S\o, what’s with that plus sign in the title of this year’s 26th International Technical Meeting of The ION Satellite Division — ION GNSS+ 2013?

Seems as though we had just gotten comfortable with GNSS for the conference focus, not just GPS. And now this “plus.”

Well, all will be revealed at the world’s oldest GNSS conference, set for September 16–20 in Nashville, Tennessee.

For those who have been following the positioning, navigation, and timing (PNT) news in recent years, the answer to the GNSS+ puzzle comes as no surprise. GNSS applications have proliferated beyond the professional and commercial realm during the past decade, becoming deeply embedded in a wide range of consumer devices and location-based services (LBS).

With that burgeoning popularity, however, has come a growing recognition of the limitations of this preeminent PNT technology and an increasing concern about threats to the system. So, as the addition of the + indicates, the 2013 program will address the growing emphasis on GNSS and the rapidly evolving field of alternative navigation methods.

Two of the GNSS+ 2013 plenary presentations under the theme, “Confronting Challenges,” explicitly address the need for, respectively, GNSS-integrated or GNSS-alternative PNT solutions: Logan Scott, of LS Consulting, with a presentation entitled, “Defining the Gold Standard for Navigation,” and Nunzio Gambale, CEO of Locata Corporation, speaking on “Establishing a Complementary PNT Capability.”

Moving around indoors or in GNSS signal–challenged environments is one of the most active research areas in navigation today.

In the commercial realm, this motivation underlies Apple’s acquisition of WiFiSLAM earlier this year. Less than two years old, WiFiSLAM — the SLAM stands for simultaneous location and mapping — combines the fingerprint of nearby WiFi networks with compass and accelerometer taken from a mobile device, such as a smartphone. WiFiSLAM software matches

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It’s been an active few months for ION’s international activities that included an African Outreach workshop, the Chinese Satellite Navigation Conference and the International Beacon Satellite Symposium.

In April, ION once again supported a very successful African Outreach program. The purpose of this program is to develop expertise in Africa to utilize GNSS for applications with societal benefits and scientific exploration. Over the last few years, four programs have been held hosting over 300 scientists from numerous African countries for an intensive school on GNSS.

ION members provide the lectures, host laboratories that provide opportunities for hands-on experience and spend time getting to know our African colleagues. This program is designed under a partnership between Boston College and the International Centre for Theoretical Physics in Italy. Much of the success of the program is attributed to the great dedication of ION members participating in the program. Please see the article “Next Stop Rwanda” on page 12 in this newsletter for more information on the most recent workshop and our plans for the future of this very rewarding program.

ION members also participated in the Chinese Satellite Navigation Conference held in Guangzhou, China. Dr. Jade Morton, ION’s Satellite Division Chair, was quite a success as an invited speaker in the plenary session. It was attended by a very large audience of GNSS professionals eager to participate in the development of BeiDou and GNSS applications.

Although I wasn’t there, I’m sure Jade did her best to motivate them. During the conference, the Satellite Division also hosted a panel discussion covering a variety of GNSS and PNT topics. An article on page 17 of this newsletter describes the event in greater detail. Thank you to Dr. Xiancheng (Hunter) Ding and Dr. Jade Morton for organizing the panel and for representing the ION at this conference.

In July, I chaired the 2013 International Beacon Satellite Symposium held in Bath, UK. The symposium is held every two to three years in a different part of the world to discuss science, research, applications and engineering interests in all aspects of satellite signals observed on the ground and in space. The symposium is attended by ionospheric and space scientists from around the world. Topics for presentation include the use of GNSS for studies of space weather, space physics, and space-based applications dependent on GNSS signals.

The symposium is primarily sponsored by the Beacon Satellite Studies group of the International Union of Radio Science (URSI) Commission G. Other sponsors for this most recent event included ION as a technical co-sponsor. I’d like to thank ION for this prestigious support. I’d also like to thank the ION members who participated in the symposium. A special thank you goes to Dr. Cathryn Mitchell of the University of Bath for hosting this very successful meeting in the beautiful setting at the Assembly Rooms at Bath. I felt like we were in a Jane Austen novel...

I would like to remind you that October 15 is the last day to submit Annual Award and Fellow nominations. Please consider submitting nominations for worthy individuals.

ION GNSS+ 2013 is being held September 16-20, 2013 in Nashville, Tennessee. Please join us for a dynamic international technical program and premiere pre-conference tutorials being taught by an elite group of internationally recognized experts. You will also find many related meetings, dynamic workshops and panel discussions, new product introductions and of course the opportunity to network and meet up with colleagues and friends. I look forward to seeing you in September! ♦

Patricia Doherty
And numerous technical sessions will explore related topics, including a two-part set of papers on “Alternatives and Backups to GNSS” and “Multi-Sensor and Integrated Navigation in GNSS-Challenged Environments.” Here, papers will explore such alternative PNT technologies as observed time difference of arrival (OTDOA) positioning for 4G mobile phones, signals of opportunity, vision-based systems, and georeferenced image and map databases.

Other sessions reflecting the GNSS+ theme, include “Indoor Navigation and Timing,” “GNSS-MEMS Integration,” “Advanced Inertial Sensing and Applications,” and “Future PNT and Its Applications.”

On the Monday and Tuesday preceding the conference program, attendees will have their choice of 18 tutorial courses taught by some of the world’s leading GNSS educators. These range from “Fundamentals of GNSS 1” to “Personal Navigation in Difficult Environments.”

Nearly 70 companies and organizations have signed up to exhibit at this year’s conference. This year, the commercial exhibition will be consolidated into two days — Wednesday and Thursday.

Two other speakers are on the plenary session agenda: Junya Nishimoto, Director General, Office of National Space Policy, Cabinet Office, who will discuss “Evolution of Japan’s Space Policy,” and consultant Martin U. Ripple, formerly director of Thales Air Traffic Management in Australia, speaking on “Challenges of Globally Implementing ADS-B.”

Dr. Jade Morton, ION Satellite Division Chair, will serve as ION GNSS+ 2013 General Chair; Mr. Douglas Taggart, CEO of Overlook Systems, is this year’s program chair.
When we hear about navigation methods that use “signals of opportunity,” most people think it refers to manmade signals, typically radio frequency (RF) transmissions such as TV, WiFi, FM radio, and so forth.

But many natural phenomena — such as gravity, lightning, light, X-Ray pulsars, and sound — also emit signals, some of which may be useful for navigation and positioning. (Pulsars are already used as a timing source.) Among the natural signals attracting attention as navigational resources are those generated by magnetic fields.

In a new paper to be presented at a NATO lecture series this fall, John Raquet and colleagues at the Air Force Institute of Technology (AFIT) describe the results of field experiments to demonstrate the potential for magnetic field navigation by any kind of land vehicle.

The research is part of an AFIT effort to define and create “world models” that describe how sensed measurements generated by various types of technologies relate to the real world. In the case of magnetic field navigation, the world model is a map of magnetic field variations generated in advance using a three-axis magnetometer and GPS positioning.

“While using Earth’s magnetic field for navigation is certainly not a new concept, the use of specific magnetic field information mapped to a geographic position is growing in popularity,” the authors write. Among the earlier work in this area, they cite papers presented at past ION events: “Passive Navigation Using Local Magnetic Field Variations,” from the ION International Technical Meeting in 2006 and “Magnetic Field Aided Vehicle Tracking,” from the ION GNSS 2009 conference.

In the AFIT project, a magnetometer is mounted in a convenient location in a vehicle and aligned with the body frame, taking care to avoid large emitters of electromagnetic interference (EMI). The unit is then calibrated in order to mitigate the magnetic field distortion caused by the vehicle, including a profile of the characteristics of the associated measurement noise, which is needed in order to properly use the data later.

A mapping stage follows in which three-axis magnetic field data is collected from the magnetometer as the vehicle is driven over a series of roads or streets. The magnetometer data is gathered at times when the vehicle position is known (e.g., GPS is available) and stored along with the corresponding positions. This creates a “world-model” or map of the 3D magnetic field surrounding the field-test routes.

In the navigation stage, the vehicle is driving over these mapped routes in an effort to determine position using only the measurements from the magnetometer. This is accomplished by taking the raw measurements, applying the previously determined calibration, and then comparing them to the map. The AFIT system employs Gaussian likelihood, which assigns a higher likelihood value to places on the map that closely match the collected measurements.

A key element in the AFIT methodology was its use of a “MagNavigate” particle filter. This technique implements a recursive Bayesian filter using Monte-Carlo methods during which the particle filter attempts to represent a required posterior density function (PDF) using a set of random samples with associated weights. The estimates are then determined from the samples and weights, with each sample considered as an individual state estimate whose importance is represented by the associated weight.

“In terms of magnetic field navigation, the particle filter allows the multiple estimates to represent possible locations in the magnetic field map, and the
incoming measurements help convey the importance a particular estimated location should possess," according to the paper.

The MagNavigate particle filter consists of propagation, a road penalization update, and a measurement update (using either estimated position or direct magnetometer measurements).

**Field Testing**
The AFIT researchers conducted a field test to assess the feasibility of their approach using three different types of vehicles in order to demonstrate portability across vehicles: a 2004 Chevrolet Avalanche truck, a 2003 Pontiac Aztek sports utility vehicle (SUV), and a 2005 Nissan Altima car.

A Honeywell HMR2300 magnetometer was mounted inside the cargo or passenger areas of the vehicles on a level surface and aligned with the body frame as much as possible. Under typical operating conditions, EMI was present from the engine, turn indicators, and other sources. A NovAtel SPAN GPS receiver collected position information for mapping and to serve as a truth reference. (Only the GPS solution from SPAN was used; so, the authors believe that any GPS receiver would have been adequate.)

The AFIT team conducted field tests in three different road environments: a fairly benign environment around the AFIT campus, a suburban neighborhood with a grid of parallel roads, and a large area route. Environments with stretches of highway and roads without significant structures to create magnetic features resulted in less differentiating information that could be used to map and subsequently navigate using only the magnetic field data.

Compared with the GPS “truth” data, the road tests showed that the MagNavigate positions followed the routes fairly closely. However, along-track errors appeared intermittently and could grow in size over periods of tens of seconds before a correct group of particles regained the weight to shift the navigation solution back to where it should be.

Nonetheless, the AFIT researchers concluded that the tests demonstrated the capability for road-level navigation using magnetic field variations in differing environments. They further noted that, because prior mapping might not be possible in certain (e.g., military) applications, the need remained for developing methods in which vehicles that have a good navigation solution can build up a magnetic field map at the same time it is being used by those that do not.


Magnetic field navigation is also one of three prospective methods discussed in a paper that will be presented at ION GNSS+ 2013 in a technical session on “Alternatives and Backups to GNSS,” “Novel Environmental Features for Robust Multisensor Navigation,” by researchers at University College London and Terrafix Ltd.

While using Earth’s magnetic field for navigation is certainly not a new concept, the use of specific magnetic field information mapped to a geographic position is growing in popularity.
the signal strengths and unique identifiers from surrounding WiFi networks against a reference data set for the area either accessed over the Internet or stored on the device.

A two-part session at ION GNSS+ 2013 this year, “Alternatives and Backups to GNSS,” will extend this search for ubiquitous location into many new areas. Among the papers are many that focus on vision-aided approaches.

**Vision-based Real-Time Estimation of Smartphone Heading and Misalignment**

Nowadays nearly all phones are equipped with cameras, which has encouraged research into vision-aided navigation systems that can compensate for the drift experience by inertial sensors (such as accelerometers, gyroscopes and magnetometers). This paper presents a novel method of estimating a device’s absolute heading and the heading misalignment between the device and person using time-synchronized images. The algorithm relies on edge detection and the calculation of vanishing points and lines in successive images. The algorithm is implemented on Android smartphones where the orientation information is provided in real time.

**Nav-by-Search: Exploiting Geo-referenced Image Databases for Absolute Position Updates**

Recent work in the field of vision-aided navigation has demonstrated that by recognizing previously visited or mapped places, the navigation solution can be updated, eliminating drift. However, place recognition presents a number of challenges: repetitive appearance, different scales, different viewpoints, different illumination conditions, the presence of moving objects, and the heavy computation load associated with such techniques. According to the authors, the paper presents an appearance-based place recognition algorithm that addresses these challenges, thus providing absolute position updates enabling GPS-like, drift-free navigation and the ability to construct compact maps for place recognition from various external databases.

**Stereo-Vision Aided GNSS for Automotive Navigation in Challenging Environments**

The approach proposed in this paper focuses on the design and accuracy constraints of multi-camera (i.e., stereo) vision-aided GNSS-based automotive navigation and combines the advantages of both systems to provide a robust positioning solution with increased availability. While using a GNSS-based solution for position estimation and simultaneous vision system calibration in open-sky environments, the vision system can assist with position estimation in urban areas and be the primary system in underground environments.

**Chameleon v2: Improved Imaging-Inertial Indoor Navigation**

This paper describes the current generation of a SLAM-based system consisting of visual stereoscopic imaging sensors, which are collocated with an inertial measurement unit (IMU). By using stereoscopic cameras to create images of visited locations, 3D point cloud models can be created. Projecting these point clouds onto the horizontal plane provides overview maps. The authors also discuss sensor fusion algorithms for integrating foot-mounted IMUs with imaging sensors. Results show that sensor fusion improves the navigation solution considerably in scenarios where either the foot-mounted or the camera-based system is unable to navigate on its own.

**Integrating Vision Derived Bearing Measurements with Differential GPS and UWB Ranges for Vehicle-to-Vehicle Relative Navigation**

In this paper, a peer-to-peer network using both differential GNSS and direct pseudoranging is combined with bearing measurements from multiple cameras and ultrawideband ranging among the vehicles.

**Integration of Vision and Navigation**

This paper presents a unified theory for merging GNSS and IMU data based upon development of evolving attitude (pose) by defining a transition matrix between observations related to pose. It describes how overlapped image sequences can be cast into a stochastic Markov representation that merges all 3D information from camera sensors. A sequence of image frames forms a Markov process for evolving pose that is merged with traditional IMU and GPS stochastic models. ◆
A n old Zen koan asks about the sound of one hand clapping.

Swiss researchers at École Polytechnique Fédérale de Lausanne (EPFL) recently asked — and answered — a less mystical but only slightly less difficult version of that question.

"Imagine that you are blindfolded inside an unknown room. You snap your fingers and listen to the room’s response. Can you hear the shape of the room?"

With that introduction to their paper published in a recent issue of the Proceedings of the National Academy of Sciences, a team of EPFL authors headed by Ivan Dokmanic propose one of the more novel possibilities of human indoor navigation: echo-based location.

As the authors point out, some animals — most famously bats and dolphins, but also certain species of birds — probe the environment by emitting sounds and then using the echoes to navigate.

In attempting to replicate this feat, the paper shows how the EPFL team computed the shape of a convex polyhedral room based on its response to a known sound as recorded by a few microphones. Geometric relationships between the arrival times of echoes enabled the researchers to estimate the room geometry by exploiting the properties of Euclidean distance matrices.

Their echo-sorting algorithm starts from the recorded impulse responses and proceeds by learning the correct assignment of echoes to walls. “In contrast to earlier methods, the proposed algorithm reconstructs the full 3D geometry of the room from a single sound emission, and with an arbitrary geometry of the microphone array,” the authors state.

The researchers validated their concept experimentally employing a loudspeaker and four microphones in acoustic facilities at the EPFL campus and later in a portal of the Lausanne cathedral. A minimum of four microphones is needed to achieve three-dimensional shapes, but they used five in the cathedral.

Using the early (first order) reflections in the room impulse response (RIR), their algorithm distinguishes between early and later echoes to select “correct” combinations of echoes that correspond to the walls. In the cathedral, the loudspeaker emitted chirps that swept from 200 hertz to 10 kilohertz. The EPFL researchers recorded the resulting reflections and analyzed them to trace the cathedral’s 3D shape and the location of the sound source.

Although the primary applications of their technique that occurred to the researchers included virtual reality, auralization, architectural acoustics, and audio forensics, they suggested that their solution could be useful beyond simply “hearing” and mapping rooms.

“As an extension of our method,” they wrote, “a person walking around the room and talking into a cellphone could enable us to both hear the room and find the person’s location.”

Dokmanic, recently seconded to Microsoft Research in Redmond, Washington, says the indoor localization application could be ready within a year’s time. ♦
The world’s GNSS programs have entered a troubled period with GPS money worries, a launch failure and political wrangling afflicting GLONASS, and delays in getting the first full operational capability (FOC) Galileo satellites into space.

The BeiDou program is taking a break from launches following declaration of regional operational capability and release of an interface control document last December. Meanwhile, the Indian Regional Navigation Satellite System (IRNSS) has completed navigation and ranging payload in orbit tests with operations reported as normal.

**GPS**

The fourth GPS Block IIF satellite, space vehicle number (SVN) 66, was launched successfully on May 15 on board a United Launch Alliance Atlas V rocket, the first time that an Atlas V had been used to launch a GPS spacecraft. The new satellite built by Boeing will transmit with the pseudorandom noise code (PRN) 27 designation. With the fifth Block IIF expected to launch in October, the next-generation GPS satellite program continues on track, despite uncertainties about funding.

Lockheed Martin delivered a full-sized, functional prototype of the GPS Block III satellite — Non-Flight Satellite Testbed (GNST) — to Cape Canaveral Air Force Station on July 19. The GNST will be used to test launch facilities and pre-launch processes in advance of the arrival of the actual GPS III flight satellites, which will undergo similar testing. The first flight-ready GPS III satellite is expected to arrive at Cape Canaveral late in 2014 for launch the following year.

The GNST was developed and then completed a series of high-fidelity activities to “pathfind” the integration, test, and environmental checkout that all production GPS III satellites undergo at Lockheed Martin’s new satellite manufacturing facility.

On July 19, the U.S. House of Representatives approved a Fiscal Year 2014 (FY14) defense appropriations bill that reflects cutbacks in several areas of the GPS program. These include a $44 million reduction from President Obama’s requested budget in allocations for GPS III Space Segment Advance Procurement for the ninth and later space vehicles (SVs) and another $15 million for GPS III development as “ahead of need.”

Another $18 million in requested Next Generation Operational Control System (OCX) financing was cut due to what the House report called “Excessive growth in FFRDC [Federally Funded Research & Development Center] support” and $10 million from the Military GPS User Equipment (MGUE) line item due to “excessive growth in management services.”

Finally, the House appropriations measure also proposes to cut all funding ($20 million requested) for civil GPS requirements and reduce Wide Area Augmentation System (WAAS) support by $29 million below the president’s proposed budget.

The cuts came on top of what was already a lean White House spending proposal for civil GPS. Previous requests for civil funding had been in the range of $40 million to $50 million per year.

The civil community is supposed to contribute a total of $235.5 million to the GPS program to help pay for civil signals and, in particular, civil signal monitoring. Civil funding had sustained substantial cuts in each of the previous three years and more money, not less, was needed to get modernization programs back on track.

At the GPS Directorate, Col. Bernie Gruber turned over responsibilities for the directorate to its new chief, Col. William Cooley, in a change-of-leadership ceremony on June 13. Cooley is scheduled to take part in a GNSS Program Updates panel discussion at ION GNSS+ 2013 on September 18.

**GLONASS**

Loss of three GLONASS-M satellites in a failed July 2 launch attempt undermined Russia’s plans for building out its constellation.

A Russian Space Agency investigation into the accident attributed the failure to incorrect installation of angular velocity sensors caused the crash of the Proton rocket carrying
the satellites from the Baikonur space center in Kazakhstan. The combined cost of the lost rocket and satellites is 4.4 billion rubles ($136 million), according to Russian government sources.

It was the second loss of a GLONASS-M trio in the past three years. A December 5, 2010, failure led to the dismissal of two high-ranking space officials and the subsequent resignation of the head of the Russian Space Agency.

Russia reportedly will launch two GLONASS-M satellites this summer to help make up for the loss. The Russian news agency RIA Novosti quoted Nikolay Testoyedov, general designer and director general of Joint Stock Company “Information Satellite Systems – Reshetnev Company” (JSC “ISS”), that the launches would take place from the Plesetsk space center north of Moscow using Soyuz rockets. The first would come at the beginning of September and the second at the end of October.

JSC “ISS,” based in Zheleznogorsk, Krasnoyarsk region of Russia, manufactures both the current generation (GLONASS-M) and next-generation (GLONASS-K1) satellites. A full constellation of 24 satellites is currently operating.

Meanwhile, the System of Differential Correction and Monitoring (SDCM), Russia’s satellite-based augmentation system (SBAS) has passed its preliminary design review, with the Russian government confirming a system deployment plan that should lead to an operational service covering Russia by 2018.

**BeiDou**

China’s GNSS program has entered a quiet period with a cessation of additional launches, as previously announced, during which its managers and engineers are analyzing performance of the current space and ground segments.

China currently has 14 operational satellites in a regional system whose footprint stretches from 55° to 180° East and delivers 10-meter real-time positioning accuracy and one-way 55-nanosecond timing accuracy, according to Ran Chengqi, director of the China Satellite Navigation Office (CSNO).

Due to the larger number of satellites in the Asia/Pacific area, BeiDou signal availability will improve and accuracy should also be better when compared with global performance. “We expect a 5 to 10 percent improvement in BDS positioning accuracy in Asia/Pacific area compared with the rest of the world,” says Jingnan Liu, head of the National Engineering Research Center for Satellite Positioning System based at Wuhan University’s GNSS Research Center.

Another major advantage for the Asia/Pacific area is that SBAS service can be acquired from the current BeiDou geosynchronous satellites, which means sub-meter and meter level positioning accuracy for dual-frequency and single-frequency receivers, respectively. “Once full global service is available, the GEO satellites will undoubtedly be maintained as the components of BDS’s SBAS,” Liu says.

Five test satellites reportedly will be launched beginning in 2014 to help BeiDou system engineers evaluate the third-phase technologies, including new Chinese-built atomic clocks and new signal designs and frequency.

Qiangwen Yang, a senior engineer at the CSNO, told attendees at the fourth China Satellite Navigation Conference (CSNC 2013) held in Wuhan during May, “Industries related to the BeiDou system are entering a booming development stage.”

Yang’s statement was borne out by the 109 companies and organizations taking part in the CSNC 2013 commercial exhibit.

By 2015 China is expected to invest 7 billion yuan (US$1.13 billion) to support the development of related industries, according to the CSNO, on top of 3.5 billion yuan already invested to date.

**Galileo**

The first Galileo full operational capability (FOC) satellite arrived May 15 at ESA’s European Space Technology Center (ESA/ESTEC) in Noordwijk, The Netherlands to begin a rigorous set of tests to check its readiness for launch.

The tests simulate various aspects of the launch and space environments and will validate the new design of the other 21 FOC satellites ordered thus far by ESA. The second FOC spacecraft is expected to arrive at Noordwijk in August. However, first launch date for the new satellites has been delayed until December 28 at the earliest.

Originally, two dual-satellite launches had been planned for this year.

The satellite’s prime contractor is OHB in Bremen, Germany and the navigation payload was produced by Surrey Satellite Technology Ltd in Guildford, UK.

Thermal vacuum testing simulates the temperature extremes the satellites must endure in the vacuum of space throughout their 12-year working lifetimes. Without any moderating atmosphere, temperatures can shift hundreds of degrees from sunlight to shadow.

Other activities on the schedule include shaker and acoustic noise testing — simulating the vibration and noise of launch — as well as electromagnetic compatibility and antenna testing, placing the satellite in chambers shielded from all external radio signals to reproduce space and check that the SV’s various antennas and electrical systems are interoperable and without harmful interference.

**Regional and Space-Based Augmentation Systems**

India’s Space Research Organization (ISRO) has successfully launched its first Indian Regional Navigation Satellite System satellite (IRNSS-1A) into geosynchronous orbit and all subsystems are operating normally.
The spacecraft was launched July 1 on board of a Polar Satellite Launch Vehicle, PSLV-C22, from Satish Dhawan Space Centre, Sriharikota. On July 31, ISRO announced successful completion of tests of the satellite’s navigation and ranging payload with normal operations now under way.

With a mission design life of ten years, IRNSS-1A is the first of the seven satellites that will comprise the IRNSS space segment of the Indian Regional Navigation Satellite System designed to provide positioning for India region and 1,500 kilometers (930 miles) around the Indian mainland. It will operate at 55 degrees east longitude with an inclination of 29 degrees with respect to the equator.

IRNSS will provide two types of navigation services, namely, a standard positioning service (SPS) available to all users and encrypted, restricted services (RS) provided only to authorized users. This payload will operate in the aeronautical radiodetermination L5 band (1176.45 MHz) and S-band (2492.028 MHz).

In June, the European GNSS Agency (GSA) announced award of an eight-year, 450 million (US$585.4 million) European Geostationary Navigation Overlay Service (EGNOS) Service Provision (ESP) contract to ESSP, the European Satellite Services Provider. EGNOS is a space-based augmentation system (SBAS) designed to augment the GPS L1 signal by broadcasting signals from geostationary satellites to provide differential correction messages and integrity data.

EGNOS-enabled procedures are already in use in France, the United Kingdom, Italy, and Germany. The EGNOS service area includes all European nations and has the capability to be extended to other regions, such as EU neighboring countries and North Africa.

Also in June, more than 30 specialists representing the world’s five satellite navigation augmentation systems gathered in St. Petersburg, Russia during June, working on interoperable standards basis that would allow end users to pass seamlessly between SBASs.

The SBAS Interoperability Working Group was hosted 25–27 June in St Petersburg by Russia’s Roscosmos space agency and the Russian Academy of Sciences. Among the most important achievements of the meeting was agreeing a common SBAS message based on dual-frequency multiconstellation (DFMC) signals from up to four constellations – GPS, Galileo, Compass and Glonass – for the post-2020 era.◆
Costa Concordia Disaster Prompts Action on Maritime Safety

The 92nd session of the International Maritime Organization Maritime Safety Committee (IMO MSC92) met from June 12 to 21 at IMO headquarters in London, England. Peter Chapman-Andrews, the International Association of Institutes of Navigation (IAIN) representative at IMO, provided the following report based on a meeting synopsis by Kim Fisher, secretary of the International Electrotechnical Commission Technical Committee 80 (maritime navigation and radiocommunication equipment and systems).

The topic of the review and reform of the organization was a major issue for the meeting. The secretariat had produced detailed terms of reference for the new sub-committees, which had been discussed at the Marine Environment Protection Committee (MEPC) meeting in May. A Working Group studied these and the meeting generally agreed with the proposals.

The meeting confirmed a merger of NAV and COMSAR panels to be called the Subcommittee on Navigation, Communications, and Search and Rescue (NCSR). It will meet in the early months of the year except next year when it will meet nine months after the last NAV meeting (around June 2014). NCSR will be allowed to retain two intersessional working groups that involve other UN organizations – the International Civil Aviation Organization/IMO Joint Working Group on Search and Rescue (ICAO/IMO JWG on SAR) and the IMO/International Telecommunication Union Joint Experts Group. The proposals for the restructuring now go the IMO Council meeting in July and the IMO Assembly in November.

Passenger ship safety was again an important issue for the meeting. The report into the loss of the Costa Concordia had been published shortly before the meeting and a number of recommendations were available for consideration. The Costa Concordia ran aground at Isola del Giglio, Tuscany, Italy on January 13, 2012, with the loss of 32 lives. The meeting decided that issues of bridge management and safe manning were already adequately covered in IMO instruments.

A circular on enhancing the safety of passenger ships was further developed and a recommendation added that companies are encouraged to investigate means of providing rolling motion to the vessel data recorder. The action plan for long-term work on passenger ship safety was further developed. Work will continue in the Stability and Load Lines and on Fishing Vessels’ Safety (SLF) Subcommittee to review the subdivision and damage stability regulations in the International Convention for the Safety of Life at Sea (SOLAS) chapter II-1 on Construction - Subdivision and stability, machinery, and electrical installations.

Changes were agreed to SOLAS Chapter V on safety of navigation to make the installation of the Bridge Navigational Watch Alarm System (BNWAS) a requirement for ships built before 2002. A request from the Marshall Islands for further clarification on the use of the automatic mode of operation of the BNWAS was referred to the NAV subcommittee. The performance standards for electronic inclinometers developed by the NAV subcommittee were adopted following a review by the SLF subcommittee, which had removed the need for an alarm function concerning parametric roll and synchronous rolling detection.

The circular developed by the COMSAR subcommittee regarding guidance on the validity of radiocommunication equipment installed on ships was approved, including amendments from Japan that make the necessity to update radio equipment an administration decision. The circular developed by the NAV sub-committee on information on the display of automatic identification system–search and rescue transponder (AIS-SART), man overboard, and similar devices was also approved. A new work item was agreed for interconnection of NAVTEX and SafetyNET receivers on integrated navigation display systems.

The United States requested the initiation of the process for recognition of the Iridium satellite system. The proposal was referred to the new NCSR subcommittee for evaluation.

The next MSC meeting is planned for May 14–23, 2014. ♦

Damage to the hull of the Costa Concordia is visible after it hit a reef off the coast of Italy last year and capsized.
The Institute of Navigation once again served as a prime sponsor for the fourth workshop on Satellite Navigation Science and Technology for Africa.

Designed and directed by Patricia Doherty, ION president and director of the Institute for Scientific Research (ISR) at Boston College, and Sandro Radicella, head of the Radiopropagation Laboratory at the Abdus Salam International Centre for Theoretical Physics (ICTP), the workshop focused on educating African university professors and graduate students on the use of GNSS applications with societal benefits and scientific exploration.

The workshop was held on May 6–17, 2013, at the ICTP, an international organization located in Trieste, Italy. ICTP is sponsored by two United Nations agencies, the UN Educational, Scientific and Cultural Organizations (UNESCO) and the International Atomic Energy Agency (IAEA). ICTP’s mission is to foster advanced studies and research, especially in developing countries. Thus it is a logical choice for the location of this workshop.

This most recent event differed slightly from earlier GNSS workshops as participants from other developing nations joined our African colleagues. Broadening workshop participation proved quite beneficial because interest in GNSS around the world is increasing rapidly.

This expanded workshop drew nearly 200 applicants from which 70 were selected to represent GNSS interests in more than 26 countries, including Cote d’Ivoire, Egypt, Ethiopia, Kenya, Nigeria, Rwanda, Uganda, Argentina, Bolivia, Brazil, Colombia, Peru, Indonesia, Malaysia, Nepal, India, Philippines, People’s Republic of China (PRC), Croatia, Kazakhstan, the Russian Federation, and the Ukraine.

The lecturers included GNSS experts from the United States, Europe, and India. ION members supporting the workshop included Chris Hegarty, John Raquet, Frank van Graas, Todd Walter, Anthea Coster, Endawoke Yizen-gaw, Susan Delay, Charles Rino, and Patricia Doherty. The workshop integrated formal lectures with hands-on practice in a laboratory setting.

Extensive Program of Lectures, Labs

The first week of lectures focused on GNSS fundamentals and aviation applications. Chris Hegarty captured the audience’s interest with opening lectures in “GPS Fundamentals, Measurements and Error Sources,” “Modernized GPS,” other emerging GNSS systems, including Galileo, GLONASS, Beidou, the Indian Regional Navigational Satellite System (IRNSS) and Japan’s Quasi-Zenith Satellite System (QZSS).

John Raquet followed with lectures and compelling laboratories on the “Navigation Solutions” and “Kalman Filtering.” The participants were amused when one of his presentations was interrupted by a Skype call from home, during which class members got to talk with his family.

Frank van Graas joined our workshop this time and collaborated with Raquet for a session on “Differential GPS” and an associated laboratory demo. Frank continued with presentations on “Inertial Navigation Systems” and demos on “Kalman Filtering” and “Inertial Navigation.”

Todd Walter rounded out the first week of lectures with his engaging lectures on “GNSS
and Aviation Applications.” Many of the countries in the developing world are beginning to research and appreciate the benefits of GNSS for aviation. His lectures provided participants with a great overview of the benefits and caution required for successful ground-and space-based augmentation systems.

The second week of the workshop was dedicated to scientific exploration using GNSS with a particular focus on ionospheric characteristics and effects on GNSS systems and space weather studies. Lectures on the ionosphere-related issues were presented by Patricia Doherty, Sandro Radicella, and Paluri Rama Rao from India’s Andhra University, Department of Physics.

These were followed by presentations on “Space Weather,” by Anthea Coster, MIT Haystack Observatory, and Endawoke Vizen-gaw, Boston College, who further motivated participants with laboratories that introduced the participants to datasets and a general “how to” perform space weather research using GNSS. Ionospheric scintillation was introduced by Charles Rino, Boston College, in a comprehensive and logical approach. (Readers with any scintillation experience know that this must have been a difficult task.)

Patricia Doherty provided a glimpse of the capabilities of a multi-instrument network to perform regional and global ionospheric studies by introducing the LISN (Low-latitude Ionospheric Sensor Network) and SCINDA (Scintillation Network Decision Aid) networks. Dieter Bilitza, George Mason University Space Weather Lab, addressed the subject of “The International Reference Ionosphere.”

These lectures were complemented with lectures and laboratories conducted by European colleagues: Bertram Arbesser-Rastburg, European Space Agency/ESTEC; Roberto Prieto-Cerdeira, ESA/ESTEC; Bruno Nava, ICTP; Luigi Ciraolo, ICTP; Luca Spogli, Katy Alazo, ICTP; Gabriella Povero, Istituto Superiore Mario Boella Navigation Laboratory, Turin, Italy; and Sergey Pulinets, Space Research Institute, Moscow, Russia. Although the lectures are the main focus of the workshop, among the highlights for the participants and lecturers are the hands-on laboratories that give them an opportunity to try out what they have learned. During this workshop, the participants had an opportunity to try geocaching using single-frequency GPS receivers in a treasure hunt that brought them to the Miramare Castle garden.

They also participated in a lab project in which they were assembled in teams that had the task of analyzing the effects of a solar storm on ionospheric behavior. The teams worked on the project at defined times over the course of several days. On the last day of the workshop, the teams presented the results of their remarkable research with each team taking a different approach and finding the correct results. All the lecturers agreed that the teams all deserved an A+!

Benefits for Science and Developing Nations
One of the benefits of ION’s sponsorship of the ICTP program is that our engineers and scientists have opportunities to discuss common interests with their counterparts from developing countries. From a scientific perspective, a number of research programs use GNSS ground and space-based measurements to observe ionospheric and space weather phenomenon.

Africa and South America’s proximity to the magnetic equator make the regions of great interest to space weather scientists. Unfortunately, studies over these regions have not been possible due to the lack of dependable, long-term measurements. The ICTP GNSS workshops provide opportunities to establish a base of measurements for joint studies with colleagues from the low-latitude regions as well as help develop the infrastructure and sustainability of GNSS applications there.

Overall the workshop seemed to be a great success, according to Patricia Doherty, who said the lecturers regarded it as a most enriching teaching experience. Participants said that they learned a lot and were very appreciative of the opportunity to partake in this program and to get to know some of the GNSS professionals from North America and Europe. At the completion of the workshop, participants were given textbooks on GNSS and Space Weather. They were also awarded with Certificates of Completion and received gifts of ICTP t-shirts and Boston College baseball caps which they wore proudly!

In response to the success of these workshops and the great encouragement and appreciation of the African communities, ICTP and ION plan to continue this program with a workshop in July 2014 in Kigali, Rwanda. Bringing this program to Africa will further encourage accessibility to GNSS training and infrastructure for more participants in Africa. Hosting a workshop in Africa also brings awareness of the capabilities and importance of GNSS to local governments. Details for the upcoming workshop will be available soon.

The Institute of Navigation sponsorship of the outreach workshops and the participation of its members are sincerely appreciated. It enables the participation of some of the Institute’s dynamic and experienced ION members to lecture at the workshops.

The continued support of the ICTP, Boston College, the European Space Agency, the Federal Aviation Administration, the European Air Force Office of Scientific Research and the United Nations Office for Outer Space Affairs is also deeply appreciated. These sponsors together with the lecturers and participants represent a diverse collection of people who are committed to provide GNSS technology for socio-economic benefits and scientific exploration in Africa and other parts of the developing world. ◆
This is the second of a series of three articles about the 16th century Portuguese explorer Captain General Ferdinand Magellan. In the first article, the circumstances leading up to Magellan’s historic circumnavigating expedition were discussed. This second article covers his voyage from 1519 to 1521.

By 1515 Ferdinand Magellan was a 20-year veteran of the flourishing Portuguese maritime industry. He had served — and been permanently injured — on several dangerous military expeditions to Morocco, India and Malaysia, and he wanted recognition and a pension from the king. He also sought financing for an expedition to the Spice Islands west of New Guinea in the Indonesian archipelago.

Portugal’s King Manuel and his counselors scornfully denied Magellan’s petitions. Manuel said he couldn’t care less where the navigator went or what he did. Disgruntled and determined, Magellan switched allegiance to his country’s archrival Spain and its teenage king, Charles I, grandson of Columbus’ sponsors Ferdinand and Isabella.

When Magellan arrived in Seville in 1517 to propose a westward expedition to the Spice Islands, Spanish authorities already knew that he was “very knowledgeable in matters concerning navigation.”

The Spanish wanted a westward route to the Orient, since all possible stopovers on the long eastern route were controlled by Portugal. At the age of 42 in an era when 50 was considered old, Magellan thought leading such an expedition might earn him the honors and wealth that had been denied to him at home.

Magellan believed the Moluccas to be closer to the Americas than they actually were and that they fell within the Spanish hemisphere of influence as declared in the Treaty of Tordesillas. The treaty, named after the Spanish city where it was signed in 1494, set the line of demarcation at 370 leagues — 1110 nautical miles — west of Cape Verde.

The treaty stipulated that Portugal would have precedence for new discoveries over all new lands discovered in the hemisphere east of 47 degrees west longitude up to the antemeridian at 133 degrees east longitude, and Spain would have precedence for the other hemisphere.

Portugal’s colonization of eastern Brazil, India and Macau were consequences of this treaty.

However, the line of demarcation was disputed because the definitions of a league and the determination of longitude were uncertain at the time. This was due in part because the once-authoritative Ptolemaic estimate of
the Earth’s circumference was incorrect — 18,000 statute miles as opposed to what is actually around 25,000 statute miles.

Magellan tried to convince potential Spanish sponsors that he could reach the Moluccas by sailing west and demonstrate that these valuable islands belonged to Spain. But to establish their precise location, a reasonable estimate of their longitude was essential, a definitive solution of which was still a couple of centuries away.

The Voyage Begins
In March 1518, King Charles made Magellan and his friend, noted navigator Rodrigo Faleiro, joint commanders of a five-ship expedition called the Moluccan Fleet.

By April 1519, the ships had been reconditioned, armed, and outfitted for a long sea voyage.

While Magellan managed the fleet preparation, the scholarly but eccentric Faleiro oversaw the preparation of charts, globes, and navigational tables, and the procurement of compasses, astrolabes, and speed logs.

Faleiro prepared a 30-chapter manual of astronomical tables, diagrams, and instructions for three methods of estimating longitude.

Faleiro’s own method depended on changes in compass variation observed as ships traveled east or west. He had charted these as a system of isogonal lines, lines of constant magnetic variation, but only for the North Atlantic. He hoped that the use of magnetic compasses with speed logs might help to determine longitude. Unfortunately, magnetic variations beyond the North Atlantic were unknown, making this technique nearly useless.

The other two methods in Faleiro’s manual measure lunar distances, the angular distance between the moon and a celestial body, to estimate astronomical time. This was the critical unknown for celestial navigation prior to chronometers and was based on previously compiled ephemerides of lunar motion.

On September 21, 1519 the five ships with a 260- to 270-man crew, set off from St. Lucar, Spain.

The group had divided loyalties. The Spanish backers, including the agency in charge of exploration, didn’t trust the Portuguese Magellan. Meanwhile, agents of the Portuguese crown tried to wreck the expedition. The crew was predominantly Spanish and Portuguese. They didn’t get along and that got worse at sea. Meanwhile, Magellan’s co-leader and ally, Faleiro, couldn’t sail because of mental problems.

Magellan’s course westward across the Atlantic was planned to avoid Portuguese interference. They sailed south of the Canary and Cape Verde Islands towards the east coast of Brazil.

After four stormy months, they arrived at the spectacular harbor of Rio de Janeiro, known to Portuguese navigators since 1502.

The respite in Rio was the highlight of the expedition for the crew. The indigenous Guarani people were friendly and helped resupply the ships with food and water as well as female company.

The Spanish king had charged Magellan to find a passage across the South American mainland, and the expedition continued southwest along the east coast of South America desperately searching for fresh water and a winter haven stopover. One of the ships went aground.

Battered by storms and groundings along the cold and barren Patagonian coast, they finally anchored at St. Julian at South latitude of about 49.3 degrees, even further south than Africa’s Cape of Good Hope.

At the start of the voyage, and disheartened at the prospect of overwintering — were conspiring to mutiny and remove Magellan from command.

The conspirators had the advantage of firepower and ships, but on Easter 1520 Magellan employed quick, calculated, and ruthless tactics to subdue them. He executed one captain and left another on shore.

Another ship deserted. Over the next six months, the remaining three painstakingly probed the rivers and inlets of the southeastern coast of South America for the coveted passage westward across the tip of South America towards Asia.

Finally, in late October 1520, the carrack Victoria successfully crossed the complex, treacherous, 310 nautical mile long straits that lead from the Atlantic to Pacific Oceans.

Magellan named the westernmost point Cape Desire in joy at finally reaching it.

Antonio de Pigafetta, the Italian chronicler of the expedition, originally called it the Victorian Strait after the first ship that went through, but within a decade the passage widely known as the Estrecho de Magellan or Straits of Magellan.

When Magellan reached the vast “Sea of the South,” he called it Pacific because the expedition’s voyage was so calm at the time. And that misapplied name stuck.

Proceeding successively northwest by west, west-northwest, west by north, and northwest, the expedition reached the vast “Sea of the South,” he called it Pacific because the expedition’s voyage was so calm at the time. And that misapplied name stuck.

Proceeding successively northwest by west, west-northwest, west by north, and northwest,
The small fleet of three ships crossed the Equator on February 13, 1521 at about 160 degrees west longitude.

During this 8,000 nautical mile voyage from the Straits of Magellan through the South Pacific, hunger and scurvy ravaged the remnants of the crew.

Pigafetta, one of only 18 men to finally complete the 1,081-day voyage home, wrote, “We ate biscuit that was no longer biscuit, but powder of biscuits swarming with worms… it stank of rats’ urine. We drank yellow water that had been putrid for many days. Rats were being caught and sold for food.”

In early March 1521 they were saved by exchanging iron for fresh water, fruit, and fish with the Chamorro people of Guam.

**A Fatal Alliance**

A few weeks later they anchored on the small island of Suluan-Homonhon in the Gulf of Leyte, about 400 nautical miles southeast of Manila in the Philippines.

Magellan’s chief pilot, Andrés de San Martín, was a skilled astrologer with a knowledge of astronomical measurements applied to celestial navigation. According to many sources, he brought his instruments ashore and used Faleiro’s lunar distance methods to calculate their longitude. His calculation, accurate to better than two degrees, indicated that Magellan’s expedition had now crossed the antemeridian into Portuguese territory. San Martín’s calculations were not matched for 200 years.

Magellan now suspected that his commitment to King Charles of Spain to show that the Moluccas were situated in Spanish territory could not be fulfilled. But all was not lost. Legal interpretations of the treaty stated that unclaimed territory, discovered, and occupied in the hemisphere assigned to the other country, would be considered within the dominion of the occupying power if trading posts had been established and agreements made with the native population.

So, Magellan set out to do just that. With, literally, a missionary zeal, he made an alliance with one Muslim rajah and converted him to Christianity. This ally persuaded him to approach a rival, Chief Lapu-lapu. Magellan’s heavy-handed tactics, which had served him well up till then, led him to underestimate the danger of this course of action. Magellan and eight of his crew died on April 27, 1521 during the Battle of Mactan with Lapu-lapu’s large army.

The chronicler Pigafetta survived the battle and wrote, “[T]he captain [fell] face downward, when immediately [the enemy soldiers] rushed upon him with iron and bamboo spears and with their cutlasses, until they killed our mirror, our light, our comfort, and our true guide. When they wounded him, he turned back many times to see whether we were all in the boats. Thereupon, beholding him dead, we, wounded, retreated, as best we could, to the boats, which were already pulling off. . . .”

If Magellan had dreamed of circumnavigating the planet, no mention was made of it in the plans he submitted to King Charles, nor is there any evidence that he divulged any such plans to his captains and pilots of his fleet.

At the time of his death, none of the economic and political objectives at the heart of his expedition had been fully realized.

It would be 517 days later that the remnants of his crew aboard the lone ship Victoria, commanded by a mutineer that Ferdinand Magellan had grudgingly pardoned, circled the world.

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**Note:** Much of the information in these first two articles was drawn from Tim Joyner’s book, *Magellan, International Marine*, McGraw-Hill, 1992. The third part will recount the history of the completion of the Moluccan Expedition as well as the legacy of Ferdinand Magellan.

**Marvin B. May** is the Chief Scientist of Pennsylvania State University’s Navigation R&D Center in Warminster. He may be reached at mbm16@arl.psu.edu.

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**Historian column continued from page 15**

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**Armillary sphere Tratado del esphera y del arte del marear, Seville, 1535.** From one of the earliest books on seamanship by Portuguese cosmographer and pilot Francisco Faleiro, who worked for Spain. He was the brother of Ruy Faleiro. (Brown University).

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Dr. Jade Morton, ION Satellite Division Chair, presented an invited keynote address at the fourth China Satellite Navigation Conference (CSNC 2013) and coordinated a half-day special ION session at the event held May 15–17 in Wuhan, China.

More than 2,700 people attended the conference, which represents the leading GNSS gathering in China and is supported by a long list of Chinese governmental agencies, academia, and research organizations.

The first day of the conference featured an elaborate opening ceremony presided over by conference chairman Academician Sun Jiadong, chief designer of the BeiDou system. Attendees had their choice of 627 technical papers spread across a broad array of topics under the conference theme: “BeiDou Application — Opportunities and Challenges.”

The opening plenary was followed by “System and Service Provision Updates” from satellite navigation providers and invited keynote presentations. Representing the United States, David Turner, deputy director of the Office of Space and Advanced Technology, Department of State, discussed “U.S. GPS Policy, Program, and International Update.”

Dr. Morton addressed the subject, “Ionosphere and Space Weather Effects on GNSS: from Nuisance to Signals of Opportunity.”

The conference offered nine parallel sessions covering the following topics:
1. BeiDou/GNSS Navigation Applications
2. Satellite Navigation Signals and Systems Compatibility and Interoperability
3. Precise Orbit Determination and Positioning
4. Atomic Clock Technique and Time-Frequency Systems
5. Satellite Navigation Augmentation and Integrity Monitoring
6. BeiDou/GNSS Test and Evaluation Technologies
7. BeiDou/GNSS User Terminal Technologies
8. Satellite Navigation Models and Methods
9. Integrated Navigation and New Methods

The Institute of Navigation hosted its panel on the morning of May 17, with presentations by eight members covering important current topics in GNSS and PNT. The session was chaired by Dr. Morton and Dr. Xiancheng (Hunter) Ding, ION’s BeiDou advisor who is also a senior advisor for the Chinese BeiDou Management Office.

The presentations, available for download at ION website: http://www.ion.org/news/csnc-presentations.cfm, included the following:
1. The Institute of Navigation and Panel Introduction, Dr. Jade Morton, Miami University
2. First Experiences of Using BeiDou in a Multi-System GNSS Receiver for Precision Applications, Stuart Riley, Trimble Navigation
3. BeiDou in A-GNSS Consumer Products Worldwide, Dr. Frank van Diggelen and Kathy Tan, Broadcom
4. GNSS in High Precision Agriculture, Dr. Liwen Dai, John Deere
5. GNSS Overview, Dr. Christopher Hegarty, The MITRE Corporation (on behalf of FAA)
6. GNSS in Remote Sensing and Earth Science, Dr. James Garrison, Purdue University
7. Chip Scale Atomic Clock and GNSS Systems, Steve Fossi, Symmetricom

The conference also hosted two well-attended full-day events: Application and Industrialization Forum, and a special track on Policy and Regulations, Standards and Intellectual Property.

ION panel members Dr. Frank van Diggelen and Dr. Christopher Hegarty, along with Professor Naser El-Sheimy of the University of Calgary, Greg Turetzky of Intel Corporation, and Professor Sang Jeong Lee from Chungnam National University of South Korea also contributed to a special International Expert Panel organized by Dr. Jinling Wang, University of New South Wales, Sydney, Australia.

Forty students and young researchers received awards for their conference papers. ♦
DEFENSE MATTERS

WHAT IS THE GOAL?

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

I am a planner. I take pleasure in creating a plan, and I gain satisfaction in seeing a plan come together to achieve a defined goal. Although I don’t consider myself to be obsessed with the need to plan, I will admit that I am quick to offer one if I perceive a lack of clarity or forethought in an ongoing effort to accomplish something.

Countless books and articles have been written about the relationship between setting goals and establishing plans. In planning this article I did a quick “Google” search using an entry of “goals and plans,” and it yielded 184 million hits. For reasons I attribute simply to idle curiosity, I reversed the phrase to “plans and goals,” and that search yielded 187 million results — 3 million more! Maybe the 3 million additional hits are dedicated to cautioning all would be planners that it is best to first define the goal before starting the planning phase.

I didn’t check to see whether the additional 3 million Internet hits are in support of that theory. However, I suspect that anyone, when confronted with the question of what comes first, a goal or a plan, would agree that focused planning should first involve setting clear goals.

This leads me to the focus of this article, civil GPS signal monitoring. I’m struggling with one nagging question — what is the goal?

An Inside GNSS article from June 28, 2013, titled “Congress Slashes Civil GPS Funding” reported on reductions of civil funding for GPS modernization, drawing particular attention to impacts on the civil signal monitoring initiative. The article indicated that anticipated multi-year civil agency contributions to civil GPS modernization improvements were on the order of $235.5 million.

With the pending FY14 cuts included, the aggregate civil funding shortfalls will be approaching $100 million with specific consequences for the civil signal monitoring initiative not fully understood. The Inside GNSS article also stated that the Air Force was unable to comment on the impacts of the proposed cuts at the time of the article.

It appears from this situation that a plan for implementation of civil signal monitoring is either not completely thought out or that the goal to be achieved is not well defined.

For argument’s sake, let me propose the hypothetical scenario that all of the civil funding is on track and that monitoring of civil GPS signals, e.g., L1 C/A, L2C, and L5, will be ready to commence when sufficient satellites are on orbit so that the services can be declared ready for use. From the perspective of the United States as a space-based, global positioning, navigation, and time (PNT) provider, what is the goal of showcasing that capability? In other words, is civil GPS signal monitoring an essential element in declaring the signals fully operational with a specific purpose in mind, or have we just talked about it for so long that it is considered to be a necessary part of the civil modernization package?

If the former is the case, then why has civil signal monitoring by the Air Force not been a central focus over the nearly 20 years that the GPS L1 C/A signal has been operational? Civil users, and in particular government agencies, have monitored GPS signals for years to meet specific needs, creating the Nationwide Differential GPS, International GNSS Service, Continuously Operating Reference Station, and Wide Area Augmentation System monitor station networks in the process. Will the advent of Air Force civil signal monitoring eliminate the need for some or all of these specialized networks?

In an effort to find the answer, I looked to the 2012 Federal Radionavigation Plan (FRP) (available at <http://www.navcen.uscg.gov/pdf/2012_FRP_Final_Signed.pdf>). A simple search of the FRP document for the word “goal” yields 14 hits, a few of which are useful here. The FRP’s Executive Summary (top of page xiii and repeated in the Policy Section 3.1) suggests that the goal of the U.S. is to operate PNT systems “... enable safe transportation and encourage commerce within the United States. ...” and to provide these PNT services “... in a cost-effective manner.”

A later passage states that “A major goal of DoD and DOT is to ensure that a mix of common-use (civil and military) systems is available to meet user requirements for accuracy, reliability, availability, continuity, integrity, coverage, operational utility, and cost; to provide adequate capability for growth; and to eliminate unnecessary duplication of services."

Further on in the document, on the bottom of page 1-12, the “International Considerations” (Section 1.7.6) includes a statement that “The goals of performance, standardization, and cost minimization of user equipment influence the search for an...”
international consensus on a selection of PNT systems. ICAO establishes standards for internationally used civil aviation PNT systems. IMO plays a similar role for the international maritime community.”

These are reasonable, high-level goals for PNT services in general, but they do not immediately lend themselves to an understanding of the specific goal that provides a basis for the Air Force to implement a civil signal monitoring capability as part of the civil GPS signal modernization plan.

So, once again I ask, what is the goal of civil signal monitoring? Is it to enable a United States renewal of offers to the International Civil Aviation Organization and the International Maritime Organization, similar to what was done by the Federal Aviation Administration and the Coast Guard when GPS became operational back in 1994? The goal of the FRP at that time was to achieve international acceptance of GPS civil service as an aid to worldwide civil navigation. Continuous monitoring by the Air Force of L1 C/A was not a factor in that plan.

Will the addition of civil signal monitoring for modernized civil GPS services make them more attractive within world market? If so, in what ways and for what specific purpose?

The funding challenges for FY14 are very real, and I am not suggesting that civil funding isn’t an important part of the overall GPS modernization initiative. However, I do believe that a defendable advocacy position must be built around the new capability for civil signal monitoring in order to survive the budget axes.

Having a defined goal to guide and justify a plan is much more productive than simply expecting the Air Force to explain the consequences of not having sufficient funding to execute civil signal monitoring, particularly if the purpose of the monitoring is not well understood. ♦

Corporative Profile

VectorNav Technologies
www.vectornav.com

VectorNav Technologies specializes in manufacturing high-performance navigation and inertial sensors using the latest miniature MEMS sensor technology. Since its founding in 2008, VectorNav has been providing customers worldwide access to high quality, fully calibrated inertial sensors with state-of-the-art digital filtering technology. With a strong background in aerospace engineering and experience in the development and testing of spacecraft, launch vehicles, and micro-aerial vehicles, VectorNav brings high performance aerospace filtering and calibration techniques into the world of low-cost industrial grade MEMS sensors, expanding the possibilities of today’s MEMS sensor technology.

Calendar

SEPTEMBER 2013
16-20: ION GNSS+ 2013, Nashville Convention Center, Nashville, Tennessee Contact: The ION Tel: +1 703-366-2723 Fax: +1 703-366-2724 Web: www.ion.org

OCTOBER 2013
22-24: International Symposium on Precision Approach and Performance Based Navigation (ISPA) 2013, Berlin, Germany Contact: German Institute of Navigation E-mail: dgon.bonn@t-online.de Web: www.ispa2013.de

DECEMBER 2013
2-5: ION Precise Time and Time Interval Meeting (PTTI) 2013, Hyatt Regency Bellevue, Bellevue, Washington Contact: The ION Tel: +1 703-366-2723 Fax: +1 703-366-2724 Web: www.ion.org

JANUARY 2014
27-29: ION International Technical Meeting (ITM) 2014, Catamaran Resort Hotel, San Diego, California Contact: ION Tel: +1 703-366-2723 Fax: +1 703-366-2724 Web: www.ion.org

APRIL 2014

MAY 2014
5-8: IEEE/ION PLANS 2014, Hyatt Regency Monterey Hotel & Spa, Monterey, California Contact: The ION Tel: +1 703-366-2723 Fax: +1 703-366-2724 Web: www.ion.org

JUNE 2014
16-19: ION JNC 2014, Renaissance Orlando at SeaWorld, Orlando, Florida Contact: The ION Tel: +1 703-366-2723 Fax: +1 703-366-2724 Web: www.ion.org
DISPO DRONES

Unmanned Aerial Vehicles in Paper and Poly

A $600 polypropylene UAV designed by University of Colorado engineers will soon land on the Arctic Ocean and send sensors down 33 feet (10 meters) to measure the temperature of the water as part of their investigation into the causes of rapid ice melt. After about 10 to 14 days, its battery will stop working, but no big deal.

It’s a disposable drone.

National Geographic published an article about these low cost unmanned aerial systems on July 25. A number of engineers, they say, are prototyping UAS that can go “Where No Man Has Gone Before” . . . or, if they have, it’s been dangerous and expensive.

There’s the Australian-designed paper airplane with task-specific 3D-printed circuits applied directly onto its little cellulose body, for example. The motherboard blog said the paper is treated with UV lights to “make the body a mandible circuit board which manages the plane’s two elevons (the control surface of the flight craft that functions as an elevator and aileron) and thus, the unmanned aerial vehicle’s steering.”

The same University of Queensland team responsible for the paper airplane has also built a Samara-shaped drone — it looks like the winged maple seed of the same name. The UAV carries a tiny circuit board with a sensor. When dropped, it floats slowly and safely to the ground without assistance, just like its nature-made counterpart. The seed-drones are expected to cost about $5 a piece when they go into production.

All of these inventions target hard-to-reach places that require lots of money or lots of safety precautions to explore — radioactive wastelands, hurricanes and cyclones, raging mountain fires, or freezing ocean depths.

Expand this idea a bit and soon we’ll have single-use UAS for all kinds of hazardous situations — from fourth grade lunchrooms to fraternity parties.

WEATHER GOEST THOU?

New App Gets Humans With Smartphones to Enhance Weather Satellite Data

Grab the SatCam app for your iPhone (Android coming soon) and you’ll be able to contribute to weather prediction and climate studies then science will return the favor.

The University of Wisconsin Space Science and Engineering Center (SSEC) has a problem with weather satellite data from the three spacecraft collecting information on Earth’s weather and climate.

The data can tell scientists many things, but at a certain point, the human eye has the last word. Liam Gumley, an SSEC researcher,
said “We have to take an image from the satellite and look at each pixel and say this one is a cloud, that one isn’t, this one might be . . . .”

It takes a person to tell the difference between “a snow-covered college quad and a fluffy white cloud.”

But people now have smartphones with cameras, GPS, and Internet access.

“Let’s put those to work,” Gumley said.

The three satellites are in polar orbit and complete one revolution every 100 minutes. The SSEC’s app, SatCam, alerts the phone when one of those satellites passes overhead.

The app prompts users to take a picture of the sky directly above them, and another of the horizon to give researchers a peek at the surrounding terrain.

Then the app sends a picture back — the very one the satellite took of the area the photographer is standing on. (The photographer, of course, is too tiny to get a personal portrait.)

So far users have submitted 4,600 observations of cloud cover or clear skies on five continents.

The SSEC is working on a website that will compile all those photos. To download the app, go to <http://satcam.ssec.wisc.edu/index.html>.

CROWD SOURCING A RESCUE

Lancashire researchers use UAVs, Virtual Volunteers for Search and Rescue Experiment

One hiker among many disappeared in mountainous territory in England’s Lake District on July 25.

Usually when this happens, the local rescue team heads out and tries to locate the victim, often searching for several hours in bad weather. This time, a UAV and 350 people from the United Kingdom, Africa, the United States, and the rest of Europe helped find the right person from their home locations, using desktop computers, tablets and smartphones.

It was a test of AeroSee, a search and rescue system developed by the University of Central Lancashire’s engineering school and Media Innovation Studio. Hikers get lost or injured hundreds of times each year in the region, which has some of the highest landforms in England. The university and the researchers wanted to see if remotely operated aircraft and crowd-sourced information could improve and simplify this time-critical and laborious task.

“We wanted to use a thousand pair of eyes,” said Dr. Darren Ansell, one of the developers.

Here’s how it works. When the Patterdale Mountain Rescue service gets a call, they plan their search area and UCLan deploys its UAV. The real-time video link on the “octo-rotor” transmits images of the terrain and the virtual volunteers tag photos if they see something that should be investigated on the ground.

Special software on UCLan servers process that data, which get passed to the rescue team for review. An image that gets lots of tags is an indication of a good lead. Then the Patterdale team sends out their searchers to the area.

The pilot project website received 211,000 hits and the volunteers located the missing person within five minutes.

In all, 100 images were tagged per minute and 3,500 images were tagged within the first hour of the experiment. More details at <http://www.aerosee.org/>. ◆
Members are encouraged to submit nominations for one or more of the following annual awards given by The Institute of Navigation for excellence in navigation.

- **Early Achievement Award** — for an individual early in his or her career who has made an outstanding achievement in the art and science of navigation.
- **Superior Achievement Award** — for individuals making outstanding contributions to the advancement of navigation.
- **Captain P.V.H. Weems Award** — for continuing contributions to the art and science of navigation.

- **Norman P. Hays Award** — for outstanding encouragement, inspiration and support leading to the advancement of navigation.
- **Tycho Brahe Award** — for outstanding achievement in space navigation.
- **Thomas Thurlow Award** — for outstanding contributions to the science of navigation.

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

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

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

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

International Technical Meeting, January 28-30, 2014, in San Diego, California. The ION urges you to participate in the nomination process so deserving individuals from the navigation community will receive appropriate recognition.

In addition to the above awards, the winner of the Samuel M. Burka Award — for outstanding achievement in the preparation of papers advancing navigation and space guidance — as chosen by the editorial panel of ION's Journal, NAVIGATION, will be honored.

Address correspondence to Awards Committee, The Institute of Navigation, 8551 Rixlew Lane, Suite 360, Manassas, VA 20109, phone: 703-366-2723; fax: 703-366-2724; e-mail: mlewis@ion.org. Website: www.ion.org

ION Position Location and Navigation Symposium

Show Dates: May 6 – 7, 2014  •  Technical Meeting: May 5 – 8  •  2014 Hyatt Regency, Monterey, California

Abstracts Due November 1, 2013

www.plansconference.org
Section News and Notes

SOUTHERN CALIFORNIA SECTION

The Northern California section has been active of late. On March 29, 2013, Peter Levin spoke about his experience serving four years in the Obama Administration as Chief Technology Officer in the Department of Veterans Affairs. On April 5, 2013, Prof. Brad Parkinson spoke about his vision for the future of GPS entitled “GPS 2030.” And on April 26, 2013 Prof. Ada Poon spoke about navigation within the body in her talk entitled: “Emerging Wireless Applications in Biomedicine.”

DAYTON SECTION NEWS

Dayton section had its annual June banquet, officer elections, and golf putting competition. The annual banquet concluded the 2012-2013 year. Monthly meetings will resume in September.

The newly elected section officers are as follows: Chair: Dr. Eric Vinande, Air Force Research Laboratory; Vice Chair: Mr. Tom Pestak, Air Force Institute of Technology; Secretary: Mr. Brian Roadruck, AFLCMC; Treasurer: Maj. Marshall Haker, Air Force Institute of Technology.

Congratulations

A member of the United States Merchant Marine Academy presenting Cadet Tyer William Driscoll with the ION Student Academy Award at the USMM class of 2013 graduation ceremony this past June.

In Memoriam

Navigation Expert Passes from the Scene

Ray Duncombe, ION past president (1966-1967) passed away the morning of July 12, 2013. Ray was director of the USNO Nautical Almanac Office, professor in the Aerospace Engineering Department at the University of Texas, founding chairman of the AAS Division on Dynamical Astronomy, executive editor of Celestial Mechanics, president of IAU Commission 4 on Ephemerides, secretary of the AAAS Astronomy Section, and a member of many scientific organizations.

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