GPS Impact

(Cyber Physical System Security)

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Introduction

- Global Positioning System (GPS), is a satellite-based navigation system owned by the U.S. government that allows users to determine their precise location, velocity, and time anywhere on Earth.

- We have other Navigation Systems also. For example, NavIC (Navigation India Constellation).

Global Positioning System (GPS)

- **Space Segment:** A constellation of 31+ GPS satellites orbits the Earth in six orbital planes. They are in a Medium Earth Orbit at approximately 12,550 miles (20,200 km) and complete two orbits per day.

- **Control Segment:** A network of ground stations on Earth monitors and maintains the satellites, ensuring they function correctly.

- **User Segment:** GPS receivers, found in devices like smartphones and car navigation systems, receive signals from the satellites.

Global Positioning System

- **Trilateration:** To determine a location, a receiver needs signals from at least four satellites.
  - It measures the time it takes for signals to arrive from each satellite.
  - This is used to calculate the distance to each satellite.
  - By using the locations of at least four satellites, the receiver can pinpoint its latitude, longitude, altitude, and precise time (with 3 only we can get for 2D that means latitude and longitude not the altitude).

- **Accuracy and Time:** GPS satellites rely on atomic clocks for extreme accuracy. The system accounts for relativistic effects to maintain precision; without this correction, GPS would be inaccurate by several miles each day.

Global Positioning System

- **An atomic clock keeps time by using the extremely consistent frequency of radiation emitted or absorbed by atoms.**

- Atoms vibrate at a *perfectly stable* rate, far more precise than mechanical or quartz clocks.
  - Cesium atoms oscillate **9,192,631,770 times per second**.
  - This vibration is **identical everywhere in the universe**—temperature, pressure, or aging do not change it.
  - So the clock never drifts more than a second in **millions of years**.

List of Global Positioning System

- As of 25 June 2025, 83 Global Positioning System navigation satellites have been built: 32 are launched and operational, 7 are in reserve or testing, 39 are retired, 2 were lost during launch.
- One non-operational prototype satellite was never launched.
- Two Block III satellites have completed construction and have been declared "Available For Launch" (AFL).
- The next launch is GPS III SV09, currently targeted for late 2025.

https://en.wikipedia.org/wiki/List_of_GPS_satellites

Navigation with Indian Constellation (NavIC)

- NavIC is the operational name for the Indian Regional Navigation Satellite System (IRNSS), an independent satellite navigation system developed by the Indian Space Research Organisation (ISRO).

- There are seven satellites active.

- Some newer phones in India support **NavIC**, and Google Maps began enabling NavIC support in 2024, improving accuracy.

https://en.wikipedia.org/wiki/Indian_Regional_Navigation_Satellite_System

Global Navigation Satellite System

- GNSS is a general term for all satellite systems that provide global positioning, navigation, and timing (PNT).
  - GPS (USA)
  - GLONASS (Russia)
  - Galileo (EU)
  - BeiDou (China)
  - NavIC (India)
  - QZSS (Japan)

Global Navigation Satellite System

- **Process: GPS Satellites sends signals to GPS receivers on Earth. These receivers then calculate their position based on the time it takes for these signals to arrive.**

- Satellites continuously broadcast signal with:
  - Its precise position in space
  - The exact time the signal was transmitted (from the satellite's atomic clock)
- Receivers pick up signals
  - Your phone, car, or GPS device receives signals from multiple satellites at once (ideally 4 or more)
- Measure signal travel time
  - The receiver calculates how long the signal took to travel from the satellite
  - Since radio signals travel at the speed of light, this gives the distance to each satellite
- Trilateration
  - With distances from at least 3 satellites, the receiver can calculate your 2D position (latitude and longitude)
  - With 4 or more satellites, it can calculate 3D position (latitude, longitude, altitude) and correct for clock errors
- Display position
  - Your device shows your location on a map, navigates routes, or tracks movement

GPS Spoofing

- This is also known as GPS simulation referring to the practice of manipulating or tricking a GPS receiver by broadcasting false GPS signals.
- Essentially, it misleads the GPS receiver into believing it is located somewhere actually it is not, resulting in the device providing inaccurate location data.
- The weak signal strength of the GPS satellites can be easily overwhelmed by fake signals, resulting in inaccurate location data on the receiving device.
- These fake signals are stronger, causing the receiver to recognize them as authentic signals.
  - As a result, the victim's GPS receiver ends up processing these counterfeit signals, leading to erroneous location information.

https://www.mcafee.com/learn/what-is-gps-spoofing/

GPS Spoofing: Possible Solutions

- **Signal detection and anomaly analysis:** Receivers can detect anomalies in signal strength, arrival time, or angle, as a spoofed signal is often more powerful or comes from a single, static direction.
- **Signal authentication:** Using signals with built-in cryptographic authentication, such as Galileo's OS-NMA (Open Service – Navigation Message Authentication), can verify the signal's authenticity before use.
- **Cross-referencing multiple systems:** Receivers can process and compare data from multiple global navigation systems (like GPS, GLONASS, Galileo) to identify inconsistencies that may indicate a spoofing attack.
- **Advanced signal processing:** Sophisticated techniques use algorithms to identify and flag spoofed signals, making receivers more resilient to advanced spoofing attacks.

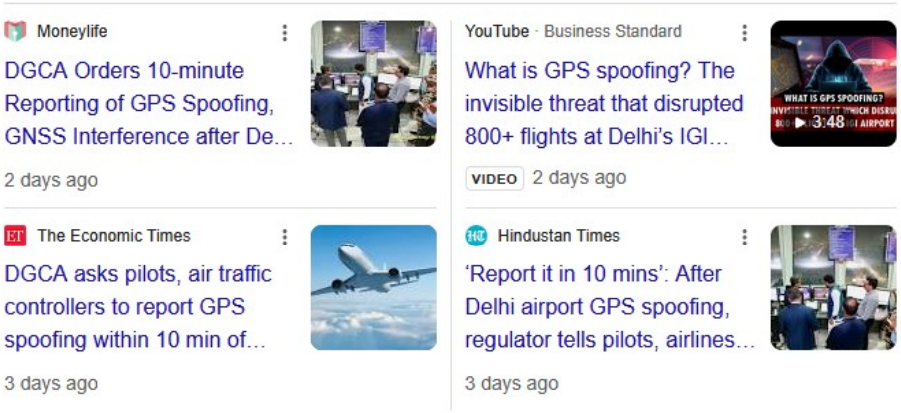
GPS Jamming

- Jamming is the process of intentional interference with GPS transmissions to disrupt the signals that ships rely on for navigation.
- GPS jamming occurs when a jamming device emits radio signals on the same frequency as GPS satellites which are more powerful than the satellite signal rendering navigation systems ineffective.
- GPS
  - L1 --- 1575.42 MHz ----- Civilian use (C/A code) & some military (P(Y) code)
- NavIC
  - L5 (1176.45 MHz) & S band (2492.028 MHz)

https://north-standard.com/insights-and-resources/resources/articles/gps-jamming-spoofing-and-hacking

CPS : Automotive Impact

- Aircraft system
- Train System
- Car System



What about Encrypted or Authentic Communication?

Google access on 15th November 2025

Thank You