



CENTER FOR APPLIED
COMMUNICATIONS AND NETWORKS

GPS as Critical Infrastructure

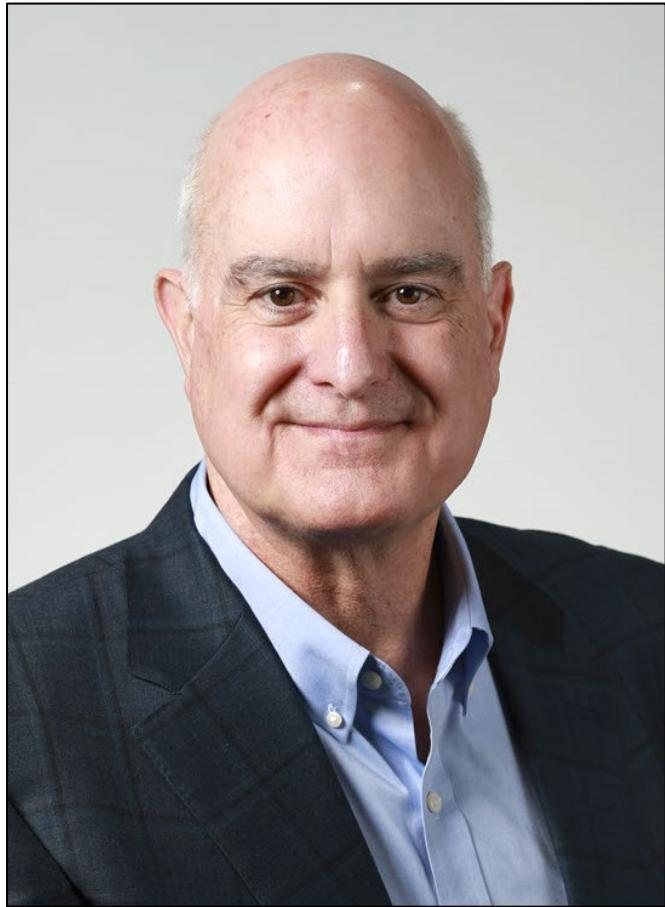
SORM Symposium 2025

August 15, 2025

Agenda

- Introductions
- Positioning, Navigation, and Timing
- Risk to GPS
- Impact of Losing of GPS
- Mitigating / Eliminating the Risk
- Interoperability Institute 2025

Who Am I?



Michael E Fox

Executive Director

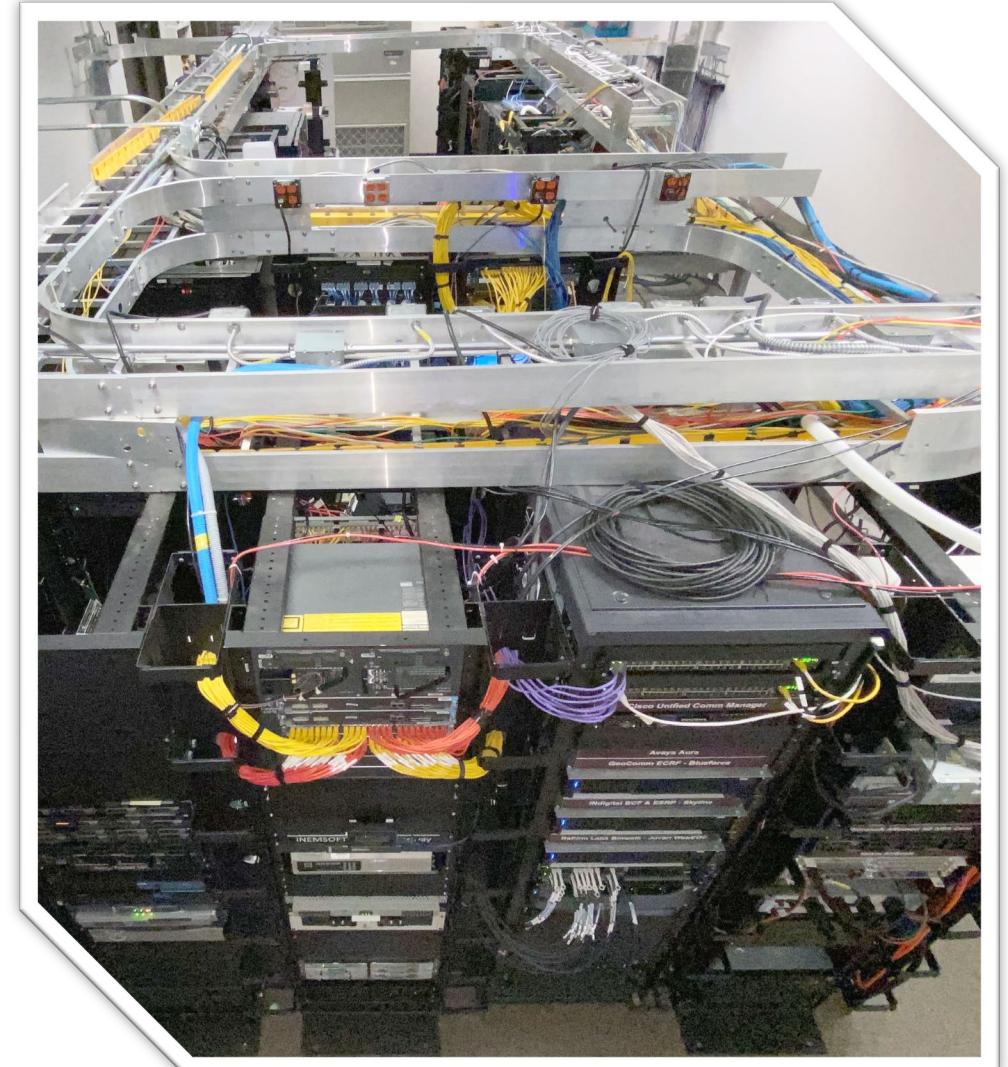
THE TEXAS A&M UNIVERSITY SYSTEM

**CENTER FOR APPLIED
COMMUNICATIONS AND NETWORKS**

- 40 years experience in network engineering
- VP Worldwide Systems Engineering, Nortel
- VP Sales, Service, Consulting Engineering: Atrica → Nokia
- VP Services & Operations: Vyatta → Brocade
- Public safety communications: HF ... *uwave*
- Last 5 years: applied research @ Texas A&M

CENTER FOR APPLIED COMMUNICATIONS AND NETWORKS

- Applied research, testing and evaluation
- Wireless and Next Generation communications systems
- Public safety, defense, critical infrastructure
- Interoperability, resiliency, cybersecurity
- Some recent and current activity
 - 4G/5G/NextG wireless connectivity and security
 - Government voice security
 - Mission Critical Services / Sidelink
 - Next Gen 9-1-1 interoperability & security
 - Positioning, Navigation, Timing / GPS denied
 - ...





THE TEXAS A&M UNIVERSITY SYSTEM

TWELVE UNIVERSITIES (AS OF SEPT 1)



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A&M UNIVERSITY



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TEXAS A&M
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CENTRAL TEXAS

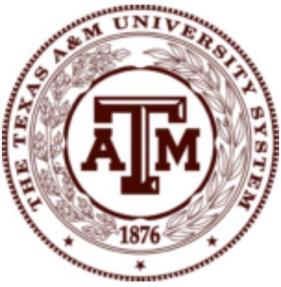


TEXAS A&M UNIVERSITY
SAN ANTONIO

TEXAS A&M
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EFFECTIVE SEPT. 1, 2025

System Campus
R E L L I S

Office of
Research

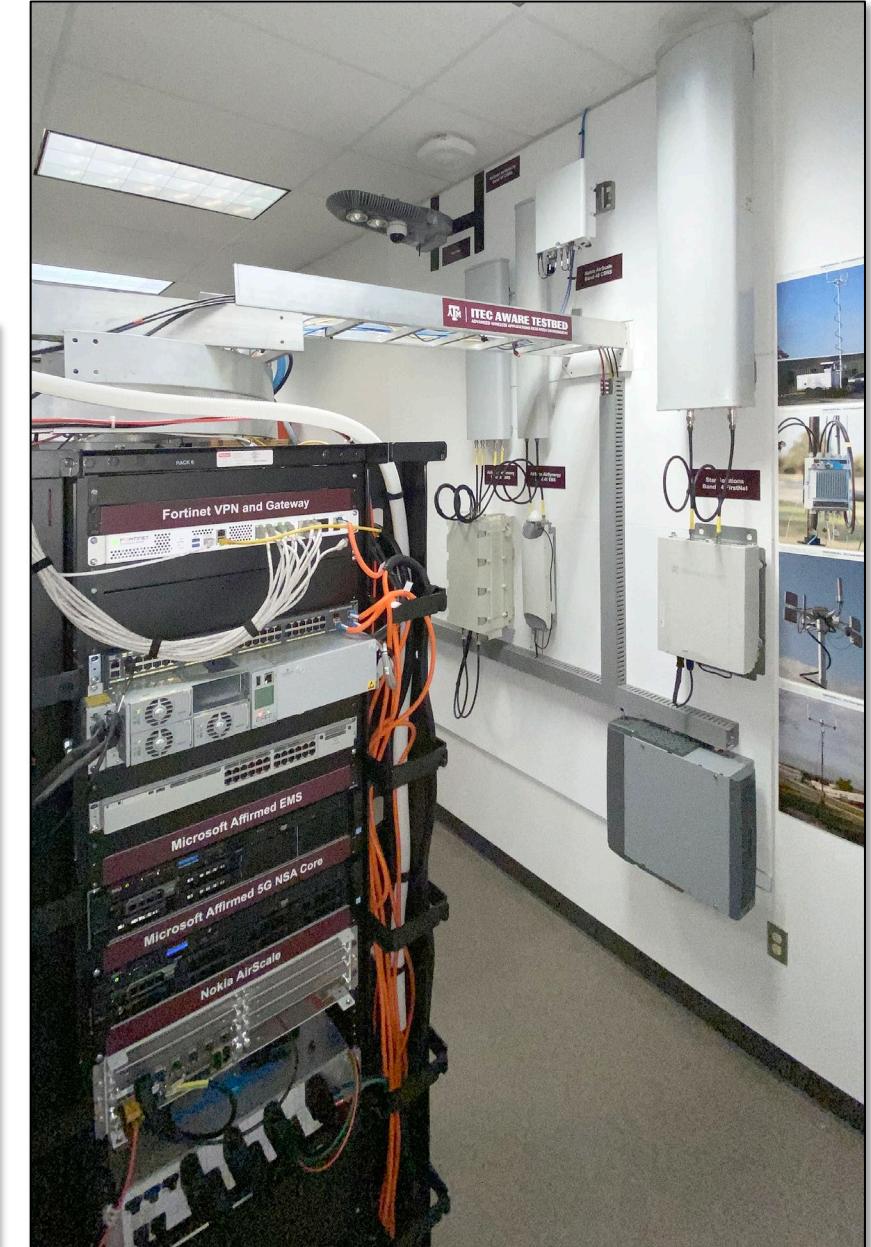
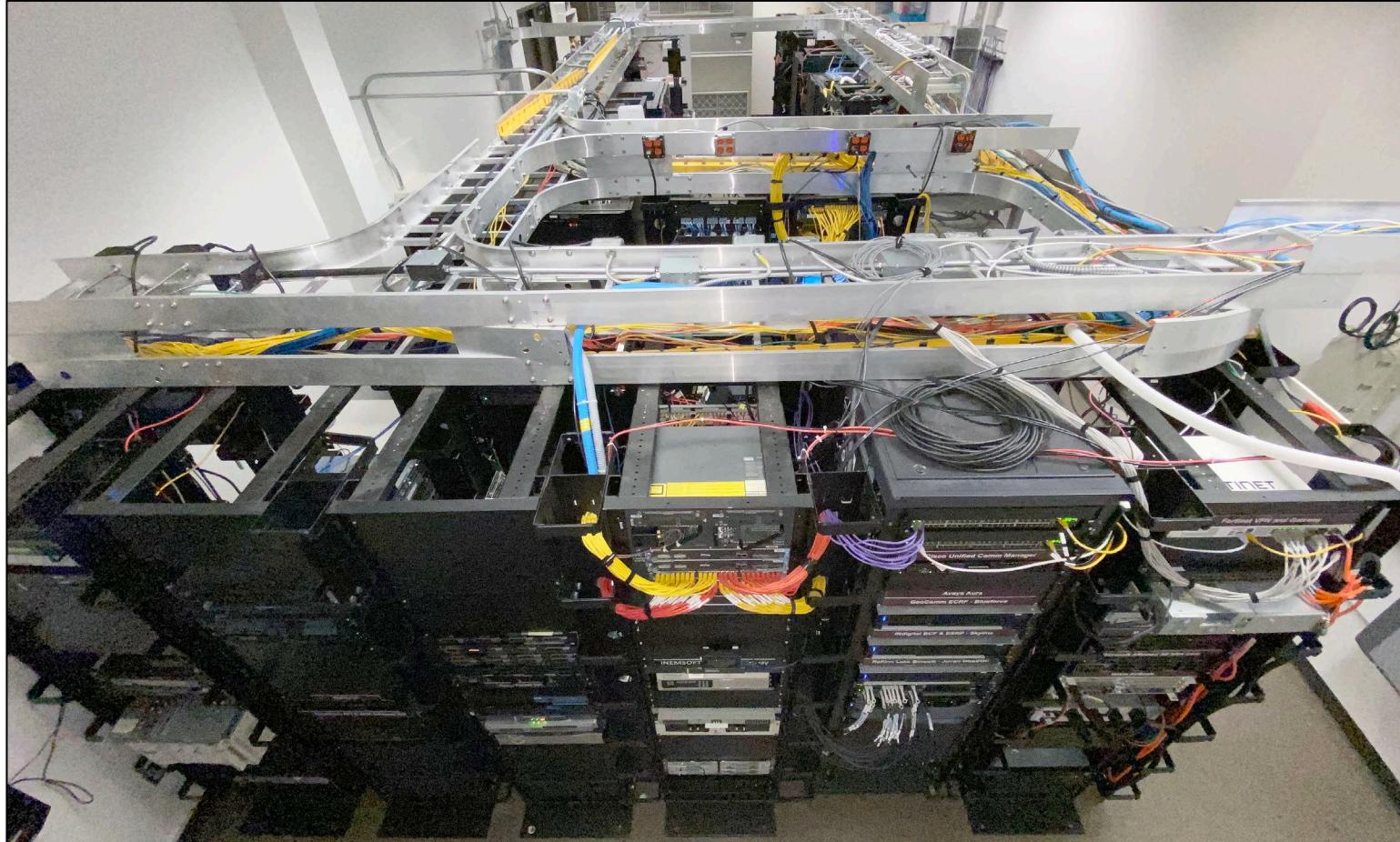


Office of Research

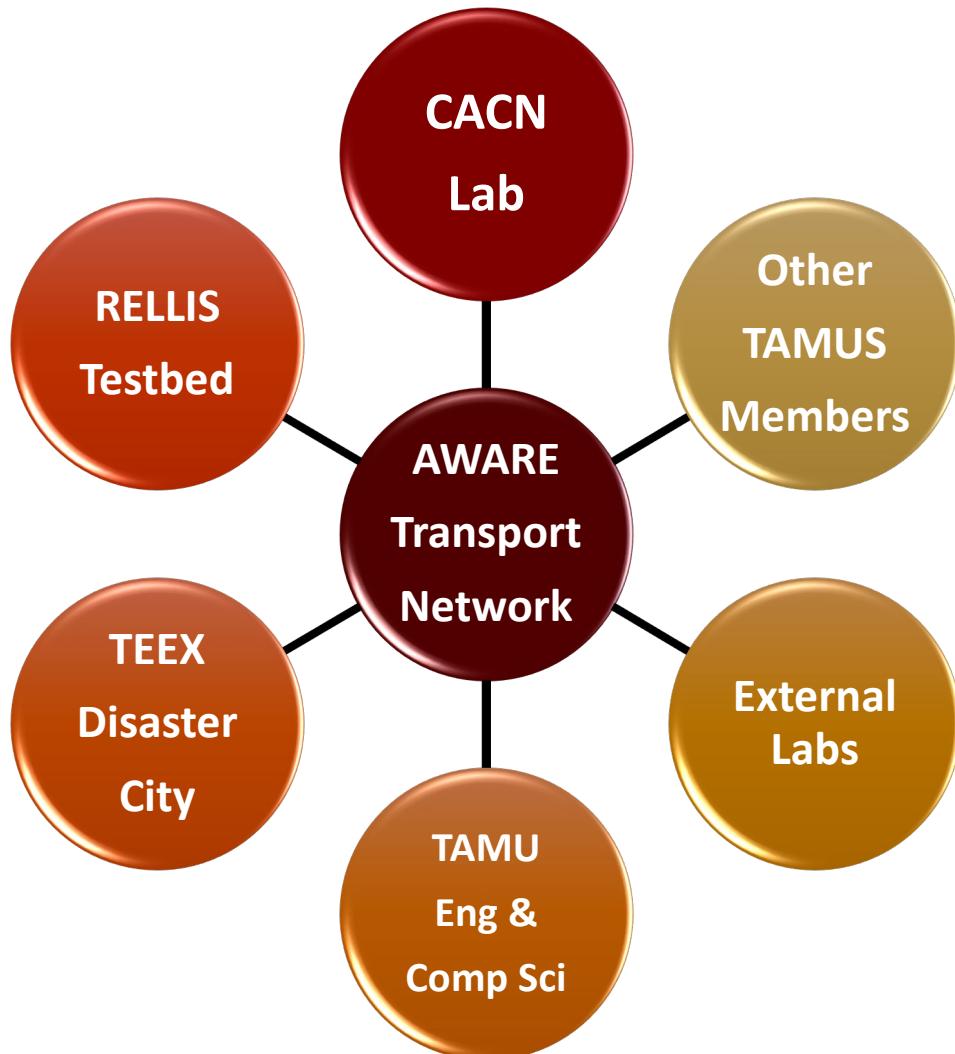
- Texas A&M Innovation
- Nuclear Security Office
- Bush Combat Development Complex
- Texas A&M Semiconductor Institute
- Research and Innovation Security and Competitiveness Institute
- **Center for Applied Communications and Networks**
- Research Security Office
- Research Compliance Office
- Research Development Office
- Research Administration Office
- Texas A&M Fort Worth

CACN Lab Facilities

Includes **AWARE** (ADVANCED WIRELESS APPLICATIONS RESEARCH ENVIRONMENT)



AWARE Transport Network (ATN)



The network itself is part of the research

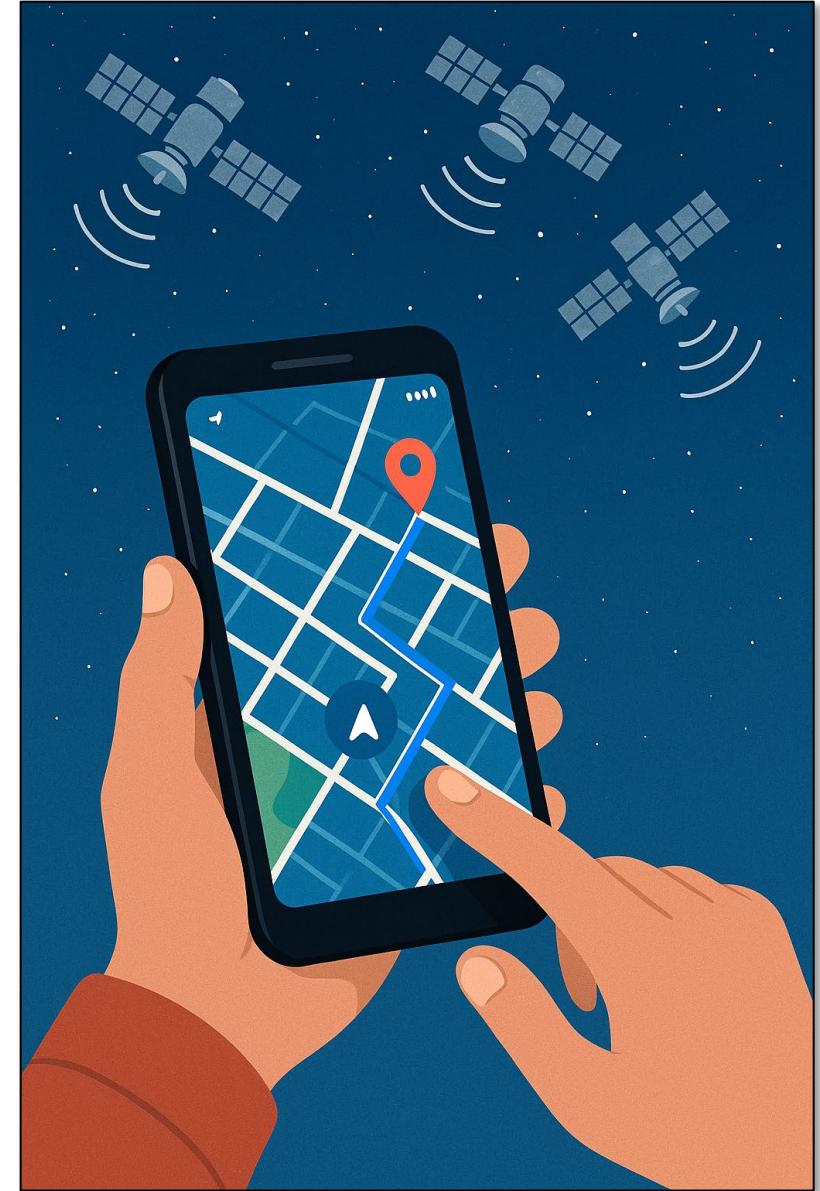
- Slicing, timing, security, management, network as code, ...

Includes and/or integrates:

- **Technology:** Commercial, Open-source
- **Terrain:** Indoor, Urban, Suburban, Open
- **Cores:** 4G/5G, IMS, MCX
- **RAN:** Traditional, O-RAN, experimental
- **Transport:** SDN, Sliceable, IP/MPLS, SR, L2/L3VPN, ...
- **MEC:** VMs, containers/Kubernetes
- **Timing:** GNSS, STL, PTP, SyncE, ITU-T G.8275.1 & G.8275.2, rubidium oscillators, GNSS jamming & spoofing mitigation, ...
- **Security:** Firewalls, slicing, scanners, ...
- **Applications:** Public Safety, Defense, Transportation, Energy, Wireless Research

Positioning, Navigation, and Timing (PNT)

What Most People Think About When You Mention GPS



A Closer Look at GPS

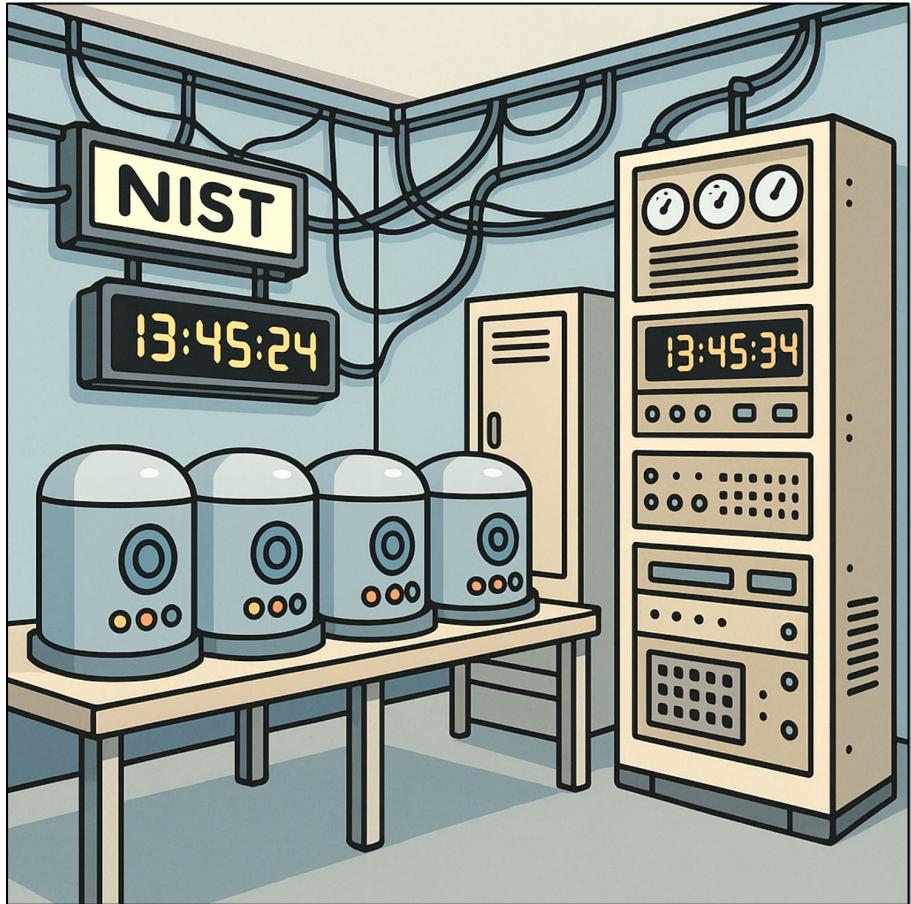
GPS and other Global Navigation Satellite Systems (GNSS) provide:

- **Positioning:** Determining your location on Earth (latitude, longitude, altitude)
- **Navigation:** Determining how to move from one location to another
- **Timing:** Providing highly accurate time signals used in communications, energy grids, finance, and other critical infrastructure

Time



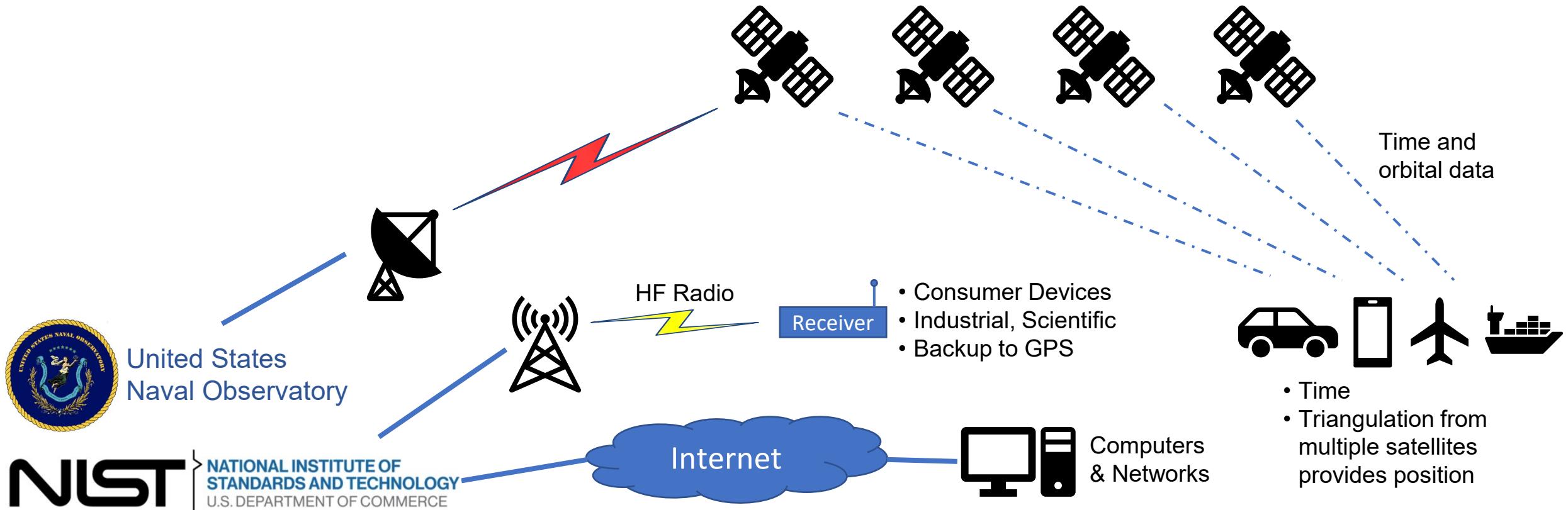
United States
Naval Observatory



- UTC – Coordinated Universal Time
 - The world's primary time standard for civil use
 - Maintained by international network of timing labs (including NIST)
- Clock "Ensemble"
 - NIST and USNO use a network of ultra-stable atomic clocks
 - Weighted average produces free-running atomic time scale
 - Small adjustments are made to align with UTC, producing UTC(NIST) and UTC(USNO)
- UTC(NIST) – the official U.S. realization of UTC
 - Precise, legally recognized time
- UTC(USNO) – time used to feed GPS network
- NIST and USNO make regular comparisons

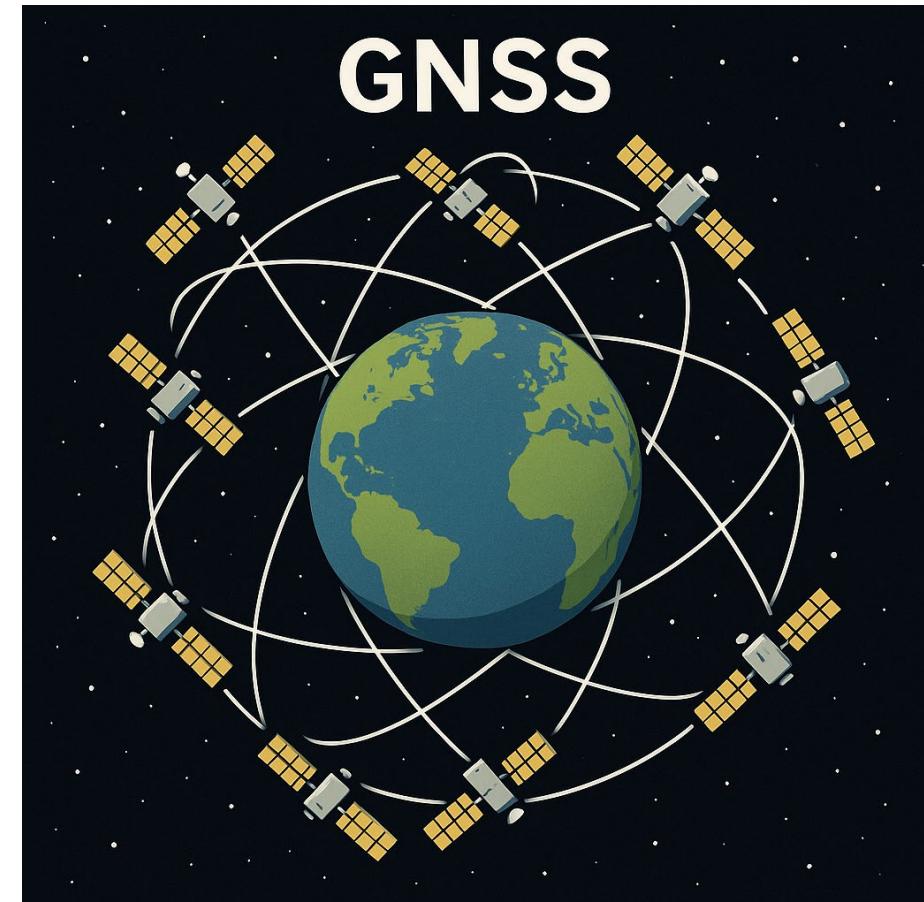
How Time is Distributed

Time is distributed worldwide via the Internet, radio, and satellite (GPS)



Satellite-based PNT

- Satellites broadcast precise time and orbital information. Receivers calculate position by measuring how long the signals took to arrive from multiple satellites
- Global Navigation Satellite System (GNSS)
 - USA: GPS (Global Positioning System)
 - Russia: GLONASS (Globalnaya Navigazionnaya Sputnikovaya Sistema)
 - European Union: Galileo
 - China: BeiDou
- Regional constellations also exist
 - Japan: QZSS (Quasi-Zenith Satellite System)
 - India: NavIC (Navigation with Indian Constellation)



DHS Critical Infrastructure Dependent on GPS

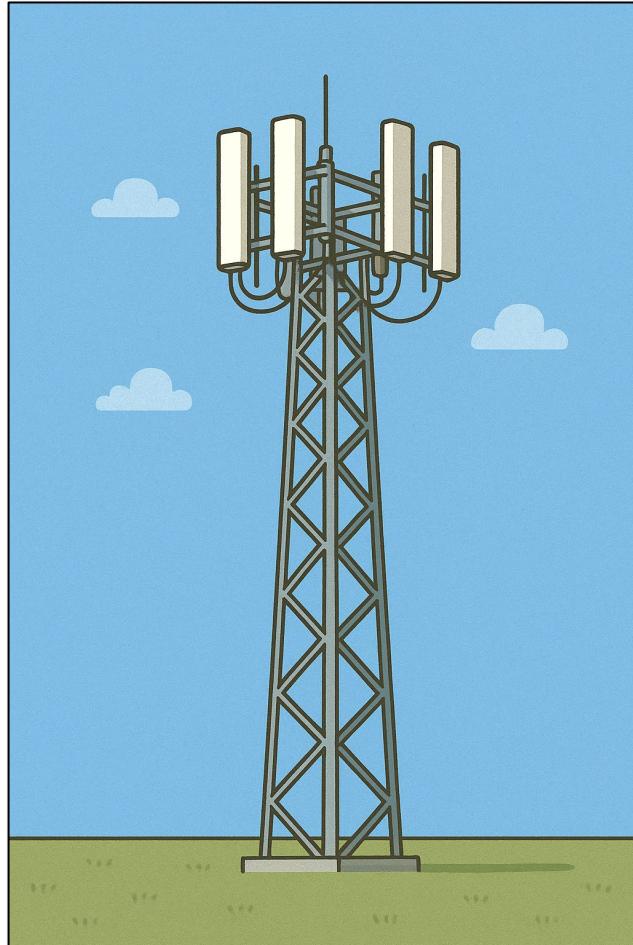
Timing Dependence



Positioning/Navigation Dependence



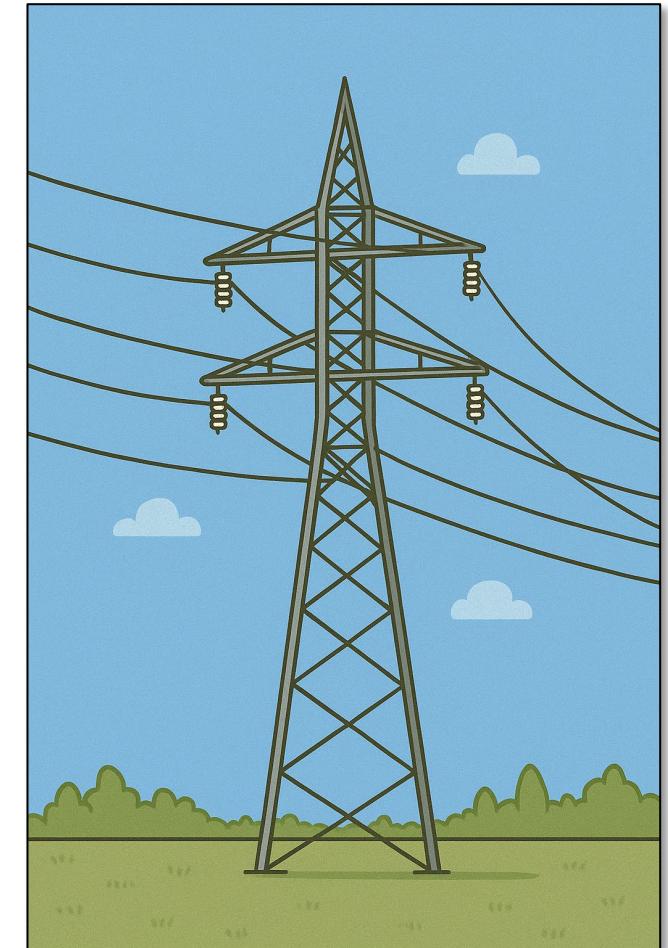
Communications Use Cases



- Core Network Synchronization
 - Modern networks require timing accuracy within nanoseconds
- Cellular Networks
 - Align transmission slots to eliminate interference
 - Support handover between cells
 - Massive MIMO beamforming accuracy
- Internet Backbone
 - Packet ordering, traffic management, fault detection
- Public Safety & Emergency Communications
 - 9-1-1 call routing and dispatch systems
 - P25 radio simulcast synchronization

Energy Use Cases

- Grid monitoring and control
 - Phasor Measurement Units (PMUs) measure voltage, current, and phase angle across the grid
 - GPS provides common, accurate time reference across wide area (possibly hundreds of miles apart)
- Synchrophasor Systems
 - Use time-synchronized phasor measurement data used to monitor grid oscillations
- Fault detection and location
 - Triangulation of faults by comparing arrival times of electrical disturbances
- Substation automation
 - Automated protection relays and breakers require exact timing to coordinate fault isolation and load shedding



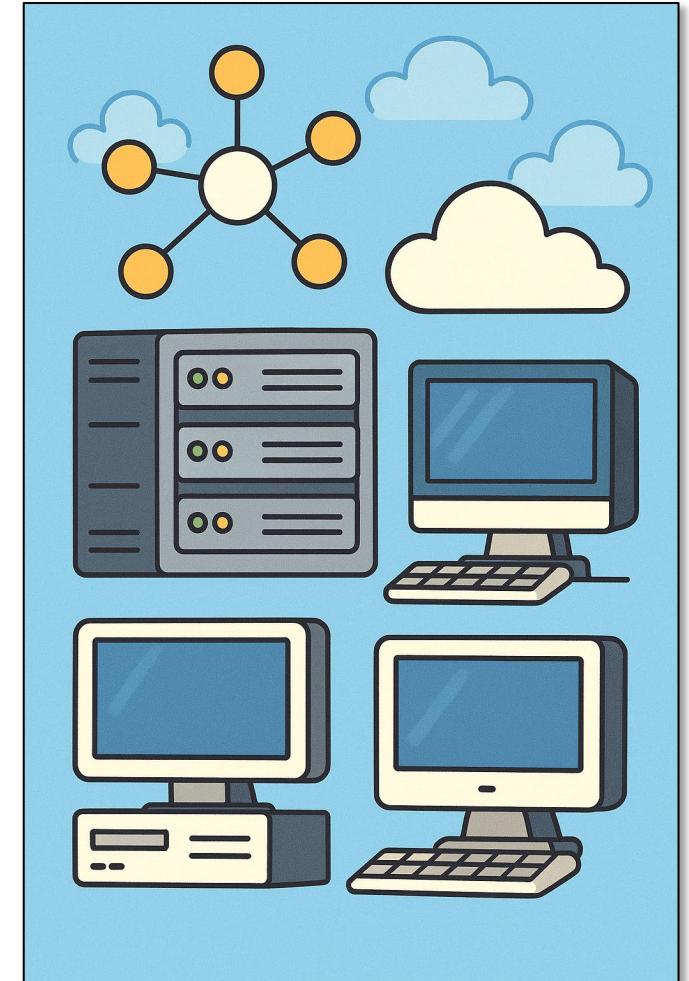
Financial Services Use Cases



- Transaction Timestamping
 - Timestamps required by regulators
 - Trade sequence reconstruction for audits, detecting market abuse, resolving disputes
- High-Frequency Trading
 - Algorithms execute trades in microseconds or less
- Global Market Synchronization
 - Fair order matching across geographically distributed data centers

Information Technology Use Cases

- Network Time Synchronization
 - Servers, routers, and switches in data centers, cloud services, enterprise networks
- Data Integrity and Logging
 - Financial, legal, regulatory compliance, forensic analysis
- Cybersecurity
 - Authentication systems, encryption protocols, detecting replay attacks or mismatched transactions
- Distributed Systems and Cloud Computing
 - Applications running across multiple locations
- Telecommunications Backbone
 - Overlap with telecom; sync edge servers



Transportation System Use Cases



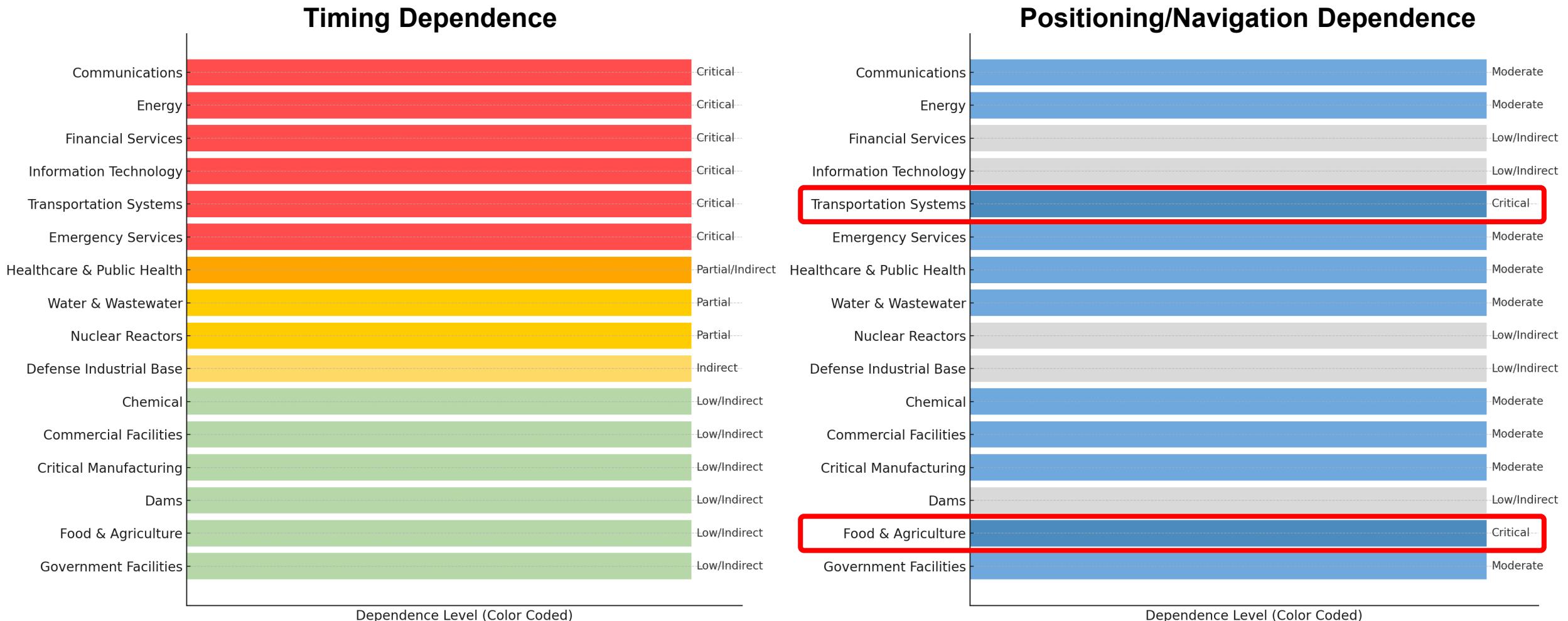
- Precise Time
 - Traffic Signals & Control Systems
 - Synchronization of traffic lights and highway sensors
 - Railway Signaling
 - Track-side and onboard control systems
 - Air Traffic and Port Operations
 - Radar, communications, data system synchronization between control towers, ground stations and vehicles
- Positioning and Navigation
 - Aviation: en-route nav, approaches, landings, ...
 - Road: turn-by-turn directions, fleet tracking, ...
 - Rail: Positive Train Control (PTC)
 - Maritime: Automatic Identification Systems (AIS), nav

Emergency Services Use Cases

- Precision Time
 - 9-1-1 call routing
 - Infrastructure for routing 9-1-1 calls to the correct PSAP
 - Radio Networks
 - Trunked, simulcast digital radio systems require microsecond-level time synchronization
 - Data & Video Feeds
 - Sync mobile data terminals, body cams, vehicle dash cams
 - Interagency Coordination
 - Synchronized applications and logs for event timelines
- Positioning and Navigation
 - Dispatch and Routing
 - Search and Rescue
 - Incident Tracking and Situational Awareness



DHS Critical Infrastructure Dependent on GPS

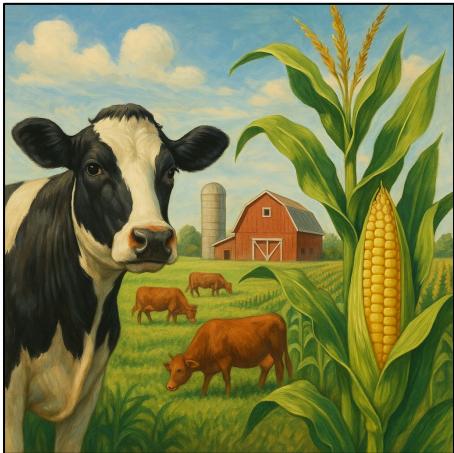


Position & Navigation Use Cases



Transportation Systems

- Aviation: en-route navigation, approaches, landings, ...
- Road: turn-by-turn directions, fleet tracking, ...
- Rail: Positive Train Control (PTC), ...
- Maritime: Automatic Identification Systems (AIS), navigation, ...



Food and Agriculture

- Precision Agriculture
 - Field mapping, variable rate application, harvest optimization
- Livestock Management
 - Animal tracking, fence mapping
- Supply Chain & Logistics
 - Fleet tracking, cold chain monitoring
- Environmental monitoring, Disaster Response, Food Security

Is GPS at Risk?

(Hint: YES! Absolutely!)

GPS Is Easy To Jam

- GPS Jamming:
 - Blocking reception of the GPS signal
- GPS signal is weak
 - At -130 dBm or about 1×10^{-16} watts, the GPS signal is about a billion times weaker than the signal received from a nearby cell tower
 - Less power than the thermal noise floor of many receivers
- Used for hijacking shipments, disrupting services, or just creating chaos
- 2024: 175% increase in jamming

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APJ-16 - portable All in one jammer
The APJ-16 is a portable jammer in the 164-5900 MHz band. Below you can see all the available jamming frequencies: APJ-16 for Europe APJ-16 for America 758-830MHz: 1.0W 5G, 4G LTE Low 850-895MHz: 1.0W.

\$1 200.00

More info

GJ6 Portable All Civil Bands GPS Jammer, anti tracking device
GJ6 is a device to work with all types of GPS, as well as civil frequencies GPS, GLONASS, and LoJack. With this device, you can block all the listed signals. It is suitable for use at home, outdoors, or while traveling. This device protects your privacy and reduces the risks of tracking, which is es...

\$395.00 \$459.00

More info

GP5000 Car Anti-Tracking GPS Blocker, Navigation jammer
GP5000 is a special car jammer. This device has been specially designed to be compact so that truck drivers can use it. They can now turn off GPS tracking devices to keep personal data safe from employers. Jammer GP5000 will help solve the problem of privacy once and for all. Any driver who cares ab...

\$119.99

More info

TITAN - 8 bands mobile phone jammer (8W)
TITAN jammer is one of the most powerful portable jamming solutions currently available on the market, with a jamming range between 10-30 meters. It feels portable in your hands. However, it behaves like a high-power desktop unit. Dimensions are just 23*9*5cm, making this jammer look a bit more mass...

\$620.00

Articles

Alternatives to GPS Jammers and Blockers

Effectiveness of GPS Jammers and Blockers

Understanding GPS Jamming Technology

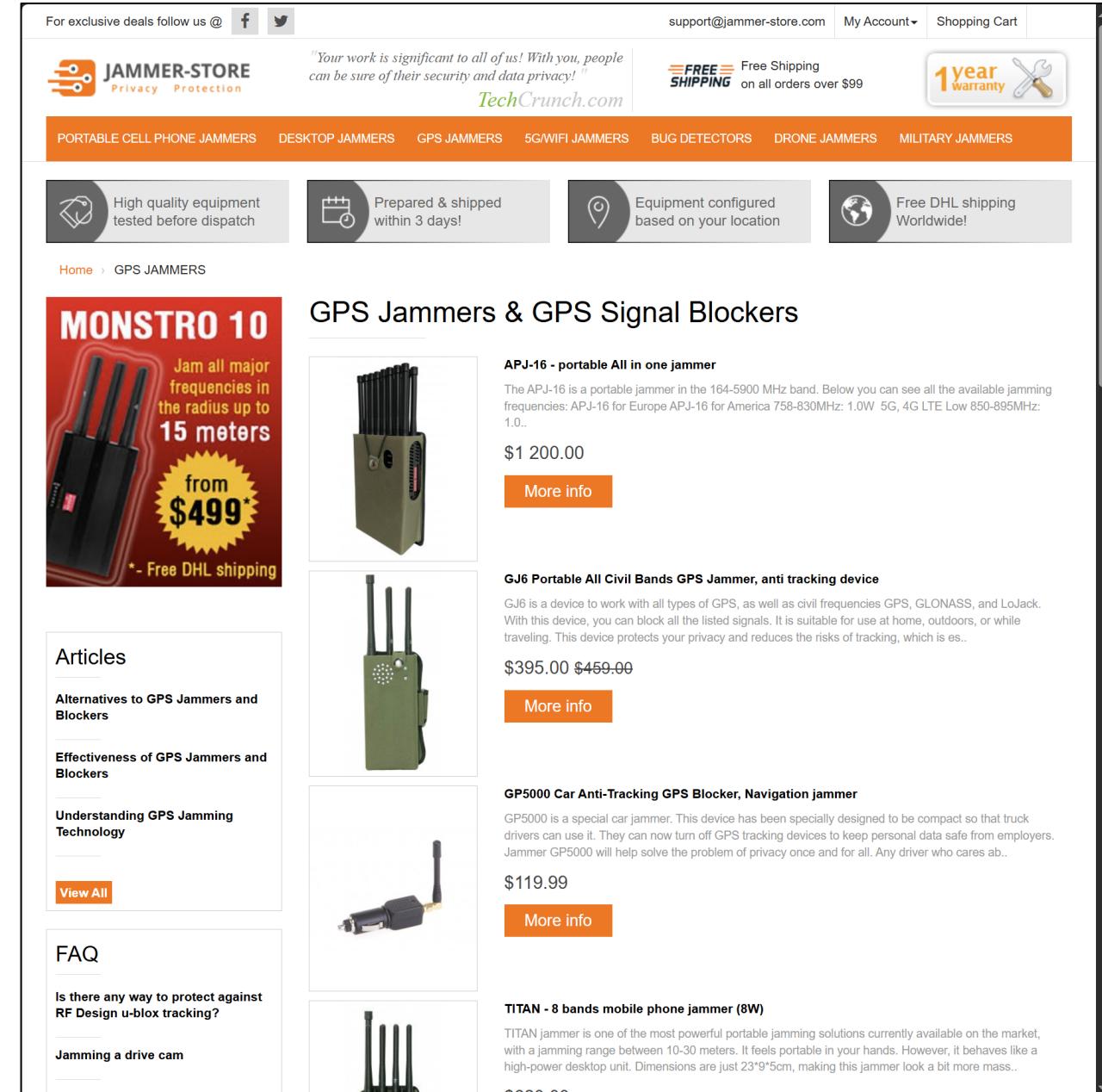
View All

FAQ

Is there any way to protect against RF Design u-blox tracking?

Jamming a drive cam

Is it possible to maintain privacy



GPS is Easy to Spoof

- GPS Spoofing
 - Manipulating the GPS data to mislead a GPS receiver about its actual location
 - Re-broadcast of GNSS/GPS signals recorded at some other place or time
 - Hackers generate and transmit modified satellite signals to the target
 - GPS signals are unencrypted (and weak)
 - More sophisticated attack than jamming, but happening more frequently
 - Can cause airplanes, ships to crash
 - 2024: 500% increase in spoofing

[Safe to Use] Top 5 Pokemon GO Spoofers for iOS & Android

Daniel
Jan 13, 2022 (Updated: Apr 03, 2025) • Filed to: Change GPS Location
0 ★★★★★

Note: Only works when you grant permission.

"Which app are you guys using for fake gps? I currently found out the old fake gps is not working (Unable to find location (12)... Any suggestions?"
--From Reddit

If you're looking for a reliable Pokémon GO spoofing tool to fake your GPS location, you've come to the right place. In 2025, location spoofing remains one of the most popular ways to play Pokémon GO without geographical restrictions. That's why we've tested and ranked the top 5 Pokémon GO spoofers for iOS and Android, ensuring you get the best features, security, and reliability. Keep reading to discover the safest and most powerful tools for your gameplay.

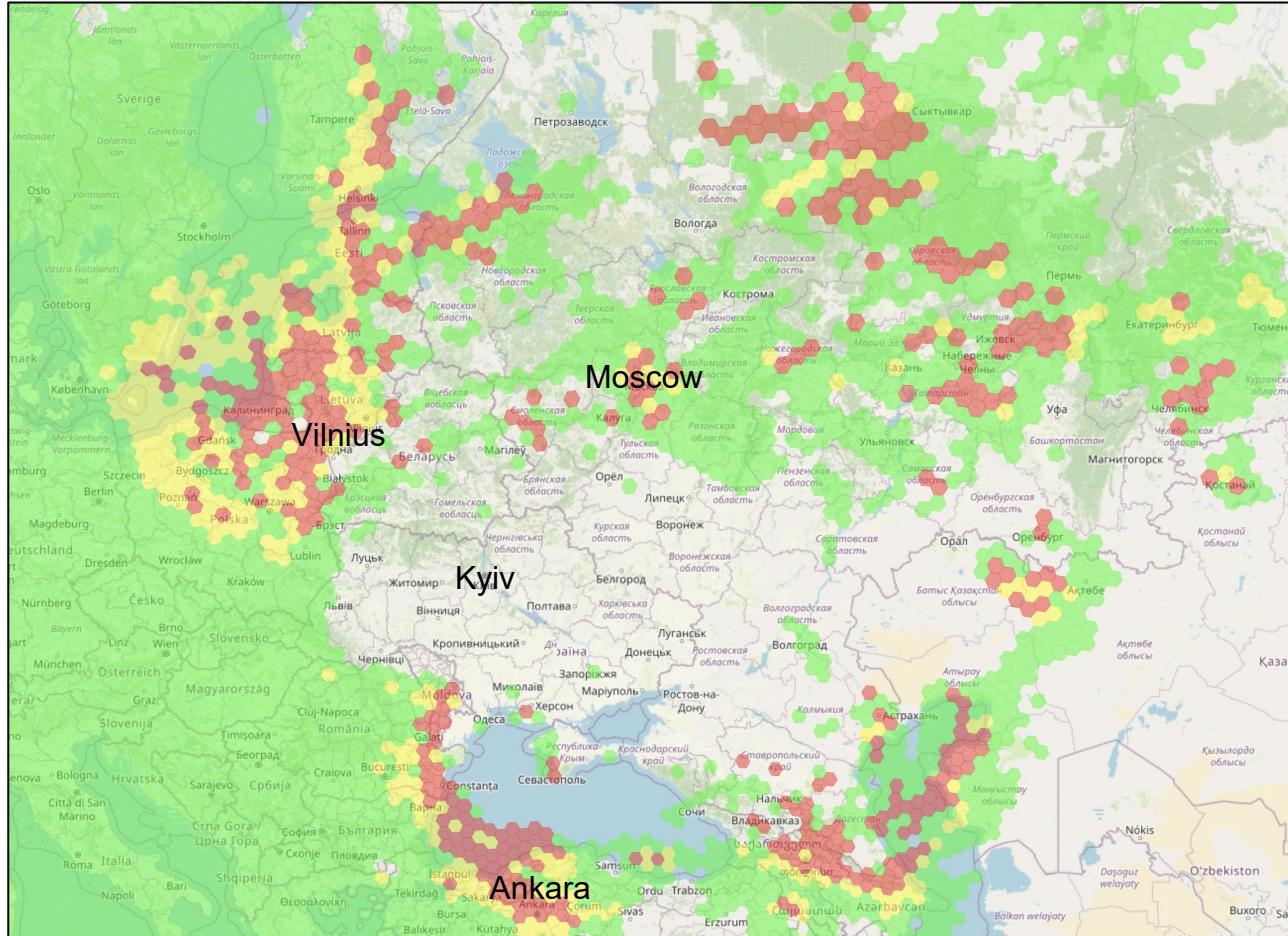
Part 1: An Overview of Spoofing in Pokemon Go
Part 2: Best 5 Pokémon GO Spoofers for Android & iOS

- ▶ WooTechy iMoveGo - Up to iOS 18 & Android 15 **HOT**
- ▶ PGSharp - Android Only
- ▶ iPogo - iOS Only
- ▶ MobiAnyGo - iOS Only
- ▶ Spoofex - iOS Only

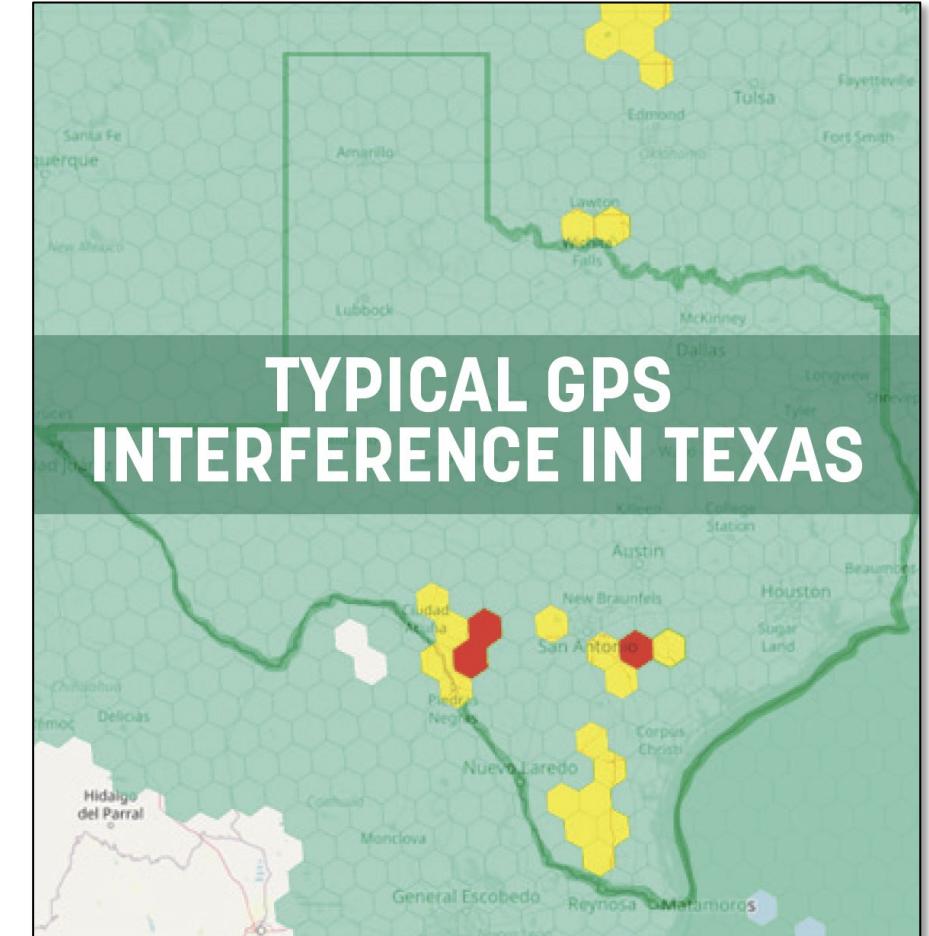
Extra Tips for Making Your Pokemon Go Spoofing safer

Localized GPS Interference

Expected

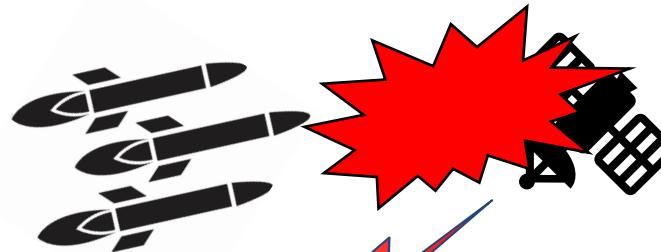


Unexpected?



Global Loss of GPS

Attack against the GPS satellite constellation (cyber, kinetic, directed energy, ...)



Jam uplink



United States Naval Observatory

Attack against USNO



Russia and China have terrestrial alternatives to their GNSS. We don't. What do they know that we don't?

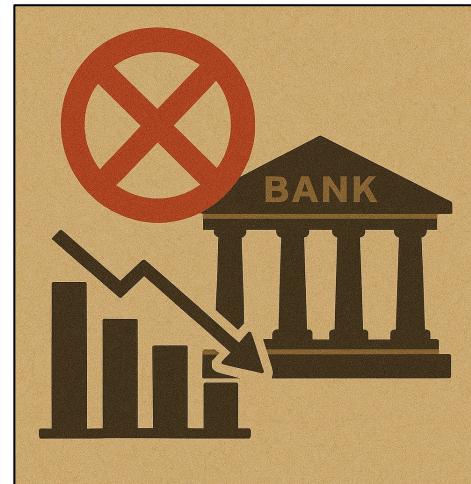
What Would Be The Impact of Losing GPS?

Results of a GPS outage:
Power Grids, Financial Systems, Cellular Networks, Public Safety Communications, Computer Networks, Traffic Control, and Air Traffic would fail or severely degrade

\$1B to \$1.6B Per Day!
Estimated cost of GPS outage

Secondary Effects of Sustained Loss of GPS

- Can't communicate
 - Cell networks lose power and time sync
 - No power, time sync for land lines, business phone systems
 - Public safety radio systems lose power & time sync, ...
- Can't travel
 - No electricity to charge your EV, or to run gas pumps
- Can't get money
 - No power or networks for banks, ATMs, ...
- Can't get food and supplies
 - No electricity for refrigeration
 - No fuel for planes, trains, trucks to transport food, goods
- Can't get water
 - Water pumps down; sewage systems stop functioning
- Can't get help
 - Police, fire, EMS, hospitals, have no power, fuel, comms, ...
- ...



What Will a Sustained Outage Look Like?

Some Say This ...



... or this



Maybe some of both! Or, something in between.

Mitigating or Eliminating the Risk

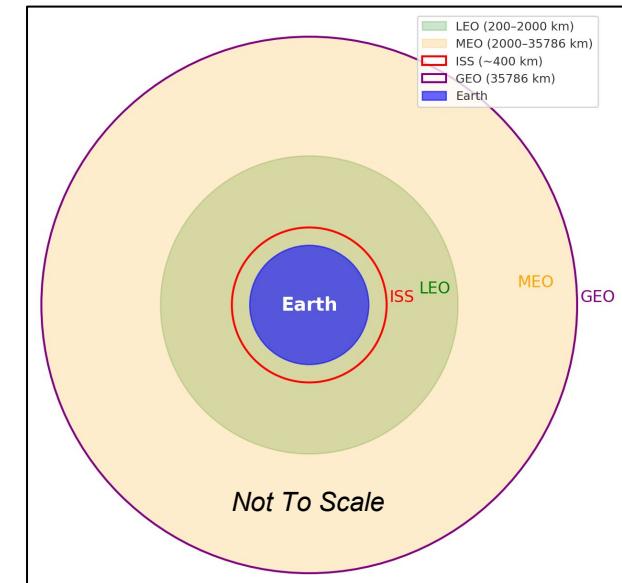
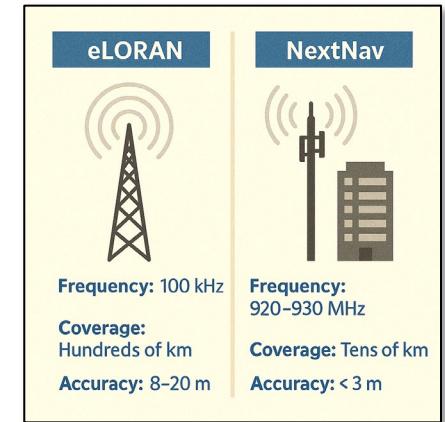
We Need an Alternative!

“I’ve heard about ...”

- WAAS – Wide Area Augmentation System
 - Augmentation to GPS, not replacement. Precisely surveyed ground stations monitor GPS signals to detect errors. Correction messages are broadcast from geostationary satellites. Result is more accurate GPS location.
- A-GPS – Assisted GPS
 - GPS receiver gets info on GPS satellite orbits from a server over the network to help it know which GPS satellites to look for. Result is faster time to first GPS fix.
- Both work with GPS. They are not alternatives to GPS.

Alternative Distribution Methods for PNT

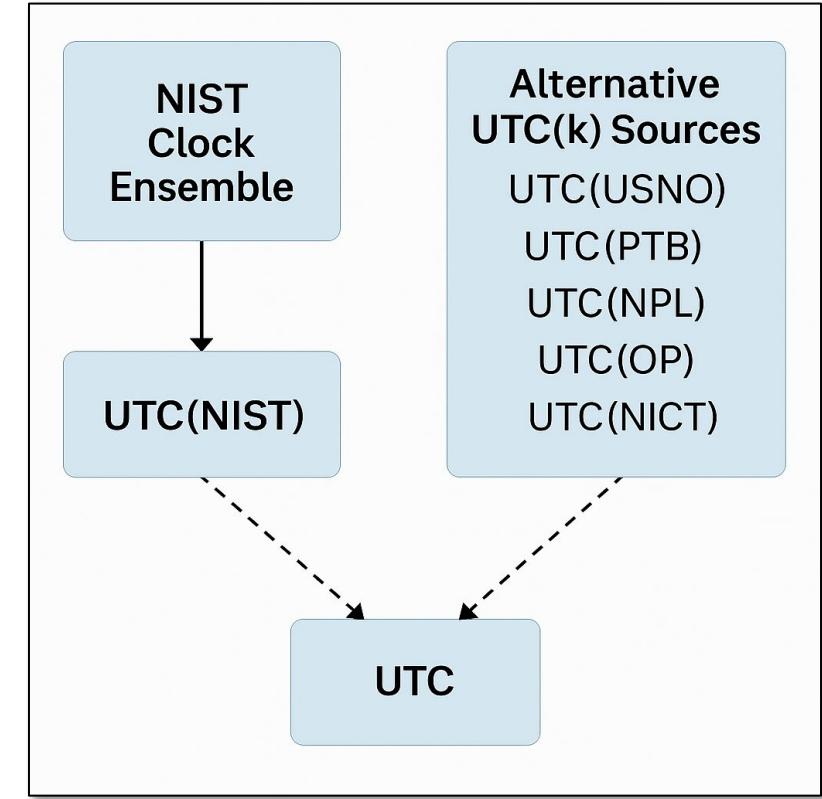
- eLORAN
 - Modernized version of old LORAN-C technology. Broadcasts time and location from ground-based towers at low frequency (100 kHz). Receivers triangulate location from multiple towers, instead of satellites. Could have continent-wide coverage.
- NextNav
 - Commercial service. Broadcasts time and location from ground-based towers at 900 MHz. Higher precision location than eLORAN but only city-scale coverage.
- STL
 - Commercial, encrypted, high-power (1000x stronger than GPS) timing and location service. Uses Iridium satellites in Low Earth Orbit (LEO). (GPS uses MEO.)
- PTP (Precision Time Protocol - IEEE 1588)
 - Protocol for distributing precise time over networks, such as fiber optic circuits.
- ATSC 3.0
 - Digital television broadcast standard that includes time signal. Not as accurate as PTP.
- Combination can be used as a defense in depth



We Also Need an Alternative Timing Source

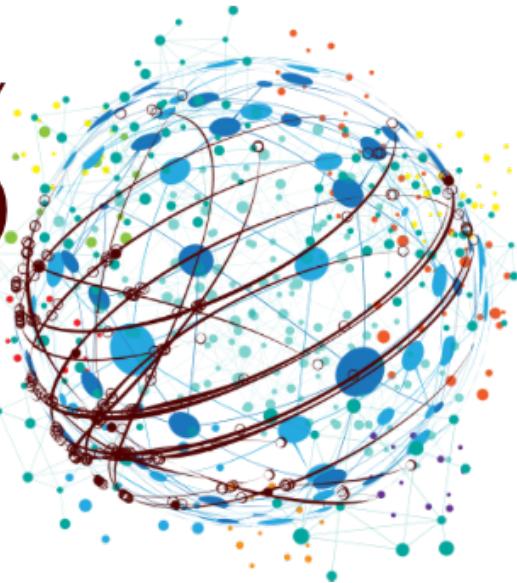
Alternative Time Sources

- National laboratories
 - UTC(NIST) – Boulder, CO
 - UTC(USNO) – US Naval Observatory
 - UTC(PTB) – Germany
 - UTC(NPL) – UK
 - UTC(OP) – France
 - UTC(NICT) – Japan
- For ultimate resiliency, survivability, generate time locally (Texas) at multiple locations and network together as an ensemble



How Do We Learn More?

TEXAS A&M UNIVERSITY
INTEROP
INSTITUTE
NOVEMBER 17-21, 2025



New this year:
Includes PNT
discussion panel,
workshop, and
vendor demo/display

<https://interopinstitute.com>

“Interop” convenes government, vendors, practitioners, and academia to tackle the most important communications challenges for public safety and defense



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