Program Management Office, described the first phase, named “Minnow,” designed to spot jamming and interference around airports. This would be the initial component of a larger interference detection and mitigation (IDM) architecture known as Patriot Watch.

As the system develops, Merrill said, cleansed data could be added from other sources, such as the Coast Guard/Army Corps of Engineers differential GPS network, the NOAA National Geodetic Survey’s (NGS) continuously operating reference stations (CORS), mobile telephone cell towers, and even GPS transport users, such as FedEx. These could be combined with DHS information to identify where interference is occurring in near real-time.

**SUBCOMMITTEE SESSIONS**

Four subcommittees also gathered during the two-day CGSIC meeting representing the international, timing, state and local governments, and surveying, mapping, and geosciences communities.

The timing subcommittee heard discussion about the usefulness and disadvantages of the leap second that keeps digital systems using Coordinated Universal Time (UTC) in sync with Universal Time or UT1, the time system reflecting the Earth’s position in the space relative to the sun and other bodies.

A proposal now on the final agenda of the International Telecommunication Union would eliminate leap seconds from UTC. An article on page 1 of this newsletter discusses the issue in greater detail.

The surveying subcommittee heard program overviews on CORS by Giovanni Sella, NOAA/NGS CORS program manager; and the On-line Positioning User Service (OPUS), a growing set of applications offering web-based access to NGS tools and resources, presented by Neil Weston, chief of the NGS Spatial Reference System Division.

The CORS network has grown from fewer than 10 sites in 1994 to more about 1,900 today, evolving from a GPS-only system to one with a substantial presence of multi-GNSS receivers.

Dave Doyle, chief geodetic surveyor for NGS, provided an update on the 2011 national adjustment of the North American Datum of 1983 (NAD83) and its affect on NGS products and services and the work of surveyors who uses the datum.

The states and localities subcommittee had a busy session, with presentations, among others, on Tennessee’s 511 Traffic incident reporting system and next-generation 911 system, a Texas A&M low-cost unmanned aircraft system for mapping, and an overview of geospatial positioning in Oregon.

The international information subcommittee heard reports on GPS and Australian aviation, GPS-related activities in Japan, the MULTI-POS (multi-technology positioning) training network being established among a consortium of European universities and industry partners, the Asia-Pacific Economic Cooperation (APEC) GNSS Implementation Team and experience with vehicle-borne GPS jamming incidents detected in the United Kingdom’s SENTINEL project.

Slides from the CGSIC presentations can be downloaded from the official U.S. government GPS website <http://www.gps.gov/cgsic/meetings/2012/>.
UTC is defined by the International Telecommunication Union radiocommunications sector (ITU-R) and is maintained by the International Bureau of Weights and Measures (BIPM) in cooperation with the International Earth Rotation and Reference Systems Service (IERS).

Leap seconds help keep UTC closely aligned with universal time scales, such as International Atomic Time (TAI), based on the rotation of the Earth. Because Earth dynamics fluctuate infinitesimally and somewhat unpredictably, leap seconds cannot be preprogrammed because they are typically announced only six months in advance by the IERS.

A variety of continuous internal system time scales have proliferated to provide a solution to the problems associated with discontinuities, including the leap second, in UTC.

In contrast, GPS system time (GPST) is a continuous time scale without leap seconds maintained by the GPS control segment. GPST is not a reference time scale but rather an internal time for GPS system synchronization. Europe’s Galileo and China’s Compass (BeiDou-2) GNSS systems also operate on continuous time scales that exclude leap seconds, but with offsets from GPS system time.

GLONASS, however, follows current UTC practice regarding insertion of leap seconds. Indeed, the most recent GLONASS Interface Control Document (ICD) released in 2008 has a separate appendix providing recommendations to designers and users of GLONASS receivers for how they should operate during a UTC leap second correction.

**GNSS System Times versus Time Scales**

GPST is formed by creating a virtual or “paper clock” through the weighed average of times generated by atomic clocks on most GPS satellites and ground stations.

USNO employs a bank of specialized Selective Availability/Antispoofing (SAASM) GPS time monitor receivers located at USNO in Washington, D.C. and at the USNO Alternate Master Clock (AMC) in Colorado Springs, Colorado.

The USNO time monitor receivers are used to make carefully calibrated measurements of each GPS space vehicle (SV) clock relative to UTC(USNO).

According to a September 17 CGSIC presentation by USNO representatives Stephen Mitchell and Ed Powers, these observations are filtered, averaged, and provided to the 2nd Space Operations Squadron (2SOPS) at Schriever based on the USNO to GPS ICD-202 interface and used to produce a daily correction that is broadcast to users in the GPS navigation message.

GPS time repeats every 19.6 years, Epoch #1 started counting whole seconds on Jan 6, 1980. GPS time Epoch #2 started on Aug 22, 1999 and Epoch #3 will start in 2019.

The GPS navigation message broadcast by satellites includes the offset of GPS sys-
tem time from UTC, as well as the necessary information to convert GPS time to UTC.

Currently, GPS time is 16 seconds ahead of UTC. Receivers subtract this time difference from GPS system time to calculate UTC as well as local times by applying the sub-frame 4, page 18, corrections in the GPS message. This allows the timing user to recover UTC time traceable to UTC (USNO). New GPS CNAV and MNAV messages have improved versions of this correction, according to Mitchell and Powers.

UTC is the only international standard time scale, represented by local approximations in time laboratories, that should be used for worldwide time coordination and measurement traceability. Joe White, of the Naval Research Lab (NRL) told the subcommittee.

“TAI is not an option for applications needing a continuous reference as it has no means of dissemination, and it is not physically represented by clocks,” he said.

The existence of multiple system time scales creates potential problems in operational use as well as conceptual confusion on the proper definition and roles of time references, White argued.

Showdown at WRC-15

For more than a decade, advocates of eliminating the leap second from UTC — in part because of the rise of GNSS systems — have pressed their case before the ITU-R and elsewhere.

In June 2009, the Assistant Secretary of Defense (ASD) signed a memorandum stating that the U.S. Department of Defense supports a change in policy that would lead to the discontinuation of the insertion of occasional leap seconds as of January 1, 2019.

ITU-R Working Party (WP) 7A established a formal “question” on “The Future of the UTC Timescale,” addressing the future definition and use of UTC. The current focus of the discussion is a proposed Recommendation ITU-R TF-460-6 on standard-frequency and time-signal emissions.

In January of this year, the International Telecommunications Union–Radiocommunication (ITU-R) assembly deferred a decision about eliminating leap seconds in UTC until the World Radiocommunication Conference 2015 (WRC-15). A conference preparatory meeting for WRC-15 in February designated (WP) 7A as the responsible group to conduct further studies into the feasibility of achieving a continuous reference time-scale for dissemination by radiocommunication systems as well as the issues related to possible implementation of a continuous reference time-scale, including technical and operational factors.

The United States already has an official position on the subject.

During the January meeting, the U.S. delegation supported an amendment to ITU-R TF-460-6 that would discontinue use of the leap second in UTC. “The increasing use of, and reliance on, satellite-based navigation and positional reference favors the suppression of leap seconds,” U.S. representatives said in a prepared statement. “Systems for space activities, global navigation satellite systems, telecommunications, network synchronization, and electric power distribution desire a continuous, uninterrupted time reference. UTC without leap seconds can provide this.

“By suppressing the use of leap seconds in UTC, the repeated effort and cost required of users to successfully accommodate the introduction of each new leap second into UTC would be eliminated. The safety and reliability of systems dependent on UTC would be improved.”

The official U.S. policy initiative is based in part on the following considerations:

- The use of leap seconds in UTC introduces discontinuities or disruptions into what would be an otherwise uninterrupted, continuous time stream. Organizations involved with space activities, global navigation satellite systems, telecommunications, network synchronization, and electric power distribution have all requested a continuous time scale.
- The use of leap seconds in UTC adds complexity to systems dependent on precise time keeping. They require additional software, protocols, and coordination to ensure that no disharmony is introduced to these systems.
- Leap seconds are not inserted regularly into UTC. Each leap second requires human intervention at some level.
- The use of leap seconds introduces the possibility of technical problems each time they are inserted into UTC. This can impact the safety and reliability of systems dependent on precision time keeping.
- A variety of continuous “pseudo-time scales” have proliferated to provide a solution to the problems associated with discontinuities in UTC. The existence of these multiple time scales creates potential problems in operational use and may complicate unnecessarily not only their inter-operability but also their reliability.

Be a part of the Third Annual ION Autonomous Snowplow Competition

How much snow can you move using state of the art navigation and control technologies?

Challenge your team to design, build and operate a fully autonomous snowplow, which will remove snow from a designated path rapidly, accurately, and safely.

January 24 – 27, 2013
St. Paul, MN

Open to both academic institutions and the general public.

To learn more visit: www.autosnowplow.com
**Space Weather? There’s an App for That**

When solar activity causes the ionosphere to fluctuate, it can wreak havoc on GPS signals. The University of Svalbard’s Kjell Henriksen Observatory — a dynamo of Arctic Studies — is running an urgent monitoring project to see just how much disruption these solar storms cause.

On a normal day, GPS readings in Svalbard, located at 78° N. can be off by 1 to 3 meters; strong solar storms can result in errors much greater than that. By firing a 16-megawatt radio signal into the ionosphere, researchers are attempting to duplicate the disruption caused by solar flares. Just as the auroras — visible effects of solar flares — are most noticeable in polar regions, GPS disruptions there are also more substantial.

KHO has also designed a free auroral forecast app for smartphones, now available for Android, iPhone, and Windows. You can download the app at Windows Marketplace, the Apple App store, or Google Play.

The program, Auroral Forecast, predicts up to one hour in advance the size and location of the auroral ovals or the impact zone of energy particles from the sun. The service also includes local weather, solar illumination, and star charts from seven well-known auroral observatories.

You can also link to the app from the observatory home page at <KHO.unis.no>.

**Stone Age Navigators?**

Archaeologists keep finding new ways to tell us that our distant ancestors were so much more adventurous than our contemporary cube-farm, mall-walking selves tend to be.

Crete has been an island for five million years. But several years ago, archaeologists found quartz hand axes that looked like they came from the toolkits of pre-modern humans.

The established theory assumed that farmers from Europe and Asia Minor settled in Crete only about 9,000 years ago. But the newly discovered tools dated to at least 130,000 years ago. And, since active earthquakes in that part of the world have lifted Crete between 300 and 400 feet since that time, the tools had been moved from levels much, much older — 700 thousand years, perhaps.

The Mediterranean was a popular place for hominids and distances from island to isthmus to mainland have altered over time.

However, the tools show an early occupation that indicate very early humans built watercraft that could traverse 24 miles of ocean from the European mainland to Crete — or the 125 miles from Libya, if they had more sophisticated vessels — much earlier than we have given them credit for.

“The early inhabitants of Crete reached the island using sea craft capable of open-sea navigation and multiple journeys — a finding that pushes the history of seafaring in the Mediterranean back by more than 100,000 years and has implications for the dispersal of early humans,” said Curtis Runnels, a member of the research team from Boston University.

The project leader, Thomas Strasser, said, “These weren’t individuals who were lost at sea.”

The Untold Story of Getting from Here to There

The Smithsonian’s new exhibit on Time and Navigation will open at the National Air and Space Museum on the National Mall in Washington D.C. in March 2013.

But you can preview the stories, watch the progress of the installation, read the design team’s blog, download images, and see how the new gallery will be organized right now on the exhibit’s new Website at <http://airandspace.si.edu/exhibitions/gal213/time-andnavigation/index.cfm>.

Exhibit highlights include a large representation of a 19th century ship from the U.S. Exploring Expedition of 1838-42.

Visitors will also see a TRANSIT navigation satellite; Stanley, a robotic vehicle from the DARPA Challenge; the USS Alabama submarine’s navigation system; Wiley Post’s airplane, the Winnie Mae, and the first sea going marine chronometer made in the USA.

With 144 objects and the stories behind them, the new gallery will cover satellite navigation and the history of precise time-keeping and navigation at sea, in the air and in space.

The ION is one of the sponsors of the new exhibit, as is the National Coordination Office for Space-Based Positioning, Navigation, and Timing.

Robo Turtle

First they tried a tuna, but its narrow agile body made it difficult to robotize. Then students at the Swiss Federal Institute of Technology (ETH) in Zurich looked at sea turtles and, voila! — the perfect model for autonomous underwater navigation and transport.

The naro-tartaruga, is an aluminum swimming robot with a top speed of about two meters (6.6 feet) per second.

The two front flippers can be maneuvered in three dimensions underwater, and the rear flippers also aid with steering and propulsion.

The rigid oval body is big enough to carry cargo and lots of regular-sized electronics and sensors — including pressure, temperature, water leakage, and water flow sensors, along with gyro, surface GPS, a compass, and motor encoders.

The working model — pictured on page 19 — is about 3 feet long and weighs 165 pounds.

Navigation Novelties continued on page 19
During the summer of 2012, Garmin International, a manufacturer of GPS receivers, introduced the Garmin GLO for pilots. The new receiver combines GPS and GLONASS signals with Bluetooth technology and connects to — and displays position information on — mobile devices such as iPad, iPhone, and Android devices.

This capability allows tracking of up to 24 more satellites than receivers that rely on GPS alone, yielding improved performance, especially under vegetation and in urban canyons.

Very useful! So why did this rapprochement occur four decades after these two systems emerged?

Clearly, complex geopolitical events complicated the technical challenges that lie behind this long awaited marriage. To understand these events, this article reviews the history of the Soviet Union/Russian satellite navigation system.

1957-1964: Sputnik, TRANSIT, and the Khrushchev Era
On October 4, 1957, the Soviet Union sent into orbit Sputnik 1, the first artificial satellite in history. A month later, an even larger and heavier satellite, Sputnik 2, carried the dog Laika into orbit.

Sputnik’s launch came as an unnerving surprise to the United States. The space age had dawned and America’s Cold War rival suddenly appeared technologically superior. During this period of relative economic prosperity under Premier Nikita Khrushchev, the Soviets emphasized scientific research and solidified their position as one of the two supreme world powers.

Although the USSR was first in space, they were decidedly not the first in space navigation. Sputnik stimulated a virulent American response that included the U.S. Navy’s TRANSIT, a navigation satellite system developed between 1960 and 1964 for Polaris ballistic missile-equipped submarines. TRANSIT was a silent American space victory until it was approved for commercialization in 1967 and came into the public eye.

1964-1982: The Brezhnev Era, Tsiklon, and the Arms Race
The full-fledged development of the Soviet Union’s navigation satellite capability began in the mid 1960s. The draft project was approved in 1962, but development was prolonged due to very poor accuracy associated with software problems and the lack of accurate geodetic data.

The first Soviet navigation satellite Cosmos-192/Tsiklon 1 was launched on November 23, 1967 from Plesetsk Cosmodrome.

The system was finally accepted for service as an interim measure in 1972 pending deployment of an improved version, Tsiklon-B/Parus.

The Soviet system essentially duplicated TRANSIT, more or less. It consisted of six satellites that orbited the earth at an altitude of 1,000 kilometers (620 miles). The system enabled a ship or submarine to obtain a horizontal position fix at 1.5-2 hour intervals with an accuracy of about 0.1 nautical mile.

During this era, Premier Leonid Brezhnev led the Soviet Union in a massive military buildup, expanding both nuclear and conventional arsenals. The Soviet leadership believed that a strong military would be useful leverage in negotiating with foreign powers and would increase the nation’s security from attacks. The Soviet Union achieved nuclear parity with...
the United States by the early 1970s and Russia was confirmed as a “superpower.”

The apparent success of its military build-up led the Soviet leadership to believe that the military, and the military alone, would bring the Soviet Union security and influence. Meanwhile the juggernaut American economy with its technological prowess continued to put pressure on the Soviets to maintain parity.

In 1967, the United States gained a Cold War propaganda victory, and a foundation for economic advantage, when U.S. Vice President Hubert Humphrey announced that the TRANSIT system would be available to civilian ships.

The dramatic American moon landing success in July 1969 not only signified a “giant leap for mankind” but also the moment when the West pulled inexorably ahead in the arms race.

The era also marked the high point of the Soviet Union’s ability to marshal enough resources to compete with the West. In the later years of Brezhnev’s reign, it became official defense policy to invest only enough to maintain military deterrence.

1976-1982: GLONASS Takes Off

The Tsiklon system’s limitations became unacceptable by the early 1970s and the Soviet military conceived a new three-dimensional, continuous worldwide satellite navigation system.

Active development of GLONASS, the acronym for Globalnaya Navigatsionnaya Sputnikovaya Sistema or Global Navigation Satellite System, began in 1976.

The planned system was to consist of 24 satellites operating at an altitude of 20,000 kilometers in medium circular orbit. They would be launched three at a time on the heavy-lift Proton rocket.

As with the American Global Positioning System, signals from four satellites would fix the receiving station’s position to an accuracy of 20 meters.

On October 12, 1982, three satellites, designated Kosmos-1413, Kosmos-1414, and Kosmos-1415 were launched aboard a Proton rocket.

But that wasn’t quite true. In fact, only one GLONASS satellite was ready in time for the launch instead of the expected three. The Soviet government decided to send it up along with two dummy satellites.

The American media reported the event as a launch of one satellite and “two secret objects.” For a long time, the Americans could not find out the nature of those “objects.” The difficulty with these first GLONASS satellites foreshadowed a long period of low reliability and performance.

GLONASS: FDMA vs. CDMA

Although GLONASS was eight years behind GPS, it was similar in many ways.

Probably the most significant difference, technically and economically, lay in the modulation techniques used to discriminate among satellite signals being received simultaneously.

GLONASS satellites transmit two types of signal: a standard precision (SP) signal and an obfuscated high-precision (HP) signal.

The signals use similar direct sequence spread spectrum (DSSS) encoding and binary phase shift keying (BPSK) modulation, just like GPS signals.

However, GPS uses code division multiple access (CDMA) in which each satellite has a unique code.

GLONASS satellites transmit the same code on their SP signal; however each transmits on a different frequency using a 15-channel frequency division multiple access (FDMA) technique spanning a swath of the L1 band.

The center frequency is $1602 MHz + n \times 0.5625 MHz$, where $n$ is a satellite’s frequency channel number ($n=-7,-6,-5,...,0,...,6$, previously $n=0,...,13$). Signals are transmitted in a 38-degree cone, using right-hand circular polarization with an equivalent isotropically radiated power (EIRP) between 25 to 27 dBw (316 to 500 watts).

The 24-satellite constellation gets by with only 15 channels by using identical frequency channels to support antipodal (opposite side of planet in orbit) satellite pairs, because these paired satellites will never be in view of an earth-based user at the same time.

The HP signal (L2) is broadcast in phase quadrature with the SP signal, effectively sharing the same carrier wave but with a 10-times-higher bandwidth.

The L2 signals use the same FDMA as the L1 band signals. They transmit straddling 1246 MHz with the center frequency determined by the equation $1246 MHz + n \times 0.4375 MHz$, where $n$ spans the same range as for L1. Other
Many Launches, More Plans

GPS

A third GPS Block IIF satellite launched successfully on October 4 from Cape Canaveral Air Force Station, Florida — the first GPS launch of the year. The spacecraft was carried aboard a United Launch Alliance Delta IV Launch Vehicle.

Designated Space Vehicle Number 65 (SVN-65), the spacecraft will assume its position in slot 1 of plane A, replacing SVN-39. The latter satellite will be moved to another auxiliary position of the GPS constellation, according to the U.S. Air Force Space & Missile Systems Center (SMC) at Los Angeles Air Force Base, California.

SVN-65 is expected to be set healthy for navigation users approximately 90 days after launch to conduct an extended navigation signal test.

According to Col. Bernie Gruber, director of the GPS Directorate at Los Angeles Air Force Base, nine more GPS IIFs are in the pipeline: SVs 5-7 are in storage, and SVs 8 and 9 are in assembly, integration, and test phase. The IIF manufacturer is on track to finish up satellite production by summer 2013, Gruber added.

On August 24 Raytheon Company and Lockheed Martin successfully completed the first launch readiness exercise for the GPS III satellites. The exercise is a key milestone demonstrating that the team remains on schedule to achieve launch availability in 2014, although the first launch is not expected to take place until 2015.

The launch readiness exercise, completed over a three-day period by mission operations personnel, validated the basic satellite command and control functions, tested the software and hardware interfaces, and demonstrated basic on-console procedures required for space vehicle contacts during the launch and early orbit mission. The event sets the stage for the first GPS III satellite’s mission readiness timeline, which includes five short-duration exercises and six five-day mission rehearsals leading up to launch.

Last January, the companies established a factory-to-factory link between the Lockheed Martin facility in Newtown, Pennsylvania, where the GPS III is being developed and a Raytheon facility in Aurora, Colorado. This enables the team members to transfer space vehicle and control segment information back and forth through a secure communications link.

The factory-to-factory link allows both contractors to identify and solve integration issues at an engineering level early in the process, reducing risk early and saving money in the long run, according to the companies. Specifically, it enables Raytheon to test their next-generation GPS operational control system, known as OCX, under development against high-fidelity simulations of the GPS III space vehicle that incorporate flight-equivalent hardware, software, and databases.

Command and control can also be tested and spacecraft telemetry returned using the factory-to-factory link in place of the radio links that will be used for the operational flight vehicles.

The Air Force’s GPS and Launch directorates are also assessing whether some of the later SVs in the next-generation GPS III program could be launched two at a time to reduce program costs. Early studies indicate only minor changes needed to support this capability, Gruber said.

The GPS program will continue with its modernization plans and expects to have 18 satellites with the new L2C signal by 2017 and L2C FOC with 24 satellites by 2020, Major General Jack Weinstein told attendees at the Civil GPS Service Interface Committee (CGSIC) meeting on Tuesday. Additional details of Weinstein’s presentation can be found in the separate CGSIC article on page 9.

Meanwhile, the GPS Directorate has approved three contracts to continue the military GPS user equipment (MGUE) development program for portable, ground-based receivers.

Contracts were let to the following companies: L-3 Communications Systems Co./Interstate Electronics Corp., Anaheim, California, $31,882,577, with work scheduled for completion by October 30, 2014;
Rockwell Collins, Cedar Rapids, Iowa, for a $30,894,212 cost-plus incentive fee contract, with work to be completed by October 28, 2014; Raytheon Co., El Segundo, California, $29,836,354, with completion by October 28, 2014.

GLONASS

GLONASS also won approval in March to proceed with a new nine-year program for which funds have already been allocated for the first three years. The program will develop the next block of GLONASS-K2 satellites, which will have a 10-year design life and offer a new CDMA (code division multiple access) signal.

GLONASS now has a 347 billion ruble (US$11.81 million) budget approved through 2020, by which time the system is scheduled to have 24 satellites transmitting both the new CDMA and legacy FDMA signals.

GLONASS program mangers are also studying a new signal in the L5 frequency, said Dr. Sergey Revnivykh, deputy director of the Central Research Institute of Roscosmos, the Russian Space Agency. If realized, this development could support the creation of another common GNSS standard on a single frequency — this one a protected safety-of-life band, Revnivykh added.

The Russian GNSS system has been operating with a full 24-satellite constellation since last year. However, problems with Russia’s overall launch program and a politically fraught dispute between Roscosmos and principal GLONASS contractor JSC Russian Space Systems have hobbled the program somewhat.

The program’s last launch from the Plesetsk space center north of Moscow was a single GLONASS-M satellite placed into orbit on November 28, 2011. The Russian program had planned to place a second GLONASS-K satellite into orbit this year, but the launch date remains uncertain, although the Plesetsk Cosmodrome reportedly a reserved launch slot for a GLONASS-K satellite on November 14.

Launch of the Luch-5B Multifunctional Space Relay System (MSRS) geostationary satellite, which will support the GLONASS augmentation System of Differential Correction and Monitoring (SDCM), is scheduled for November 2 from Baikonur cosmodrome in Kazakhstan. To be located in geostationary orbit at 95° East longitude, the spacecraft is the second of three planned Luch-5 space vehicles.

The satellite carries seven Ku- and S-band transponders intended for relaying communications and telemetry data between LEO spacecraft and the Russian ground control segment. It also carries a COSPAS/SARSAT search and rescue transponder as well as the GLONASS satellite-based augmentation system (SBAS) transponder.

Compass/BeiDou

China successfully launched another two Compass/Beidou-2 satellites into space at 3:10 a.m. Beijing time on September 19.

They are the 14th and 15th satellites for the nation’s GNSS system, and the fourth and fifth middle-Earth-orbiting (MEO) satellites in the constellation. The satellites, launched from the Xichang Satellite Launch Center in southwest China’s Sichuan Province, were boosted by a Long March-3B carrier rocket.

Three Compass satellites were sent into space early this year. The 11th satellite was boosted by a Long March-3C carrier rocket on February 25, while the 12th and 13th — MEO satellites — were sent aloft on a Long March-3B carrier on April 30.

A Long March III rocket carried the 16th Chinese Compass/Beidou2 navigation satellite into orbit from the Xichang Launch Center on October 25 at 1533 GMT (11:33 a.m. EDT).

The satellite has been identified as Beidou G6 (or G2R), the latter designation suggesting that the spacecraft may be intended as a replacement for the geostationary satellite launched April 14, 2009, which drifted out of its intended orbital position and is identified by the International GNSS Service (IGS) as “inactive; uncontrolled.”

This would be the sixth Compass satellite placed into orbit this year, bringing the Beidou-2 constellation to a total of 16 spacecraft: six in geostationary orbit, five in inclined geostationary orbit (IGSO) and five in medium Earth orbit (MEO), including Beidou G2. The newest two Beidou satellites launched on September 19 have already begun transmissions.

Meanwhile, China and the European Union (EU) have signed a Joint Statement on Space Technology Cooperation that indicates they will try to work out a long-standing dispute over a the overlay of an encrypted Beidou signal planned for government/military use on the same frequency as Galileo’s proposed Public Regulated Service (PRS).

“Both sides . . . look forward to the resolution of the Galileo/EGNOS and Compass frequency issue under the ITU [International Telecommunication Union] Framework and welcome the agreement for an ITU coordination meeting in December 2012 in Paris,” stated a document signed September 20 as an annex to a broader EU-China summit in Brussels.

As in the case of a once-planned overlay of PRS on the GPS M-code, such situations prevent nations from jamming the signals of
adversaries in time of conflict because they would effectively disrupt their own secure GNSS service.

The network will provide satellite navigation, time and short message services for Asia-Pacific regions within 2012 and global services by 2020.

**Galileo**

A Soyuz ST-B launcher carrying two Galileo in-orbit validation (IOV) satellites took off on October 12 from the European Spaceport in French Guiana. Four IOV spacecraft are now on orbit.

All the stages of the Russian-built, modified Soyuz vehicle performed as planned and the Fregat-MT upper stage released the Galileo satellites into their targeted orbit close to 23,200-kilometer altitude, three hours 45 minutes after liftoff.

The satellites were built by a consortium led by Astrium as prime contractor, with Thales Alenia Space in charge of assembly, integration, and testing.

From a performance point of view, the IOV satellites are the same as the fully operational satellites. With four identical satellites in operation, ESA will be able to demonstrate the performance of the Galileo positioning system before the deployment of the remaining full-capability satellites.

Head of Sector Galileo Program, Services and Exploitation at European Commission (DG ENTR), is a new GNSS regulation — the law that will enable Europe’s GNSS program to carry out all of its activities.

“The new regulation is on the table right now, it is not totally authorized or approved — but it is stable. It is supported by the member states,” Tork told an ION GNSS 2012 audience.

While not a “done deal,” Tork said, they expect that the final version will be close to what is now proposed. Part of what is awaiting approval is a delineation of new roles. The European GNSS Agency or GSA is expected to take the lead in promoting and implementing the services that Galileo will provide. The Commission will then ease out of its lead role, said Tork.

The GSA officially took up residence at its new headquarters location in Prague, Czech Republic, on September 1.

**Augmentations**

The Japanese Cabinet Office announced on September 21 that it had approved plans to procure and finance construction of the ground control system and operation of the next phase of the Quasi-Zenith Satellite System (QZSS). Procurement is going to be carried out using a private finance initiative (PFI) scheme.

The QZSS program has been so successful that the original three-satellite plan has been accelerated to placing four satellites in orbit by the end of this decade. That may be further expanded to seven satellites, Satoshi Kogure of the Japan Space Exploration Agency said at ION GNSS 2012.

Although the program is still under development and continues to test its sole operational spacecraft, QZSS has already demonstrated that it can improve access to navigation signals in challenging environments. Tests in an urban canyon area of Tokyo showed that without QZSS a navigation signal is available only 28.5 percent of the time while that figure jumps to nearly 80 percent when using QZSS.

The construction of the space segment itself is excluded from the operational control segment PFI approved by the Japanese Cabinet at the time of the cabinet announcement, the next phase of the QZSS space segment will consist of the first quasi-zenith satellite (QZS), two additional QZSS, and one geostationary space vehicle.

Each SV will transmit the following signals: L1 C/A, L2C, L5, and the future L1 civil signal L1C (which shall be modulated in the same way as the future L1 civil signal that will be implemented on GPS III satellites), L1S (formerly called L1-SAIF — L1-Submeter-class Augmentation with Integrity Function) and L6a (a public regulated service), L5S (an augmentation signal on the GPS L5 frequency), and L6b (formerly called LEX — L-band Experimental, a high-accuracy augmentation signal centered at 1278.75MHz, the same as Galileo E6).

The requirements document specifies that check-out of the on-orbit QZSS SVs and the ground system must be finished by March 2018.
Meanwhile, Arianespace successfully launched India’s GSAT-10 satellite on September 28 on board an Ariane 5 rocket from Europe’s Spaceport in Kourou, French Guiana.

The GSAT-10 carries India’s second GAGAN (GPS Aided GEO Augmented Navigation) payload, following a successful launch of the nation’s first space-based augmentation for GPS last year.

Equipped with 30 Ku- and C-band transponders and the GAGAN payload, GSAT-10 is to join the Indian National Satellite (INSAT) system of geostationary spacecraft.

Operating in the GPS L1 and L5 bands, the GSAT-10 is predicted to have a minimum operational life of 15 years.

With an orbital position of 83° East, GAGAN will be used primarily to provide increased accuracy and reliability for civil aviation navigation.

Historian Column continued from page 17

details of the HP signal have not been disclosed.

GLONASS historians haven’t given a definitive reason why the USSR defense ministry chose FDMA over CDMA.

FDMA requires a larger number and more complex RF front end than a CDMA receiver and the cost of a modern digital GPS receiver is significantly driven by the number and complexity of these components.

Both GPS and GLONASS were originally developed and funded exclusively by their respective nations’ militaries. Early GPS designers foresaw an evolution to lower cost, higher quantity, commercial applications. Under Soviet centralized planning, it is apparent that the early GLONASS designers were not similarly motivated by profit or potential.

A conservative state bureaucracy triggered a financial and economic crisis in the Soviet Union that contributed to the political decline of the nation.

Satellite navigation development is just one example of the pressure put on the Russian state to maintain parity with successful Western systems such as GPS. Without capitalistic incentives or a culture of civil innovations, this unsustainable pressure contributed to the Soviet decline and prolonged the commercial introduction of GLONASS into the GNSS community.

Marvin B. May is Chief Navigation Technologist at Pennsylvania State University’s Navigation Research and Development Center in Warminster. Email him at mbm16@arl.psu.edu.

Navigation Novelties continued from page 13

pounds or so. Note the turtle fins, which make all this maneuverability and speed possible. And, last but not least, a camera where the more traditional wrinkled head ought to be. (Furthermore, the 17 dual-core processor offers a bit more oomph than a real turtle’s brain, too.)

Water tests were postponed from this summer. This fall, the team intends to test it to see if human-made propeller technology is more efficient — or if mimicking naturally evolved systems, such as the sea turtle’s, is the way to go.

The project has attracted lots of attention and has inspired many comments in the blogosphere, including this one: “So what happens when drug lords find these in the sea. Steal them, and reprogram them to be drug running robots?”

Something that had, actually, never occurred to us . . .

The robotics projects at ETH: <http://www.naro.ethz.ch/p2/robots.html>.
Defense Matters
So, Where Do We Go from Here?

By Doug Taggart, President, Overlook Systems Technologies, Inc.

The week after the ION GNSS 2012 conference in Nashville I was invited (or rather, I volunteered) to provide a presentation on navigation issues to the National Geospatial-Intelligence Agency (NGA).

The presentation to more than 40 NGA employees took place at the agency’s Campus East located on Fort Belvoir’s North Area in Springfield, Virginia. At the end of my presentation I was asked a good question. That question, reflected in the title of this column, is the subject of these comments.

For those of you who have not had the pleasure of visiting the NGA Campus East in Springfield, it is a very impressive facility that now serves as NGA’s headquarters. Designed for 8,500 employees — civilians, military members, and contractors, the campus opened in 2011. It is the third-largest federal facility in the Washington, D.C. area, behind the Pentagon and the Ronald Reagan building.

Although the topic for the presentation was of my own choosing, NGA requested that it be related to the field of navigation and complementary to the NGA Source Directorate’s portfolio. The directorate’s work focuses on satellite imagery, geospatial data, geodetic data, and safety of navigation data for maritime and aeronautical users.

This opportunity presented itself as the result of a meeting between the NGAs’ Source Directorate Workforce Development and Education/Training Officer (Mr. Jose Deguara) and the ION’s Executive Director (Ms. Lisa Beaty) at the 2012 ESRI User Conference held this past summer in San Diego.

In coordinating my presentation, Mr. Deguara informed me that his objective in extending invitations to speakers from outside NGA is to “raise the awareness of NGA employees to various technologies, processes, disciplines, situations, emerging realities, emerging efforts, or other subjects within the wide realm of NGA’s Geospatial Intelligence (GEOINT) business operations.”

In preparing my talk — which Mr. Deguara said should last one hour and be conducted without the aid of PowerPoint slides — I decided to focus on a handful of significant navigation-related incidents that have influenced the course of navigation policy and related technologies. I believe it is important to understand the respective contributions of those policies and technologies over the last 40 years.

The incidents that I highlighted were ones that played a part in shaping and influencing things in which I was personally involved and which dated back to the 1970s. Space limitations prevent me from providing all the details of my talk, but I highlighted a handful of incidents and discussed the policy implications and the ensuing application of navigation technologies stemming from each.

I noted that radionavigation systems such as Loran-A and Loran-C were around for approximately 50 years each, Omega was operational for 30 years, Transit was also operational for about 30 years. I pointed out that GPS had been conceived in the late ’60s/early ’70s but was only declared operational in 1994; so, it has been available for almost 20 years.

The first incident I reflected on was the November 1975 sinking of the Great Lakes ore carrier, the Edmund Fitzgerald. This mysterious sinking and the loss of the entire crew resulted in a U.S. Coast Guard investigation that made numerous recommendations that included upgrading electronic navigation capability and updating nautical charts for the Great Lakes. The emphasis on Great Lakes electronic navigation resulted in the U.S. Coast Guard Research & Development Center initiating studies on precision navigation applications that used Loran-C (both the Saint Marys River Mini-Loran-C chain and later the Great Lakes Loran-C chain), the development of inland navigation...
requirements for precise navigation, the development of electronic charts and the presentation of own-ship position on those charts, and the advent of differential techniques both with Loran-C and, later, GPS.

Another incident with significantly more far-reaching implications was the downing of Korean Air Lines Flight 007 in September of 1983. This event led to President Reagan declaring that the Global Positioning System — at the time, early in its development phase — would be made available free to all when it became operational in order to prevent similar navigation tragedies. This same incident also led to the Coast Guard cooperating early on with the Soviet Union, and later Russia, to improve electronic navigation in the Bering Sea. This was done through an action to dual-rate the U.S. Coast Guard’s Loran-C Station at Attu, Alaska, with the Russian Chayka station located on Petropavlovsk.

Finally, less well known is the September 1994 single-engine plane that crashed onto the White House lawn two stories below the West Wing’s presidential bedroom. (President Clinton was not there at the time.) The timing of this incident, combined with GPS nearing the declaration of operational status, helped influence the development of the March 1996 release by the Clinton/Gore White House of the first U.S. policy on GPS, Presidential Decision Directive/NSTC-6. This policy addressed the timeline for the disestablishment of Selective Availability, provided direction to the Department of Defense for pursuing the development of capabilities designed to mitigate hostile use of civil GPS capabilities by adversaries (Navwar), described how the enhancements to civil GPS (e.g., the Coast Guard’s Maritime DGPS and the FAA’s Wide Area Augmentation System) would be managed, and also how the U.S. would cooperate on GPS with the international community.

In my presentation of these events, I emphasized how technologies available at the time were applied to support the release of national policy and also how the evolution of technology influenced the need for new policy. On this latter point, I offered that incremental improvements to GPS capabilities, such as the addition of new signals and signal capabilities, would likely make systems such as maritime DGPS unnecessary. However, I emphasized the point that prudent navigators should never find themselves dependent on one system alone. Under certain circumstances, GPS limitations necessitate augmentation.

In response to this last point, one of the attendees asked, “So, where do we go from here?” I began to answer the question from the perspective of the challenges facing navigation users today. These issues include navigation inside buildings, urban canyons, areas with RF interference, and the like. She listened intently, but went on to clarify her intended meaning by saying, “You misunderstood! What comes after GPS? What comes next?”

The question is a good one. Current navigation policy and technology is GPS-centric. With augmentations used to overcome limitations, GPS promises to suffice for decades to come. But one has to wonder, “What does come next?”
In Memoriam

Joseph Nathaniel Portney

Joseph Nathaniel Portney, a true gentleman, was born to Russian immigrants, Marcus and Sarah, on August 15, 1927 in the Boyle Heights (Russian Flats) section of East Los Angeles. "Yossel" passed away just hours short of his 85th birthday and enjoyed a full life that included, a 47 year marriage to his true love and best friend, Ina Mae (Leibson), two sons and a "stellar" 60 year career as an expert navigator. He graduated Roosevelt High School a semester early, with honors, enlisted in the Navy under his mother's signature and served in World War Two as a radio electronics technician. After the war, Seaman First Class Portney received an honorable discharge and attended UCLA while waiting to enter the United States Naval Academy in 1948. At Annapolis, Midshipman Portney studied Russian literature and earned a degree in electrical engineering. After four years at the Academy, where one got a $100,000 education stuffed down their throat a nickel at a time, he graduated in the infamous class of 1952. Their motto was "Tough Shoes To Fill" because they discarded their dress shoes on the parade grounds and perpetrated numerous other sacrilegious pranks during the formal graduation ceremony. The Academy would have revoked all 900 commissions, but for staggering personnel shortages caused by the Korean War. Joe opted out of a career as a naval officer and took his lieutenant's commission in the newly created Air Force, where he earned his flight wings and logged over 3,000 hours as a navigator/bombardier in B-26 and B-47 combat crews. He served eight years on active duty with the Tactical and Strategic Air Commands and attained the rank of Major during an additional twelve years in the reserves. In 1960, Joe hired in with Litton Guidance and Control Systems in Woodland Hills and had an illustrious 38 year career as an inertial navigation engineer and advanced programs manager. As a field engineer with a Top Secret security clearance and a "Special Access" enhancement, he regularly boarded Air Force One to install, test and service its inertial navigation equipment. Joe went on to command three historic navigational test flights over the North Pole for the Department of Defense, serve as President (1989-1990) and a Fellow of the Institute of Navigation, earn the prestigious Weems Award in recognition of continuing contributions to the art and science of navigation and serve as a trustee for the United States Naval Academy Alumni Association. For several years, Joe contributed a column to the ION Newsletter — Portney's Corner — which featured articles and "brain teasers" from the "Portney's Ponderables" of his Website. After retiring from Litton, Joe created Navworld.com, a website dedicated to the advancement and history of inertial navigation. Joseph Nathaniel Portney achieved great professional and personal success by following Naval Academy core values of Honor, Courage and Commitment in conjunction with life-lessons learned in East Los Angeles. He is survived by his two sons, Philip and Jeffrey, sister Leonora and numerous adoring cousins, nephews and nieces. His beautiful, kind, and charming wife, Ina Mae, predeceased him in 2008.

The North Star Section is Crossing its Fingers for Lots of Snow in Minnesota this Winter!

Fast approaching in January 2013 is the Third Annual Autonomous Snowplow Competition hosted by the North Star Section of the ION®. The competition has grown significantly, from six initial competing teams in the first year of 2010 to 10 competing teams in 2013. Last year's competition was challenged by the lack of snowfall in Minnesota, however, the competition successfully went forward by using "snow" shaved off a local ice rink.

Returning to the 2013 competition are Miami University, University of Minnesota, Dunwoody College of Technology, and two-time winner Ohio University, as well as the University of Michigan — Dearborn, with three teams! The newcomer teams, from Iowa State University, North Dakota State University, and Case Western Reserve University, round out the 2013 competition.

This is the third annual competition, which is a four-day event that runs in conjunction with the Saint Paul Winter Carnival in Minnesota, and begins on Thursday, January 24. Thursday evening, each team presents their vehicle design to a panel of judges composed of professional engineers from event's sponsors: Honeywell, ASTER Labs, Alliant Tech Systems, Lockheed Martin, Toro, SpaceX, and US Bank. On Friday, the teams are required to pass their Final Qualifying Review, during which their vehicle goes through stringent testing to ensure compliance with all competition requirements. Saturday and Sunday are dynamic competition days, where teams are judged on how quickly and accurately their machine can clear a designated snowfield. Besides competing for cash awards and trophies, the teams learn how to build a project from concept to reality, while using state-of-the-art navigation technology. Competitors receive great exposure to industry design and development standards, interact with industry professionals, experience the cold Minnesota winter elements, and have lots of fun throughout it all!

Proof positive that competitions like this are beneficial to both the sponsors and participants, the University of Michigan — Dearborn, a competitor for the past two years, has had an explosion of exchange students from China applying to their university, largely due to its participation in this event. The fervor began in 2011, with the lone Chinese exchange student on the team blogging on what a valuable experience the event was to him. Inspired by his experience, in 2012 the University had a second team comprised of Chinese exchange students who also blogged about their participation. In anticipation of the 2013 event, over 60 exchange students have come to the University to take part in the event! This event benefits the sponsors as well. These companies are easily tapped in with emerging engineering talent, all receiving the resumes of each competitor that will aid in finding the next generation of engineering greats! To learn more about the competition and follow the results, please visit autosnowplow.com.
The following nominations were submitted by the 2013 Nominating Committee for officers of The Institute of Navigation. The nomination committee was chaired by Dr. Mikel Miller and included three representatives from each region.

President
Ms. Patricia Doherty

Executive Vice President
Dr. Dorota Grejner-Brzezinska
Mr. Doug Taggart

Treasurer
Dr. Frank van Graas

Eastern Vice President
Mr. Jan Anszperger
Mr. Charles Schue

Western Vice President
Mr. Charles Bye
Dr. Sherman Lo

Eastern Council Member-at-Large
Mr. Greg Gerten
Dr. Young Lee

Western Council Member-at-Large
Mr. Steve Rounds
Mr. Logan Scott

Air Representative
Dr. Christophe Macabiau
Dr. Terry Moore

Land Representative
Mr. Neil Gerein
Dr. Todd Humphreys

Marine Representative
Dr. Alan Grant
Mr. Arthur Helwig

Space Representative
Mr. Frank Czopek
Mr. John Nielson

Voting. Voting will be conducted electronically via the ION website. On-line ballots will be available after November 15. On-line voting must be completed by December 7 to be counted.

Election Results. Results will be announced at the ION 2013 International Technical Meeting, January 28–30, 2013, in San Diego, CA. Newly elected officers will take office on January 30, at the conclusion of the meeting. Election results will be reported in the ION Newsletter.

Corporate Profile

Navxperience gmbh
www.navXperience.com

Navxperience gmbh was established in November 2009 with the ambition to merchandise new navigation and location technology from Germany throughout the world. Close collaboration with the Fraunhofer Institute as well as with the Technical University of Berlin helps us to remain in the position as technological leader. All our products are developed and produced in Germany to provide the highest possible quality standards. The development processes are technically oriented to the engineering standards of the German automobile industry. This allows us to guarantee the highest level of quality and security to our clients. The founders and managing directors, Dirk Kowalewski and Franz-Hubert Schmitz, are both experts in the field of navigation and location. Together they have assembled a unique network, consisting of producers and suppliers and thus creating a stable platform for the distribution of technologic innovations.

The ION wants you!

Help shape policy in Washington, D.C.

To learn more about the ION’s Government Fellows Programs please visit: www.ion.org/outreach/fellowship_programs.cfm.

This may be a perfect fit for you now, or in the future!

Reserve your booth today!

ION WANTS YOU!

ION 2014
POSITION LOCATION AND NAVIGATION SYMPOSIUM

Show Dates: May 6 - 7, 2014
Technical Meeting: May 5 - 8, 2014
Monterey, California

ION, IEEE AGIS, PLANS

Reserve your booth today!
www.plansconference.org
Partial list of session topics:

- Alternative Sensors and Emerging Navigation Technologies
- Augmentation Systems (SBAS, GBAS, etc.)
- Autonomous Navigation
- Aviation Applications
- Emerging GNSS and Modernization
- GNSS Processing and Integration
- Interference and Spectrum Management
- Marine Applications
- MEMS, Atomic Clock and Micro PNT
- Receivers and Antenna Technology
- Space Applications and Remote Sensing
- Space and Atmospheric Weather
- Terrestrial Applications
- QZSS
- Urban and Indoor Applications

www.ion.org/itm