Defense Matters

Train as You Fight

A Challenging Requirement for GPS

The DoD considers GPS interference testing on its U.S. test ranges to be important for warfighters to understand: how systems will function when confronted with interference; how to recognize interference when it is occurring; how to locate the source of interference; and how to develop tactics, techniques, and procedures to successfully complete a mission when GPS is no longer available.

Dealing with the challenges of locating the source of GPS interference, whether intentional or unintentional, is "in the news" as incidents of reported jamming have escalated over the last 15+ months.

Reports of interference in Europe were observed in March 2022 along the Finnish/Russian border. More recently there are a growing number of reports linked to the on-going Russian conflict in Ukraine.

Here in the U.S., noteworthy interference occurrences include those reported around the Denver Airport in January 2022, as well as the Dallas-Fort Worth International Airport experience of having a runway closed and having to reroute air traffic for nearly two days in October 2022.

Eurocontrol Activity On Testing

What is not so commonly available is information on how authorized agencies and organizations go about the process of gaining approval to intentionally radiate interference in the GPS (GNSS) bands within the Continental U.S. (CONUS) so that testing, training, and exercises in the presence of interference can be conducted.

As a representative non-U.S. example of such GNSS test procedures, in early March 2023, EUROCONTROL published a document titled EUROCONTROL Guidelines on a Process for Civil and Military GNSS Interference Testing, Edition No. 2. This document can be found on EUROCONTROL's web site at https://www.eurocontrol.int/publication/eurocontrol-guidelines-process-civil-military-gnss-interference-testing.

The Executive Summary of the guideline emphasizes: "This document describes a process on the planning, notification, and execution of GNSS interference testing activities, to minimise their impact on aviation."

It also states "This document may be applied by any state authorised entity performing GNSS interference tests, such as military, police or customs."

The guideline suggests that any state authorized entity performing GNSS interference test should include an INTERRUPTION procedure "… to halt immediately the GNSS interference testing when unforeseeable events occur, such as reported impacts on airspace users beyond the specified interference range causing hazardous situations."

As the guideline's source is EUROCONTROL, the process it describes is aviation focused and it notes that the "…impact of GNSS interference testing on other user segments (e.g., maritime, terrestrial) is not addressed in this document as they should be alerted through the GNSS users support services (the European GNSS Service Centre (GSC) for GALILEO users, the Navigation Center of the US Department of Homeland Security (NAVCEN) for GPS users…"

FAA's Role in Testing

Here in the U.S. the Federal Aviation Administration (FAA) has a coordination process that is reported to be contained in FAA JO Order 7610.4 Special Operations. A Google search for the document indicated that it contains Sensitive Unclassified Information (SUI) and is only available on a need-to-know basis to the military, government employees, contractors, and grantees.

The FAA's April 20, 2023, Aeronautical Information Manual, Official Guide to Basic Flight Information and ATC Procedures notes that "Recognizing that GPS interference and test events resulting in the loss of GPS services have become more common" the FAA continues to require operators "conducting IFR to retain a non-GPS navigational capability to either DME/DME, IRU, or VOR for enroute and terminal operations, and OR and ILS for final approach."

Although official statistical information regarding the number of DoD initiated interference tests requested, and ultimately approved, cannot be found with internet searches, it is intuitively obvious that the number of tests over the last few years has been rising significantly.

One available source of information on the number of test/training events indicated that in 2012 there were 41 approved tests, and by 2017 the number had grown to 128. As one might expect, the number fell off during the COVID pandemic, but it is now reported to be approaching 200 or more per year.

Doug Taggart
President
Overlook
Systems
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DOD Processes

Within the DoD, the process to request and gain approval to conduct GPS interference testing is contained in a Chairman of the Joint Chiefs of Staff Manual. Per the Manual, USSTRATCOM must approve all requests for GPS L1 and/or L2 band interference testing prior to engaging in national level coordination via an interagency approval process. In that process, the DoD coordinates test/exercise times and locations with the FAA for interference affecting civil aviation traffic in the National Airspace System (NAS).

Once again, official statistics on how many events are entered into the interagency approval process but not approved are not openly available; nor is information about how long it takes to gain approval through that process.

In an attempt to generate a tally of how many approved events there have been in the NAS for a particular year, one might consider that any approved event would include an issued FAA NOTAM. In an attempt to gather up this data, the FAA's online NOTAM service, e.g., https://notams.aim.faa.gov/notamSearch/ seemed like a logical source. However, it turned out to not be convenient for requesting information on a focused search such as listing all GPS interference NOTAMs issued across the NAS for a particular period (a year).

Similar to the information in the EUROCONTROL guideline, all approved DoD CONUS interference tests include a mandatory CEASE BUZZER notification process for safety-of-flight or safety-of-life purposes. Activating the CEASE BUZZER immediately terminates interference transmissions on notification from the FAA's air traffic control system, based on real time civil pilot reporting of adverse interference effects.

Again, official information on how often a CEASE BUZZER is experienced isn't openly available, but when it does occur, it is safe to assume that months of planning as well as significant test range and military aviation test execution resources will have been lost. In addition, that does not even consider the impact to warfighter training and readiness and other program delays when tests and exercises must be rescheduled.

Civil and Military Cooperation Opportunities

Here, the EUROCONTROL guideline is interesting because it refers to interference testing for "Civil and Military" purposes. And now here in the U.S. the requirement for "civil" interference testing appears to be growing.

For example, Executive Order 13905 of February 12, 2020, Strengthening National Resilience Through Responsible Use of Positioning, Navigation, and Time Services assigns to the Department of Homeland Security the requirement "to develop a plan to test the vulnerability of critical infrastructure systems, networks,

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Calendar of Upcoming Events

SEPTEMBER 2023

5-8: The 2nd International Symposium of Commission 4: Positioning, the Wissenschaftsetage Potsdam, Germany

Contact: International GNSS Service (IGS)

Web: www.iag-commission4-symposium2022.net

11-15: ION GNSS+ 2023, Hyatt Regency Denver at Colorado Convention Center, Denver, Colorado

Contact: ION

ion.org

JANUARY 2024

22-25: ION International Technical Meeting (ITM) & ION Precise Time and Time Interval (PTTI) Meeting 2024, Hyatt Regency Long Beach, Long Beach, California

Contact: ION

ion.org

MARCH 2024

20-22: Munich Satellite Navigation Summit 2024, Alte Kongresshalle, Munich, Germany

Contact: Munich Satellite Navigation Summit

https://www.munich-satellite-navigation-summit.org/

APRIL 2024

15-18: ION Pacific PNT, Hilton Waikiki Beach, Honolulu, Oahu, Hawaii

Contact: ION

ion.org

JUNE 2024

3-6: ION Joint Navigation Conference (JNC) 2024, Northern Kentucky Convention Center, Greater Cincinnati Ohio Area

Contact: ION

ion.org

SEPTEMBER 2024

16-20: ION GNSS+ 2024, Hilton Baltimore Inner Harbor, Baltimore, Maryland

Contact: ION

ion.org

OCTOBER 2024

28-31: International Association of Institutes of Navigation (IAIN) 18th World Congress, Beijing, China

Contact: IAIN

https://www.iainav.org

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and assets in the event of disruption and manipulation of PNT systems."

Additionally, at the most recent PNT Advisory Board meeting held on May 3, 2023, a Department of Transportation presentation titled DOT System-of-Systems Interference, Detection, and Mitigation referred to the Defense Innovation Unit's Harmonious Rook project involving the use the billions of distributed, networked GNSS devices as sensors to generate an accessible common operating picture to detect and locate GNSS disruptions.

Both initiatives support the need for further civil/military cooperation on interference testing planning and execution that may result in the sharing of approved test events that will benefit both national security objectives, e.g., 1) train the warfighter; and 2) strengthen national PNT resilience for civilian critical infrastructures such as transportation. One can only hope that the obvious benefits to both can be achieved.

Historian
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proach to relativistic issues; rather than waiting for the theoreticians to have a consensus on the formulations, they marched ahead based on the ultimate GPS position solutions being accurate.

(3) What about the effect of Earth's rotation during the approximate 40-milliseconds of signal transit time from the GPS satellite to the user equipment on or near the Earth's surface? I began to study this effect and pondered whether it was part of relativity. I learned that this effect was called the Sagnac effect. I furthermore learned that this phenomenon was named after Georges Sagnac (b. 1869-d.1928), a French physicist who was an ardent anti-relativist, perhaps as a concession to the rising tide of antisemitism in France. I pondered if the Sagnac effect was part of the Doppler effect, special, or general relativity and contemplated if and how the SSG should account for the Sagnac effect.

When my personal involvement with the SSG ended in 1994, I never was sure that relativistic and/or Sagnac effects were correctly implemented, and I was only sure that I would not be the one to prove or disprove their validity.

On a somewhat more positive note, I recently did find an outstanding person, who unlike Willie Mays or Albert Einstein, I could at least strive to emulate. He or she will be the subject of the next newsletter article.

The following references and links were used in the preparation of this article:

Ashby, N. (2004). The Sagnac effect in the global positioning system. In: Rizzi, G., Ruggiero, M.L. (eds) Relativity in Rotating Frames. Fundamental Theories of Physics, Vol 135. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-0528-8_3

DiEsposti, R., Fliegel, H., GPS and relativity: An engineering overview, Proceedings of the 28th Annual Precise Time and Time Interval Systems and Applications Meeting, December 3-5, 1996

Ashby, N., and M. Weiss, "Global positioning receivers and relativity," NIST Technical Note 1385, U. S. Government Printing Office, Washington, D.C., March (1999)

The Sagnac effect and its interpretation by Paul Langevin - ScienceDirect

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