GNSS navigation is usually thought of something that happens beneath the 12,000-mile orbits of the satellites. Systems such as GPS, after all, are typically Earth-centered/Earth-fixed (ECEF) for a reason: to optimize the accuracy of positioning that occurs on or above the surface of the planet. The ECEF principle locates positions in a coordinate system that can be readily linked to map datums and latitudes and longitudes.

Civil aviation, of course, also makes extensive use of GNSS, and applications have become common up to 3,000 kilometers altitude, a region of space also known as the GPS Terrestrial Service Volume (TSV). This includes low Earth orbit (LEO) operations such as the International Space Station and LEO communication satellite systems that exploit GNSS positioning and navigation.

But some researchers aren’t stopping there. The sky is no longer the limit — if we are defining that as the upper extent of the exosphere 10,000 kilometers (6,200 miles) into space.

Turn Up the Volume
A fairly recent initiative supported by NASA and the International Committee on GNSS seeks to extend this operational environment to higher altitudes by using the “spill-over” energy of GNSS signals radiating over the limb of the Earth into a region called Space Service Volume (SSV) between 3,000 kilometers altitude and geosynchronous orbit (GEO) altitude of about 36,000 kilometers.
Marking the most significant change to the Institute of Navigation’s visual identity in its 72-year history, The Institute is proud to introduce our new organization logo.

Several factors were driving the need for a new visual identity. We needed a clear and identifiable statement given the many and varied new platforms that are required for its use. The new ION logo is both simple and bold and is in keeping with the growing trend of less complicated designs with greater visual impact. This new logo design will be visually legible and clear for all our users on all platforms.

The new logo features an eight-point compass rose — an iconic navigational design element that unites the rich and proud history of the organization with a new visual look. We felt it was important to satisfy any expectations of what our original mark stood for by recognizing the organization’s historical legacy while developing a new look.

Additionally, it was apparent that ION represents a technology that has evolved substantially since the historical logo was conceptualized. Advances in Positioning, Navigation and Timing are revolutionizing the world around us, and it’s important for ION to grow and advance with it.

Looking Ahead to JNC
We are looking forward to hosting the ION Military Division’s Joint Navigation Conference (JNC 2017), which will take place June 5–8, 2017, in Dayton, Ohio. This year’s technical program appears very strong with scheduled keynotes from Major General John Morrison, Commanding General of the Cyber Center of Excellence, U.S. Army; Brig. Gen. Ronald Buckley, Deputy Director of Operations for Headquarters U.S. Northern Command, USAF; Mike Emerson, Director of Marine Transportation Systems, USCG; Dr. Brian Teeple, Acting Department of Defense Deputy Chief Information Officer for Command, Control, Communications and Computers and Information Infrastructure Capabilities; and Brig. Gen. Robert Gwyn Armfield, VJ5, U.S. Central Command, USAF. See www.ion.org/jnc for attendance requirements.

The Joint Navigation Conference has grown through the years to become what I consider a “must-attend” event for those who are involved in military PNT technology, and I hope to see many of you there!
Satellite Division Adds Free Short Courses to Technical Program

ION GNSS+ 2017, the ION Satellite Division’s annual conference and exhibition, will feature a set of complimentary short courses taught by internationally recognized GNSS experts and educators.

This year’s event, scheduled September 25–29 in Portland, Oregon, includes a keynote address on “Navigation Adventures” by Stan Honey, a yacht racing navigator, Emmy Award–winning developer of TV graphics, and an engineer in navigation and remote sensing.

On April 25, The Institute released an advanced program — available online at <https://www.ion.org/gnss/program.cfm> — listing the technical sessions, panel discussions, short courses, invited speakers, and exhibition hours and participants.

The free short courses, to be held on Monday of ION GNSS+ week, will complement the fee-based tutorials offered on Tuesday. The 90-minute classes will be presented lecture style on a variety of topics including: GNSS 101, Resilient Position Navigation and Time, Assisted GNSS, Fundamentals of GNSS Receiver Design, A Practical Introduction to GNSS/INS Integration, Precise Time and Time Interval Services from GPS and GNSS Systems, Image-Aided Navigation, and Nonlinear Estimation Techniques for Navigation Systems.

These introductory courses will be available to all paid ION GNSS+ attendees with the compliments of the Satellite Division and the ION’s Master Instructors, who have generously donated their time and talents to this effort as a service to the GNSS community, with the ION’s gratitude.

The goal of the short courses is to help prepare attendees to receive the full benefit of the week’s technical presentations, provide an update and refresher on selected topics, and, for those in the industry, and offer an opportunity to hear the viewpoint and expertise of some of the world’s foremost authorities on the topics.

Of course, attendees can also expect another outstanding technical program and dynamic commercial exhibit – all hosted in hip and happening Portland, Oregon. Mark your calendar. See you there! 🌺

Call for Nominations: The Johannes Kepler Award

Nominations Due: June 30

The purpose of the Johannes Kepler Award is to honor an individual for sustained and significant contributions to the development of satellite navigation. A special nominating committee will determine the winner of this award. The Kepler Award is presented only when deemed appropriate. All members of the ION are eligible for nomination.

You are encouraged to submit nominations for deserving individuals. For complete nomination instructions, and to submit a nomination, go to <www.ion.org/awards>, and click on “Kepler” in the left-hand menu. Nominations must be received by June 30.

For a complete list of previous winners, please visit <www.ion.org>.

Dr. Dorota Grejner-Brzezinska, 2016 Kepler Award Winner. For outstanding contributions in advancing high-accuracy GNSS/INS integrated systems, educating future navigation leaders, and for strengthening the ties between satellite navigation and geodesy.
By 2016 these efforts had matured to the point that all global and regional positioning, navigation, and timing (PNT) service providers were in the process of characterizing the SSV performance of their own respective GNSS constellations in consultation with the world’s space agencies.

At the ION International Technical Meeting in Monterrey last January, Frank H. Bauer, formerly NASA’s chief engineer for exploration systems, and three coauthors addressed this subject in their paper, “Developing a Robust, Interoperable GNSS Space Service Volume (SSV) for the Global Space User Community.”

According to Bauer, missions in the SSV segment benefit from current GNSS capabilities, including fast recovery from trajectory maneuvers, improved operations cadence, increased satellite autonomy, improved navigation performance, and precise timing reducing the need for expensive on-board clocks.

For example, NASA’s Magnetospheric Multi-Scale (MMS) mission, launched in March 2015, is a formation flyer consisting of four GPS-equipped spacecraft operating in a highly eccentric orbit to measure the properties and effects of space weather. MMS’s Navigator GPS receiver has enabled onboard (autonomous) navigation well beyond GPS altitude, and its measurements have greatly improved researchers’ understanding of GPS performance in the high-Earth-orbit (HEO) environment well beyond GEO. MMS tracks 8 to 12 GPS signals in an orbit with an apogee at 70,000 kilometers, or approximately double the altitude of GEO, the formal boundary of SSV coverage.

Shooting the Moon
The potential utility of GNSS in space doesn’t necessarily end at HEO, however.

In a presentation at the 2015 ION GNSS+ conference entitled, “Weak GNSS Signal Navigation for Lunar Exploration Missions,” Norbert Witternigg, of the Joanneum Research Institute for Space and Communication Technologies
based in Graz, Austria, and co-authors described how GNSS could be part of the navigation solution during various phases of a mission to the moon. The mission phases investigated by the study included transfer orbit, low lunar orbits, lunar ascent and descent as well as surface operation and navigation at the Lagrange points L1 and L2.

At that distance (up to 238,900 miles or 384,400 kilometers), GNSS spill-over signals around the Earth would suffer from very low power levels, be partially masked by the Earth, and have to deal with an unfavorable satellite geometry (high dilution of precision). Witternigg described a European Space Agency (ESA) study to evaluate the challenges of such a navigation solution using GPS and future Galileo signals with carrier-to-noise-density ratios as low as 10 to 15 dBHz.

In simulations, the research team demonstrated how an on-board navigation propagator fused sensor data coming from the GNSS position/velocity/time (PVT) solution with long coherent integration times with other PNT sources the use of an Extended Kalman Filter (EKF).

The authors concluded, “With the addition of hardware sensors like IMU [inertial measurement unit], Doppler radar altimeter and other sensors, we expect that a high degree of autonomy of navigation during lunar exploration missions can be achieved.”

Other researchers are taking the GNSS concept even farther.

The Mars Systems Laboratory and Faculty of Aeronautics of Technical University of Kosice, Slovakia, has proposed an autonomous GNSS system for use on Mars. This would employ a constellation of the 15 navigation satellites in three orbital planes, each containing five satellites. The concept is a part of a scientific research project called “GNSS FATIMA.” The lead scientist working on this project is Dr. Jozef Kozar.

“This system will dramatically reduce the costs of future exploration of Mars. It will allow us to focus our engineering resources more into the field of design and production of research systems, to planning complex missions and to simplify some parts of the planetary exploration itself,” Dr. Kozar says.

Such efforts could coincide with other Mars-related efforts, such as those supported by Elon Musk and his Space Exploration Technologies Corporation (SpaceX). The company is already using GNSS and inertial navigation to recover and land the first stage booster of SpaceX’s Falcon 9 launcher on unmanned sea-going barge or “droneship” (described in a Spring 2016 ION Newsletter article), a technique that Musk says would be essential for a manned mission to the red planet.

On March 31, for the first time in the history of spaceflight SpaceX reused a rocket from a previous mission to launch a satellite into geosynchronous orbit. After successfully launching the spacecraft, the rocket then returned to Earth and landed on a droneship in the Atlantic Ocean. It was the company’s sixth successful landing on a seaborne platform.
September 25-29, 2017
Tutorials: September 25-26
Show Dates: September 27-28
Oregon Convention Center • Portland, Oregon

ION GNSS+ 2017
The 30th International Technical Meeting of the Satellite Division of The Institute of Navigation

SAVE THE DATE
Exhibitors, reserve your booth today; space is limited.
www.ion.org/gnss
INDOOR LOCALIZATION

‘Indoor GPS’ Apps Closer to Reality with New NIST Challenge

GPS usually works great outdoors, but what if you are disoriented in a large building such as a museum or a mall? There are no smartphone apps for indoor navigation, but new data collected by the National Institute of Standards and Technology (NIST)—and a competition to find the app developers who can make the best use of it—may help solve the problem.

A NIST-led research team spent more than 18 months collecting data from four different smartphone models to facilitate the development of indoor navigation apps. The data, which includes smartphone sensor readings, radio frequency (RF) signal strengths and GPS fixes, should help developers create better apps to assist users in finding their way inside unfamiliar buildings.

Such “indoor localization” tools could help emergency responders find victims—or each other—when seconds count. They also could assist with locating specific works of art in large museums or misplaced equipment in hospitals, factories, or warehouses.

In the future, if you ask your smartphone where you are, it will create the answer using many bits of disparate information—among which are signals received from Wi-Fi access points and local cell towers that it can use to triangulate your location. It will also use its internal sensors, such as accelerometers and gyroscopes, which tell it how far you might have moved and in which direction since its last signal check. But the lack of validated testing has made their results untrustworthy.

“The user community has expressed the need for careful testing of indoor localization solutions,” said Nader Moayeri, NIST’s principal investigator on the project. “Fire departments, for example, strongly desire ways to find a comrade who’s fallen inside a burning building, and who may die because he cannot determine the exit location due to low visibility from smoke or some other reason. Fire departments need to know how well these solutions are going to work before they invest their limited financial resources in them.”

The people who first responders are seeking to help need a solution just as badly. The FCC estimates that more than 10,000 lives can be saved annually with better and timely location information for 911 calls placed from cellphones, many of which are made from indoor locations.

The NIST team walked the smartphones along 30 different set courses in four different buildings, including factory, warehouse and subterranean settings. At numerous predetermined locations along each course, the researchers created “time-stamps” on all the phones corresponding to the times the person collecting the data was going over test points on the floors, whose locations had been professionally surveyed. The resulting data is now freely available online to the general public for developing smartphone indoor localization apps.

To encourage their development, NIST is sponsoring a competition called PerfLoc to generate the best apps from the developer community. Developers have until August 17, 2017, to create computer algorithms that can make sense of the data and to submit their estimates of the smartphones’ locations along the courses.

The team has developed a methodology to evaluate the algorithms’ performance over the internet.

By making the data available to everyone, NIST is giving a chance to individual app developers and smaller companies that may not have the resources to collect their own data. In addition, by using the same data sets for developing the apps and evaluating their performance, it will be possible to compare the performance of the resulting apps.

NIST is offering cash prizes of $20,000, $10,000 and $5,000 to the top three submissions. The grand prize winner will also be flown to a conference in Japan to present their idea and do a live demonstration of their app.

“Of course the biggest reward will not be the cash prize,” Moayeri said. “The prestige that goes with it will matter to the designer.”


While GPS rarely works well indoors, NIST research into ‘indoor localization’ could allow smartphones to pinpoint your location in large buildings—potentially helping emergency response teams.

Credit: N. Moayeri/NIST
I recently crossed off an item from my bucket list. (For the uninitiated, a bucket list is a compilation of experiences or achievements that a person hopes to obtain or accomplish during his or her lifetime.)

My bucket list item: I purchased my own personal sextant.

Surely you are surprised that the one and only Historian of the International Institute of Navigation who has taught celestial navigation and who has often written about “shooting the stars” never owned his own personal sextant. I have a series of lame excuses for why I never previously owned a sextant. They include the perception that:

a) GPS solves all of our problems.

b) Celestial navigation is obsolete.

c) A sextant’s use requires extensive training.

d) My wife did not like the name of the device.

e) I am cheap . . . er, thrifty, and a sextant can be expensive.

So, I systematically reviewed the foregoing five excuses and finally resolved that I should buy a sextant.

Here is how I rebutted each of my lame excuses:

First, maybe GPS was originally supposed to tell us exactly where we are and replace all of the other navigation aids. But certainly you have heard of Assured Position Navigation and Time (APNT). APNT is a large thrust by the Department of Defense (DoD) to ensure the availability of PNT by finding alternatives to GPS in view of its ostensible susceptibility to jamming, spoofing and other efforts to disrupt GNSS satellite transmissions. After working 30 years proselytizing the benefits of GPS, however, I knew the government was seriously concerned about “GPS frailties” as satellite navigation does not ensure its citizens’ health or safety; so, the focus is not on assured PNT.

Second, it is true that celestial navigation is rarely, if ever, used aboard modern vessels for conventional navigation. The present celestial navigation methods used aboard ships is still a labor-intensive relic from the past that ultimately doesn’t yield position accuracies much better than those needed to meet open ocean requirements.
Nonetheless, the last five years has brought a resurgence of interest and capability in this ancient art. Now, an approach generally referred to as Automated Celestial Navigation (ACN) is being explored by a variety of military organizations. Starting in 2012, the United States Naval Observatory, acting in its role as the DoD Celestial Reference Frame (CRF) manager, has convened the Star Tracker Working Group (STWG) to pull together all Defense efforts to develop star trackers — optical devices that track dozens of bright stars used for navigation.

The Office of Naval Research, for example, is investigating the utility of Resident Space Objects (RSOs) such as, artificial satellites and space debris as objects to be tracked in addition to conventional celestial bodies. This relaxes the requirements of establishing the reference vertical by either inertial methods or visually tracking the horizon, while adding the requirement to obtain the ephemerides of the RSOs. Recently, the U.S. Navy listed celestial navigation as a viable APNT technology to pursue for major combatant surface ships.

Third, celestial navigation solutions historically required either a comprehensive knowledge of astronomy and spherical trigonometry and/or the use of volumes of nautical almanacs and hydrographic office publications. Now, as with most other problems in life, there are apps for that. Just go to Apple Store or Google Play and you will find a dozen user friendly celestial apps that require no training other than a capability to pinch, swipe, drag, and spread your fingers on your smartphone while the ship you are on is rolling and pitching.

Fourth, surely we know that spouses can be difficult when you buy a toy only for yourself. But this obstacle was circumvented, or circumnavigated, when I explained to my wife that — despite its somewhat misleading name — it’s not that kind of toy. (To quote the all-knowing Wikipedia, “The frame of a sextant is in the shape of a sector which is approximately one-sixth of a circle (60°), hence, its name — sextāns, -antis is the Latin word for ‘one sixth.’”)

Lastly, the issue of my frugality was a difficult obstacle. Should I buy a new one or an old vintage one? Should it be an accurate, working unit or a lower cost model? Aluminum, plastic, or brass? American, German, Japanese or British made?

Several of these choices were easily resolved when I explored the prices of new, accurate sextants and of old vintage ones. It was apparent that the manufacturing of new, accurate sextants is not a growth industry. The one German manufacturer that dominates the market advertises that: “This is a beautiful hand-down-to-your-grandchildren instrument, and a real pleasure to use.”

Well, if I am inclined to hand down anything that costly to my grandchildren it will be help with their college education. As for the vintage sextants, I perused Peter Ifland’s beautiful book Taking the Stars: Celestial Navigation from Argonauts to Astronauts. It has numerous pictures of sextants going back to their origin in the late seventeenth century. These are truly works of art and are priced as museum collection items.

I did consider undertaking the project described in the January 2017 Popular Science article entitled “How to Make a Sextant from Random Junk,” and the price, $7, was well within my budget. But I thought that might be carrying austerity a bit too far.

So, that left me with old faithful eBay, which had several hundred sextant related items varying from true antiques costing thousands of dollars to toy models for $29.
All of that nostalgia, however, did not overmatch my thrifty nature as I wrote to the captain who was selling the sextant to ask him if he would give me — a lowly professor of navigation — a special educational discounted price?

The captain responded as follows: “It is a fine instrument from both a functional or historic point of view. These models #5226 usually trade on eBay at $500+ so it indeed has a fair start price. A trip to the Grand Banks this time of year where the money was got that purchased it would help you understand altruism and commerce never ship together. Thanks for your interest.”

Alas, I ultimately wound up losing my opportunity to buy this perfect complement to my K&E slide rule in a last-minute eBay bidding war to a snipe.

Soon thereafter, I won an eBay auction for a 1974 Japanese Ogawa Seiki Tamaya sextant (pictured). It has all the features I ever wanted in a sextant, except the reminiscence. Surely you know my next Bucket List item: to use this sextant on an exotic voyage and not get lost.

Marvin B. May is Chief Scientist of the Pennsylvania State University’s Navigation Research and Development Center where he teaches navigation courses. His email is mbm16@arl.psu.edu

Other related ION Historian articles of potential interest are: Winter 2011–2012 “Navigation History on Ebay” and Fall 2003 “Why Teach Celestial Navigation”
I have noted with interest a growing number of references to the idea of developing and adopting standards related to positioning, navigation, and timing (PNT) systems and services. While elements of PNT are present in many of the standards that for decades have underpinned diverse technology enterprises, it is perhaps surprising that little attention has thus far been given to the PNT enterprise itself.

This now-emerging focus on PNT standards stems in large part from a recent awakening among government and industry leaders to the value that PNT represents for global economic and national security sectors, based upon the ubiquitous presence of GPS (GNSS) as a single-source delivery system for PNT information. Awareness of the urgent need to both protect access to GPS itself and to complement GPS with additional sources of PNT information has generated interest in how the use of standards can play a role in furthering both objectives.

An example of using standards as protection for GPS is found in an April 17, 2017, Inside GNSS article titled, “Europe’s GNSS Receiver Standard Nears Approval” (by Dee Ann Divis) <http://www.insidegnss.com/node/5438>. This article highlights European efforts to fend off adjacent band interference by adopting a GNSS standard that specifies a specific level of interference from the 1525 MHz to 1549 MHz band with no more than one-decibel degradation in the signal to noise ratio in GNSS receivers. The article includes the statement, “The United States does not have standards for GNSS receivers. . . .”

Another example is found in the responses to a November 2016 Federal Register request for information (RFI) issued by the Office of the Secretary (OST), U.S. Department of Transportation (DOT) on Positioning, Navigation, and Timing (PNT) Service for National Critical Infrastructure Resiliency (Docket Number DOT–OST–2016–0227). This example demonstrates the potential application of standards to help determine requirements for suitable complements to GPS in critical infrastructure applications.

In its response to the RFI, A Roadmap for Protecting Critical Infrastructure (see <https://www.regulations.gov/docket?D=DOT-OST-2016-0227>, the Society of Automotive Engineers (SAE) International pointed out that in August of 2016 its Avionics Systems (AS) Group PNT Committee (AS-5) had launched two new standards development projects related to GNSS receivers and terrestrial-based PNT systems for Critical Infrastructure Security.

The AS-5 work activity falls under SAE’s Avionics System Division (ASD), which is preparing to begin work on the projects at the next committee meeting to be held in Nashville, Tennessee May 15–18, 2017. The two AS-5 projects are summarized in the response as follows:

ARP6856 – Improving Unmanned Vehicle Navigation Solutions Using Raw Measurements from Global Navigation Satellite System (GNSS) Receivers provides users with the technical requirements and methods for accessing, viewing, and processing raw GNSS receiver measurements for improved unmanned vehicle navigation solutions.


The foregoing examples highlight the reality that, while there are many standards-focused organizations worldwide, standards actually tend to be geographically and technically focused in their use and relevancy.

Universal or Regional?

Noting Europe’s initiative to develop a GNSS receiver standard to establish protection levels for adjacent band interference, it is likely the final standard would affect only how a particular manufacturer might build a receiver to be marketed in Europe. The same manufacturer would almost certainly consider separate standards developed for U.S. markets if such standards were presented and adopted by organizations recognized within the United States.

Specifically, in its DOT RFI response SAE indicated “they have a long and successful history of working with U.S. Government agencies on standards for.
a broad spectrum of applications. . .” and that, “both civil and military agencies rely on SAE standards to provide industry and stakeholder expertise and definition as an integral part of government regulation, certification and operation.”

Additionally, the term “standard” is often misused and misinterpreted. For example, the Universal Serial Bus (USB) “standard” is not actually a standard but is rather a specification defined by a joint copyright filed by several influential companies (Compaq Computer Corporation, Hewlett-Packard Company, Intel Corporation, Lucent Technologies Inc., Microsoft Corporation, NEC Corporation and Koninklijke Philips Electronics N.V.). This industry-developed specification has become a de facto standard but is not as yet one promulgated by any standards organization.

As with the PNT enterprise, standards in many cases tend to be written after products are built, specifying a set of rules, procedures, interface requirements, test vectors, and training parameters the represent consensus among a broad spectrum of parties and are often published by a neutral party. Such standards are useful references to be included in contracts. Including published standards by reference in government-issued contracts ensures an ability to measure performance and ensure compliance with particular requirements.

In the case of developing system architectures where performance metrics are critical, e.g., safety-critical systems such as those incorporated in the aviation industry, or security-focused systems such as those in critical infrastructure or military applications, standards provide a means to enhance safety, provide common interfaces, promote uniform testing and performance criteria, and ultimately help reduce systems costs.

This is particularly relevant to the Department of Defense, which is now considering the utility of standards in developing interoperable interfaces to incorporate multiple PNT sources in an Open System Architecture for multi-Service military applications.

Among other things, incorporating standards as a means of integrating multiple PNT sources into systems that support a diverse set of military platforms and mission sets can help reduce development costs, support end-state interoperability, and improve PNT functionality in challenged environments, e.g., Navwar.

Finally, such standards can be instrumental in achieving a workable open-system architecture that enables tailored incorporation of plug and play devices and applications to meet the demands of diverse mission scenarios requiring assured PNT for their successful execution.
Tips for Meeting with Senate Staff

Dr. Kyle Wesson

I am over halfway through my fellowship serving in the Office of U.S. Senator Richard Blumenthal (D-CT) as the 2016–2017 Institute of Navigation Congressional Fellow. Since January, the pace has been, to quote a veteran staffer, “unprecedented.” Through March, the Senate was in session for 12 of 13 weeks, breaking for only a single “state work week” — Hill code for recess. With committee hearings, floor votes, and appropriations ongoing, the Hill literally hums with energy.

Meetings with stakeholders, constituents, and other offices are one constant in every staffer’s job. On one day in February, our office held 24 meetings with one of our three conference rooms reserved for seven hours straight. For many, a meeting with a Senate office may be a stakeholder’s only opportunity to explain their issue or concerns with a staffer face-to-face.

To assist those in the ION community who engage with the Senate, I want to share my perspective of these meetings based on my experiences sitting on the other side of the table. Here is my “Top-10” list of tips, observations, and suggestions to prepare for a meeting in a Senate office.

1. Have a Clear “Ask” Up Front

Some call it an “ask,” others the “bottom line up front.” Let the staffers know what you want and how the Senator can help your cause. Should the Senator write or co-sign a letter? Sponsor a bill? Is your group seeking additional funding? Is there an upcoming committee hearing at which the Senator could ask questions about your issue? Explain your “ask” in the first five minutes and repeat it at the end.

2. Understand Why Your Issue Matters to the Senator’s State

Advocating for your concern means explaining why it matters to the Senator’s constituents. Sometimes your issue may be tangential — perhaps it relates only to a committee or caucus on which the member serves — but the member serves on those committees for a reason. Clearly articulating how the issue benefits their state will benefit your cause as well. And remember that there are two Senators for each state.

3. Be Concise

Enough said.

4. Know with Whom You Are Meeting

Often, you will meet with a member of the Senator’s legislative team. This could be a legislative correspondent or aide. They will be knowledgeable about your area of concerns and will communicate your issue to the Senator. If the issue warrants, you might meet with someone higher in the chain of command: perhaps the legislative director, general counsel, or even the chief of staff. If you are meeting with a Senator, then the first three tips become even more important. Consider the following actual example: you have only 15 minutes to talk with the Senator in the anteroom of a committee hearing room between the Senator’s questions to the testifying witnesses and the Senator’s floor speech. Do you really want to spend the time talking about the weather?

5. Examine the Senator’s Voting Record

Will the Senator be in favor of or in opposition to your issue? Has the Senator signed letters or advocated for your cause before? If this is a new issue, expect to spend time educating the staff and advocating for your concerns over multiple meetings.

6. Keep Handouts Brief

Being concise also applies to handouts — one-page explanations work well. Anything longer can be emailed after the meeting. For better or worse, that one page can frame the issue and leave the staffers with a lasting impression. In one unfortunate instance, we received a handout of data overlaid on a map of the State of Connecticut. Unfortunately half of the state was cut off by the margins of the paper. Whoops.

7. Follow Up

One of the first rituals of the meeting is the business card exchange. You’ll get the names and contact information for the staffers who are knowledgeable about the issue. If you promise more information, be sure to follow up after the meeting.

8. Anticipate Last-Minute Changes

Last-minute changes are the exception and not the rule, but they do occur. Sometimes we juggle conference rooms for meetings that have run over, hold meetings for other staffers if they get pulled into hearings, or postpone meetings at the last minute.

9. Understand the Ethics of Gifts

The Senate ethics rules apply to all offices, members, and staffers. The rules prohibit gifts of any kind from lobbyists and place annual limits on the dollar value of gifts. Before you bring gifts to an office, understand the ethics rules, described on-line at <https://www.ethics.senate.gov/public/index.cfm/gifts>.

10. Leave Envelopes Unsealed

Since the anthrax scare, all mail and packages are screened off-site for potential threats. If you want to deliver “mail” to a Senate office in person, don’t seal the envelope.

**Bonus – Explore and Enjoy**

While you’re on the Hill, take some time to enjoy the action unfolding around you. Schedule a tour of the Capitol, visit with your own state’s House or Senate offices, or take a lunch break to eat with the staffers and visitors in the cafeteria. You never know whom you might bump into along the way.
EIGHT TEAMS FINISH WITH BORROWED SNOW

2017 Robotic Snowplow Contest
ION North Star Section

Even though the Minnesota sun was shining bright, it still was a wintry wind tunnel on the competition snowfield.

The sunny days and other Winter Carnival events last January drew big crowds to Rice Park in downtown Saint Paul to watch innovation and teamwork on the field of competition, but the brisk, icy winds reminded everyone that they were definitely in Minnesota. While the weather last winter had been typically cold, it did not provide the Twin Cities with much measurable snow.

The competition committee trucked in manufactured snow produced for the Winter Carnival’s famous snow sculptures so that each team could compete on fresh snow that was similar in texture and consistency from one run to another.

This year, 13 teams signed up to compete in the Seventh Annual Autonomous Snowplow Competition (ASC), organized by the Institute of Navigation North Star Section.

Five teams dropped out because of mechanical and electrical problems but eight teams made it through the final round.

The “sidewalk” and “driveway” shaped fields — officially Single-I and Triple-I — challenged the teams again this year.

The “sidewalk” and “driveway” shaped fields — officially Single-I and Triple-I — challenged the teams again this year.

Many contestants continued to refine their plowing based on lessons learned from the 2016 competition.

The Triple-I field in particular tested robot navigation because of its larger size, which requires more complicated plowing strategies to place the snow into the specific zones. Teams continue to use state of the art navigation systems such as LIDAR, optical navigation systems, inertial instruments, magnetic sensors, ultra-wide-band radio reflectors, visual odometry, GNSS, and differential GPS.

The vehicle and navigation designs have progressed towards more marketable techniques, with some teams working towards the goal of producing a commercial snowplow product.

A new element to the event that entertained the crowds and intrigued the students was the Cooperative Navigation and Operation Challenge, organized by committee member Dr. Demoz Gebre-Egziabher of the University of Minnesota – Twin Cities. This new plowing demonstration illustrated how autonomous robot vehicles can work cooperatively together, both while plowing snow and avoiding each other on a fixed simulated sidewalk.

Can self-driving snowplows learn to cooperate? New navigation and operational challenge tests the possibilities.

The competition’s four-day event, which ran in conjunction with the Saint Paul Winter Carnival in Minnesota, began on Thursday, January 26, 2017. That evening each team presented their vehicle design at the Science Museum of Minnesota in Saint Paul to a panel of judges comprised of professional engineers from event sponsors and contributors Honeywell, Hassig Consulting, Orbital ATK, Optum, The Toro Company, University of Minnesota, and UTC Aerospace Systems.

On Friday, January 27, the teams attended the Final Qualifying Review, where their vehicle went through stringent testing and verification to ensure compliance with all competition requirements.
Case Western Reserve University’s “OTTO-XL” Wins the Gold Snow Globe

Above: Case Western Reserve University’s “OTTO-XL” Wins Top Prize at in Saint Paul. Team members include, from left: Vibhor Bageshwar (Honeywell and Autonomous Snowplow Competition Committee), Matthew Klein (OTTO-XL), Charles Hart (OTTO-XL), William Buck Baskin (OTTO-XL), Kristen Sheikh (ASTER Labs and Autonomous Snowplow Competition Committee), Anjanu Sheikh, Suneel Sheikh (ASTER Labs and Autonomous Snowplow Competition Committee)

At left, team members from Dunwoody College of Technology, whose snowplow “Wendigo” took third place.

Saturday and Sunday, January 28 and 29, were the dynamic competition days, in which teams were judged on how quickly and accurately their machine cleared a designated snowfield.

To learn more about the competition and to view videos, press coverage, photos, and information about the 2017 competition, follow the activity on Facebook at “Autonomous Snowplow Competition,” and on Twitter and Instagram at “autosnowplow.”

ION Autonomous Snowplow Competition 2017

TEAM AWARDS
Gold Snow Globe + $7,000 prize money and $3,000 travel grant to present at ION GNSS+
OTTO XL, Case Western Reserve University
Cleveland, Ohio

Silver Snow Globe + $4,000
Yeti 7.0, University of Michigan
Dearborn, Michigan

Bronze Snow Globe + $2,000
Wendigo, Dunwoody College of Technology
Minneapolis, Minnesota

4th Place $1,000
GOFIRST Snow Squirrel, University of Minnesota

5th Place $700
Snow Devils, Dunwoody College of Technology
Minneapolis, Minnesota

6th Place $300
Blizzard Byter, University of Saint Thomas
Saint Paul, Minnesota

Other Competing Teams
Case Western Reserve University, The Robot Formerly Known as Snow Joke; Iowa State University, Robotics Club Snowplow; Michigan Technological University, Longshot; North Dakota State University, Lil Bison and THUNDAR 3.0; University of Michigan, Dearborn, Z3PO (Zenith 3.0); and Wayne State University, Snow Wizard 1.0.

THE SPONSORS
The Institute of Navigation Satellite Division
Honeywell International, Inc.
ASTER Labs, Inc.
Orbital ATK, Inc.
Oshkosh Airport Products – part of Oshkosh Corporation
The Toro Company
SICK, Inc.
US Bank Corp.
Grizzlies Wood-Fired Grill
The MPX Group

EVENT HOSTS
The Institute of Navigation North Star Section
ARCS Foundation (Achievement Rewards for College Scientists) Minnesota Chapter

'Wendigo' works the course
SHACKLETON continued from page 1

Camp to McMurdo and back again. Bergel completed the 30-day journey — driven in a Hyundai Santa Fe, a modified four-wheel-drive car with a 2.2-liter diesel engine — along the route that Shackleton set out on more than 100 years ago.

“I like to think, he’d be proud and pleased that a member of his family had finally pulled off something that he’d tried to do,” Bergel told Reuters in London. “But . . . what we’d done was maybe a thousandth as hard as it had been back in 1916–17.”

The expedition, facilitated by Hyundai Motor, saw Bergel and a small team in three pick-up trucks to provided support take on almost 5,800 kilometers (3,500 miles) of icy terrain in bitter conditions. They not only had to cover large distances at temperatures down to minus-28 degrees Celsius but also needed to plot new paths on floating ice caps that have never been travelled by wheeled vehicle before.

Not only was the feat not accomplished by ship and sled, as Shackleton intended, but rather than maps, chart, and compass, Bergel used a GPS receiver to navigate his route.

Bergel, 46, a British technology entrepreneur, admitted, “I’m not a polar explorer; I’m an indoor guy. So, it was a big cultural shift — and it was quite something to have been the first to do this. Getting to the South Pole was a special moment. The fact that this was a place my great grandfather tried to get to more than once and I was there, it felt like a genuine connection.

“What we did though was one thousandth as hard as what they did. You know, no comparison — modern appurtenances, comparative luxury. But it was an amazing journey, and an amazing achievement.”

The expedition was supported by Hyundai Motor Company and inspired by Shackleton’s heroic Trans-Antarctic journey of 1914–17 when, having been beaten to the South Pole by Roald Amundsen, he tried to become the first to cross the continent. His ship was trapped in an ice pack and sank, but the heroic explorer and five men sailed 800 miles across open, stormy seas to South Georgia, from where a successful rescue could be launched.

Scott Noh, Hyundai’s head of its Overseas Marketing Group, said, “We were aware of Sir Ernest Shackleton’s story and as a company felt a resonance with his courage and pioneering spirit. Our film celebrates this spirit and through Patrick, his great-grandson, completes his dream to cross Antarctica — just a hundred years later.”

Original artifacts from that expedition were too fragile and precious to be taken by Bergel on this expedition; so, he opted for a far more modern solution.

“There was a compass, but unfortunately it is uninsurable and the first editions, memoirs, and so on were not very Antarctic-friendly,” he said. “So I took the diaries with me . . . on a Kindle! They were fascinating and it meant much more than just reading them in London.”

The team travelled from Union Glacier to the South Pole then followed the Leverett Glacier and the Trans-Antarctic Mountains, past smoking Mount Erebus volcano, to the Ross Ice Shelf and McMurdo.

“Some sections were unbelievably beautiful, and only a few dozen people actually get to see the Trans-Antarctic Mountains,” Bergel said. “That was the point at which nobody in a wheeled vehicle had been beyond. My great-grandfather was the first to climb Erebus, and I’d seen pictures of it as a child. It is quite spectacular, with plumes of smoke coming out, and it was pretty special to be driving and see it come out of the cloud.”

The journey was carefully plotted on
GPS and locations of potential danger areas were reviewed in detailed meetings with experts at Union Glacier before departure, but there were still plenty of pitfalls along the way.

“When you’re driving through a total white-out you start hallucinating, seeing things that aren’t there,” said Bergel. “Our brains often confused us into believing we were going uphill rather than down. In one area, a giant crevasse field, we had to rope up the vehicles to make sure if one fell in, it could be recovered by the others. We had one scary moment there — but we managed to get through OK.”

One of Antarctica’s most experienced driving experts, Gisli Jónsson from Arctic Trucks was tasked with managing the vehicle’s preparation before the event and then led the expedition out in the Antarctic.

“People who have a lot of experience of Antarctica know what it does to machinery: basically, anything and everything falls apart,” said Jónsson. “Even the big machines crack up and break apart. This was the first time this full traverse has ever been attempted, let alone doing it there and back. A lot of people thought we would never ever make it, and when we returned they couldn’t believe we’d actually done it!”

The expedition which took place in December 2016 has been made into a short film by Hyundai which was shown for the first time at an April 20 event at the Hospital Club in London. The film can be viewed at www.Shackletonsreturn.hyundai.com or https://youtu.be/J01mggN0h8.
Cincinnati Hospital Launches App for Indoor Wayfinding

Indoor positioning and navigation holds a special allure for engineers trying to replicate the accuracy and availability of GNSS outdoors in environments where the satellite signals are blocked, reflected, or attenuated.

For the last several years at the ION GNSS+ conferences, The Institute of Navigation has sponsored technical sessions with demonstrations of current advances in indoor location. Related paper presentations crop up in other GNSS+ sessions and at other ION events.

Covered shopping malls have been a common example of the kind of venue in which indoor or ubiquitous positioning would be desirable and even commercially attractive. But Mercy Health – Jewish Hospital in Cincinnati, Ohio, has launched an innovative wayfinding system for patients and visitors characterized as an “Indoor GPS.”

“Right This Way” facilitates patients’ and visitors’ efforts to find their way around the hospital. It offers detail-rich indoor maps, turn-by-turn indoor navigation, parking help and more on cell phones, kiosks, and on Mercy Health’s website.

“We’re always looking to improve the experience of both our patients and visitors, and we launched the app to guide you to the department or room you want to visit, remember where you parked, and help reduce missed or late appointments,” Pat Davis-Hagens, Mercy Health Central Market President and CEO, tells would-be users of the system.

“Right This Way” runs on the MediNav Navigator v. 2.0 system from New York City-based Connexient Inc., which employs Bluetooth low-energy beacons and handset sensor fusion technology.

According to the company, MediNav features include:
• turn-by-turn indoor navigation with indoor positioning accuracy of one to two meters, navigation cues, visual landmark references, off-route notification, and more
• a “My Car Saver” feature that saves visitors’ parking locations and guides them back to their cars when they are ready to leave the hospital
• an “all screens solution” that enables patients and visitors to access information anytime and anywhere across mobile and desktop web platform as well as at three, touch screen kiosks located in Mercy Health – Cincinnati hospital
• outdoor, indoor, campus-wide wayfinding that guides users across the entire hospital campus, including the hospital itself and Mercy Health Physician practices located both at the hospital and in The Jewish Hospital’s medical office buildings across the street from the hospital.

The MediNav HTML5 Application Suite features integrated links to Google Navigation and supports automatic transitions between mobile devices operating that app to indoor navigation systems such as installed at Mercy Health.

The “Right This Way” app links to whatever GNSS-based navigation app operates on a user’s mobile phone, says Craig Schmidt, chief operating officer of Jewish Hospital, who led the team that worked on the mapping system.

On a smartphone, which must have the Bluetooth function activated, the app can audibly tell users which way to turn. Right This Way can use the hospital’s guest Wi-Fi system or the phone’s cellular data, Schmidt says.

A provider directory in the app lists the names of doctors and nurses at Mercy Health – Jewish Hospital and can display their photos and office locations.

APPLICATION DEVELOPMENT

Corporate Profile

Talen-X brings a breath of fresh technology to the field of Global Navigation Satellite Systems (GNSS). Talen-X enhances their customer success by providing the highest quality products at the best value reducing cost, risk, and schedule. Products include test tools such as BroadSim [Redefining the GNSS Simulator market], PANACEA [Automating Test control and reporting], RxStudio [GNSS receiver control and data collection], Panorama [GNSS test data reduction and analysis], as well as operational tools like BroadSense [GPS jamming and spoofing detection sensor], BroadShield [Embeddable GPS jamming and spoofing algorithms], and Valiant153M [GB-GRAM / M-code test fixture]. Yesterday’s solutions won’t fix tomorrow’s problems. Our goal is to revolutionize the PNT market through better testing, resulting in better products, one customer at a time.

Learn more at www.talen-x.com.

For more information on corporate membership in the Institute of Navigation, please contact Kenneth P. Esthus at 703-366-2723 extension 1004
DC Section

The DC Section February meeting featured an overview of the ION Congressional Fellow Program presented by Kyle Wesson, Ph.D. Dr. Wesson is the ION Congressional Fellow who is currently working with Senator Richard Blumenthal, United States Senator from Connecticut. Held in the Hart Senate Office Building, Dr. Wesson’s in-depth presentation provided insight into the Fellow Program and the position’s role in supporting the legislative process.

In March, the DC Section toured the McMurdo, Inc. facilities in Lanham, Maryland, and heard a presentation on the role of PNT in the company’s work as a leader in emergency readiness and response.

Dayton Section

The Dayton Section has remained very active this year despite the fact that the chair, Major Scott Pierce, has been away since October on military assignment. Vice Chair Brian Roadruck and Executive Secretary Mark Carroll have filled in ably. There have been five meetings since October, with an average attendance of 28.

In November, Dr. Chris Bartone of Ohio University and GNSS Solutions, Ltd., described work to achieve one null for interference suppression using an amplitude and phase control subsystem on a circular four-probe-fed GPS L5 patch antenna. At the January meeting, Brian Roadruck, who is supporting the F-35 Joint Strike Fighter program as a navigation engineer, presented some of the considerations related to certifying the Joint Precision Approach and Landing System (JPALS) for active operations. The F-35 is slated to be the first platform to implement JPALS.

In February, Dr. Michael Veth, of Veth Research Associates, gave an interesting talk on High Accuracy Moving Platform Surveying for GPS-Denied Environments. The work is being performed under a Small Business Innovation Research contract, now in Phase II, with Holloman AFB. In March the Section convened at Modern Technology Solutions, Inc. to hear Ben Downing of that company describe his work evaluating a methodology for assessing the pseudo-random noise (PRN) code tracking performance of various GPS receivers.

Most recently, on April 13, the Section heard Dr. Robert Leishman of the Air Force Institute of Technology describe a Relative Navigation Approach for Vision-Based Aerial GPS-Denied Navigation, with intended application to autonomous aerial vehicles. The Section’s next meeting is planned for May 11.
Snail Mail . . . at Warp Speed

Occasionally, Canadian ION members may wish to send a letter the old-fashioned way, and what better way to indicate your pride in the field of navigation than new commemorative stamps that honor those very first navigation futurists, the Star Trek crews?

In April, Canada Post issued a set of seven Star Trek stamps that celebrate each of Starfleet’s finest leaders, dramatically depicting them with the most cunning of the adversaries they confronted on their voyages.

Two other stamps show the shuttlecraft Galileo, used for dangerous missions, and the notorious Borg Cube. The characters and their nemeses include:

- Admiral James T. Kirk with Khan Noonien Singh (Star Trek II: The Wrath of Khan, 1982)
- Captain Jean-Luc Picard with Locutus of Borg (Star Trek: The Next Generation, 1987–1994)
- Captain Benjamin Sisko with Dukat (Star Trek: Deep Space Nine, 1993–1999)
- Captain Kathryn Janeway with the Borg Queen (Star Trek: Voyager, 1995–2001)
- Captain Jonathan Archer with Commander Dolim (Star Trek: Enterprise, 2001–2005)
- The classic shuttlecraft Galileo (first appearance in Star Trek, 1966)

Mystery of the Northern Lights

Everyone thought the Northern Lights’ plasma turbulence interfered with GNSS. Not so fast — University of Bath researchers tested the proposition and found a mystery instead of an affirmation. They used co-located GNSS receivers and radar to observe the aurora in Tromso, in northern Norway, and found that turbulence did not exist: Something else was interfering with the signals.

“The experiment has provided new insights into the type of structures that cause scintillation on GPS L band signals at auroral latitudes . . . a new instability mechanism [exists] and more measurements and new theory are necessary to understand this issue,” they said. For more about the study, visit: <http://www.bath.ac.uk/research/news/2017/03/13/new-research-on-northern-lights-will-improve-satellite-navigation-accuracy>.

Mountain Bike Magnetic Mapping

A mountain bike equipped with a magnetic sensor and GPS is a cost-effective and simple way to gather ground data for regional mapping, Eos magazine reports (and it’s better than walking, . . .)

The University of Haifa and Israel’s Geological Survey designed the bike to address the limitations of the current approach employing a pedestrian field worker with a backpack and a helper. Afoot, the crew can cover just a few miles each day and “very few surveyors have the endurance of a marathoner,” Eos reported.

The field workers collect magnetic values to create maps of subsurface magnetism —magma pools and the like — that form the basis for calculating earthquake and hazard assessments.

The bike, which went through several iterations, enables a single person to gather data. It has a polypropylene pipe framework attached to the bike frame and carries the sensors at a fixed height above the ground and in front of the handlebar. The GPS antenna is mounted behind the rider, who wears a magnetic receiver strapped to his chest.

In addition to working well, the bike attracted friendly attention from the people the researcher met along the way, the developers said.
GPS ON BOARD

Tracking the Giant Iceberg

A n iceberg seven times bigger than the Berlin metro area is beginning to separate from the fourth-largest Antarctic ice shelf, Larsen C. Within the foreseeable future, it will break away.

Shaped like a table, with straight sides and a flat top, this “tabular” freshwater block of ice will be nearly 110 miles long and more than 30 miles wide.

So, what will drive this frozen mountain range, where will it float, and how fast will it melt?

Scientists have been trying to figure out what will happen to these giant icebergs for a number of years, ever since it became clear that accelerating ice melt will change the ocean’s composition and life forms in ways that will affect us all.

In April, researchers from the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany announced they had figured out how icebergs — from small ones to the upcoming mega berg — will move.

The scientists said small icebergs move with the winds and currents, but giant bergs move by their own weight, following the varying surface height of the ocean. In effect, they surf the tilted sea surface, and tend to veer to the left and stay close to the coast for a few years because of the Coriolis effect created by the rotation of the Earth. (In the Arctic, presumably they would veer to the right.)

Large icebergs can take 10 years to melt completely. If they escape the Antarctic coast, they eventually float northward, where the waters are warmer.

Once there, tabular icebergs start to melt at the bottom and, depending where they began, follow one of the four “highways” that drives all floating ice to the top of the map. One goes up the east coast of the Antarctic Peninsula, heading toward the Atlantic. A second exit opens at the Prime Meridian, on the eastern edge of the Weddell Sea. The third exit is at the Kerguelen Plateau in the eastern Antarctic and the fourth heads north from the Ross Sea.

It took more than a decade to figure out the paths of the Antarctic icebergs and their methods of locomotion.

The drift and decay of those icebergs were simulated for more than 11 years until December 2008. The scientists compared the modeled results with observed trajectories from the Antarctic Iceberg Tracking Database at Brigham Young University and with the actual tracks of smaller icebergs that had been tagged with GNSS-equipped buoys in 2000 and 2002.

Information for the new study began with the Radarsat-1 Antarctic Mapping Project (RAMP) in which a mosaic of Antarctica and the ocean around it — including iceberg sizes and locations — were created from 3,000 high-resolution Synthetic Aperture Radar (SAR) images acquired in September and October 1997.

Icebergs can cover thousands of miles before they disappear — some have been seen off New Zealand and the coast of South America.

Of course, many unexpected events can change the trajectory of any given iceberg. The upcoming megaberg could break up quickly, or run aground.

If you want an expert opinion, here’s what the lead investigator says: “If it doesn’t break up, chances are good that it will first drift for about a year through the

GPS TRACKING

A ship meets a very large iceberg — but this one is not nearly as massive as the one yet to come.

Alfred Wegener Institute photo

Trajectories for all known Antarctic icebergs, categorized by size

AWI photo

Weddell Sea, along the coast of the Antarctic Peninsula. Then it will most likely follow a northeasterly course, heading roughly for South Georgia and the South Sandwich Islands.”

Given its massive weight, the Larsen C iceberg will likely survive for 8 to 10 years; according to the computer model, that’s the maximum life expectancy for even the largest “white wanderers.”

Global Positioning System

Defense officials appear ready to buy up to 22 new GPS III spacecraft. Although three firms are now well positioned to bid on the potentially lucrative contract, the Defense Department continues to leave the contracting doorajar for newcomers, just in case.

The Air Force will release a request for proposals (RFP) later this calendar year for a fixed-price contract to begin delivering spacecraft in 2025. The winner will be announced late next year according to the RFP announcement.

Meanwhile, Raytheon expects to deliver the Block O Launch and Checkout System to the U.S. Air Force this fall as part of the GPS Next-Generation Operational Control System (OCX). Bill Sullivan, Raytheon vice-president and program manager for GPS OCX, told the recent 33rd annual Space Symposium meeting in Colorado Springs, Colorado.

OCX’s development is delivered in “blocks,” with Block 0 comprising the Launch and Checkout System to take GPS III satellites into early orbit. Block 1 is built on Block 0 and delivers the full OCX capability, which allows the Air Force to transition from its current GPS ground controls to the modernized and secure GPS OCX master control station.

Block O was originally deployed to Schriever Air Force Base, Colorado, in 2015, Sullivan said. “It’s undergoing site acceptance testing. We’re about ready to wrap [testing] up and deliver,” he said. Sullivan said that Block O will fully implement the Defense Department’s 8500 cyber security standard without any deviation.

The House passed a new Defense budget bill (HR 1301) on March 8 and sent it to the Senate. The two houses have been coordinating on the revised bill; so, it should not be controversial.

Under that agreement lawmakers fully funded the GPS program — in fact they gave it a boost to slightly more than $908 million from the Obama administration’s proposed $847.3 million. The latter figure is also the total included for GPS in the 2017 National Defense Authorization Act signed by President Obama on December 23. The act includes policy and funding guidance for the GPS program and would need to be amended to accommodate the higher spending appropriated for GPS.

The 2017 appropriations request of $34.1 million for GPS III satellites procurement was granted in full while GPS III development was bumped up by $30 million to $171.9 million.

Despite unhappiness about cost overruns, lawmakers also agreed to fully fund the Next Generation Operational Control System (OCX). That program and the GPS Enterprise Integrator received $393.3 million. The development work on Military GPS User Equipment (MGUE) was fully funded at $309 million. This appears to be a bit more than requested, but Congress did some bookkeeping cleanup, moving a little more than $30 million from other budget line items that contained MGUE monies into the MGUE line item.

BeiDou

China’s domestically produced satellite navigation system BeiDou has made significant progress in terms of its accuracy, according to reports out of China in March. At a recent press conference, BeiDou engineers claimed that a new accurate positioning chip can now help users arrive at their destinations with an error margin of just one to two meters.

Another announcement indicated that the BeiDou program China’s GNSS system will be installed in more than 10 million Chinese cars this year. In addition to the automotive industry, BeiDou expects its technology soon to be applied to several other application areas, including city management, transportation regulations, and care for the elderly.

“It is estimated that by 2018, around [more] 18 satellites will be launched, and the global network will more or less be built up. By 2020, over 30 satellites will have been successfully launched, and our BeiDou Navigation Satellite System will cover the world,” Chinese rocket scientist Sun Jiadong told the official English-language website of the China News Service (CNS), Ecns.cn.

According to Fu Yong, head of China National Administration of GNSS and Applications, the BeiDou system civil user base has exceeded 10 million. In addition, BeiDou has finalized an inspection of 18,000 kilometers of gas pipe in Beijing, as Beijing Gas Group plans to replace its former GPS system with the BeiDou system.

Beidou was also in the spotlight in the annual Government Work Report, the latest edition of which Premier Li Keqiang presented to the National People’s Congress on March 5, according to China Daily. The report addressed the promotion of high-end manufacturing and the Belt and Road Initiative, as well as helping Chinese companies to globalize their equipment and homegrown technologies.

BeiDou, a product of the Chinese National Space Administration, and managed by the China Satellite Navigation Office, plans to accelerate its expansion into economies along the Belt and Road Initiative as China plans to launch six to eight BeiDou satellites this year.
This go-global strategy is part of China’s broad plan to build a navigation system with a constellation of 35 satellites by 2020. The system currently only provides full operational capability over the Asia Pacific region.

**GLONASS**

Roscosmos, the Russian Federal Space Agency, plans on building dozens of GLONASS ground facilities in more than 30 countries to monitor the GNSS system’s satellite constellation, according to the company’s deputy director general, Sergey Savaliev.

In an interview with RIA Novosti news agency, said the GLONASS program would establish the stations in Kazakhstan, Belarus, Armenia, China, India, Vietnam, Cuba, Spain, Argentina, Ecuador, Venezuela, Mexico, Indonesia, and Sweden to monitor and upload corrections to the satellite signals. At present, only eight GLONASS stations are operating outside the Russian Federation territory: four in Brazil, three in Antarctica, and one in the Republic of South Africa.

On April 7, Russia announced the opening of another monitoring station near Managua, Nicaragua.

New GLONASS satellites will be transmitting a new encoded signal, according to Mikhail Khailov, the deputy CEO of Roscosmos.

The manufacturer, ISS Reshetnev, has seven GLONASS-Ms in storage of which six will have an encoded CDMA navigation signal added to the L3 frequency,” he said.

Currently one GLONASS-M satellite and two new generation GLONASS-K satellites transmit the CDMA signal.

**Galileo**

In early April, for the first time, European Union (EU) officials presented keynote addresses at the 33rd Space Foundation Space Symposium, perhaps the world’s premier space conference, to report on progress of the EU’s flagship space programs — Galileo, EGNOS and Copernicus.

Elżbieta Bieńkowska, EU Commissioner for Internal Market, Industry, Entrepreneurship and SMEs, became the first European Commissioner to address the Space Symposium declaring that “space matters for Europe,” according to a news report from the European GNSS Agency (GSA).

“We are delivering on clear priorities,” said Bieńkowska. “Galileo went live last December and Europe has now joined the club of providers of global navigation services. In 2016, we launched six Galileo satellites that built on the six the year before. . . . We are ready to grasp the full opportunity of space, not only for economic returns, but also for a better world.”

On behalf of the EU, representatives from the European Commission and the GSA communicated the progress and next steps of Galileo, EGNOS and Copernicus. In addition to notable presence throughout the speaker agenda, the EU was represented at the Symposium exhibition.

The four-day space conference attracted more than 10,000 attendees, 180 exhibitors, and space, government and defense officials from more than 30 countries.

---

### Calendar of Upcoming Events

**JUNE 2017**

- **5-8:** ION JNC 2017, Dayton Convention Center, Dayton, Ohio  
  **Contact:** The ION  
  **Tel:** +1 703-366-2723  
  **Web:** www.ion.org

- **21-23:** TransNav 2017, Gdynia, Poland  
  **Contact:** The Gdynia Maritime University  
  **Tel:** +48 58 5586136  
  **Web:** www.transnav2017.am.gdynia.pl

**SEPTEMBER**

- **4-15:** ESA/JRC International Summer School on GNSS 2017, Longyearbyen, Svalbard-Spitsbergen, Norway  
  **Contact:** Bundeswehr University Munich, Germany  
  **Tel:** +49 89 6004 3425  
  **Web:** www.esa-jrc-summerschool.org

- **25-29:** ION GNSS+ 2017, Oregon Convention Center, Portland, Oregon  
  **Contact:** The ION  
  **Tel:** 703-366-2723  
  **Web:** www.ion.org

**NOVEMBER**

- **28-30:** International Navigation Conference (INC)  
  **Contact:** Royal Institute of Navigation (RIN)  
  **Web:** http://www.internationalnavigationconference.org.uk  
  **Email:** conference@rin.org.uk

---

**JANUARY - FEBRUARY 2018**

- **Jan. 29-Feb. 1:** ION International Technical Meeting (ITM) & ION Precise Time and Time Interval Meeting (PTTI) 2018, Hyatt Regency Reston, Reston Virginia  
  **Contact:** The ION  
  **Tel:** +1 703-366-2723  
  **Web:** www.ion.org

**APRIL 2018**

- **16-20:** ICASC International Flight Inspection Symposium, Hyatt Regency Monterey, Monterey, California  
  **Sponsored by the International Committee for Airspace Standards and Calibration (ICASC) Hosted by ION,**  
  **Contact:** The ION  
  **Tel:** +1 703-366-2723  
  **Web:** www.ion.org

- **23-26:** IEEE/ION PLANS 2018, Hyatt Regency Monterey, Monterey, California  
  **Contact:** The ION  
  **Tel:** +1 703-366-2723  
  **Web:** www.ion.org
June 5-8, 2017

Tutorials: June 5
Show Dates: June 6-7
Dayton Convention Center
Dayton, Ohio

“Military Navigation Technology: The Foundation for Military Ops”

The Classified Session will be held June 8 at the Air Force Institute of Technology

www.ion.org/jnc