View from America: Strengthening PNT Resiliency
Remarks for the Royal Institute of Navigation

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Introduction

It is an honor and a privilege to be speaking to the Royal Institute of Navigation in this beautiful city, the home of Adam Smith. Adam Smith, who wrote widely about the benefits of trade, would certainly appreciate the invisible hand of Global Navigation Satellite Systems that help move global goods to their final destinations.

I speak officially, and in friendship, as a like-minded partner, to your noble goals. The Royal Institute's very charter speaks of its aims as "charitable – to promote knowledge in navigation and its associated sciences, including positioning, timing, tracking and conduct of a journey [by] land, sea, air or space."

It is this great good of the Global Positioning System which informs my remarks: its strengths and its vulnerabilities; its growing economic importance; and our essential collaborations ahead.

Before I speak about PNT, spectrum bands, and transmitter power levels, please permit me some poetic license. Our technologies –for all their technicalities – lend themselves to wonder and inspiration, like that only the best and the brightest can provide. Our systems are named for explorers and scientific geniuses – Galileo for the European Union Navigation satellite system and the NASA probe to Jupiter. And Magellan for the second GPS III satellite and the NASA probe to Venus.

In The Tempest, Shakespeare's Prospero speaks of "The cloud-capp'd towers, the gorgeous palaces, /The solemn temples, the great globe itself…"

Prospero's link to Prosperity, and his reference to "the great globe itself," is no coincidence. With wonder we see how GPS can measure mathematically and precisely to help us navigate our earthly journeys as much as our space explorations, increasing the wealth of nations.

Considered as a whole, GPS is one of the great heroic systems of our times: a monumental human scientific and technical effort that has transformed culture, politics, and society.

GPS

As all of you know better than anyone else, a lot of the work in research and technology at the Transportation Department, under the leadership of Secretary Elaine L. Chao, assumes the existence of GPS. It assumes that GPS will continue to work, sight unseen, without interference.

Practically everything done in my Office of Research and Technology benefits from GPS. The reliability and ubiquity of GPS have transformed society, but created a world where the public understands GPS technology as little more than an invisible hand guiding our wanderings in work and leisure. Daily uses are of course critical, but consider the serious and profound transformations and uses of GPS.

A recent Department of Commerce study found that GPS enabled more than $1trillion (£775 billion) in economic benefits in the States between 2007 and 2017. A 30-day loss of GPS could cause as much as $45 billion, or (£35 billion) in economic harm in the State if the 30-day outage hits during critical agriculture planting season and have serious safety of life implications.

GPS plays a vital role in achieving the Transportation Department's most important goals: Safety, Infrastructure, and Innovation.

In terms of safety, the aviation industry heavily relies on GPS-based navigation systems, as do positive train control, first responders, coordination of disaster response and relief, and geofencing.

GPS revolutionized the maritime industry by enabling us to track ships around the world, increasing safety in the industry and lowering the cost of trade.

In terms of infrastructure: GPS is used to guide machines doing surveying and construction at building sites, leading to large cost savings. New digital-assisted technology is common in vertical building sites, such as large buildings, and we hope that it will become more common in horizontal building sites, such as highways, tunnels, and bridges.

In terms of innovation: Unmanned aircraft and autonomous vehicles rely on GPS.

And, on the more pedestrian level – pun intended, ride share services such as Uber and Lyft, and the revolution in micro mobility—app-based scooter, bikes, and Vespa rentals—are based on GPS.

The Air Force has made GPS technology so reliable that it is now ubiquitous. It has enabled applications we never would have envisioned.

The Transportation Department has long been the civil lead on GPS, and partnership with the Air Force has been crucial to doing this successfully. The Transportation Department provides funding to the Air Force to monitor civil GPS signals. It funded implementation of the new L1C, a civil GPS signal that is placed on GPS III satellites, the newest generation of GPS satellites, to be interoperable with the EU Galileo constellation broadcasting the same signal. This just started launching on the new GPS III satellites.

In August the Air Force launched the second GPS III satellite (known as Magellan) at Cape Canaveral Air Force Station. It will join the current GPS constellation of 31 operational spacecraft.

With a third GPS launch (known as Columbus) planned for early next year, the United States continues to try to expand the boundaries in position, navigation, and timing services.

Threats to GPS

As technology advances, and GPS becomes essential in global and political life, so do the number of threats facing GPS. Two of these are jamming and spoofing.

Jamming has long been a threat to GPS. NATO military drills in the Baltic Sea last year, with 40,000 troops and all 29 countries participating, experienced GPS jamming.

Spoofing is also a problem. It was discussed in a report by the Transportation Department's Volpe Center back in 2001—18 years ago—on the vulnerability of transportation infrastructure and its reliance on GPS.

Spoofing was discounted as a realistic threat for many years because it is complicated to perform. However, high-profile demonstrations at the University of Texas that spoofed a drone and a £62 million yacht, brought spoofing into the public eye a little more than a decade after the Volpe Center issued its report.

As anyone knows who has watched "child's play" take on new meaning among tech-savvy youth, teenagers have figured out ways to spoof GNSS using chips in their phones in Pokemon GO, an app-based augmented reality game based on GPS.

If teenagers have figured out how to spoof the GPS on their phones to play Pokemon, others with more malicious intentions most certainly have done the same.

The rise of the low-cost software-defined radio has enabled, if not "spoofing for everyone," spoofing for many tech-oriented teens. This is a radio that can operate in a lot of different bands, rather than being limited to one. Today, the tool of choice for the casual user is often the HackRF or bladeRF. People can buy small software-defined radios that cost around £155 with open-source GPS simulation software, and they have a basic spoofer.

The 2017 incident in the Black Sea in which over 20 ships reported their positions inland at an airport was likely a spoofing attack. The number of separate vessels that reported the same false position and the characteristic jumping between the false and true position of the ships is strong evidence of a large-scale spoofing attack.

One likely explanation for spoofing of vessels in the Black Sea is drone defense. Many drones have geofencing logic that requires them to land if they are over an airport. This would be a logical way to spoof drones to prevent surveillance.

GPS interference and spoofing have been confirmed in the Persian Gulf and Strait of Hormuz, where the British vessel was lured into Iranian waters.

Backing Up GPS

Under National Security Presidential Directive 39, issued in December 2004 and still in force, the United States is committed to developing, maintaining and modernizing GPS, including providing a backup capability in the event of a GPS disruption.

The directive gives the Transportation Department lead responsibility over the full range of civil uses of GPS, and, along with the Defense Department, it makes our Department co-chair of the National Space Based Positioning, Navigation, and Timing Executive Committee. We are working closely with DHS and the federal departments and agencies to address policy and technical issues, including the security of resilience of GPS receivers.

There are three major categories of things we need to do to protect GPS.

First, we need to protect GPS from harmful interference, including interference from adjacent frequencies.

Threats to radio frequency bands adjacent to GPS pose a serious problem for GPS. The Transportation Department is committed to protecting the spectrum needed for reliable use of GPS.

The Transportation Department's Adjacent Band Compatibility assessment is the only validated test to determine degradation at various received power levels, according to the National Space-Based PNT Engineering Forum.

The FCC is also considering a request by Robert Bosch LLC to modify tough restrictions on devices and systems relying on Ultra-Wideband technology. The restrictions were originally set in place partly because UWB devices might interfere with GPS receivers. The Transportation Department is monitoring this issue.

Second, we need to toughen receivers. GPS receivers require cyber security.

Third, the Department is seeking to augment GPS capability through use of alternate Positioning, Navigation, and Timing technologies.

In September, the Department announced an opportunity for technology vendors to participate in the demonstration to examine possible technologies to augment the GPS system. Earlier this month our Volpe Center awarded 11 contracts to technology vendors to participate in a demonstration of GPS Backup/Complementary PNT technologies. The Department intends to conduct a demonstration of these technologies next March.

This effort will inform implementation of a system that by law is required to be terrestrial, wireless, have wide area coverage, be difficult to disrupt, and be capable of expansion to provide positioning and navigation services.

The Department is seeking the best solutions to ensure that America has a combination of PNT systems which, when used together, will be difficult to disrupt. These solutions include the use of multi-GNSS systems to improve accuracy, availability, and integrity of satellite-based solutions, as well as terrestrial and self-contained solutions (e.g., clocks and inertial navigation systems).

Conclusion

GPS has become an invisible hand on which many of our technologies depend. You don't get a bill for it, as you get a bill for electricity, water, natural gas, Internet, and phone, but it is there for you anyway.

The use of GPS, along with other satellite navigation systems, will become even more important in the coming years than it is today. Technology is developing so fast that a dedicated GPS receiver sounds as old-fashioned as a pager. GPS is now built into cars, mobiles, tractors, electric logging devices for lorries, and this groundbreaking shift continues to have political implications.

The autonomous vehicles and unmanned aircraft that are being developed will rely heavily on GNSS. Building augmented capabilities utilizing other PNT technologies in conjunction with GNSS will ensure that our new technologies don't need to be retrofitted in the future.

The Department will continue to work on critical research such as the adjacent band study and complementary PNT in conjunction with other government departments and industry.

President Trump's top priorities are national and economic security. We cannot have GPS signals be a single point of failure for transportation and other critical infrastructure sectors.

More safety applications will depend on PNT in the future. Public confidence in these will be critical. People will not be comfortable getting into an automated vehicle or with platooning driverless trucks heading down the highway if they think that their invisible hand is not reliable and that their GPS might be spoofed.

Getting public adoption of other PNT capabilities—space-based, terrestrial, and self-contained—integrated with GPS technology will be critical to the success of any such system.

This means increasing public awareness of the many dependencies we have on GPS and some of the vulnerabilities the system faces—and addressing these vulnerabilities. I hope that we can all join together to accomplish this for the prosperity of Shakespeare's "great globe."