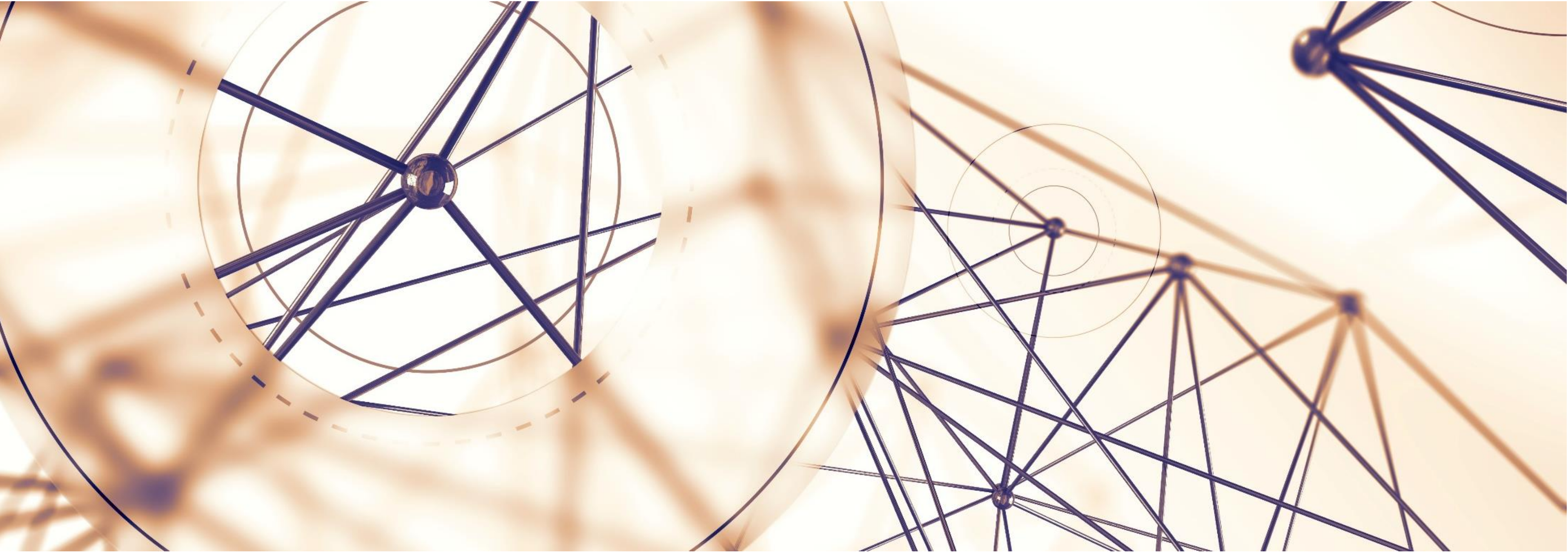

GPS/GNSS Jamming & Spoofing Mitigation Best Practices & Strategies

ITSF 2021

Nino De Falcis, Sr Director, Business Development Americas

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What is the aPNT mandate?

Driven by US federal gov's executive order 13905 of Feb 2020

- **Protect** critical gov & industry infrastructure against PNT disruptions from GPS/GNSS jamming/spoofing & cyberattacks

- **Define** critical infrastructure under national security threats
  - Power grid
  - Finance
  - Transportation
  - Communications
  - Data centers

- **Use** published PNT assurance guidelines in progress & evolving
  - DHS Resilient PNT Conformance Framework *(IEEE P1952 Resilient PNT UE working group)*
  - NIST Cybersecurity Framework for PNT Profile (*NISTIR 8323*)

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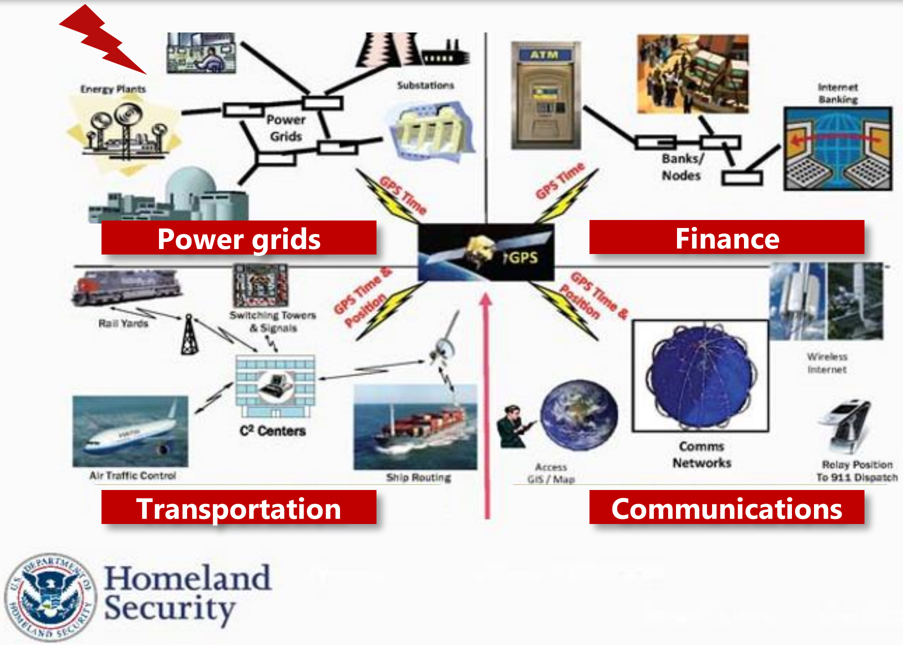
The problem

PNT
cyberthreats

$1B/day in economic cost if PNT is disrupted*

GPS & US critical infrastructure under national security threats



Power grids

Finance

Transportation

Communications

All supported by

Data centers

*source: RTI & NIST 2019

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PNT cyberthreats & GNSS vulnerabilities

PNT cyberthreats

External GPS/GNSS level

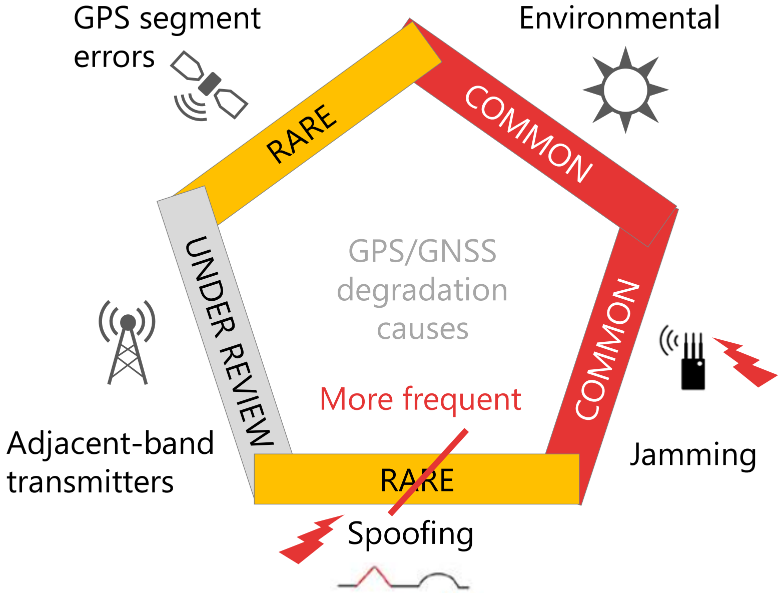
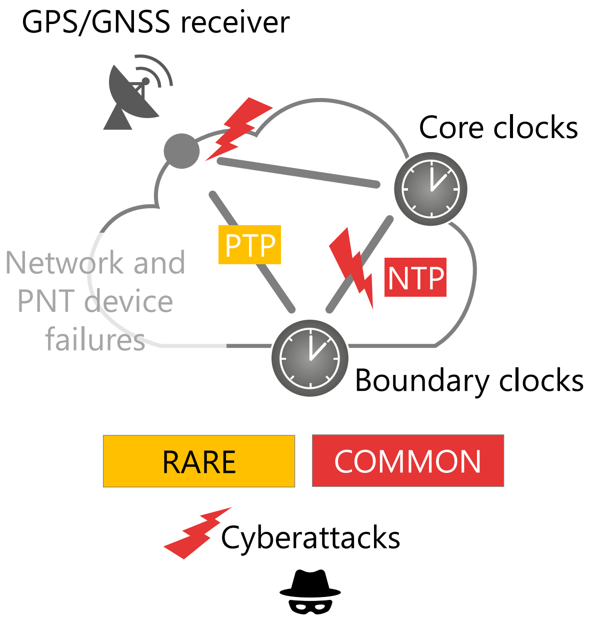


Figure 4.1 – Known GPS vulnerabilities to telecom

Internal network level



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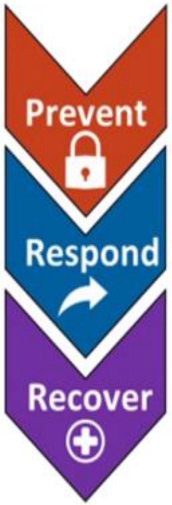
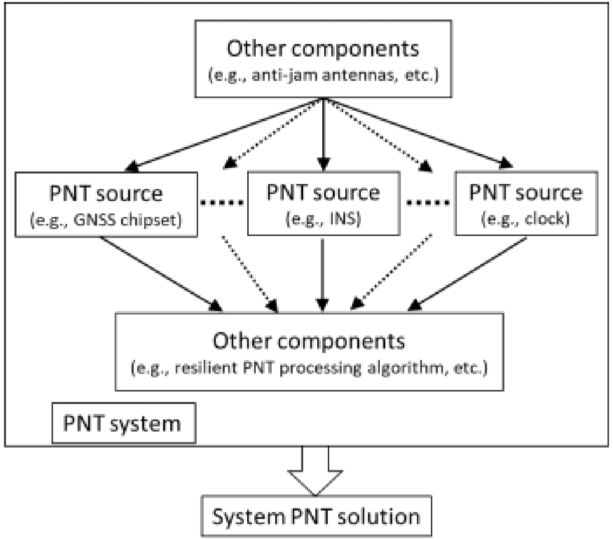
What are DHS' resilient PNT assurance guidelines?

DHS Resilient PNT Conformance Framework

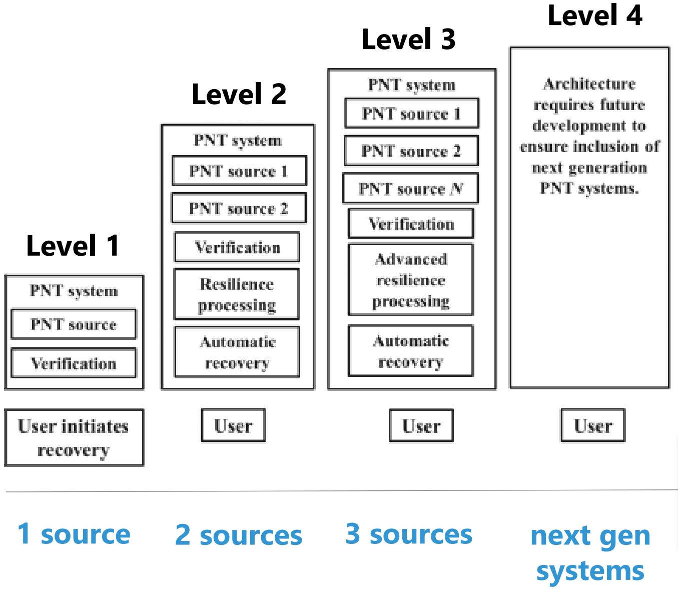
Core functions



Functional diagram



PNT Resiliency levels



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DHS anti-spoofing open-source resources

Released on Feb 26, 2021

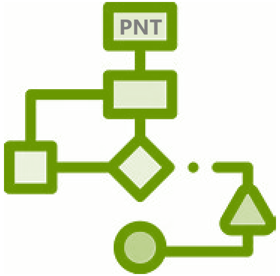
PNT Integrity Library & Epsilon Algorithm Suite*

Spoofing Detection Library

- Designed for GNSS receiver/time server OEMs
- Provides spoofing detection capabilities for GNSS PNT sources
- Provides scalable framework for GNSS PNT manipulation detection
- Allows additional checks to be added as new threats arise

GNSS Spoofing Detection Algorithm

- Detects inconsistencies in position/velocity/clock observables provided by GPS receivers
- Enables end-users to have basic spoofing detection capabilities without any modifications to the existing GPS receiver



*source: DHS

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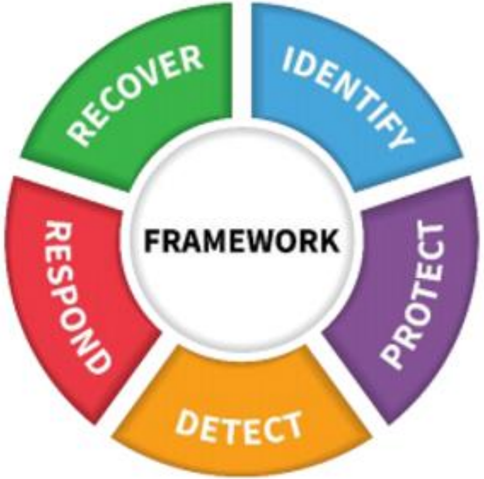
What are NIST's cybersecurity assurance guidelines?

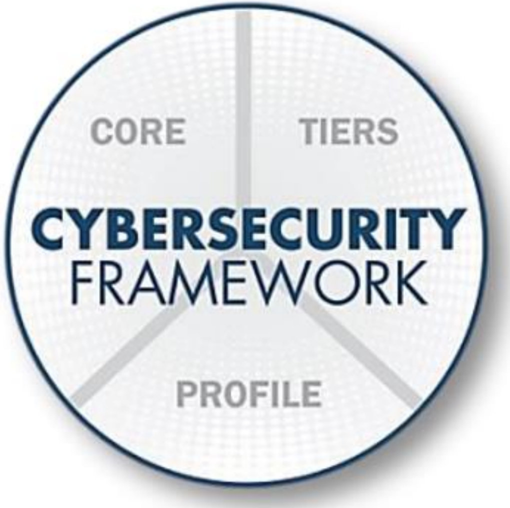
PNT Defense in Depth

NIST Cybersecurity Framework for PNT Profile

Goals



Framework



Core

- Guidance & controls

Implementation tiers

- Cybersecurity risk measurement & management practices

Profile

- Requirements & objectives alignment, including risk appetite & resources

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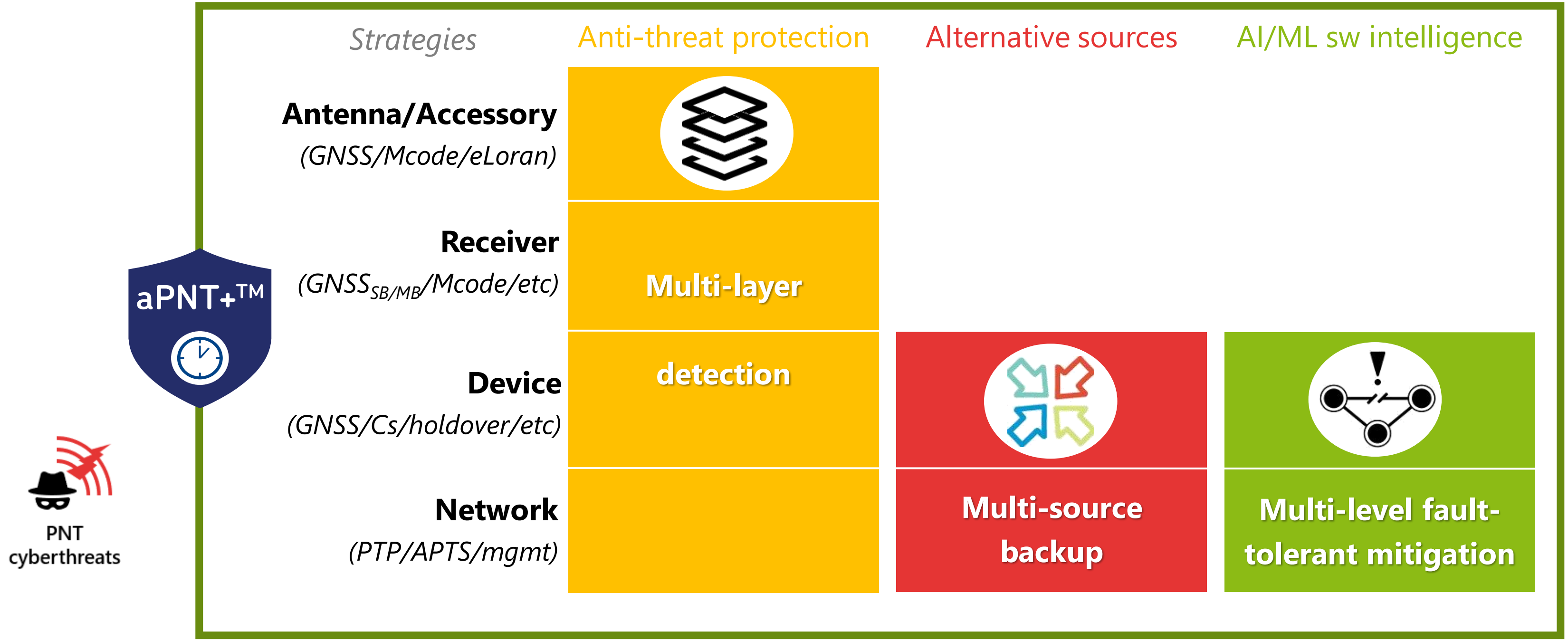
Best practice aPNT+ framework with zero-trust PNT sources

3 building blocks



Strategies

Anti-threat protection

Alternative sources

AI/ML sw intelligence

Antenna/Accessory *(GNSS/Mcode/eLoran)*

Receiver *($GNSS_{SB/MB}$/Mcode/etc)*

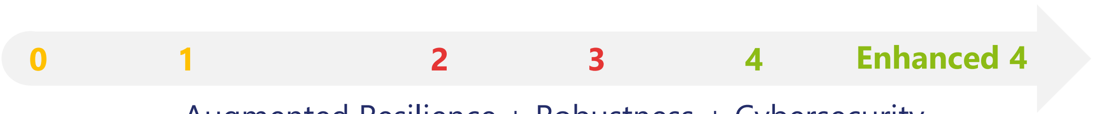
Device *(GNSS/Cs/holdover/etc)*

Network *(PTP/APTS/mgmt)*

Multi-layer detection

Multi-source backup

Multi-level fault-tolerant mitigation



DHS PNT resiliency level 0 1 2 3 4 Enhanced 4

Augmented Resilience + Robustness + Cybersecurity

PNT Defense in Depth

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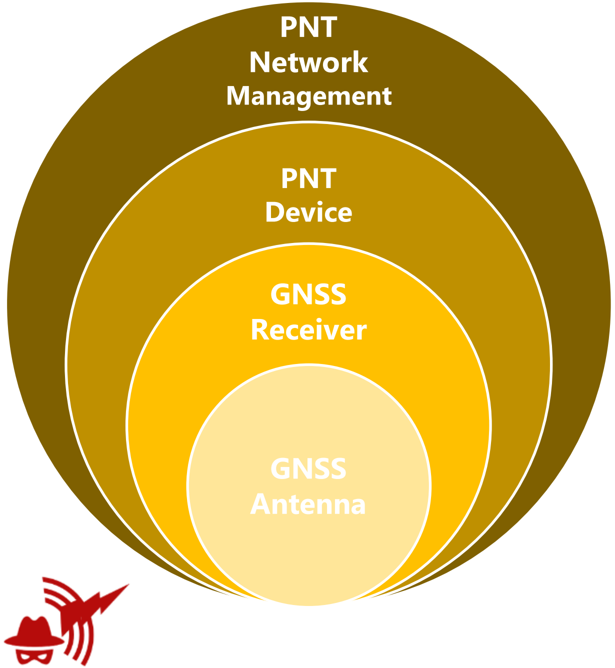
Multilayer detection approach



Level 1: GNSS Antenna

- Use anti-jam/spoof antennas, with threat alarms
- Add in-line anti-jam/spoof accessories, with threat alarms

Level 2: GNSS Receiver

- Use smarter multi-constellation/-band receivers, with jam/spoof & satellite count monitoring, jam mitigation, spoof detection, etc., and threat alarms

Level 3: PNT Device

- Use/compare 2 GNSS receivers, in fixed & nav mode, to detect location/phase/time change, with spoof alarms
- Monitor/compare/verify multisources (GNSS/PTP), with jam alarms

Level 4: PNT Network Management

- Manage/monitor/compare/verify all network devices (GNSS/PTP/ etc.) in real-time, with AI/ML-based threat analytics/alarms

4 Levels of Jamming/Spoofing Detection

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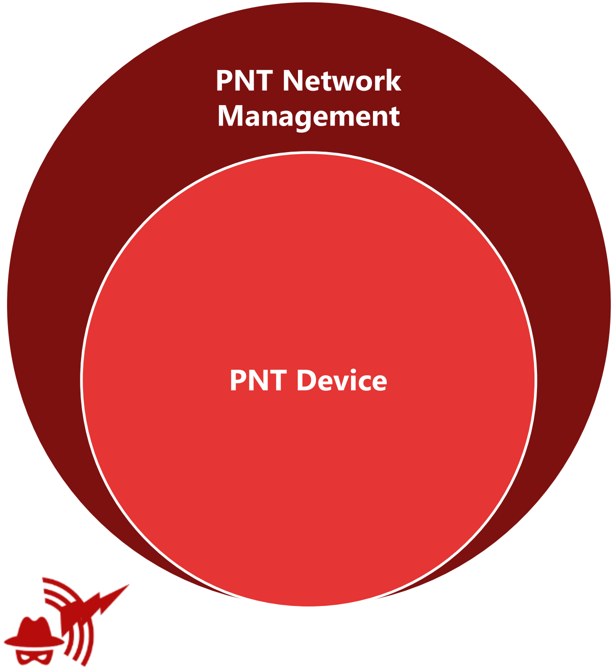
Multisource backup approach



Level 1: PNT Device

- **Source 1**: Use GNSS receiver(s) or DoD M-code receiver
- **Source 2**: Use local holdover clock (super Crystal or Rubidium atomic)
- **Source 3**: Use external standalone (no antenna) Cesium atomic clock, to provide a trusted ePRTC (enhanced Primary Reference Time Clock) with verified GNSS/PTP sources
- **Source N**: Use other sources/clocks of opportunity like White Rabbit (SyncE+PTP), etc.

Level 2: PNT Network Management

- **Source 4:** Use/manage network NTP/PTP time feeds
- **Source N**: Use/manage other sources/clocks of opportunity like White Rabbit (SyncE+PTP), etc.

Augmented PNT Resilience & Robustness

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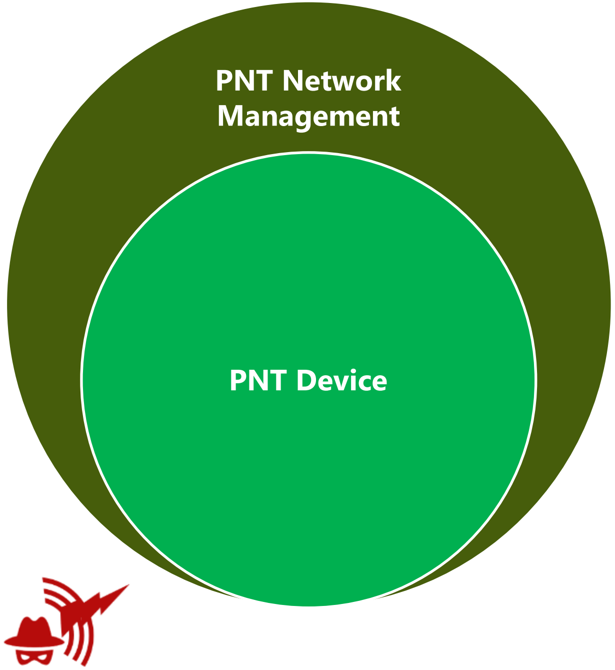
Fault-tolerant mitigation approach



Level 1: PNT Device

- Monitor/compare/verify multisources (GNSS/PTP), with fault-tolerant failover based on detected GNSS jamming/spoofing & network cyberthreat alarms

Level 2: PNT Network Management

- Manage/gather/analyze/visualize all network device data in real-time, then use AI/ML analytics to detect, mitigate & prevent:
  - Jamming/spoofing based on GNSS receiver observables, with threat alarms
  - GNSS environmental obstruction, with threat alarms
- Use a centralized, fault-tolerant network management & monitoring system at scale, with multisource failover in case of jamming/spoofing threats
- Gain complete control/visibility of threats across the network, with a geo map showing compromised/mitigated PNT devices

Complete PNT Control, Visibility & Assurance

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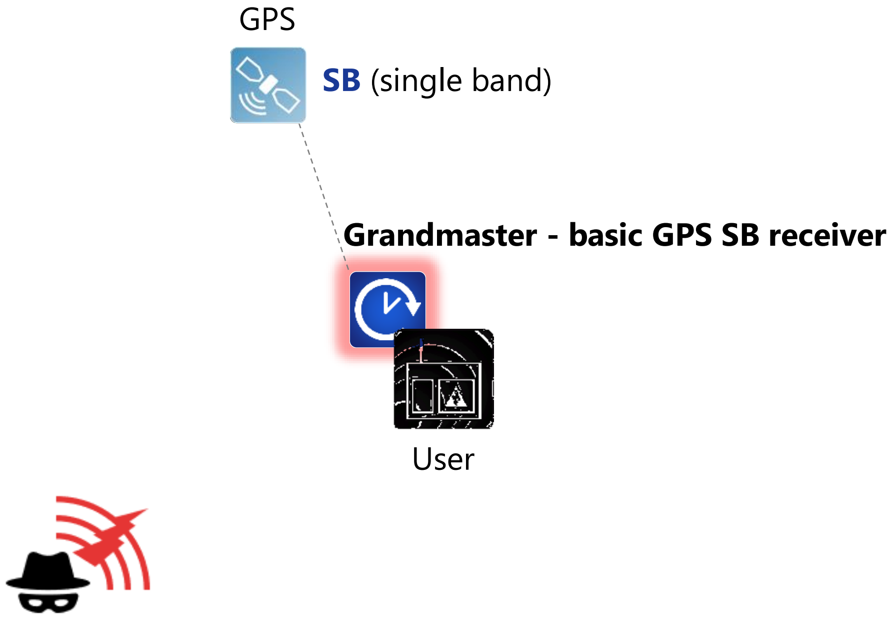
Best architecture strategies against PNT cyberthreats

Level 1 resiliency

Problem

User **level 0** PNT disruptions



GPS

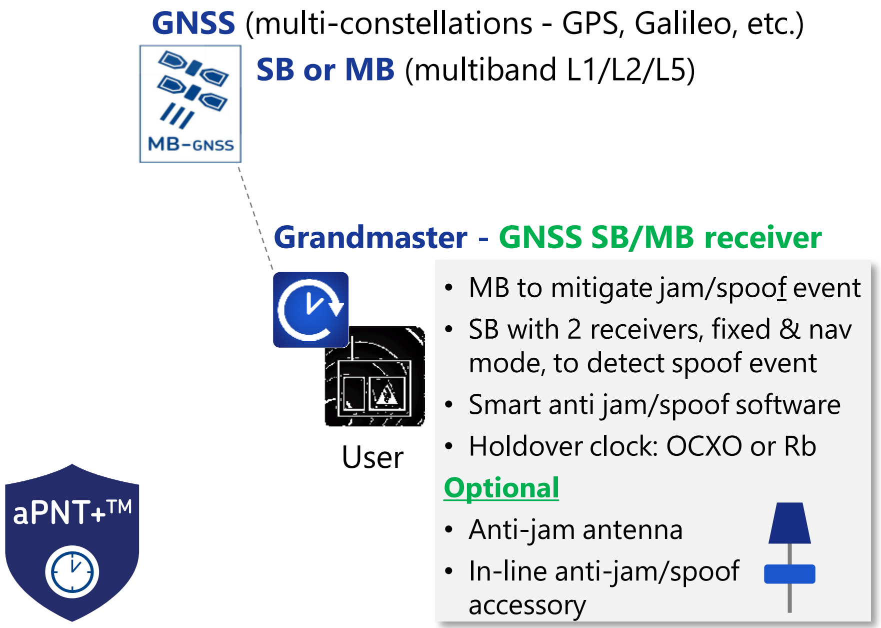
SB (single band)

Grandmaster - basic GPS SB receiver

User

Solution

User **level 1** PNT resiliency



GNSS (multi-constellations - GPS, Galileo, etc.)

SB or MB (multiband L1/L2/L5)

Grandmaster - GNSS SB/MB receiver

- MB to mitigate jam/spoof event
- SB with 2 receivers, fixed & nav mode, to detect spoof event
- Smart anti jam/spoof software
- Holdover clock: OCXO or Rb

Optional

- Anti-jam antenna
- In-line anti-jam/spoof accessory

User

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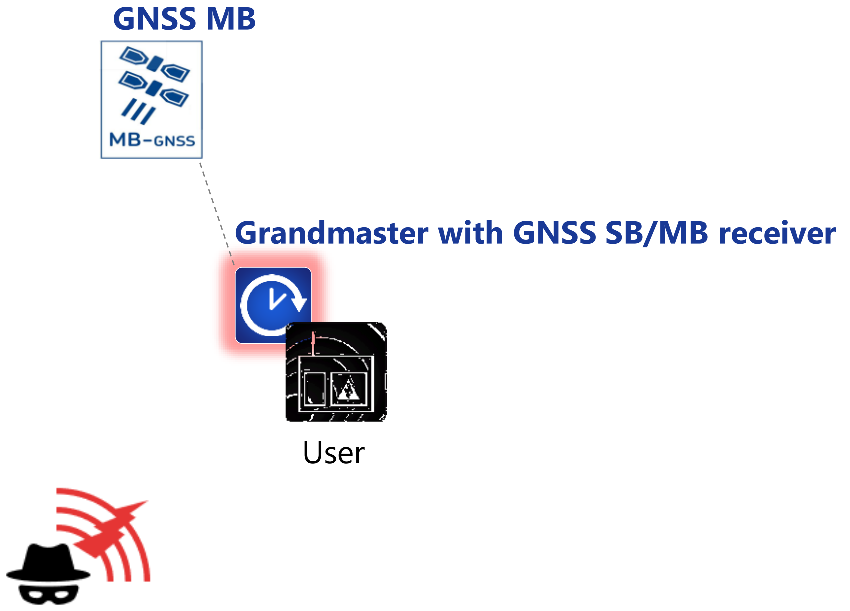
Best architecture strategies against PNT cyberthreats

Level 2 resiliency

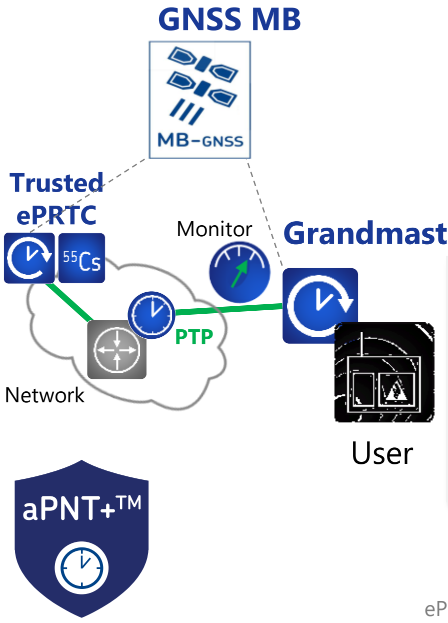
Problem

User **level 1** PNT disruptions



Solution

User **level 2** PNT resiliency



- Same config as level 1 resiliency

PLUS

- **PTP network time backup from ePRTC source**
- **PTP network time monitor**, with threat alarms

ePRTC - enhanced Primary Reference Time Clock

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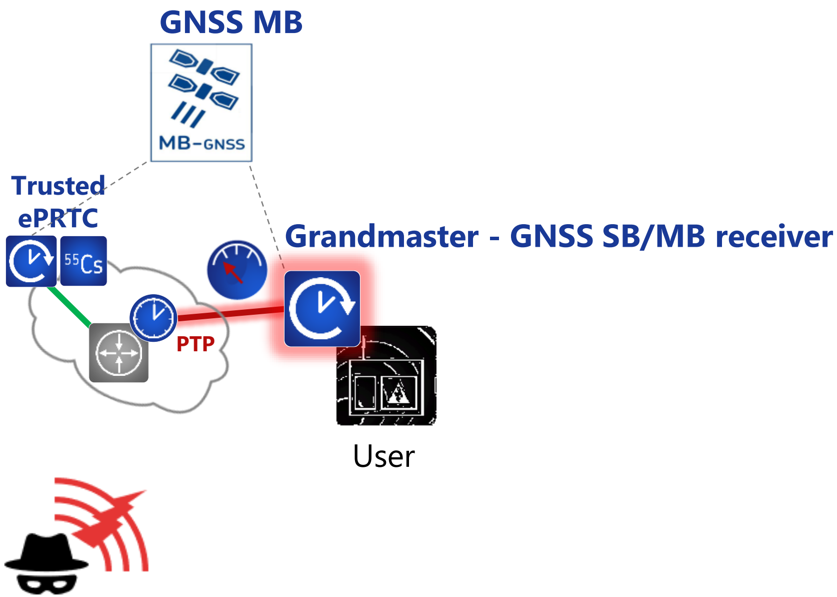
Best architecture strategies against PNT cyberthreats

Level 3 resiliency

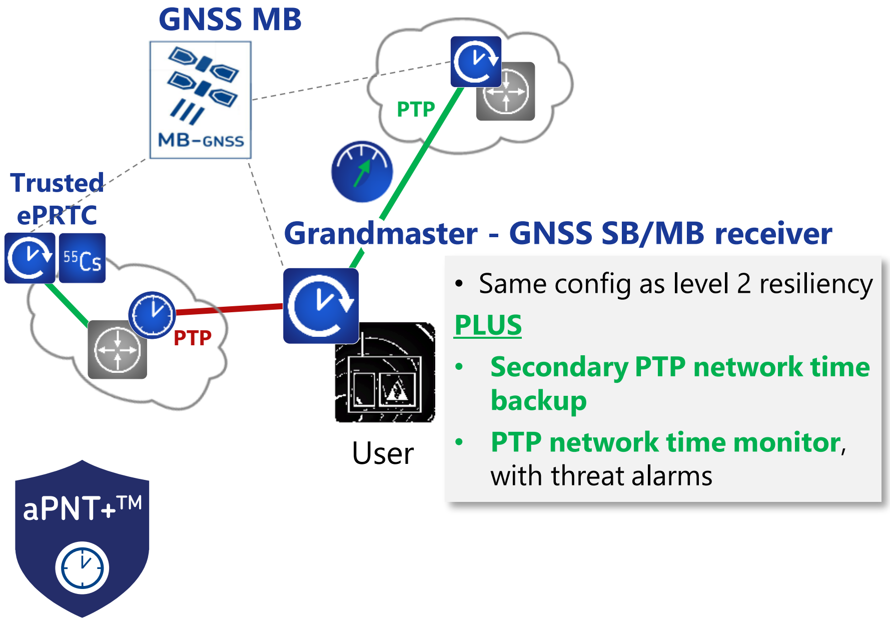
Problem

User **level 2** PNT disruptions



Solution

User **level 3** PNT resiliency



- Same config as level 2 resiliency

PLUS

- **Secondary PTP network time backup**
- **PTP network time monitor**, with threat alarms

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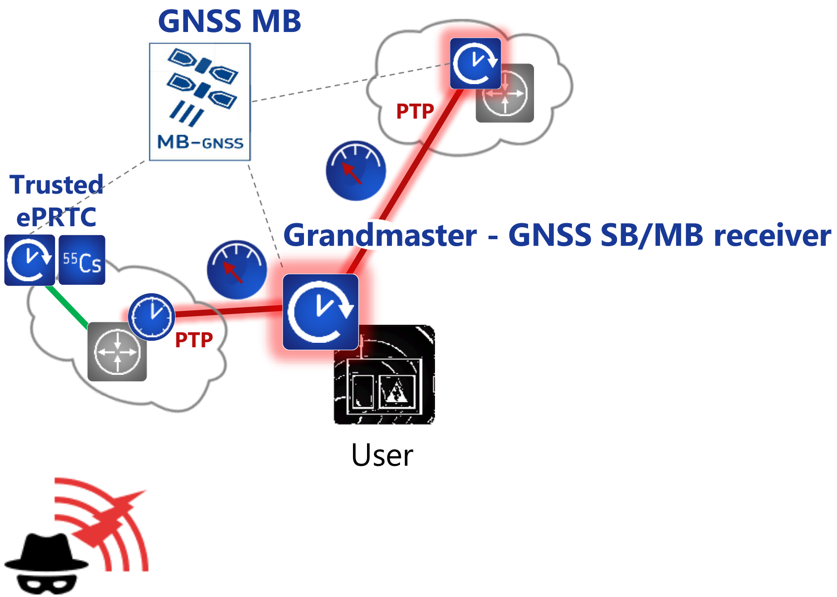
Best architecture strategies against PNT cyberthreats

Level 4 resiliency

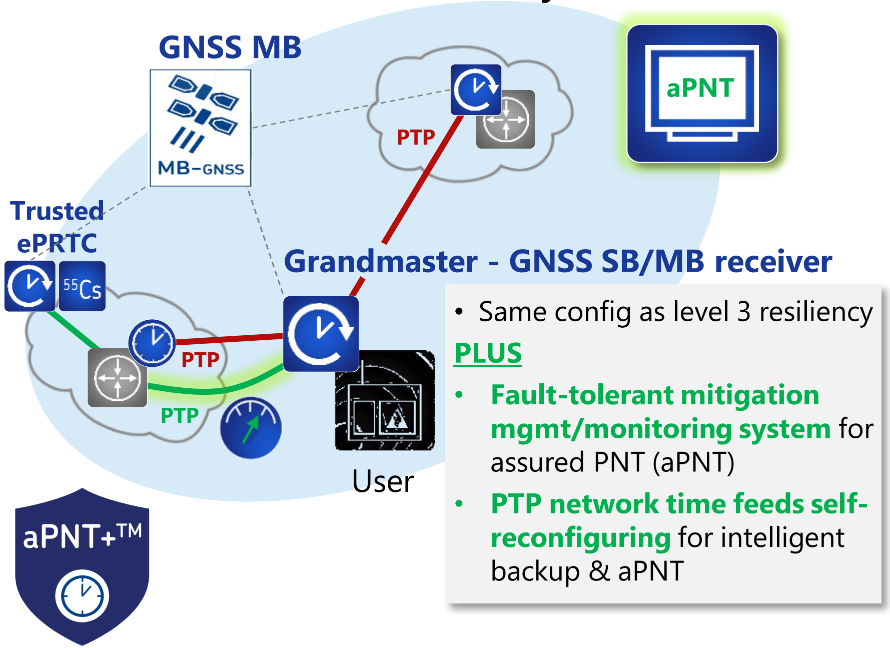
Problem

User **level 3** disruptions



Solution

User **level 4** PNT resiliency



- Same config as level 3 resiliency

PLUS

- **Fault-tolerant mitigation mgmt/monitoring system** for assured PNT (aPNT)
- **PTP network time feeds self-reconfiguring** for intelligent backup & aPNT

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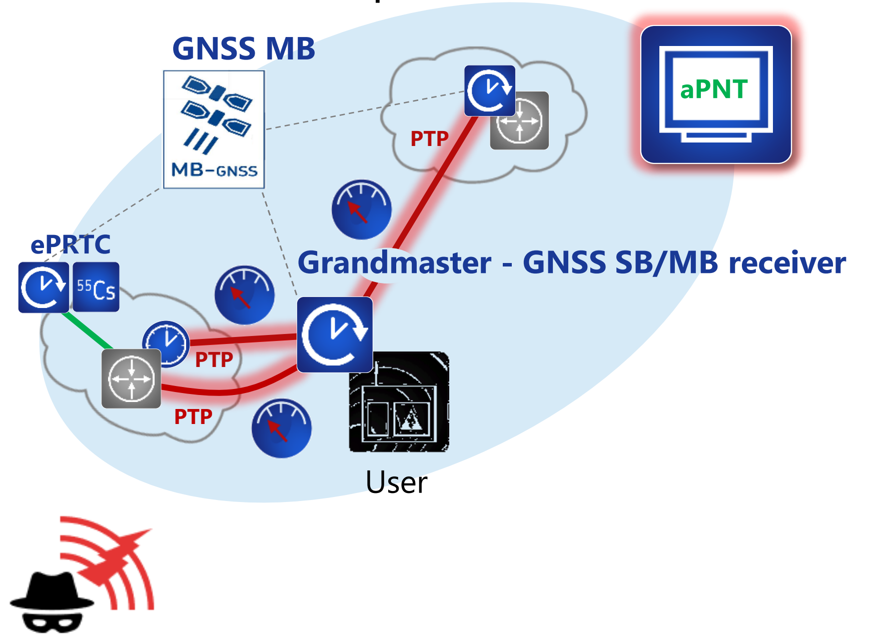
Best architecture strategies against PNT cyberthreats

Enhanced level 4 resiliency

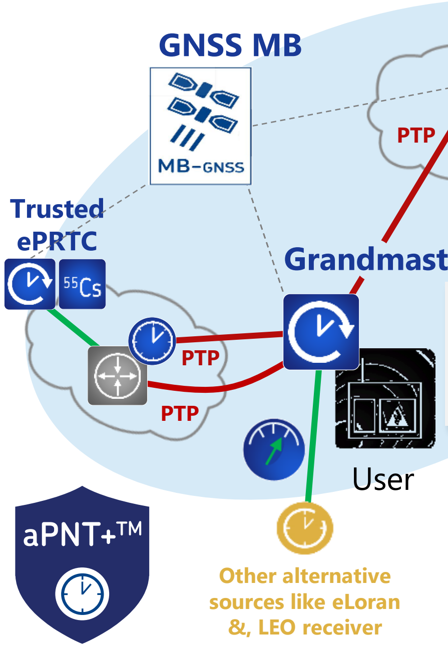
Problem

User **level 4** disruptions



Solution

User **enhanced level 4** PNT resiliency



Other alternative sources like eLoran &, LEO receiver

- Same config as level 4 resiliency

PLUS

- **Other sources of opportunity**

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Thank you

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