Recapping ION GNSS+ 2015

GNSS and Beyond in Today’s Marketplace

Dr. James Green, NASA’s Director or Planetary Science, regaled the ION GNSS+ 2015 plenary audience with stories of NASA’s exploration of our solar system over the last several decades and its plans for the years ahead. See related articles on pages 2, 3, 7, and 8.

NEW GPS DIRECTORATE CHIEF

Col. Whitney Debuts at ION GNSS+ 2015 Conference

U.S. Air Force Col. Steven Whitney, the new director of the Global Positioning Systems Directorate, made his debut appearance before the GPS community during a GNSS Systems Update panel at the ION GNSS+ 2015 conference in Tampa, Florida. He also provided a GPS Program report at the Civil GPS Service Interface Committee (CGSIC) meeting co-located with the ION event. The following article by Dee Ann Divis, based on an exclusive interview with Col. Whitney, appeared in the conference Show Daily on September 16.

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With experience in satellite procurement, user equipment development and working with Congress, Col. Steven Whitney may be just the chief the GPS Directorate needs.

The GPS program was already facing challenges when Whitney became director of the GPS Directorate in early July. The GPS III program had slipped from its original schedule and the Air Force was in the midst of an unusual search for possible new contractors. Then in September a highly critical report from the Government Accountability Office put the long-delayed ground control system and the user equipment program under fresh scrutiny.

Col. Whitney however, brings to the job a wide range of space-related and make-it-work program experience that should help the Directorate manage these challenges. An electrical engineer with three masters degrees — one each in systems engineering, national security strategy and administrative sciences — he has been part of a host of essential military space programs over his career.

Col. Whitney worked on the Defense Support Program spacecraft where he was crew commander and chief for engineering and then served as chief of the Commanders Action Group for DSP’s replacement, the Space-Based Infrared System (SBIRS). While on the SBIRS program he had responsibility for the Flight Demonstration System as operations manager.

Col. Whitney then spent four years at the Air Force Communications Support Facility at the White Sands Missile Range where he was the senior flight commander, chief of the Production Division and director of engineering. He also served at the National Reconnaissance Office as commander of the Enterprise Operations Squadron and as the space lead and chief of the Space/Whitney continued on page 13
I would like to congratulate the Satellite Division on a successful ION GNSS+ conference this past month, where over a thousand of the world’s leading authorities on Global Navigation Satellite Systems (GNSS) gathered in Tampa, Florida, for a week of technical meetings and to view the showcase of GNSS technology, products and services on display in the GNSS exhibit hall. Thank you to all the volunteers that contributed to the event, and congratulations to Dr. Wang and Dr. van Diggelen who took home this year’s Parkinson and Kepler Awards, respectively! (See pages 4 and 7 for more information.)

I found this year’s technical program strong and appealing. The variety of tutorials, technical sessions in peer-reviewed and system and applications flavors, panel discussions, new technology demos and industry exhibits offered an excellent insight into the state-of-the art in PNT and their applications. The highlight of the plenary session was a lively and engaging talk offered by Dr. James L. Green of NASA, who spoke about navigating the ever mysterious and puzzling Solar System.

Following the last few years’ trend, an increasing number of sessions were focused on indoor navigation, sensor fusion for assured navigation, alternatives and backups to GNSS and resilient PNT. These topics are of my professional interest, however, I was also very impressed with a number of high-quality talks presented on GNSS vulnerabilities and anti-jamming, advanced technologies in high precision GNSS, cloud and crowd sourced navigation, and navigation using environmental features.

I was very pleased to see the entire technical session devoted to UAVs, and, based on the discussions with several colleagues and at the ION Council meeting, I expect that ION will expand our technical scope to include more UAV-related topics in the future. The highlight of the ION GNSS+ was, as always, the reception in the exhibit hall that allowed the attendees to not only learn the latest in PNT technology, but do it while sipping a drink and chatting with colleagues and industry reps. Many thanks to the exhibitors for keeping up with this great ION GNSS+ tradition!

WOMEN IN PNT
Another highlight of the ION GNSS+ meeting this year was the inaugural Women in Positioning, Navigation, and Timing (PNT) event, hosted by ION, which took place in conjunction with the ION GNSS+ technical meeting. The ION’s Women in PNT is a voluntary networking initiative that was designed to support and engage women who are in the early stages of their PNT careers, and to provide them with the opportunity to engage with senior level mentors who are established, experienced and seasoned PNT professionals. During ION GNSS+, the mentors had the opportunity to share professional experience, provide inspiration, guidance, support, and insight to help women who are at the outset of their careers to develop and meet their professional goals. The event provided an opportunity to informally share issues vital to women including professionalism, career development, leadership, networking, and work-life balance.

I would like to extend special thanks to Ellen Hall and Sandy Kennedy, who secured the Spirent Federal Systems and NovAtel, Inc. sponsorship that made this event possible. Thank you!

ION COUNCIL AND COMMITTEES MEET DURING ION GNSS+
The ION Council and several of the ION’s committees met and transacted ION business while in Tampa, as well. The Council approved changes to the ION’s bylaws that will allow future ION Technical Representatives to self-identify their technical areas of expertise/representation on the Council, the Awards Policy was updated, and later that week, the ION Executive Committee approved the ION’s annual audited financial statement and updated the ION’s reserve fund formula. See the website for updated documents.

Finally, I look forward to seeing all of you in Monterey, California, from January 25-28 for the first co-located 2016 International Technical Meeting and Precise Time and Time Interval Systems and Applications Meeting. The ION’s 2015 Annual Awards will be presented and the 2016 ION Fellows will be named during this event. See the website for the full technical program and registration information.
The ION GNSS+ 2015 conference and exhibition returned to Tampa, Florida, in September with a rich mix of tutorials, paper presentations, exhibits, panel discussions, technology and product demonstrations, and social events for meeting colleagues.

Formally, the 28th International Technical Meeting of the Satellite Division of The Institute of Navigation, ION GNSS+, drew representatives from nations around the world to investigate, deliberate, and celebrate the preeminent space-based navigation and timing systems and related technologies. The collage of photos on pages 4 and 5 capture a few of the personalities and activities at the world’s oldest GNSS gathering.

From the keynote address — “Navigating Our Way Through the Solar System” by NASA’s director of planetary science, Dr. James Green — to the final day’s awards luncheon (see pages 7–9) and technical sessions, attendees had a wealth of choices with which to fill their individual weeklong schedules.

As Gregory Winfree, assistant U.S. secretary of transportation for research and technology told the Civil GPS Service Interface Committee meeting co-located with the ION event, GNSS “is the technological cornerstone of situational awareness in the 21st Century, yet it only makes its presence known indirectly—through the applications and services enabled by it.”

“[T]his egalitarian utility belies the [system’s] technical complexity . . . and the challenges presented by a satellite-based system,” Winfree added.

Indeed, those issues and concerns underlie the content and purpose of the ION’s GNSS+ program.

Sessions at the conference took aim at those challenges with such topics as “Next Generation Multisensor Applications and Techniques,” “GNSS Vulnerabilities and Anti-jamming,” “Alternatives and Backups to GNSS for Navigation,” “GNSS Authentication and Anti-Spoofing,” and “Next Generation GNSS Positioning.”

Dr. Terry Moore, from the UK’s University of Nottingham, served as the general chair of the event, aided by Dr. Gary McGraw, Rockwell Collins, and program chair, and Ms. Patricia Doherty, Boston College, who chaired the tutorial sessions held on the days preceding the conference.

They were backed up by an international cast of technical chairpersons, including, for the “Systems and Applications Tracks,” Dr. Paul McBurney GopherHush.
Dr. Lei Wang, Space Geodesy and Navigation Laboratory Department of Civil, Environmental and Geomatic Engineering, University College London, England received The Bradford W. Parkinson Award for his thesis: Investigation of Shadow Matching for GNSS Positioning in Urban Canyons. This award, which honors Dr. Parkinson for his leadership in establishing both the U.S. Global Positioning System and the Satellite Division of the ION, included a personalized plaque and a $2,500 honorarium.
Thanks to the ION GNSS+ 2015 Organizers

ION GNSS+ 2015 Program Organizers. Left to right: Dr. Zainab Syed, Dr. André Hauschild, Dr. Grace Gao, Dr. Gary McGraw, Dr. Terry Moore, Sandra Kennedy, Dr. Olivier Julien, Dr. Paul McBurney.
ION GNSS+ 2015

ION GNSS+ continued from page 3

Corp., USA; Ms. Sandra Kennedy, NovAtel Inc., Canada; and Dr. André Hauschild, German Aerospace Center, Germany. The peer-reviewed track chairs included Dr. Zainab Syed IvenSense, Canada; Dr. Olivier Julien, ENAC, France; and Dr. Grace Gao, University of Illinois at Urbana-Champaign, USA.

Proving that the event was not all GNSS all the time, the ION again partnered with the Indoor Location Alliance for an afternoon of live and recorded demonstrations of indoor positioning technologies as well as a panel discussion providing an update of indoor location policy and standards.

In the commercial exhibition accompanying the technical conference, many companies again used the ION GNSS+ venue as an opportunity to roll out new products. Among these were Sensonor with its new STIM210 Gyro Module; GPS Networking’s launch of a line of MILSPEC products, Skydel Solutions GPU-powered GNSS simulator, a novel test framework for threat evaluation introduced by Spirent Communications in cooperation with Nottingham Scientific Ltd., and Syrlinks’ launch of its record/playback system and LEO satellite receiver.

Next year’s ION GNSS+ will take place September 12–16, 2016, in Portland, Oregon, where the Satellite Division will be celebrating its 30th meeting (1986-2016). Portland has been a popular venue for past ION meeting, with many attendees using the event as a launch pad for visiting the Pacific Northwest with their families.
The Institute of Navigation’s (ION) Satellite Division awarded Dr. Frank van Diggelen its Johannes Kepler Award September 18, 2015 at the ION GNSS+ Conference (Tampa, Florida) for his significant and fundamental contributions to the practical, affordable and enhanced use of satellite based navigation for consumer applications, especially for mobile handheld devices; contributions to GNSS interoperability; and dedication as a navigation educator.

Dr. Frank van Diggelen is technically recognized as the inventor of the coarse-time assisted GPS technique and the worldwide reference network needed to replace the ephemerides provided by the time-consuming GPS navigation message. This allowed a GPS receiver to solve for its location under challenging conditions, and made GPS position fixing almost instant. He also developed receiver processing techniques that increased a receiver’s sensitivity, allowing GPS to work in weak-signal environments including in cell-phones in urban and indoor environments.

Dr. van Diggelen holds over 80 patents and has worked commercially for NAVSYS, Ashtech, Magellan, Global Locate and is currently Vice President of Technology for Broadcom. He has published extensively and is the author of the popular textbook A-GPS: Assisted GPS, GNSS and SBAS (Artech House 2009).

In addition to his commercial work he is an avid educator. He is a Consulting Professor at Stanford University and has been teaching graduate level courses for the past six years; and has lectured for numerous public and private organizations, including the ION Satellite Division’s African Outreach Program this past year in Rwanda. Most recently he collaborated on a massive open online course (MOOC) that was released last fall over Coursera to thousands of registered students.

Dr. van Diggelen started his career as a navigation officer in the South African Navy before going to college. He obtained his bachelor’s degree from the University of the Witwatersrand, South Africa and a PhD in electrical engineering from Cambridge University, England. He is currently serving as the ION Satellite Division’s Vice Chair.

The Johannes 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’s Satellite Division.
Best Presentation Awards

Session A1: Mobile Platform Location Fusion Technologies
Speed and Velocity Estimation Using a Smartphone Camera: Amr Al-Hamad, Bashir Kazemipur, Jacques Georgy, Zainab Syed, Chris Goodall, InvenSense, Canada

B1: Land Based Applications
Optimal Selection of an Inertial Sensor for Cycle Slip Detection by Considering INS Output Errors: Yoonsil Kim, Junesol Song, Changdon Kee, Byungwoon Park, Seoul National University, South Korea

Session B2: GNSS Integrity
URA/SISA Analysis for GPS-Galileo ARAIM Integrity Support Message: Santiago Perez Diaz, Michael Meurer, Markus Ripl, Boubekeur Belabbas, German Aerospace Center (DLR), Germany; Mathieu Joerger, Boris Pervan, Illinois Institute of Technology

Session C2: Alternatives and Backups to GNSS for Navigation
Impact of the DME Interference on the LDACS1 Ranging Performance: Thanawat Thiaisiriphet, Nicolas Schneekenburger, Michael Schnell, German Aerospace Center (DLR), Germany

Session A3: Commercial MEMS: Sensors, Integration and Applications
Sensor Augmented Indoor Navigation and Positioning: Marcello Gemelli and Keith Nicholson, Bosch Sensortec

Session B3: UAV Navigation
A Navigation and Guidance System for Autonomous Flights of MAVs into Buildings: Manuel Popp, Silvia Prophet, George Scholz, Gert F. Trommer, Karlsruhe Institute of Technology, Germany

Session C3: GNSS Augmentation Systems and Integrity 1
Overbounding False-Alarm Probability for a Chi-Square Monitor with Natural Biases: Jason Rife, Tufts University

Session A4a: Multi-Constellation and Multi-Function Chipsets in Consumer Products
GGTO: Stability and Impact on Multi-constellation Positioning: Ciro Gioia and Daniele Borio, European Commission, Joint Research Centre (JRC), Italy

Session B4: Aviation and Marine Applications
Operational Scenarios for Maritime Safety in the Baltic Sea: Heidi Kuusniemi, Sarang Thombre Stefan, Siderholm, Liang Chen, Robert Guinness, Finnish Geospatial Research Institute, National Land Survey of Finland; Zbigniew Pietrzykowski, Piotr Wolejsza, Maritime University of Szczecin, Poland

Session C4a: Interference and Spectrum Issues
Quantitative Assessment of the Impact of GNSS Threats on Governmental Applications and Receivers (QUASAR): Mark Dunville, William Roberts, NSL, UK; Jim Hammond, Mick Trosh, Association of Chief Police Offices (ACPO), UK; Chaz Dixon, Steve Hill, Satellite Applications Catapult Centre, UK; Pete Lindsay, UK Space Agency, UK

Session C4b: GNSS Augmentation Systems and Integrity 2
GNSS Integrity in the Arctic: Tyler Reid, Todd Walter, Juan Blanch, Per Enge, Stanford University

Session C5: Modernization of GNSS Signals
GNSS Nominal Signal Distortions – Estimation, Validation and Impact on Receiver Performance: Steffen Thoelert, Mariano Vergara, Christoph Enneking, Matteo Sgammini, Felix Antreich, Germany Aerospace Center (DLR), Germany; Michael Meurer, German Aerospace Center (DLR) & RWTH Aachen University, Germany; Catalina Rodriguez, Daniel Brocard, CNES, France

Session B6: Precise Point Positioning and L-Band Services
Real-Time Single-Frequency Precise Point Positioning on the Road, and on Track: Peter F. de Bakker and Christian C.J.M. Tiberius, Delft University of Technology, The Netherlands

Session C6: Modernization of GNSS-Systems
GPS Space Segment Science & Technology Investment at the Air Force Research Laboratory: Donna Cowell Senft, Kevin Slimak and Lawrence (Robbie) Robertson, AFRL Space Vehicles Directorate

Best Paper Awards

Session D1: Next Generation Multisensor Applications and Techniques
Kalman Filter with Hard and Soft Constraints for the Integration of Multiple Pedestrian Navigation Systems: Haiyu Lan, University of Calgary, Canada / Harbin Engineering University, China; Chunyang Yu, University of Calgary, Canada; You Li, University of Calgary, Canada / Wuhan University, China; Yuan Zhuang and Naser El-Sheimy, University of Calgary, Canada

Session E1: Advanced Technologies in High Precision GNSS Positioning 1
Fault Free Integrity of Mid-Level Voting for Triplex Differential GPS Solutions: G. Nathan Green, University of Texas at Austin; Martin King NAVAIR; Todd Humphreys, University of Texas at Austin

Session F1: GNSS Vulnerabilities and Anti-jamming
A Comparative Analysis of Adaptive Notch Filtering and Wavelet Mitigation Against Jammers Interference: Luciano Musumeci, Politecnico di Torino, Italy; James T. Curran, Joint Research Center (JRC), European Commission, ISPRA, Italy; Favio Dovis, Politecnico di Torino, Italy

Session D2: Navigation Using Environmental Features
Multipath Assisted Positioning for Pedestrians: Christian Gentner, Robert
Session E2a: Next Generation GNSS Positioning
Multi-Constellation ARAIM Exploiting Satellite Geometry Change: Mathieu Joerger and Boris Pervan, Illinois Institute of Technology

Session E2b: Advanced Technologies in High Precision GNSS Positioning 2
The Effect of Correlator and Front-end Design on GNSS Pseudorange Biases for Geodetic Receivers: André Hauschild and Oliver Montenbruck, German Space Operations Center (GSOC) German Aerospace Center (DLR), Germany

Session F2: GNSS Authentication and Anti-Spoofing
A Network-based GNSS Structural Interference Detection, Classification and Source Localization: Ali Broumandan, Ali Jafarnia-Jahromi, Saeed Daneshmand, Gérard Lachapelle, University of Calgary, Canada

Session E3: GNSS Receiver Technologies and Processing for Constrained Environments
Signal-level Integrity and Metrics Based on the Application of Quickest Detection Theory to Multipath Detection: Daniel Egea-Roca, Gonzalo Seco-Granados, José A. López-Salcedo, Universitat Autònoma de Barcelona, Spain; Carlos Moriana, Maciej Jerzy. J. Paśnikowski, Enrique Dominguez, GMV, Spain; L. Enrique Aguado, David Lowe, NSL, UK; Denis Nabertznykh, TRL, UK; Fabio Dovis, Politecnico di Torino, Italy; Juan Pablo Boyero and Ignacio Fernandez, European Commission, Belgium

Session F3a: Remote Sensing; Space Applications; Timing and Scientific Applications 1
Advanced Multi-Receiver Position-Information-Aided Vector Tracking for Robust GPS Time Transfer to PMUs: Yuting Ng and Grace Xingxin Gao, University of Illinois at Urbana-Champaign

Session F3b: Atmospheric Effects 1
Probing the Large-Scale Structure and Dynamics of the Ionosphere: An Analysis of Low-Latitude TEC: Abraham C. Stern, Eric Althshuler, Sequoia Research Corporation; Patricia H. Doherty and Cesar E. Valladares, Institute for Scientific Research, Boston College

Session D4: Urban and Indoor Positioning and Navigation
DiPLoc: Direct Signal Domain Particle Filtering for Network Localization: Siwei Zhang, Emanuel Staudinger, Wei Wang, Christian Gentner, Armin Dammann and Erik Sandgren, Germany Aerospace Center (DLR) Institute of Communications and Navigation, Germany

Session F4: GNSS Receiver Technologies Simultaneous BOC Subcarrier Ambiguity Fixing Using the LAMBDA Method: Jan Wendel, Frank Max Schubert, Ioana Gulie, Airbus DS GmbH, Germany; Alexander Rugamer, Fraunhofer-Institut fuer Integrierte Schaltungen IIS, Germany

Session D5: Enhancing GNSS with Sensors, Mapping and Cooperation
Optimal Receiver Placement for Collaborative Mapping of Signals of Opportunity: Joshua J. Morales and Zaher M. Kassas, University of California, Riverside

Session E5: GNSS Receiver Signal Processing for Degraded Signal Conditions
Signal Quality Monitoring for Discrimination between Spoofing and Environmental Effects, Based on Multidimensional Ratio Metric Tests: Esteban Garbin Manfredini, Fabio Dovis, Politecnico di Torino, Italy; Beatrice Morella, Istituto Superiore Mario Boella, Italy

Session F5: Atmospheric Effects 2
GPS Multi-Frequency Carrier Phase Characterization During Strong Equatorial Ionospheric Scintillation: Dongyang Xu, Yu (Jade) Morton, Colorado State University; Dennis Akos, University of Colorado, Boulder; Todd Walter, Stanford University

Session D6: Smartphone Applications and Multisensor Navigation
GNSS Photo Matching: Positioning using GNSS and Camera in Urban Canyon: Taro Suzuki, Waseda University, Japan; Nobuaki Kubo, Tokyo University of Marine Science and Technology, Japan

Session E6: Advances in Software Receivers
NAVSDR: A GPU-based Modular GNSS Software Receiver: Liangchun Xu, Wuhan University, China; Nesreen I. Ziedan, Zagazig University, Egypt; Wenfei Guo and Xiaoji Niu, Wuhan University, China

Session F6: Remote Sensing; Space Applications; Timing and Scientific Applications 2
A Comparative Study of SBAS Systems for Navigation in Geostationary Orbit: Erin Kahr, University of Calgary, Canada; Oliver Montenbruck, German Aerospace Center (DLR), Germany; Kyle O’Keefe, University of Calgary, Canada

ION GNSS+ 2015
ION GNSS Student Paper Award Winners: Yihe Li, University of Calgary, Canada; Alizé Guilbert, ENAC, France; and Tao An Lin, National Cheng Kung University, Taiwan.
In the last issue of the ION Newsletter, we discussed the importance of Martin Behaim’s globe, the Erdapfel, or “Earth apple,” which was completed in 1492, before Columbus’s landing in the Bahamas, before Magellan, Copernicus, and Galileo. Owned by the German National Museum, it has been digitized and will eventually be available to everyone as a virtual 3-D animation on the Internet.

The creation of the Erdapfel is a consequence of the Renaissance and the Age of Discovery, as well as a stimulus to the revolution in knowledge and consciousness of the physical world that changed European life in the following centuries. These included Columbus’s exploration of the Americas, Magellan’s circumnavigation of the world, Copernicus’ heliocentric theories and Galileo’s astronomical discoveries through the telescope. Not to mention the upheavals caused by the destruction of Earth-centric theology and the challenge to the power of the medieval Catholic Church.

Behaim’s terrestrial globe of 1492, was not so much a leap in geographic knowledge, as an exquisitely engineered and imaginatively decorated representation of the Western World’s concept of the Earth’s geography.

The globe is slightly less than 21 inches (51 centimeters) in diameter; it is fashioned from a type of papier-mache and coated with gypsum. The ball is supported on top of a wooden tripod. Glockenthon’s map drawings were detailed onto parchment strips and pasted into position around the sphere. The map appears as a nautical chart, depicting a total of 1,100 geographical locations, although no coordinates appear. Two full circumferences are described on the globe, one being latitudinal and representing the equator; the other representing the ecliptic (the path of the Earth with respect to the sun).

The tropics of Cancer and Capricorn appear also on the globe, which is decorated with a number of miniature ornamental paintings. Decorative medieval influences permeate the work, including several mythical islands. Among the illustrations are representations of the zodiac symbols, which punctuate the path of the ecliptic on the globe. Other tiny drawings depict kings, saints, sailing ships, wild animals, and fish. Forty-eight banners and 15 coats of arms appear also among the many decorations. The paintings were created originally in six colors, including a dark-blue sea, brown and green forests, and silver areas of ice and snow.

The vicinity of the Cape Verde islands is adorned with a mermaid and a merman, and a single meridian cuts across the globe, spanning 180 degrees from the North Pole to the South Pole at a longitude that is 80 degrees west of Lisbon. The map of the world as depicted on the Behaim globe represents the Ptolemaic world based on the knowledge of the ancient Greeks and Romans in the second century. However, the Erdapfel doesn’t use the longitudinal and latitudinal markings described by Ptolemy and includes some other minor deviations based on knowledge accumulated between the third and fifteenth centuries.

There are some indications that Behaim might have referenced the writings of Marco Polo. The map also bears some resemblance to the Florentine maps of the cartographer Henricus Martellus Germanus.

As for the inaccuracies of the map, some cartographers have speculated that a large and indistinct island positioned to the west of the Azores on Behaim’s map might have been intended to represent Brazil and the East Coast of South America. If that is true, then Behaim’s globe was the first known map to depict the continent of South America, by way of correcting earlier maps, although the first depiction of South America is usually credited to Martin Waldseemüller in his map of 1507.

Others have presumed the obscure island on Behaim’s globe to represent the Antilles, while the few small islands near Greenland are interpreted as the only possible indication of the existence of North America that appeared on Behaim’s globe.

A distorted extension of the Asian continent protrudes disproportionately eastward on the globe in keeping with contemporary ideas. As a result,
there appears only a slim slip of ocean to separate the western coast of Europe from the easternmost part of Asia on the globe, and the location of Japan on the globe more accurately describes some territory in northwestern Mexico.

The Corrections
The Erdapfel’s omissions and inaccuracies, coming as they did on the cusp of the Age of Discovery, were significantly corrected after the voyages of Columbus (1492-1502), Vespucci (1499-1501), Balboa (1501-1510), Cortes (1519-1521), and Pizarro (1524-1532) — all completed in the 40 years after the Erdapfel was created.

Behaim, Regiomontanus, and Nuremburg

The Erdapfel was sponsored, designed, and built in the Bavarian city of Nuremburg. Nuremberg is often referred to as “the unofficial capital” of the Holy Roman Empire, particularly because the Imperial Diet (Reichstag), and courts met there. It attracted a wide variety of merchants, artisans and intellectuals and became the center of the German Renaissance, one of the great trade centers on the route from Asia to Italy and Northern Europe.

The brilliant city had a dark side. The Jewish community suffered centuries of extortion, persecution, torture and periodic expulsion. In 1298, they were accused of having desecrated Christian sacramental bread and 698 of them were killed in one of many massacres that became known as pogroms. Behind the killings was the rulers’ desire to get rid of the Jewish section of town that was in the way of city expansion.

The increasing demand of the royal court and the increasing importance of the city attracted increased trade and commerce to Nuremberg. In her relations with East India and the Orient, Nuremberg soon became, with Augsburg, one of the two great trade centers on the route from Italy to Northern Europe.

As the center of the German Renaissance, Bavaria and its principal city attracted a wide variety of merchants, artisans and intellectuals.

Fifteenth century Nuremburg was also home to the first astronomical observatory in Germany. It was built by Regiomontanus, or Johannes Müller von Königsberg, an important mathematician, astronomer and astrologer of the time. In fact, Regiomontanus’ writings, astronomical device inventions, and celestial observatory were used by the Erpferdel’s creator Martin Behaim to hone his own skills as a cartographer and cosmographer.

In 1464, Regiomontanus wrote De Triangulis omnimodus (“On Triangles of All Kinds”) one of the first textbooks presenting trigonometry, including the spherical trigonometric formulas of a sphere, in its modern form. After studies and achievements in several cities, Regiomontanus moved to Nuremberg and wrote, “Quite recently I have made observations in the city of Nuremberg... for I have chosen it as my permanent home not only on account of the availability of instruments, particularly the astronomical instruments on which the entire science is based, but also on account of the great ease of all sorts of communication with learned men living everywhere, since this place is regarded as the centre of Europe because of the journeys of the merchants.”

He passed on to posterity a record, published posthumously, of his scientific instruments, including dials, quadrants, safea, astrolabes, armillary astrolabe, torquetum, parallactic ruler, and Jacob’s staff. In January, 1472, he used the Jacob’s staff to make observations of a great comet that were accurate enough to enable astronomers 210 years later to identify it as what is now known as Halley’s Comet.

Moveable type was invented during Regiomontanus’s lifetime, and he realized how valuable printing could be for producing identical multiple copies of scientific texts, which could be carefully edited with accurate diagrams. He set up a printing press in his own house in Nuremberg, where he printed a Prospectus announcing detailed plans for publishing many carefully edited mathematical, astronomical, and geographical texts. Regiomantus’ “Ephemeris”, published in 1474, was used several decades later by Amerigo Vespucci and Christopher Columbus to measure (presumably with astrolabes) longitudes in the New World.
appeared on Waldseemüller’s 1507 map Universalis Cosmographia

Johannes Schoner another Nuremberg, built upon the work of Waldseemüller and Behaim. The prolific mathematician, cartographer, globe maker, and astrologer, saved the maps of Waldseemüller and built several of the highest fidelity terrestrial and celestial globes available between 1515 and 1545. Schoner is often credited with influencing the work of the Copernicus, who with the publishing of his De Revolutionibus in 1543, began the modern scientific revolution by showing the earth in motion around the sun.

The historical context of Nuremberg’s relationship to scientific discovery, education and terrestrial globe making grew into a unified earth. The Nuremberg trials, by geographically representing a rotating sphere, that Bavarian city advanced civilization against humanity were brought before an international tribunal in Nuremberg. The Erdapfel, a product and legacy of that Bavarian city advanced civilization by geographically representing a rotating unified earth. The Nuremberg trials, by punishing the sins of anti-Semitism associated with Nuremberg, exemplifies in a metaphorical sense, the old adage that “what goes around, come around”.

Other ION Historian articles that may be of related interest include: “The Shape of the Earth Part I and II”, (Summer 2001, Fall 2001), “The Mercator Projection (Summer 2002)”, “Henry the Navigator (Winter 2009-2010, Spring 2010)”, “Around the World in 1081 Days” (Spring, Summer, Fall 2013), The Erdapfel Part I (Spring, 2015).

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to convene at Nuremberg and revoke German citizenship for all Jews and other “non-Aryans.”

He also ordered a new global map during the 1930s. The Hitler Globe, also known as Führer globe, was formally named the Columbus Globe for State and Industry Leaders. Two versions existed during Hitler’s lifetime, created during the mid-1930s on his orders. These globes were enormous and very costly. According to the New York Times, “the real Columbus globe was nearly the size of a Volkswagen and, at the time, more expensive.”

Several versions still exist in public collections, including three in Berlin: one at a geographical institute, one at the Märkisches Museum, and another at the Deutsches Historisches Museum. The latter has a Soviet bullet hole through Germany. Another has an American bullet hole through Germany. A much smaller version of Hitler’s globe was mocked by Charlie Chaplin in The Great Dictator, a film released in 1940. Between 1945 and 1946, German officials involved in war crimes and crimes against humanity were brought before an international tribunal in Nuremberg. The Erdapfel, a product and legacy of that Bavarian city advanced civilization by geographically representing a rotating unified earth. The Nuremberg trials, by punishing the sins of anti-Semitism associated with Nuremberg, exemplifies in a metaphorical sense, the old adage that “what goes around, come around”.

IV. The Erdapfel

The Mercator Projection

Over the following centuries, celestial and terrestrial globe making grew into a flourishing industry because of its importance to scientific discovery, education and even entertainment.

But the realization that the earth was round and should be portrayed as a globe presented practical problems to navigators during the Age of Exploration. In spite of their inherent freedom from distortion, globes were bulky, difficult to produce, awkward to employ for measurements and unstable in a moving environment. Plus, less than half of the world’s surface could be seen at one time.

The map projection developed by Gerhardus Mercator in 1569, became one of the most useful tools used by navigators, even though it had major distortions. Mercator himself was originally a globe maker. His terrestrial globe of 1541 introduced recent geographical discoveries, especially in Southern Asia, but its truly innovative feature was the introduction of rhumb lines or loxodromes. A rhumb line crosses all meridians at the same angle, and therefore allows sailors to plot on a Mercator projection a constant compass direction, or line of the same course, towards the intended destination.

Rhumb lines were first used on Porto- lan charts, attributed to the Jewish cartographers Abraham Presques and his son Jehuda of Aragon. These portolan charts are the oldest sea charts and were used by Mediterranean sailors from the thirteenth to sixteen century. On a globe, these rhumb lines spiral towards the poles.

In the 20th century, Nuremberg acquired a more recent, notorious association with globes. Because of the city’s relationship to the Holy Roman Empire and its position in the center of Germany, the Nazi Party chose the city to be the site of huge Nazi Party conventions. The rallies were held 1927, 1929 and annually 1933-1938 in Nuremberg. At the 1935 rally, Hitler ordered the Reichstag
MGUE & GPS III

One of those unique experiences, while he was senior materiel leader for the GPS User Equipment Division, was working with the 57 partner nations that buy GPS user equipment. The insight he gained there is particularly relevant now as signals from other satellite navigation constellations become available and can be incorporated into U.S. equipment — something Whitney calls “the smart way to go.”

“In the future it’s going to be important that our industry partners and the Directorate continue to investigate ways to pull in these new signals and include some the non-GPS signals into our user equipment,” Col. Whitney said, adding, “I don’t see why we shouldn’t go that way and couldn’t go that way.”

As for the GPS space segment, the GPS III program, he noted that the first of the GPS III space vehicles is fully assembled and ready for thermal vacuum testing, which verifies performance in the extremes of a simulated space environment.

“Thermal vac is one of the most important tests that we run,” said Col. Whitney. “It’s kind of a culmination of things and so we’re getting ready to go into that. It verifies all the subsystem interfaces and everything else — so, once that completes, there’s a few more remaining things that are assembly integration test flow, but we’re on track for having a satellite available for launch in August 2016.”

In terms of next steps the colonel said he was now in the process of getting price options for GPS III space vehicles 11 and 12. The Directorate is also poised to release the RFP for the first of a possible two-phase process to recompete the GPS III contract.

“Phase 1 is where we’re going to do an assessment — is there actually a competition to be had?” says Whitney. “Phase 2 is going to be acting on that information to move forward to make the purchases that we need for future satellites.”

Whatever the challenges, Whitney expressed his confidence in his team, a group of people he described as energizing to work with.

“I’ve honestly never seen a more dedicated, more passionate group for getting things done, whether it be our government or FFRDCs [Federally Funded Research and Development Centers], our contractors, our civil partners — everyone is just so focused on the mission. It’s a joy to come to work and work with them every day.”

In remarks after he was sworn in at the Space & Missile Systems Center in July, Col. Whitney singled out members of his former User Equipment Division of the GPS Directorate. “You are an incredibly talented group of individuals and I am inspired by your dedication to the mission and the passion you show each and every day,” Whitney said. “We have a great many challenges ahead of us, but I am confident that together, we can meet these and not only succeed, but do so with the style and grace befitting the ‘Gold Standard’ [of GPS positioning].”
Defense Matters
Playing Politics with the 2016 Defense

In my last ION Newsletter article (Summer 2015, “Into the Federal Doldrums”) I spoke to the possibility that the Fiscal Year 2016 (FY16) National Defense Authorization Act (NDAA) might include language directing establishment of a backup to GPS. That direction did not materialize in the NDAA, but earlier language in the report of the House Committee on Armed Services on H.R. 1735 (together with dissenting views) did have language that would have required that the Department of Defense (DoD) to provide a briefing by January 15, 2016, on DoD requirements for back-up positioning, navigation, and timing (PNT) capabilities, including an assessment of any potential benefits from a U.S. ground-based system.

It remains to be seen if the DoD will respond to the House Committee’s request with no statutory requirement in the NDAA as it is currently drafted.

However, the version of the FY16 NDAA (H.R. 1735 National Defense Authorization Act for Fiscal Year 2016 — H. Rept. 114-270) that passed both the House and the Senate does have a number of GPS and PNT items in it. Unfortunately, the entire annual defense policy bill is at risk, since the President has given indications that he plans to veto the bill because he will not support increased defense spending without more domestic spending. Also unfortunately, my vision in the previous article of what lies in store for the remaining months of the current administration is very quickly becoming a reality.

A review of the conference report to accompany H.R. 1735 with an eye towards GPS and PNT yields the following. Under “Space Procurement, Air Force, Space Programs,” the bill recommends that the GPS program should be fully funded, restoring nearly $200 million for procurement of GPS III satellites that had previously been zeroed out by the Senate.

Section 1603 of the conference report includes a provision for the DoD to establish a “Council on Oversight of the DoD’s Positioning, Navigation, and Timing Enterprise” that “shall be responsible for oversight of the Department of Defense positioning, navigation, and timing enterprise, including positioning, navigation, and timing services provided to civil, commercial, scientific, and international users.” The language includes direction on membership of the council, the co-chairs (Under Secretary of Defense for Acquisition, Technology, and Logistics and the Vice Chairman of the Joint Staff), responsibilities and annual reports, and a requirement for notification of anomalies.

The language regarding annual reports specifically references a requirement that, “Not later than 30 days after the President submits to Congress the budget for a fiscal year . . . the Commander of the United States Strategic Command shall submit to the Chairman of the Joint Chiefs of Staff an assessment of . . . whether such budget allows the Federal Government to meet the required capabilities of the Department of Defense positioning, navigation and timing enterprise during the fiscal year covered by the budget and the four subsequent fiscal years. . . .” If it does not, then a description of the steps being taken to meet those requirements must also be included in that report for comment by the chairman and forwarded within 30 days to the respective defense committees.

Regarding “notification of anomalies,” the NDAA language requires that within 14 days after the Council or the Secretary of Defense learns of any abnormality in the DoD PNT Enterprise that the respective congressional defense committees shall receive written notification of the event. The bill defines “anomaly” as any unplanned, irregular, or abnormal event, whether unexplained or caused intentionally or unintentionally by a person or system.

Oversight: Sending a Message
The passage of statutory language directing the DoD to establish the PNT Oversight Council and focusing on the concept of a PNT Enterprise rather than simply GPS clearly sends a message that Congress is increasingly aware of the importance reliable PNT plays in meeting DoD requirements.

Section 1605 of the report addresses the topic of M-Code Equipage by amending Section 913 of the Ike Skelton NDAA for Fiscal Year 2011, which requires all GPS user equipment purchased by DoD after FY 2017 to be M-Code—capable unless excepted by law or waived by the secretary of defense. The amendment states that “The Secretary of Defense may not delegate the authority to make a waiver under subsection (c) to an official below the level of the Under Secretary of Defense for Acquisition, Technol-
ogy, and Logistics.” The conference report further amended Section 1605 to add the “Secretaries of the Military Departments” to the limitation of waiver authority delegation.

Finally, Section 1621 of the conference report requires the Air Force to provide quarterly reports to the Government Accountability Office (GAO) on GPS III space and operational control segments (OCX) as well as the Military Global Positioning System User (MGUE) equipment program. The reporting requirement would sunset on the date at which GPS III, GPS OCX, and MGUE reach their full operational capabilities.

Although the president’s anticipated veto is not related to GPS or any of the PNT language, the mere fact that this traditionally bipartisan defense policy bill could be vetoed in a year when none of the agencies have approved appropriations bills is another textbook example of the “Federal Doldrums.” Again, the government cannot even begin moving forward with what has been established for more than 10 years as a requirement to establish a GPS backup.

In one news report following Senate passage of the NDAA, and faced with the likelihood of the president vetoing the bill, Senator McCain said that he and House Armed Services Chairman Mac Thornberry (R-Texas) can’t control the outcome of budget negotiations among congressional leaders and the White House.

“But I can tell you what we can do,” McCain continued, “and what we will be doing: On every street corner in America that we can stand on, we’re going to be talking about putting the lives of the men and women who are serving in the military in danger over a budgetary fight, and how disgraceful that is.”

The mere fact that this traditionally bipartisan defense policy bill could be vetoed in a year when none of the agencies have approved appropriations bills is another textbook example of the “Federal Doldrums.”
Each year the American Association for the Advancement of Science (AAAS) manages and administers Science & Technology Policy Fellowships to provide the opportunity for scientists and engineers to participate in and contribute to the federal policymaking process. AAAS provides two types of fellowships to participants. The Executive Fellowships place a fellow within agencies of the federal government and the fellow's support is provided by the hosting executive agency. The Congressional Fellowships provide an opportunity to work on the staff of a representative or senator or a congressional committee in either house. These fellows are supported by their professional societies. Having just retired from National Geodetic Survey/NOAA after 35 years in the executive branch, I opted to apply for the ION congressional fellowship to see what life is like on the other side.

The fellowship year begins September 1 with two weeks of orientation. This includes presentations on the constitution, the executive branch, the legislative branch, the judiciary, policy making, rules for networking, and proper etiquette delivered by professors, an ambassador, a judge, a congressman, the presidential science advisor, and previous and current fellows. The goal of course is to prepare us for a political environment that emphasizes brevity and quick reaction rather than the in-depth consideration scientists usually exercise.

I quickly noticed that of the 162 fellows participating in the orientation only 31 were congressional fellows. The main difference being that executive fellows already knew their assignments and the executive agencies they would be supporting. Our small band of congressional fellows would not know for another week or two where we would be working. However, there were some features of orientation unique to our group including a day's briefing on the Congressional Research Service, which operates out of the Library of Congress and provides highly specialized research exclusively for members of congress and their staffs.

Following orientation we congressional fellows continued to meet to prepare our one-page resumes (as much as any staffer or member can be expected to read) and prepared for an evening reception, affectionately known as the “Prom”, where we would commingle with staff from many of the offices interested in hosting a fellow. The Prom was a series of 5 minute encounters with staffers to listen to each other's very brief descriptions, exchange cards and promise to get in touch. This variation on “speed dating” was only interrupted by short, encouraging speeches from the congressmen and senators who also attended.

The following day the real search for a hosting office began. Armed with a lengthy list of members and committees and their contact information (there are at least twice as many offices seeking fellows as there are fellows) we sent emails requesting interviews to some of those we met at the Prom as well as some of those we missed or who didn't attend. And then we waited.

The wait was not long. Replies scheduling interviews began arriving that same afternoon and over the following days.
The remainder of that week and much of the following week (complicated by the papal visit) was populated with meetings with staffers, which gave most of us tours of each of the House and Senate buildings. Within a few days, a few of us began accepting offers they had received. By the end of September almost everyone had received and accepted an offer. Even though, as we learned, the majority in either house has enormous power to control the agenda, Democratic members of the U.S. Senate were the overwhelming favorites among this group of congressional fellows with only a few going to the House or to committees.

I was fortunate to receive an offer from my first choice; the Senate Commerce, Science and Transportation Committee on the majority side chaired by Senator John Thune (R-SD). This committee has a very large portfolio, which includes subject areas I’m familiar with and federal agencies within their jurisdiction that I’ve had an opportunity to work with during my career at NOAA. A mixture of old and new seemed like a reasonable strategy to me and I’ll let you know how that works out in future reports.

I seem to be mostly associated with the Subcommittee on Space, Science, and Competitiveness which has responsibility over NSF, NASA, NIST and other agencies. However, I’m sitting amongst a small group of people associated with other subcommittees so I expect and look forward to working on a wide range of topics. Already, after only a few days here, I see hearings and meetings appearing on my calendar on Wireless Broadband Deployment, Research Commercialization and Technology Transfer, and Cyber Security. I’ll also be attending lectures on various aspects of government, congress and legislation that should help me better understand how everything here actually works (or doesn’t, as the case may be).

I expect that I’ll be reviewing legislative proposals, preparing questions for hearings, reviewing policy positions, and distilling technical material to be understandable by laymen. It is quite a thrill to walk these halls and see the names of members you’ve heard only in the media and realize you will be meeting and working with some of them. I’m very grateful for this opportunity and am looking forward to a very interesting year.

"I seem to be mostly associated with the Subcommittee on Space, Science, and Competitiveness which has responsibility over NSF, NASA, NIST and other agencies."

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ASCE Recognizes Stanton Blatch Barney; Pioneering Civil Engineer, Suffragist

By Ben Walpole. ASCE News

Nora Stanton Blatch Barney has been posthumously elevated to ASCE Fellow status in recognition of her significant contributions to civil engineering.

After 99 years, ASCE has righted a wrong committed against pioneering civil engineer and suffragist Nora Stanton Blatch Barney.

Stanton Blatch Barney was among the first women in the United States to earn a civil engineering degree, graduating from Cornell University in 1905. She was also the first woman to earn Junior Member status in ASCE.

In 1916, Stanton Blatch Barney sought to become the first woman to enjoy full ASCE Associate member status, but the Board of Direction turned down her application. She challenged the decision in court, but a New York state Supreme Court upheld ASCE. She went on to an illustrious career, but did so without having been accorded membership in ASCE, for which she clearly was deserving.

That status changed this month.

The ASCE Executive Committee voted Aug. 11 to posthumously advance Nora Stanton Blatch Barney to the status of ASCE Fellow. “We want to recognize and appreciate those who have paved the way for today and tomorrow’s diverse leadership for ASCE and the engineering profession,” said Executive Director Thomas W. Smith III, ENV SP, CAE, EASCE. “Advancing her to the higher level of ASCE Fellow recognizes her significant contributions.”

Such contributions include hydraulics thesis research at Cornell University’s Beebe Lake Hydraulics Laboratory, which solved a key problem in hydrodynamics. Stanton Blatch Barney went on to contribute to the development of early radio broadcast technology alongside her first husband, Lee De Forest, and worked for many years as an engineer in New York City, including for the city’s Board of Water Supply. She also worked throughout her life to improve civil rights and women’s rights, following the lead of her grandmother and pioneer of the suffragist movement, Elizabeth Cady Stanton.

ASCE and the civil engineering field as a whole look much different, a century later, from the overwhelmingly male-dominated profession in which Stanton Blatch Barney worked.

According to a 1949 Civil Engineering magazine item, about 50 women had by then been admitted to ASCE membership. Fast forward to 2015, when 14 percent of ASCE’s more than 146,000 members are female. Of all U.S. civil engineers, 17 percent identify as female; of the total engineering workforce, 15 percent are women. The gains are reflected in the number of civil engineering degrees earned by women, with 22 percent earning bachelor’s degrees, 27 percent acquiring a master’s, and 25 percent becoming doctorates.

“I think it’s extremely important for the Society to celebrate Nora Stanton Blatch Barney, because she and others like her are the ones who paved the way for everything that women have achieved in the professional world today,” said ASCE General Counsel Tara Hoke, who researched Stanton Blatch Barney’s case and life for the Society.

Norma Jean Mattei, Ph.D., P.E., F.SEI, M.COPRI, FASCE, will be installed as ASCE’s new president-elect in October at the ASCE 2015 Convention in New York City. Mattei follows the lead of women like Stanton Blatch Barney, and ASCE’s first elected female president, Patricia Galloway, and the Society’s second female president, Kathy Caldwell, and countless other female civil engineering leaders who sought to be treated as civil engineers who only happen to be women.

For Stanton Blatch Barney, posthumously being advanced to the status of ASCE Fellow demonstrates how far the engineering community has come in 100 years, but it also recalls how far the push toward gender equality still has to go.

“As the civil engineering community reflects today on Women’s Equality Day, we must not only celebrate the strides we have made in supporting the equal treatment of women through our efforts to inspire, develop, and retain them in the profession, we must continue to look forward to the work to be done in how we create a climate where all feel welcomed, included, and respected within the profession,” said Constance Thompson, CCDP, ASCE’s senior manager for Diversity and Inclusion and staff liaison to the Society’s Committee on Diversity and Inclusion.

“ASCE’s Committee on Diversity and Inclusion exists to ensure that diversity and inclusion is the way of doing business within the civil engineering community, and while we are on our way, we have a ways to go until our job is done.”
Dayton Section News

The Dayton Section held their first meeting of the new season on September 17. Twenty-two attendees gathered at the Northrop Grumman facility in Fairborn, Ohio. The group enjoyed a delicious catered lunch from Taco Loco and was treated to a presentation by Dr. Ron Storm of The Perduco Group titled: "How Do You Create an Interface that is Intuitive and Trustworthy?" that addressed an effective interface between human operators and on-board navigational equipment.

The second meeting will be held at the same site on October 15, after which meetings will again be on the second Thursday of each month. Section officers for this year are Thomas Pestak, chair; Brian Roadruck, vice chair; Joseph Curro, executive secretary; and Boyd Holsapple, treasurer.

Washington D.C. Section News

The recently revived DC Section of the Institute of Navigation met on the evening of October 21, 2015 at the U.S. Coast Guard Navigation Center in Springfield, Virginia. In attendance were more than 40 current and past members of the ION.

As part of the evening’s events, the Section elected two new officers who have dedicated themselves to helping get the DC Section back up and running. Mr. Gary Thomas (CDR USCG Retired) was chosen to serve as the Section Chair, and Mr. Michael McGinn (Oceaneering International, Inc.) will join the leadership as the Section Treasurer.

The evening’s events included a tour of the NAVCEN Operations Center and a presentation by Mr. John McHale to the NAVCEN Commanding Officer, CAPT Russell E. Holmes, a book titled, "Men of the Menkar: United States Coast Guard World War Two Naval Exploits." (A description of the book can be found online at http://www.amazon.com/Men-Menkar-United-States-Exploits/dp/0966274512). The book had been autographed by the author, Captain Niels P. Thomsen (USCG Retired), and given to Mr. McHale many years ago. It includes a recounting of the role of the USS Menkar, a standard-type Victory ship, and its crew in the construction of Loran stations throughout the Pacific. In accepting the book, Captain Holmes commented, “This book will be a valued addition to NAVCEN’s library – serving as a historical reminder of the very important role that electronic navigation systems have played in our nation’s history.”

The next meeting of the Section will be held in early 2016.

Calendar of Upcoming ION Events

JANUARY 2016
Contact: ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

APRIL 2016
11-14: IEEE/ION PLANS 2016, Hyatt Regency Savannah, Savannah, Georgia
Contact: ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

MAY 2016
30 May - 02 June: ENC-GNSS 2016, Helsinki, Finland
Contact: ENC 2016 Conference Office
Email: enc2016@confedent.fi
Web: www.confedent.fi/enc2016

JUNE 2016
6-9: ION Joint Navigation Conference (JNC) 2016, Dayton Convention Center, Dayton, Ohio
Contact: The ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

SEPTEMBER 2016
12-16: ION GNSS+ 2016, Oregon Convention Center, Portland, Oregon
Contact: The ION
Tel: +1 703-366-2723
Fax: +1 703-366-2724
Web: www.ion.org

NOVEMBER 2016
8-10: International Navigation Conference (INC), Glasgow, Scotland
Contact: The Royal Institute of Navigation
Web: www.internationalnavigationconference.org.uk
Email: conference@rin.org.uk
CONTESTED TERRITORY

In October, The New York Times featured a dramatic encounter between a juvenile red-tailed hawk and a drone in an article on animals vs. recreational UAVs. The camera-equipped drone was helping its Cambridge, Massachusetts, owner photograph fall scenery last year when the hawk took umbrage and knocked the little buzzer out of the sky. The drone captured its own defeat on camera, its owner posted the video on YouTube and five million people have seen it so far.

That hawk was not alone. Animals and drones collide all of the time. And recreational UAVS are getting cheaper, smaller and easier to operate; an FAA administrator expects a million to be sold this year for Christmas.

Wildlife biologists are worried. On the one hand, UAV technology helps them observe birds and mammals unobtrusively. On the other hand, UAVs can cause stress or harm if someone who isn’t aware of animal habits operates them. Minnesota biologists investigated this recently with a family of black bears who had been outfitted with GPS collars and heart rate monitors. The bears lived on the border of human territory and were used to roads and machinery. When scientists flew quadrotors over the group, the bears didn’t run or hide. However, their heart rates increased so much the lead investigator said, “I don’t know if we have ever measured such a dramatic change other than when an animal has been shot by a hunter.”
TROJAN TUSKS

Violent Central African armed groups slaughter elephants as well as people. Ivory tusks from the increasingly endangered animals serve as a bank account for Joseph Kony’s Lord’s Resistance Army (LRA) and similar rebel bands and cults. Last year, National Geographic decided to worm its way into the illegal ivory trade and find out more about it. With a team of ingenious experts, they made artificial elephant tusks complete with hidden GPS and tracking sensors, planted them in the smuggling supply chain and the results became September’s cover story in the magazine.

An investigative reporter, a taxidermist and a wildlife tracking expert with Telemetry Solutions did the job. They used a tiny GPS device designed for asset tracking in locations without mobile service or reliable electricity. The custom device has a battery that lasts more than a year, a GPS receiver, an Iridium satellite transceiver and a temperature sensor. Rugged and waterproof, you can drive a truck over it “no problem” says the company website.

The trackers were placed inside lead and resin “tusks” so realistic the reporter was arrested in Dar es Salaam for smuggling ivory. (He was sent on his way with encouragement from the Tanzanian police once they figured out what he was up to.) The replicas — let’s call them Trojan Tusks — communicated with the Iridium satellites periodically and the investigative team tracked them using Google Earth. Occasionally, they’d commission satellite photography of a location to get even more information.

The tusks entered the ivory black market in southeastern Central African Republic and wended their way north for 53 days and 592 miles. Then they stopped — in or under a blue-roofed house in the Darfur region of Sudan. Their travels confirmed what sources had told the reporter about smuggling routes and their relationship to LRA.

So, who buys most of this bloody treasure? Upwardly mobile and status seeking younger people mainly in China with runners up the Philippines, Thailand, Vietnam, and the good ’ol USA.

EASIER RIDER

Billy is shot, Wyatt’s bike flies through the air . . . it’s safe to assume that Easy Rider ends badly. But if those 1960s rebels had used the RealRider smartphone app, they might still be taking photo ops with Captain America.

One of the top winners of the 2015 European Satellite Navigation Competition, RealRider can tell if your chopper has crashed and it notifies emergency services of your location. Developed in the United Kingdom, it’s made for the country’s 1.3 million motorcyclists, who make up only 1% of the drivers but suffer 19% of the serious injuries and deaths.

RealRider uses a proprietary crash detection technology that monitors the rider’s smartphone accelerometer together with GNSS data. An impact triggers a 2-minute crash alert countdown and then sends the last known coordinates to the EMTs with the rider’s phone number and medical information. The developers have partnered with the United Kingdom’s National Health Service and, after a trial period, RealRider will become fully integrated into the country’s emergency call system.
GNSS Program Updates
News from Systems Around the World

Based on comments from speakers at an ION GNSS+ 2015 panel discussion in September, 2020 looks to be a banner year for satellite navigation with both the Europeans and the Chinese racing to complete their constellations by the end of this decade.

Global Positioning System

As this issue of the ION Newsletter went to press, the GPS program was preparing to launch the next to the last satellite in the GPS II follow-on block (IIF-11) on October 30 from Cape Canaveral Air Force Station, California.

The Air Force launched the 10th GPS IIF satellite on July 15 and made it available to users on August 12. The American GPS constellation has 31 satellites in operation with another nine on-orbit spares. The satellites are aging, however, with one of the spacecraft close to 25 years old. The GPS Directorate is moving quickly to update the system, launching six satellites in the last 19 months, the most intense launch schedule since 1993. The last of the IIFs will be lofted in February of next year.

At present 10 of the 31 satellites in the constellation are the newest IIF satellites, which can transmit the new L5 civil signal. The latest generation of satellites may be contributing to the continued improvement in accuracy, which Col. Steven Whitney, director of the GPS Directorate, told the ION audience had reached a signal-in-space user ranging error level of only 39 centimeters on September 2.

The Next Generation Operational Control System or OCX is years behind schedule and will end up some $1.1 billion dollars over its original $886 million baseline budget, according to the Government Accountability Office (GAO). Citing cost estimates from the Defense Contract Management Agency, a GAO report released September 9 said that the final contract cost for building OCX could balloon to over $2.15 billion before the program is completed.

Exactly when OCX will be finished remains a question, the performance audit said. An advisory independent review launched in October 2014 determined that the Block 1 OCX software would most likely be delivered in November 2020 — two years later than an estimate made that summer by the Air Force when it recast the baseline budget and schedule to reflect slippages.

Although next-generation GPS III satellites now under development could still be launched beginning in 2017, “they would not be added to the constellation until OCX comes on line or until a contingency operational control capability able to command GPS III satellites is available,” GAO said.

BeiDou Satellite System

The Chinese are aiming to finish their constellation by 2020, said Jun Shen, deputy director of the International Cooperation Center of the China Satellite Navigation Office and the BeiDou representative on the ION GNSS+ panel. When complete the constellation will comprise five geostationary (GEO) satellites, three satellites in inclined geostationary Earth orbits (IGSO) and 27 satellites in mid-Earth orbits or MEO.

China launched its most recent BeiDou spacecraft, a new-generation satellite, on September 30. The new BeiDou satellite has a hydrogen maser atomic clock on board, a new development for the Chinese GNSS spacecraft. The geostationary satellite has reached its orbital slot at longitude 95 degrees East. Tests of the clock and a new navigation signal are planned, according to China’s state news agency Xinhua.

The two-dimensional, real-time positioning accuracy of the system so far is around five meters, said Shen. He added that China already has 10 monitoring stations in place for the BeiDou constellation, including locations in both the Arctic and Antarctic. A total of 10 more stations are under construction.

BeiDou is developing an augmentation system based on more than 1,000 reference network stations that will eventually help improve real time positioning and navigation accuracies to a meter or better over wide areas.

GLONASS

The Chinese and Russian governments recently signed a memorandum of understanding that spans both technical and territorial cooperation in GNSS.

“We’re going to cooperate in all technical areas,” Sergey Karutin, head of the PNT Center in the Central Institute of Machine Building, told the ION GNSS+ 2015 panel audience. This includes defining the time offset parameters and the time reference characteristics of GLONASS and BeiDou.

The two countries will also work to develop an emergency service to aid travelers between Asia and Europe with combined GLONASS/BeiDou receivers that can locate travelers that have, for example, been involved in an accident.

That cooperation extends to monitoring stations — an area of controversy between the U.S. and Russia.

“We are going to accept three BeiDou stations in the Russian territory,” said Sergey Karutin, “and China has accepted to install three of our sites within the China territory.”

The Russians have 28 satellites on orbit though two are in flight test and
two are undergoing checks by the prime contractor. The program plans to orbit up nine more modernized GLONASS (GLONASS-M) satellites by the end of next year, with the final number to be determined based on the need to replace existing spacecraft, Karutin said.

Russia last launched a GLONASS satellite in December 2014, a new-generation GLONASS-K that is still undergoing flight tests.

**Galileo**

A pair of Galileo satellites launched on September 11 have passed their initial check-out in space, allowing control to be transferred to the Galileo Operations Center (GOC) for integration into the existing constellation. The satellites — Galileo spacecraft numbers 9 and 10 (fully operational capability or FOC satellites 5 and 6) — were handed over on September 19 and 20, respectively, to the GOC, managed by SpaceOpal. Some research institutions reported the transmission of test signals from the satellites in early October, but the signals have not yet been set “healthy.”

The next launch of Galileo 11 and 12 on a Soyuz rocket is tentatively scheduled for December 17 from Europe’s spaceport in Kourou, French Guiana. Another Galileo launch — four satellites on a modified Ariane 5 launcher — is expected in the second half of 2016.

The Europeans were able to recover some of the function of the Galileo satellites launched into highly eccentric orbits last year, Eric Chatre of the European Space Agency (ESA) said during the ION panel discussion. The Galileo program will then switch to launching satellites four at a time on the Ariane 5 rocket, topping off the constellation in quasi-zenith orbit and one satellite in GEO orbit.

The GEO satellite will also be used for to provide a satellite-based augmentation system or SBAS signal that will be available starting in the early 2020s, says Yoshiyuki Murai, executive director for promotion of QZSS utilization at the NEC Corporation who spoke at ION GNSS+ 2015. NEC has a contract to support Japan Quasi-Zenith Satellite System (QSS) Services Inc.

Mentioned as a possibility last year, the Japanese government has made a definitive decision to expand the planned initial constellation to seven satellites by 2023. To support their overall service the Japanese will need to place monitoring stations outside of Japan, Murai said in response to a question through the placement of the sites did not appear to be settled.

The Indian Space Research Organization (ISRO) and Airports Authority of India (AAI) have completed implementation of the GPS Aided Geo Augmented Navigation (GAGAN) project as an SBAS for Indian airspace. ISRO provided the space segment through transponders placed on GSAT-8 and GSAT-10 and ground uplink segments. AAI established the required ground infrastructure and currently operates and maintains the system. GAGAN navigation signal is already operational, transmitting PRN 127 and PRN 128 for users.

India’s Director General of Civil Aviation (DGCA) certified GAGAN for en route operations on December 30, 2013, and on April 21, 2015 for precision approach services (APV 1). APV1-certified GAGAN signals have been broadcast since May 19, 2015. GSAT-15 satellite with another GAGAN payload is slated for launch by November 10.

All the seven satellites of Indian Regional Navigation Satellite System (IRNSS) are expected to be in orbit by March 2016, according to ISRO. The primary objective of IRNSS is to achieve position accuracy of 20 meters (2 sigma) for dual-frequency users over India and the primary service area (a region extending to about 1,500 kilometers or 930 miles).
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