

## EMERGING TECHNOLOGY SNAPSHOT

# POSITIONING, NAVIGATION AND TIMING TECHNOLOGIES

The Global Positioning System (GPS) is indispensable to the military and other industries for precise positioning, navigation and timing (PNT). However, satellite signals are increasingly vulnerable to accidental or intentional interference and are generally unavailable in certain locations, such as indoors, underground or underwater. Additionally, satellites are susceptible to damage or destruction by space debris or attack. Consequently, transitioning to non-GPS dependent solutions for PNT is essential to ensure resilience of existing and future civilian and military platforms.



## ENABLING SCIENCE AND TECHNOLOGY

### Signals of Opportunity

Signals of opportunity are the hundreds of other signals in the airspace (such as cellular, TV, Wi-Fi and Bluetooth) that can be used for positioning and navigation in GPS-challenged environments.

### Bio-inspired Navigation

Animals like bats and honeybees are excellent navigators and are skilled at avoiding collisions and maneuvering through narrow passages. Research aims to adapt these abilities to human-made systems.

### Quantum Positioning

Quantum technology will bring unprecedented sensitivity to gravimeters, accelerometers, magnetometers and other sensors, which will enable applications such as long-distance inertial navigation, quantum compasses and the most accurate atomic clocks ever produced.

### Celestial Navigation

The practice of using the sun, moon, planets or stars for terrestrial positioning has been around for centuries, but recent advances have enabled the development of systems that can be implemented in portable devices like smartphones.

### Integrated Systems

A "one size fits all" PNT solution that meets every need and is immune to every threat is not yet on the horizon. As a result, hybrid systems are the focus of a significant amount of R&D, such as techniques that fuse various sensor modalities to take advantage of the best aspects of each (for example, integrating GPS with an inertial sensor).

**"We are spoiled because space was a benign environment and GPS was always there. We can't assume that anymore. We have to train for a GPS denied environment and build resilient systems to have the capability to fight in any conditions."**

General John Hyten, Commander, USSTRATCOM, November 2018.

## SIGNALS

### Academic



Organizations from China and the U.S. dominate the PNT R&D landscape. In Canada, the leading institutions (per publication volume) are the University of Calgary, the Royal Military College and Queen's University.

### Government



Critical infrastructure depends on assured PNT. In January 2015, GPS satellites went out of sync for 13 millionths of a second, affecting the power grid and causing police, fire, and EMS radio equipment to fail.

### Collaboration



Apple and the U.S. Navy have collaborated on patent for a navigation system that uses a combination of GPS, dead reckoning and low-earth satellite data to create a highly-accurate and reliable mobile navigation solution in environments where GPS is unavailable.

### Defence



DARPA is investigating photonic integrated circuits (PICs) as a GPS-free means of PNT. PICs show promise as a compact, high-precision alternative to existing large atomic clocks and gyroscopes.

### Corporate



PNT is not only a tool of the military. Sectors such as communications, agriculture, energy, transportation and financial services are heavily reliant on precise and robust PNT technology.

**"PNT does not have a single technology product solution. Instead, it will require a flexible, incremental solution that incorporates new technologies as threat conditions become more challenging."**

Mark Johnson, Collins Aerospace. *Jane's International Defence Review*, April 2019.

## IMPACT



### Social

From finding a local restaurant to receiving emergency road-side assistance, PNT systems are integral to everyday life and will provide the foundation for future technologies such as fully-autonomous vehicles.



### Policy

The increasing civilian dependence on PNT has important economic and national security implications. In February 2020, the first U.S. federal policy on PNT was established to promote the responsible use of PNT services by both government and industry.



### Economic

The world's economy depends heavily on GPS and other satellite positioning systems. A recent study sponsored by the U.S. National Institute of Standards and Technology estimated that a 30-day outage would cost \$1 billion per-day.



### Environmental

GPS is essential to environmental applications such as mapping wetlands, assessing forest-fire damage and locating abandoned storage tanks. Farmers use GPS to monitor soil conditions and map pest, insect, and weed infestations in their fields.



### Defence

The military's reliance on PNT is ubiquitous. Vehicle navigation, positioning of ground forces and the precise guidance of missiles all depend on reliable and accurate PNT.

**"It is apparent that the long-term, global disruption of GPS capabilities would have wide-ranging negative impacts on the global economy and the daily lives of people around the world."**

U.S. Department of Homeland Security, April 2020.

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Produced in partnership by the National Research Council and Defence Research and Development Canada.

**Derived from:**  
Culhane, M. *Scientometric Study on Positioning, Navigation and Timing (PNT) Technologies*. December, 2020.

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PDF: Cat. No. NR16-341/2021E-PDF  
ISBN 978-0-660-37596-0

022021 • Également disponible en français