Protecting Critical Infrastructure: Augmenting GPS with the Broadcast Positioning System™ (BPS)

A Complementary Augmentation to GPS for Position, Navigation and Timing

How PNT Powers our World

Position, Navigation and Timing (PNT) is vital to our economic and national security. Virtually every person uses the Global Positioning System (GPS), the U.S. version of the Global Navigation Satellite System (GNSS), making it the most popular form of PNT. U.S. taxpayers fund the operation and maintenance of GPS, which has proven to be an ultra-reliable broadcast service that is freely available with no end-user subscription fees. These positive attributes have encouraged wide adoption of the system, and GPS receivers have been built into over 7 billion devices, including cars, boats, planes, phones, watches and more.

GPS satellites continuously broadcast time and their locations in space. A signal from one satellite can reveal the time at a known location. By utilizing signals from multiple satellites, it is possible to determine the correct time and the user's position through a technique known as pseudo-range multilateration. Accurate navigation is achieved by continuously monitoring these signals and computing positions in real time. Everyday applications and services like Google Maps, Waze, Uber, Lyft and DoorDash all rely on GPS, and these services could not function without it.

But GPS has uses that go far beyond replacing paper maps for navigation. Modern society and its industries, including critical infrastructure in the U.S., have become overly dependent on GPS to enable those uses. For example, adding a new electric generation plant (nuclear, solar, wind, coal-fired, etc.) to the power grid requires GPS time for synchronization. Cell sites must also be time-synchronized or mobile phones would stop working. Every stock trade must be accurately timestamped to meet government requirements; trading will otherwise be suspended without accurate time. Each of these industries and many more rely not on position or navigation, but on the fundamental service provided by GPS: accurate time.

Some of the critical infrastructure and services that rely critically on accurate time.

The Dangers of Relying Only on GPS

The main vulnerability of GPS is that its satellites orbit the Earth tens of thousands of miles above ground, operate at low power and broadcast on known frequencies. By the time they reach the Earth's surface, GPS signals are weak and can be impacted by radio noise or even solar flares. GPS jammers are easily available (even on Amazon), and America's adversaries routinely operate sophisticated "spoofing" equipment that can make the operator of an airplane or ship think it's someplace that they are not. There have been numerous cases of localized GPS outages, both intentional and unintentional, that have closed airport runways, affected navigation of cars and agricultural equipment and shut down air travel to entire cities.

From a military perspective, GPS satellites have been described as "juicy targets," and Russia and China have both demonstrated weapons capable of destroying satellites.

The reliance of U.S. critical infrastructure on time distributed by GPS satellites presents an incredible and increasing risk for the country. Recognizing these threats, President Trump issued Executive Order 13905 in 2020, directing the government to find a backup system to GPS to protect the U.S. In 2021, National Space Policy Directive 7 further reinforced the executive order.

In July 2024, the National Security Space Association (NSSA) issued a report that calculated the economic risks of a potential GPS failure:

> *"GPS is essential to America's society, economy, and security. It is relied upon by all sixteen critical infrastructure sectors and enables Americans' way of life. The economic value of GPS to the nation is trillions of dollars and the impact of its disruption or loss is incalculable."*

NSSA noted that a GPS outage would set back civilization more than 100 years and also stated:

> *"DoT, DHS, and DoC should work with the private sector to develop, field, operate, and sustain multiple complementary terrestrial PNT services. The first step, which should be achieved as soon as possible, is the acquisition of such services to protect federal systems and applications."*

Broadcasters have a long history of collaborating with the government on critical communication services, such as the Emergency Alert System (EAS), and the BPS is a terrestrial PNT service that can be a new addition to this collaboration.

How BPS Can Augment GPS

BPS is a new method of determining time and position using broadcast television signals. BPS was invented by technologists at the National Association of Broadcasters (NAB). Just like broadcast television and GPS, BPS signals are freely available with no end-user subscription fees.

Unlike a GPS satellite in space, BPS signals broadcast from a TV tower on the Earth's surface to transmit time from a known location. BPS relies on modern broadcast television infrastructure using ATSC 3.0, an international standard from the Advanced Television Systems Committee, and as a broadcast service it requires only a passive receiver to use (no internet or other two-way connection is required) and can support an unlimited number of simultaneous users.

Importantly, ATSC 3.0 has been deployed or is being adopted in other strategically important countries that have shown interest in BPS, including South Korea, Brazil and India.

Because television stations operate at very high-power levels and are located close to the Earth's surface, TV signals are exceptionally strong and nearly immune to the sorts of interference and spoofing that plague signals from GPS satellites. Additionally, unlike GPS which uses a single frequency (at least for consumer use), TV signals operate on a variety of frequencies, spanning 210 Megahertz (MHz) of spectrum over 35 6-MHz channels, making it extremely difficult to jam. BPS operates entirely independently of GPS, relying on government-recognized timing sources with atomic clocks for backup.

BPS also relies on ATSC 3.0's datacasting and configurable quality of service capabilities. The "Bootstrap" signal within ATSC 3.0 acts as a time marker and the "Preamble" carries the timestamp. The bootstrap and preamble are the most robust parts of the ATSC 3.0 signal and are detectable at 12 dB and 9 dB below the noise floor. Other components of BPS are carried in a robust physical layer pipe (PLP), which is also usable below the noise floor, and includes the precise location of the TV station's transmitting antenna to calculate the transit time to the BPS receiver. The BPS signal is very efficient and uses only a tiny fraction of the total bandwidth available in ATSC 3.0, so TV stations can simultaneously transmit ultra-high-definition video programming and other data without degradation.

The initial core capability of BPS will be providing accurate time at known locations of critical infrastructure, such as electric power generating stations, cell towers, data centers and stock exchanges. Because these locations are accurately known, this timing capability requires only a signal from a single BPS-enabled TV station. However, reception of signals from multiple TV stations provides redundancy. As BPS rolls out, the signals from multiple TV stations can also be used to independently determine the position of a user, similar to how GPS does today.

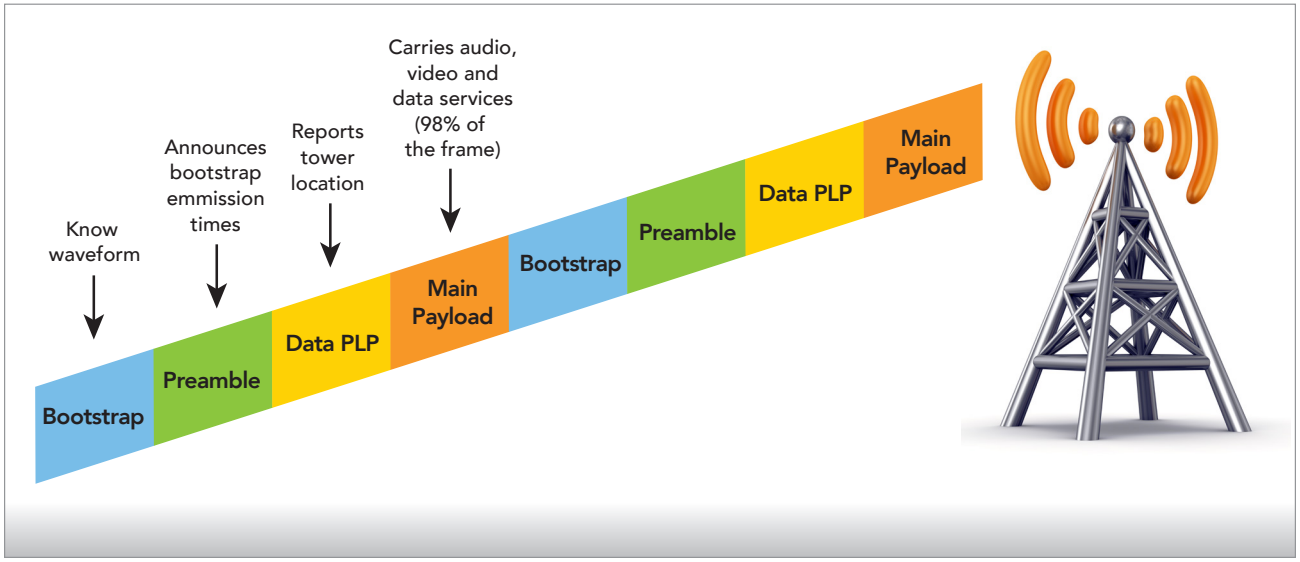

Figure 1: BPS signaling within the ATSC 3.0 frame.

BPS-enabled TV stations monitor the signals of neighboring TV stations and broadcast the measurements as BPS data. This allows cross-verification of signal integrity at the receiver. Moreover, BPS-enabled TV stations can derive timing information from neighboring TV stations as backup. This neighbor measurement broadcasting feature will make BPS a nationwide, GPS-independent and self-synchronizing network when ATSC 3.0 and BPS are fully deployed.

Because BPS operates independently of GPS, the two services can be hybridized so users can compare the two signals to detect degradation or intentional jamming or spoofing of the GPS signal. Even when GPS is operating normally, BPS can augment the GPS signal and provide greater accuracy of both time and position.

Deploying BPS

BPS was first introduced conceptually in 2021 as part of NAB's Broadcast Engineering and Information Technology Conference. Since then, it has been developed and deployed in consultation with multiple federal government agencies and timing experts. After evaluating the needs of critical infrastructure and determining that microsecond-level accuracy meets the needs of most operations, a goal of 200 nanosecond (0.2-microsecond) accuracy was established to ensure the accuracy benchmark would be reliably met.

A first prototype was developed and demonstrated in a lab environment in 2022. This prototype yielded 300 nanosecond accuracy. The results were very encouraging and a second prototype was developed in 2023. The second prototype yielded 50 nanosecond accuracy in a live, outdoor, low-power transmission across a kilometer of urban terrain.

Today, BPS has been deployed on commercially available equipment at multiple full-power television stations. Long-term stability testing at WHUT-TV in Washington, D.C., demonstrates 40 nanosecond accuracy across 10 kilometers of dense urban terrain. Technologists at NAB continue to work with experts in the timing community and government agencies to further refine and improve BPS.

BPS relies on the ATSC 3.0 Next Gen TV signal, which is already deployed in the United States and is available in over 75 markets with signals reaching more than 75% of U.S. households. Full coverage of the entire country will occur once the transition to ATSC 3.0 is completed. Once the transition is complete and BPS is fully deployed, a typical location in the U.S. will have access to over 15 different BPS signals, an exceptionally robust augmentation to GPS. Broadcasters are educating policymakers on ATSC 3.0 technology and seeking their support as they work to deploy the new standard nationwide as quickly as possible, ensuring BPS can help defend our nation's critical infrastructure, economic security and public safety.

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