

# Resilient Positioning, Navigation, and Timing (PNT) Research and Development Update



Science and  
Technology

# Why Does PNT Matter?

Accurate PNT is important for critical infrastructure.

GPS is an 'Invisible' utility that enables critical infrastructure sectors through precision timing.

GPS' space-based signals are low-power and unencrypted, so they are susceptible to intentional and unintentional disruption.



# Infrastructure Investment and Jobs Act

(P.L. 117-58, Division J)

Signed November 15, 2021



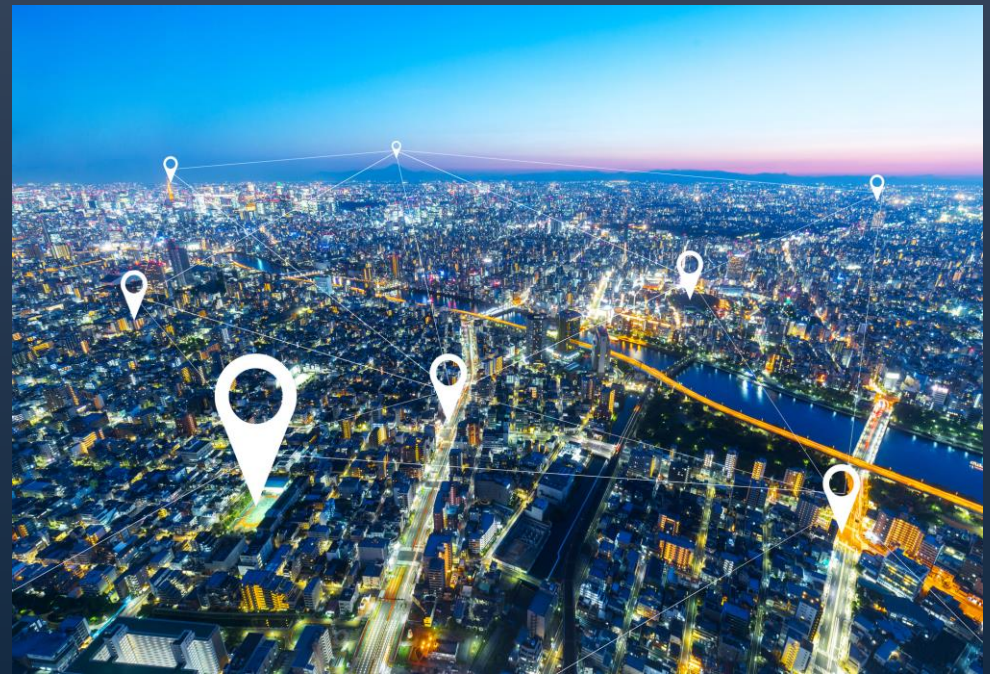
“... for critical infrastructure security and resilience research, development, test, and evaluation” ... the funds made available under this heading in this Act may be used for —

- 1) special event risk assessment ratings planning tools;
- 2) electromagnetic pulse and geo-magnetic disturbance resilience capabilities;
- 3) **positioning, navigation, and timing capabilities;**
- 4) public safety and violence prevention to evaluate soft target security, including countering improvised explosive device events and protection of U.S. critical infrastructure; and
- 5) research supporting security testing capabilities relating to telecommunications equipment, industrial control systems, and open-source software.”

## CISRR Focus Area 3: Positioning, Navigation, Timing (PNT)

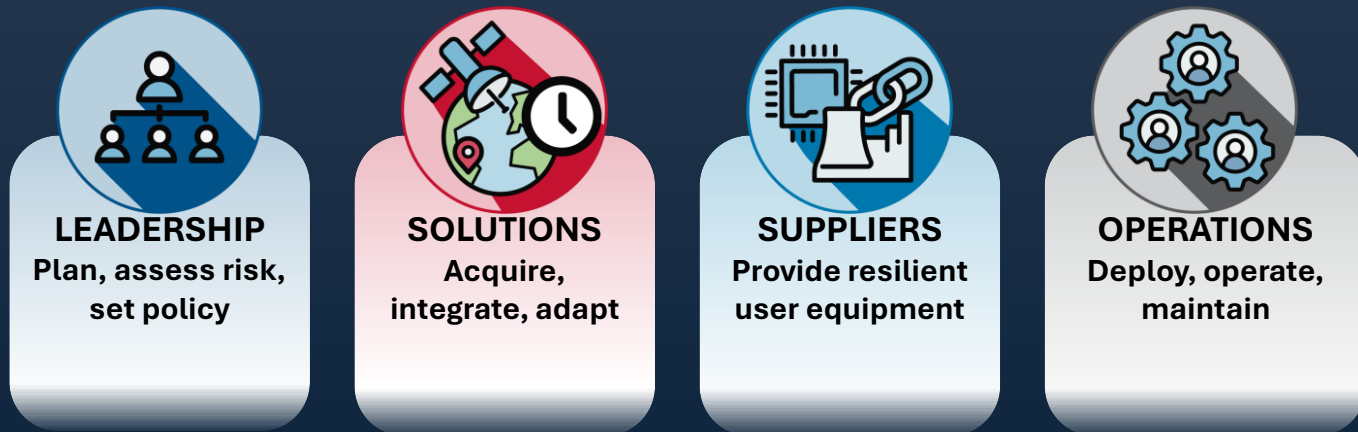
### Strategic Goal

Work with industry to fully understand the impacts of new PNT threats, and develop and make available actionable tools, resources, and frameworks with industry adoption and deployment in mind.

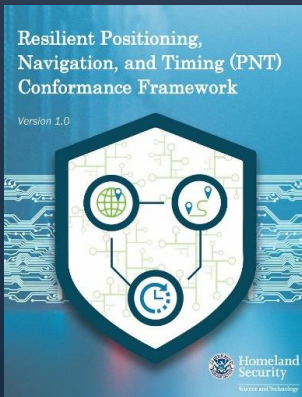


# Resilient PNT Best Practices – September 2024

This document provides an inclusive guide to PNT Best Practices for organizational policies, technology solutions, and operations and maintenance to implement resilient PNT solutions, supporting the policies set forth by E.O. 13905 and the NIST Foundational PNT Profile.



# Resilient PNT Conformance Milestones

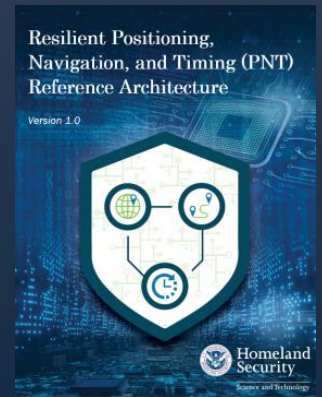


## December 2020 Resilient PNT Conformance Framework V1.0 Published

- Outlines degrees of PNT resilience in coordination with industry and government partners.
- V2.0 published by DHS S&T and CISA in May 2022 expands evaluation guidance.

## June 2022 Resilient PNT Reference Architecture V1.0 Published

- Supports Resilient PNT Conformance Framework with examples.



# Resilient PNT Conformance Milestones

September 2021

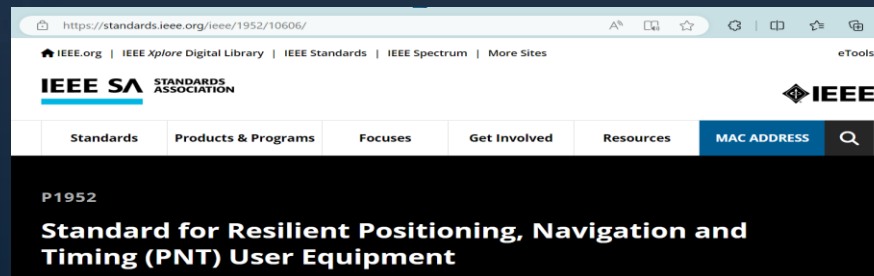
IEEE P1952TM Working Group  
Kickoff Meeting

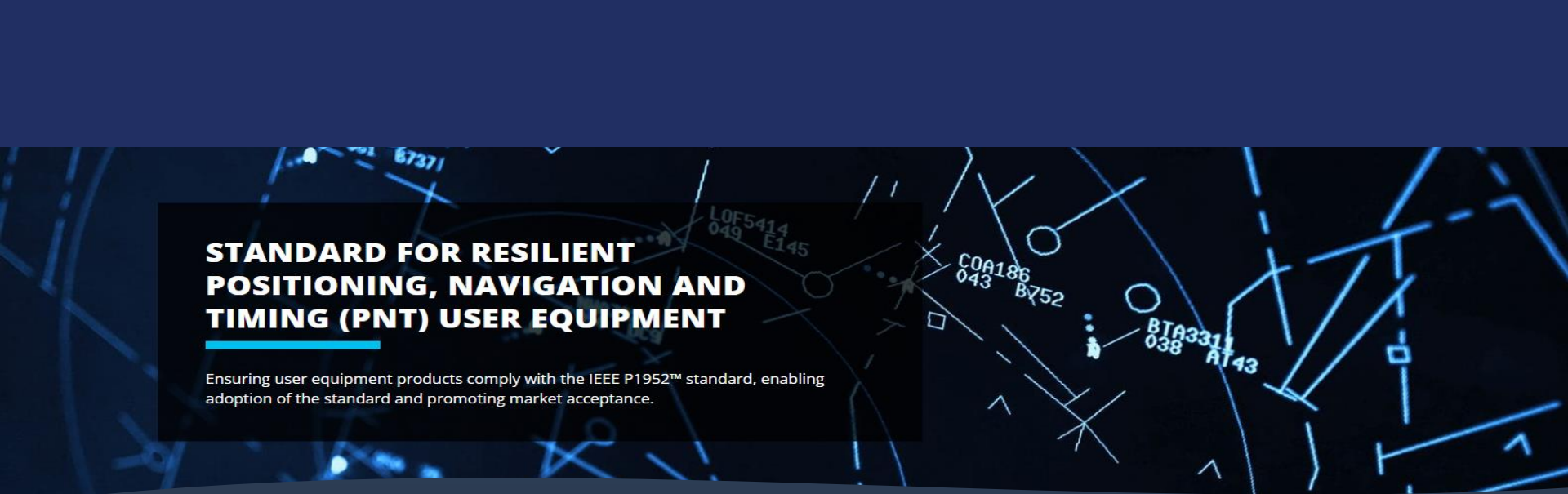
Voluntary industry Standard for  
Resilient PNT User Equipment  
(UE).

April 2024

IEEE PNT Conformity Assessment  
Steering Committee (PNT-CASC)  
for the Conformity Assessment  
Program (ICAP) Kickoff meeting

Develop assessment programs to  
accelerate market adoption  
supporting the IEEE P1952  
Standard.





## STANDARD FOR RESILIENT POSITIONING, NAVIGATION AND TIMING (PNT) USER EQUIPMENT

Ensuring user equipment products comply with the IEEE P1952™ standard, enabling adoption of the standard and promoting market acceptance.

- Scope and purpose from P1952 Project Authorization Request (PAR):
  - “Based on technical requirements, the standard **defines different levels of resilience** to enable users to select a level that is appropriate based on their risk tolerance, budget, and application criticality.”
  - “The standard allows stakeholders to **define and communicate resilient PNT User Equipment (UE)** needs and evaluate proposed resilience solutions in a consistent, uniform manner.”
- Multidisciplinary IEEE P1952 Working Group.
  - E.g., PNT UE users/manufacturers, test equipment manufacturers, test labs, government agencies.
    - Stakeholders representing Critical Infrastructure (CI) sectors providing use cases.
- Balloting process starts soon

# Resilient PNT (RPNT) Capability Maturity Model (CM2)

- Guides organizations, CI owners and operators to achieve more resilient PNT.
- Draws upon:
  - PNT Foundational Profile
  - Latest NIST Cybersecurity Framework V2.0
  - Cyber Resilience Engineering Concepts
  - PNT Reference Architecture
  - PNT IEEE Standards



Develop a Framework for Assessing PNT Resilience



Develop method and tools to support maturity assessment



Drive adoption and evolution through trial use by organizations

# Resilient PNT Capability Maturity Model (RPNT CM2)

**Objective:** Develop a capability maturity model for organizations to benchmark their PNT resilience and facilitate behaviors, practices, and processes to mature their PNT resilience capabilities. This should build on the NIST Foundational PNT Profile developed in response to Executive Order 13905.

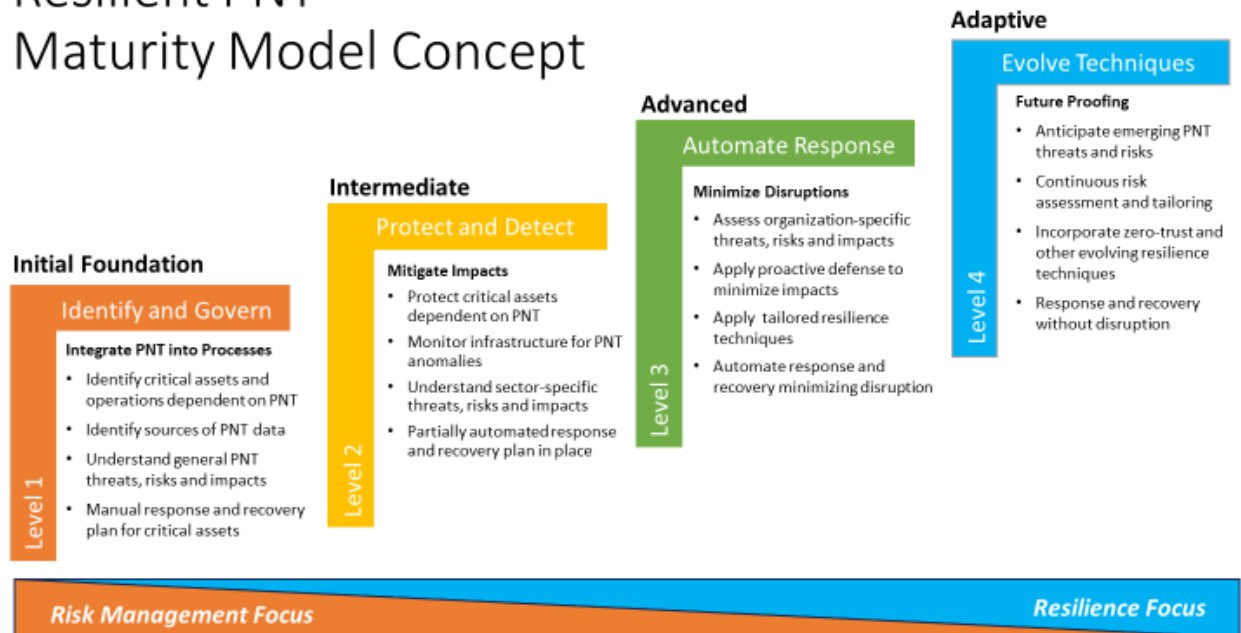
**Impact:** Enable organizations to understand their resilience to PNT disruptions and how to mature related processes and capabilities.

**Deliverables:**

- Capability Maturity Model (CM2) Tool
- Associated Documentation

BLUF: This Resilient PNT Capability Maturity Model (CM2) establishes a maturity framework and an assessment method and tool, allowing organizations to easily apply recommended PNT profile outcomes and other resilience guidance in an iterative and systematic manner. Through CM2, organizations can assess maturity, identify gaps, and develop action plans and roadmaps to achieve security and resilience aligned to their specific operating environment and vulnerabilities.

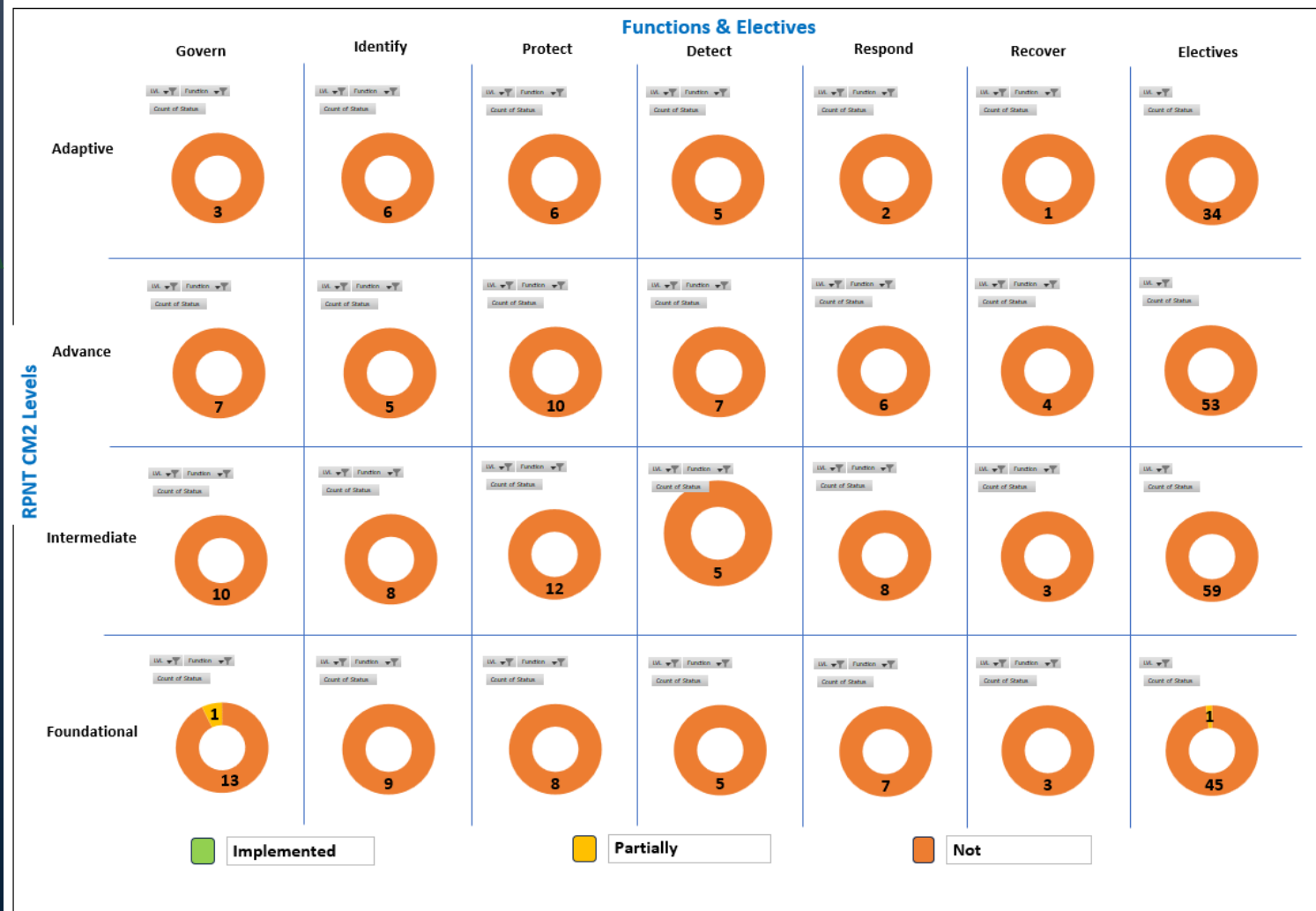
## Resilient PNT Maturity Model Concept



# Resilient PNT Capability Maturity Model (RPNT CM2) – Output Example

The CM2 creates a Resilience Profile for the user.

More Resilient



# GNSS Test Vector Suite & Distribution Methodology

**Objective:** GNSS Test Vector Suite & Distribution Methodology: Develop GNSS test vectors to be used for assessing GNSS user equipment resilience and enhance distribution methodologies.

**Impact:** Enables industry a common set of vectors to use for assessing resilience of GNSS user equipment. This will also help advance conformity assessment work associated with the Institute of Electrical and Electronics Engineers (IEEE) P1952 resilient standards for PNT user equipment.

## Deliverables:

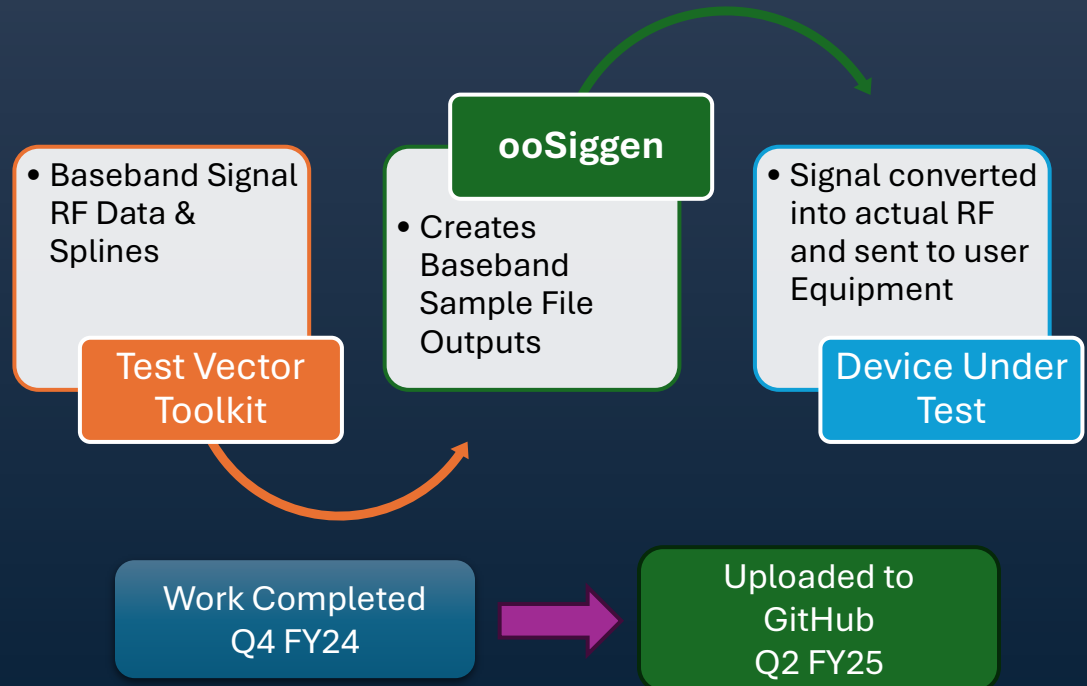
### Test Vector Suite

The Test Vector Distribution Methodology, which is a set of software tools for generating RF inputs to GNSS receivers from the input test vectors

### Exemplary GNSS Receiver Test Vectors

A set predefined set of GNSS receiver test vectors defined as an example and proof-of-concept for the GNSS Test Vector Distribution Methodology

**BLUF:** This activity has identified and defined appropriate test scenarios that support standards conformity assessment and GNSS Test Vectors based on these test scenarios providing these Test Vectors as a proof-of-concept for distribution to CI end-users.

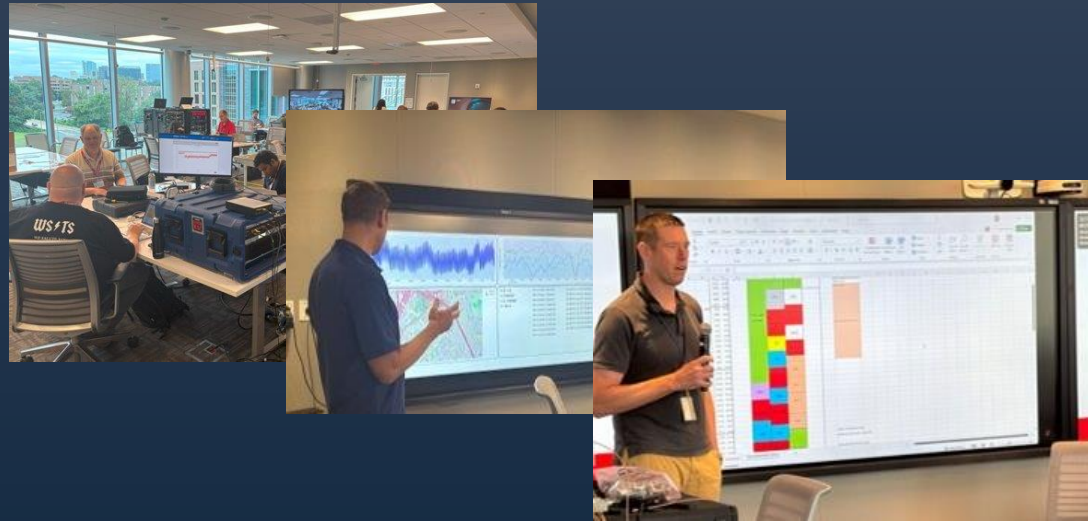


# GPS Equipment Testing for Critical Infrastructure 2025 (GET-CI) “Plugfest”

**Objective:** Continuing the GPS Equipment Testing for Critical Infrastructure (GET-CI) series of live-sky events to raise end-user vulnerability awareness and to allow equipment manufacturers to evaluate how their equipment performs in real world conditions. Event participants tested their equipment under a set of threats in a “Plugfest”-style environment where all presented signals were restricted to RF cabling.

**Impact:** Typical commercial testing and data collection are limited to laboratory environments. This event provides an opportunity for CI O&O and manufacturers of commercial GPS receivers used in CI to perform equipment evaluations in unique spoofing and jamming environment.

BLUF: Continuing the GET-CI series of events, this activity aims to raise end-user vulnerability awareness and allow equipment manufacturers to evaluate how their equipment performs in real-world conditions.



## Event Participants:

- **Government Partners:** DHS S&T, DOE Oak Ridge National Laboratory (ORNL), Volpe National Transportation System Center, and Federal Aviation Administration (FAA)
- **Industry:** Microchip Technology, Meinberg USA, Hexagon US Federal, and Safran USA

# Engage with us:

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Activity Reference	Final Deliverable	Description of Activity
PNT Best Practices	Best Practice Document/Report	This guide aims to provide CI owners and operators, PNT developers, manufacturers, integrators, test labs, and service providers with tailorable best practices for planning, development, and use of PNT systems and services.
Direct Injection	Cumulative Report	The Direct Injection (DI) effort was defined by the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) as a series of ordered to assess the impact of Positioning, Navigation, and Timing (PNT) on specific U.S. critical infrastructure (CI) sectors. This involved engaging with CI owners and operators (O&O) to develop a test and evaluation (T&E) methodology to assess the impacts of PNT adversities on fielded equipment or representative testbeds.
IEEE Conformance Assessment Program (ICAP)	Working Group developing Test Plans for Standards Development	Established the IEEE PNT Conformance Assessment Steering Committee; Developed Test plans for industry to self-assess their PNT resilience in accordance with the new P1952 Standards guidance. Establish content in terms that the IEEE 1952 standard is written in. Specific test plans for PNT UE with different interface types.
Resilient PNT Reference Architecture Implementation	Presentation at CGSIC/GNSS+ 2024	This Reference Implementation facilitates product developers implementing threshold performance levels, enabling their further innovations for market differentiation.
GNSS Test Vector Suite & Distribution Methodology	Test Vector Suite and Distribution Methodology Software	incorporating a conformity assessment program which creates a demand for a common set of vectors for GNSS based PNT source components and the means to distribute them efficiently to developers, integrators, and independent test facilities that may emerge to certify user equipment compliance.
Resilient PNT Capability Maturity Model (RPNT CM2)	CM2 PNT End-User Resilience Evaluation Tool	Model and tool for evaluating and improving PNT security and resilience maturity within organizations. The tool shall enable organizations to (1) enhance their PNT resilience posture, (2) consistently measure their PNT resilience capabilities, (3) share knowledge, and (4) inform actions and investments for reaching a target maturity level.
GNSS Spoofing Test Event – GET-CI	Industry Testing Event	This week-long event served as a live event for industry to test their equipment against a series of PNT disruptions; participants included ORNL, Department of Transportation Volpe, FAA, Microchip Technology, Meinberg USA, Hexagon US Federal, and Safran USA
Equipment Testing Framework	Resilient Requirements Evaluation Report	This work was a follow-on to the Resilient PNT Reference Architecture work, utilizing the IEEE PNT CASC