



NG9-1-1 Conformance & Interoperability: Testing Status and Lessons Learned

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Agenda

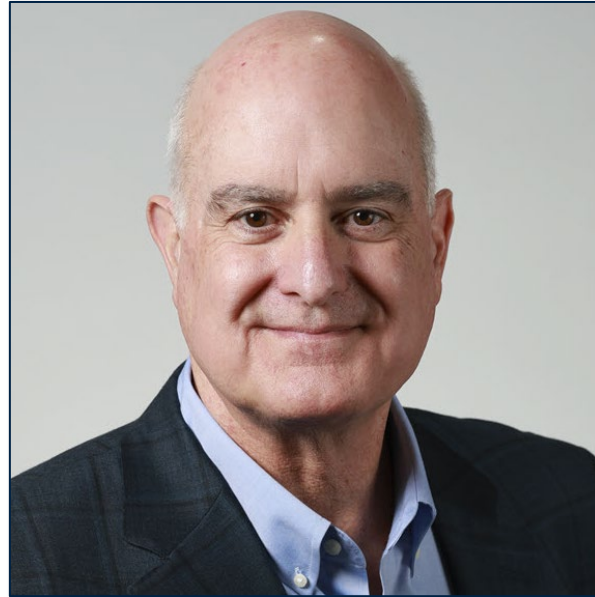
- Why NG9-1-1 conformance and interoperability testing is critical to the success of real-world implementations
- DHS NG9-1-1 Conformance and Interoperability project
- How to access and use the test suite for free
- How to tell if your vendor is really NG9-1-1 conformant, interoperable
- DHS CR9-1-1 Cyber Resilience project
- How to contribute your expertise

Today's Panelists



Brandon Abley

Chief Technology Officer
National Emergency Number
Association (NENA): The 9-1-1
Association



Michael E Fox

Executive Director
Center for Applied Communications
and Networks
The Texas A&M University System



Dr. Eman Hammad

Assistant Professor
College of Engineering
Texas A&M University



Why Conformance *and* Interoperability Testing is Critical

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NENA Standards

— — —
Brandon Abley



911NENA911



Our Vision is a public made safer by 9-1-1 services delivered by highly trained emergency-communications professionals and powered by the latest technologies.

Our Mission is to empower our members and the greater 9-1-1 community to provide the best possible emergency response through standards development, training, thought leadership, outreach, and advocacy.

NENA is an ANSI Standards Developer (ASD)

- NENA is an ANSI Standards Developer (ASD).
- Standards that are developed by NENA are “voluntary consensus standards,” created through procedures accredited for their consensus decision-making, openness, balance of interests represented, and fairness by the American National Standards Institute (ANSI).
- NENA standards are broadly implemented for 9-1-1 and NG9-1-1 in North America.

Why Are Standards Needed?

- Without standards, we would not:
 - Be able to coordinate
 - Play by the same rule book
 - Be able to support each other
 - Have products that meet our needs
 - Interoperate between disparate systems
 - Have a fair market for technology implementations
- Compliance is voluntary!
 - Public pressure, awareness, and desire to follow best practices are motivators



NENA's Standards & Documents

- ~ 140 standards and best practices documents
- Include both Technical and Operational Standards and Guidance
- Available publicly at www.nena.org/standards



NENA New & Upcoming Documents

- i3 Version 3.1 and 4
- NG-PSAP/ECC standard
- NG-SEC v2
- EIDO (Emergency Incident Data Object) v1.1
- GIS Data Model v3
- 9-1-1 Call Processing Standard v2
- NIOC PKI Certificate Policy and Validation Policy updates
- PCA Clarifications
- PSAP Transition to i3
- NENA MLTS Considerations for i3 Considerations
- Virtual PSAP Management
- NIST CSF 2.0 Crosswalk
- Security Audit Checklist
- NENA Standard for 9-1-1/988 Interactions



What is NG9-1-1?

- NG9-1-1 is built around SIP and IP
- Provides standardized interfaces from emergency call and messaging services
- Processes all types of calls: voice, text, data, and multimedia information
- Acquires and integrates additional call data useful to call routing and handling
- Delivers calls, messages, and data to the appropriate entity based on the location of the caller and other policies
- Supports data, video, and other communications needs
- Interoperates with services and networks used by field responders

Key SDOs for NG9-1-1



NENA

- NG9-1-1 and legacy 9-1-1 technical and operations standards
- Basis for International Work (e.g., Europe and Canada)
- Core NG9-1-1 Standard: i3



IETF

- Internet standards: core set of global standards for networks
- Much of i3 is built off of IETF specifications
- Handles registries and base protocols for NG9-1-1

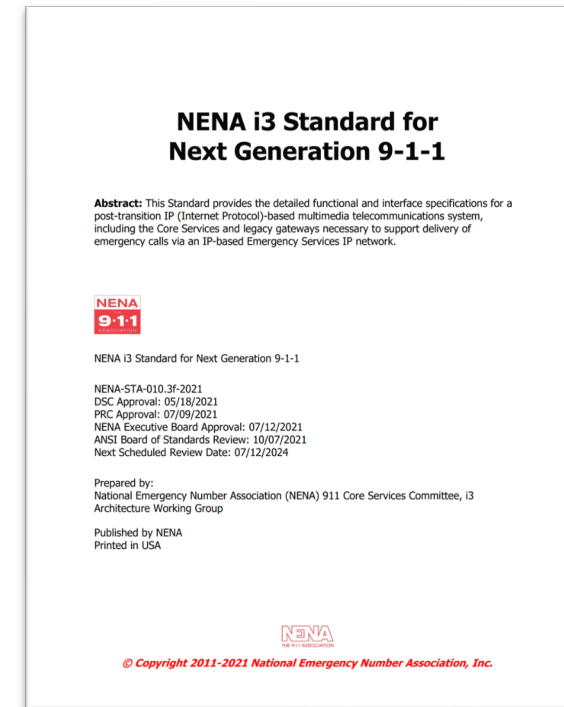


ATIS

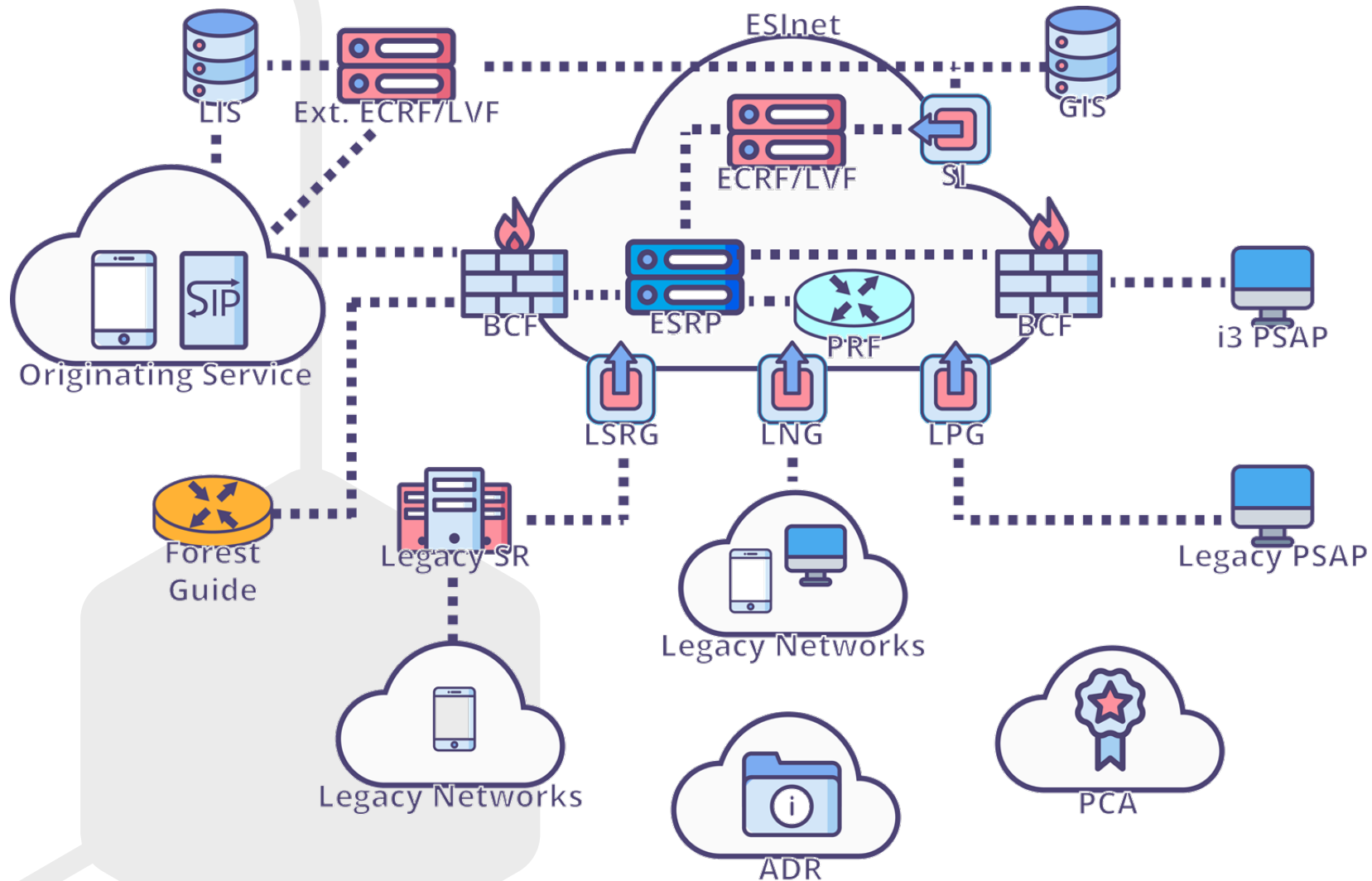
- NG9-1-1 and legacy 9-1-1 standards for OSPs
- Much effort to align with NENA, ATIS, IETF work
- Standards for how calls get to the 9-1-1 system

I3 Standard for Next-Generation 9-1-1

- “i3” refers to the NG9-1-1 system architecture defined by NENA, which standardizes the structure and design of Functional Elements making up the set of software services, databases, network elements and interfaces needed to process multi-media emergency calls and data for NG9-1-1.
- i3 is the core services standard for NG9-1-1, and is the foundational standard overall in the entire NG9-1-1 standards family
- But, i3 is not all of NG9-1-1, and increasingly, NG9-1-1 expands into other important documents (NG-PSAP/ECC, EIDO, GIS Data Model, CLDXF, etc.)
- Current published version is 3f-2021; work on version 3.1 and 4 are ongoing



NG9-1-1 (simplified)



Who can volunteer?

- Anyone! And we need YOU in:
 - Technical and Operational Roles
- YOU DO NOT have to be a NENA member or a 9-1-1 to volunteer!
- Participate by:
 - Joining a Working Group
 - Submitting Contributions to an ongoing document
 - Submitting comments during the Public Review phase
(if you are not a member of the working group)
- What's in it for me?
 - Acknowledgement as contributor in published documents
 - Learn, expand your expertise, and build your network
 - Help advance public safety and interoperability
 - Advance your career in the industry





US Department of Homeland Security Project Overview:

Conformance and Interoperability

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DHS NG9-1-1 Conformance and Interoperability Testing Project

Ready!

Open Source Testing

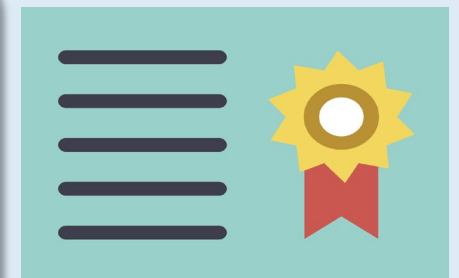
- Free
- Use as often as needed
- Integrate into QA process
- Save time/resources
- Eliminate uncertainty & ambiguity
- Limited user interface
- Need SW dev skills

Testing as a Service

- Adds ...
- Cloud-based, scalable, accessible
- Configuration management
- Extensive logging
- Reporting formatted for certification
- Affordable: subscription, pay per test models

Accredited Lab Testing

- Adds ...
- Tests run by ISO 17025 accredited lab
- No surprises
- Consistent and dependable process
- Confidential results
- Digitally co-signed test report



- Vendor submits ISO-accredited lab report to certifying agency
- Agency verifies info, posts to their website
- Vendor products are eligible for purchase using federal grant funds



Accessing and Using the Conformance and Interoperability Test Suite

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Public GitHub

<https://github.com/tamu-edu/ng911-dev>

- Code
 - Test Software
- Issues & Pull Requests
 - Future
- Actions
 - Code Quality and Security Workflows
- Discussions
 - Coming Soon!
- Wiki
 - Test Suite Information
 - ISO 17025 Lab Information

The screenshot shows a GitHub repository page for 'loganfreeman-tamu' with the following details:

- Repository Info:** 1 Branch, 4 Tags, 83 Commits, 9 stars, 3 watching, 2 forks.
- File Tree:** templates (v4.1 release, 2 months ago), test_configs (v4.1 release, 2 months ago), test_descriptions (v4.1 release, 2 months ago), test_suite (v4.1 release, 2 months ago), .gitignore (v4.1 release, 2 months ago), LICENSE (v4.1 release, 2 months ago), README.md (Update README.md, 8 months ago), _init_.py (v4.1 release, 2 months ago), main.py (v4.1 release, 2 months ago).
- README:** Titled 'Next Generation 9-1-1'. It includes a bookmark link, states it is managed by the Texas A&M Center for Applied Communications and Networks (CACN), and describes the purpose of the repository for the NG9-1-1 Conformance and Interoperability Testing program.
- Documentation:** A section pointing to the repository's wiki for background information and documentation.
- Usage Policies:** A section stating that all users agree to abide by the following Texas A&M University policies.
- Statistics:** A bar chart shows the language distribution: Python (97.9%) and Shell (1.7%), with Other (0.4%) also listed.

Wiki

<https://github.com/tamu-edu/ng911-dev/wiki>

- Program Info
 - Conformance
 - Interoperability
 - End-to-End
- Conformance Testing Software
 - Requirements
 - Test Descriptions
 - Test Software
- ISO Lab Info
 - Process for engaging with the lab
 - Documentation
 - Training

Home

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NG9-1-1 Conformance and Interoperability Program

The NG9-1-1 Conformance and Interoperability Program will deliver conformance, interoperability, and end-to-end testing of NG9-1-1 solutions.

- [Project News](#)
- [Project Overview Video](#)

NG9-1-1 Test Suite

Conformance Testing

- [Overview](#)
- [Requirements](#)
- [Test Descriptions](#)
- [Test Software](#)

Interoperability Testing

- [Overview](#)

End-to-End Testing

- [Overview](#)

Community Engagement

- [Interoperability Task Force](#)
- [GitHub](#)

NG9-1-1 ISO 17025 Laboratory

Using the Lab

- [Process](#)
- [Contact](#)

Learning About or Becoming a Lab

- [Overview](#)
- [Documentation](#)
- [Training](#)

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 - Interoperability Testing
 - End-to-End Testing
 - Community Engagement
- NG9-1-1 ISO 17025 Laboratory
 - Using the Lab
 - Learning About or Becoming a Lab

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▶ [gen-report man page](#)

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▶ [Interoperability Testing Overview](#)

▶ [ISO 17025 Lab Contact](#)

▶ [ISO 17025 Lab Documentation](#)

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▶ [ISO 17025 Lab Process](#)

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Clone this wiki locally

<https://github.com/tamu-edu/ng911-dev>

Test System Software

- Prerequisites
 - Ubuntu (recommended)
 - Python, SIPp, tshark
- Clone the software
- Configuration
 - Lab config (IPs, FQDNs of lab setup)
 - Launch config (individual run info)
- Run it!
 - Man pages for “validate”, “main”, “gen-report”

Conformance Testing Software

Michael Fox edited this page 2 weeks ago · 8 revisions

Location

The test suite can be found in the “Code” section of the repository.

Operating Environment

Hardware/Virtual Machine

- 2 CPU/vCPU
- Minimum 2GB recommended
- Minimum 50GB storage (dependent on expected log level, report volume, and retention policy)

Operating System

- Ubuntu 24.04 LTS is recommended.
- Other versions of Linux should also work, but have not been tested.

Installation

- [Prerequisites](#)
- [Test Suite](#)

Configuration

- [Test Configuration](#)
- [Lab Configuration](#)
- [Launch Configuration](#)
- [Run Configuration \(Optional\)](#)

Man Pages

- [validate](#)
 - The validate command is used before running the test suite to validate the various info and config files used as input by the test suite.
- [main](#)
 - The main command is used to execute the test suite.
- [gen-report](#)
 - The gen-report command can be used after a test campaign to generate an additional report, such as in a different format, or with more or less detail.

Output

The launch_config file specifies the directory path where all output from the test campaign will be stored. This output includes everything needed to audit the test campaign at a later date:

- all info files used: lab_info.yaml, test_info.yaml
- all config files used: launch_config.yaml, lab_config.yaml, test_config.yaml, run_config.yaml
- all logs
- all packet capture files
- all console output
- all report files in the configured format(s):
 - PDF and DOCX: summary or detailed reports for humans
 - XML/UnitXML: for CI/CD integration
 - JSON & CSV: for data analysis

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<https://github.com/tamu-edu/ng911-de>

ISO 17025 Accredited Lab

- Don't have the expertise or time?
- Want trusted, independent, 3rd party validation?
- Use an ISO 17025 accredited lab
- Wiki information includes
 - Engagement process
 - Contact info
 - Operational details
 - Policies
 - Standard operating procedures
 - Forms, logs, etc.
 - Training

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Is Your Vendor *REALLY* Conformant and Interoperable?

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Conformant and Interoperable. Really?

- Most vendors and service providers **say** they are NENA i3 compliant
 - But are they *really*?
 - Now, it's easy to tell, just run the conformance test suite
 - If you don't have the expertise, have it done at an ISO 17025 accredited lab
- Most vendors and service providers **say** they are interoperable
 - But are they *really*?
 - Have your preferred set of vendors tested at an ISO 17025 accredited lab



US Department of Homeland Security Project Overview:

Cyber Resilience CR911

#IWCE26

DHS NG9-1-1 Conformance and Interoperability Testing Project

Testbed Cybersecurity Risk Assessments and Testing

Functional Elements

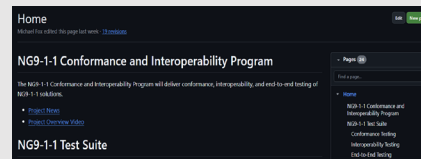
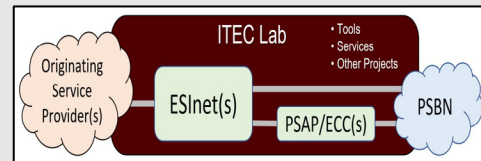
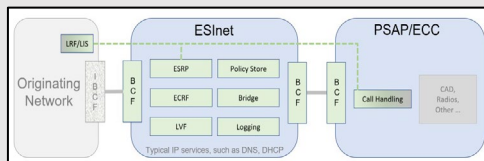
- **Objective:** Evaluate NG9-1-1 functional elements under realistic attack scenarios.
- **Approach:** Risk-based, scenario-driven black-box testing.
- **Environment:** Controlled lab testbed (Unencrypted Traffic, No TLS, Firewall Access Granted), A dedicated jump-host machine for passive network traffic monitoring from any VLAN
- **Tools:** Kali Linux, SIPp, hping3, Scapy, SIPPTS, Python scripts, tshark, pyshark, rtpflood, parallel, dd, nmap, gobuster, curl, openssl

Testbed Environment & Infrastructure

- **Objective:** Evaluate NG9-1-1 infrastructure under realistic attack scenarios and recommend mitigations
- **Approach:** Complete scan of the environment/all active IPs followed by iterative deep dives

Test Suite/Repository/Release Evaluations

- **Objective** produce repeatable self-managed process for test suite SBOM/vulnerability assessment and recommendations



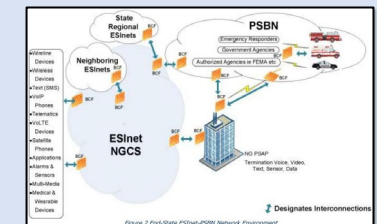
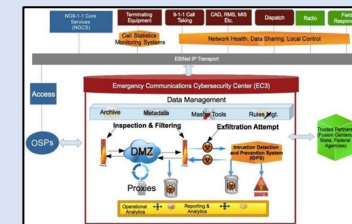
Recommendations on Architecture and Interoperability

EC3 (Emergency Communications Cybersecurity Center)

- **Build Lab PoC EC3** with integrated 3rd party solutions. Test and evaluate for example scenarios and capabilities (data collection, enrichment, analysis, sharing).
- Develop **practical recommendations for an EC3 testbed** with foundational capabilities

NG9-1-1 to PSBN Interconnection

- Evaluate implications of NENA-STA-031.1 by testing 4G/5G at CACN and PSBN connections
- Develop **recommendations for Interconnectivity**



DHS CR911 Cyber Resilient Emergency Communication Systems

Establishing a Proof of Concept (PoC) for conformity and security evaluation program for commercial Next Generation 9-1-1 (NG911)

solutions: Vendor evaluation, supply-chain protection, PSAP procurement checklists



Commercial 911 Vendors

- Free cybersecurity testing (including fuzzing)
- SBOM/Vulnerability analysis
- Recommendations to harden solutions
- Enablement tools

PSAPs and 911 Authorities

- Cyber risk management guide and best practices
- Enablement tools

DHS, CISA & The Industry

- Anonymized testing data and metrics to inform standards, practices, and policies

DHS CR911 Cyber Resilient Emergency Communication Systems



CR911 Testing Harness

SBOM Analysis

- Comprehensive SBOM analysis (commercial and opensource tools- Bomber, Grype, Osv, Trivy)
- Validated against existing repos
- Cross-checked against MITRE ATT&CK
- Recommendations

Cybersecurity Testing

- Requirements: NENA i3, NIST CSF 2.0, etc
- Consumes SBOM analysis results
- Risk-informed active threat vector simulations
- Fuzzing for unknown vulnerabilities
- Target testing automation

Simulated PSAP Operations

Test Automation Framework, Knowledgebase, CI/CD pipelines

Vendor Intake

- Secure lab hosting
- Onboarding
- Baseline evaluation

Ecosystem Enablement

- Vendor Evaluation
- Supply Chain Protection
- PSAP Procurement Recommendations

CR911 Threat-Mapping (In-progress)

CR911 (Cyber Resilient Emergency Communication Systems): A structured approach for mapping threats across emergency-service operations.

1. **Identify Functions:** Map core emergency-service processes (call routing, dispatch, responder coordination, etc.).
2. **List Disruptive Events:** Include cyber, technical, operational, and human-factor events that can affect each function.
3. **Cluster by Operational Stage:** Group events by where they occur in the workflow to show relationships and dependencies.
4. **Map Escalation Paths:** Link events to their possible downstream impacts (delay, denial, misrouting, misinformation).
5. **Add Indicators & Mitigations:** Attach detection cues, safeguards, and recovery steps for each event.
6. **Publish as an Interactive Matrix:** Show in a user-friendly format for training, analysis, and planning.

Filter tactics or techniques... Home Playbooks

Initial Access	Defense Evasion	Collection / Monitoring	Exfiltration	Impact / Availability
Legacy traffic injection via LNG (protocol conversion ingress) CR-IA-03 • T1133 Playbook	Caller identity spoofing in SIP signaling CR-ID-01 • T1036 Playbook	Unsecured RTP bridging / media path compromise CR-PA-02 • T1123 Playbook	Exfiltrate caller location or call logs CR-CO-01 • T1041 Playbook	DoS-induced isolation of legacy PSAPs (LPG failure) CR-SD-03 • T1498 Playbook
Phishing → PSAP workstation compromise CR-IA-01 • T1566 Playbook	LIS impersonation / spoofed location service CR-ID-02 • T1556.006 Playbook			GIS/LVF dataset poisoning (validation corruption) CR-DM-01 • T1565 Playbook
Supply-chain compromise of NG911 component/update CR-IA-02 • T1199 Playbook	Weak transport configuration / downgrade opportunity CR-PA-01 • T1556.008 Playbook			LIS location tampering / bogus location insertion CR-DM-02 • T1565 Playbook
				Ransomware targeting PSAP operations CR-IM-01 • T1486 Playbook
				SIP-based DDoS/call flooding targeting ESRP CR-SD-02 • T1498 Playbook
				Telephone Denial of Service (TDoS) against PSAP CR-SD-01 • T1498 Playbook

Sources: NENA i3 (i3), NG-SEC, and Internal Threat Modeling.

[Submit feedback](#) [Suggest via GitHub](#)

CR-IA-03 (T1133)

Tactic: Initial Access • Playbook: CR-IA-03

CR-IA-03

Legacy traffic injection via LNG (protocol conversion ingress)

MITRE ATT&CK mapping: T1133 → Initial Access

NG911 context: CR-IA-03

Detection & Telemetry

- Anomalous auth/config or request patterns
- Error/latency/throughput anomalies

Triage

- Scope affected elements and paths
- Compare 24h vs 7d
- Validate certs/IDs/rates/schema

Containment

- Block/rate-limit at BCF
- Quarantine & failover
- Disable creds; rotate keys

Eradication

CR911 Playbooks

Click a technique to view its rendered playbook.

Initial Access

- Legacy traffic injection via LNG (protocol conversion ingress) (CR-IA-03 • T1133)
- Phishing → PSAP workstation compromise (CR-IA-01 • T1566)
- Supply-chain compromise of NG911 component/update (CR-IA-02 • T1199)

Defense Evasion

- Caller identity spoofing in SIP signaling (CR-ID-01 • T1036)
- LIS impersonation / spoofed location service (CR-ID-02 • T1556.006)
- Weak transport configuration / downgrade opportunity (CR-PA-01 • T1556.008)

Collection

- Unsecured RTP bridging / media path compromise (CR-PA-02 • T1123)

Exfiltration

- Exfiltrate caller location or call logs (CR-CO-01 • T1041)

Impact

- DoS-induced isolation of legacy PSAPs (LPG failure) (CR-SD-03 • T1498)
- GIS/LVF dataset poisoning (validation corruption) (CR-DM-01 • T1565)
- LIS location tampering / bogus location insertion (CR-DM-02 • T1565)
- Ransomware targeting PSAP operations (CR-IM-01 • T1486)
- SIP-based DDoS/call flooding targeting ESRP (CR-SD-02 • T1498)
- Telephone Denial of Service (TDoS) against PSAP (CR-SD-01 • T1498)

<https://istar-lab.github.io/cr911-threat-mapping/cr911-matrix.html>



Contributing Your Expertise

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Everyone Can Contribute Something!

- All: NG9-1-1 Interoperability Task Force (ITF)
 - <https://ng911interop.org/>
 - Members: Vendors, standards developers, service providers, implementers, consultants
 - Expertise: Technical, financial, operational, organizational, ...
- NG9-1-1 Product/Service Vendors
 - Add your functional elements to the lab; contribute your SBOMs
 - Get early, private testing results
 - Show ISO 17025 accredited lab report to your customers; competitive advantage
- NG9-1-1 Agencies/Implementers
 - Expect excellence from your vendors. Make RFPs and future business dependent on:
 - ISO-accredited testing for conformance, interoperability, and cybersecurity
 - Maintaining cybersecurity and hardening of their solutions as a priority
 - Learn and stay updated on recent threats, mitigations, and responses



For More Information:

Next Generation 9-1-1 Information:

<https://www.nena.org/page/standards>

Project Information:

<https://cacn.tamus.edu/work/test-eval/ng911program/>

<https://cacn.tamus.edu/about-us/contact-us/>

Wiki and Software Repository:

<https://github.com/tamu-edu/ng911-dev/wiki>

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