

FISSURE for Training & Education

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1. EXECUTIVE SUMMARY

Wireless systems are everywhere, from personal devices and commercial networks to drones and industrial control systems. This rapid proliferation has expanded the electromagnetic environment far beyond what many traditional training tools were designed to handle. Students, trainees, and professionals encounter the spectrum in theory, but the leap to hands-on practice is often blocked by scattered resources. Software-defined radios (SDRs), low-cost sensors, and online lessons and reference material are widely available, yet they remain difficult to combine into a coherent learning path. Proprietary systems remain too costly or closed, while many open-source tools require expertise and customization that put them out of reach for classrooms and training programs. The result is a persistent gap between learning the fundamentals of RF, EW, and cyber operations and applying those skills in real-world environments.

Assured Information Security, Inc. (AIS) offers the FISSURE Framework, an open-source, plugin-driven system for RF, EW, and cyber experimentation that also serves as a robust training and education platform. Built on commercial off-the-shelf (COTS) hardware and software-defined radios, FISSURE provides students and operators with the ability to detect, analyze, and experiment with real signals using realistic workflows. Its modular design scales from a single workstation to distributed sensor nodes, supporting classroom learning, academic research, red/blue team training, and operational exercises.

FISSURE's dual-use nature makes it equally effective for teaching fundamentals and preparing mission-ready operators. It allows learners to explore RF reverse engineering, packet crafting, programming, machine learning, distributed networking, and spectrum situational awareness within a single framework. Universities, government training programs, and industry partners can deploy the same tools for education and workforce development that are already being used for research and operational missions.

FISSURE is more than a toolkit. It is a bridge between learning and doing, providing a scalable framework that lowers barriers for newcomers while offering professional-grade capabilities for advanced users. By combining accessibility with operational relevance, FISSURE is positioned as a cornerstone for training and educating the next generation of spectrum professionals.

2. PROBLEM STATEMENT

Mastery of RF, SDR, and electromagnetic fundamentals is vital to national security, cybersecurity, industry, and technology. These skills underpin everything from secure communications and critical infrastructure protection to advanced research and innovation. Yet most students and operators have limited opportunities to learn them in practice.

Classrooms often emphasize theory, leaving graduates without the ability to configure radios, work with Linux, or integrate open-source tools. Access to capable hardware is also limited, with many students encountering only entry-level devices such as the RTL-SDR. Few programs provide shared datasets or recorded signals, which could serve as a bridge when hardware is unavailable.

Graduates lack practical experience in:

- Configuring and operating SDRs.
- Working in Linux-based environments.
- Using open-source analysis tools such as GNU Radio or Wireshark.
- Capturing, storing, and reusing spectrum data for experimentation.
- Exploring RF protocols and networking, including packet structures, modulation types, and wireless standards.

Operational training faces similar barriers. Traditional systems tie exercises to formal ranges or costly proprietary equipment, while modern realities require operators to rehearse and practice in more flexible environments, including distributed and remote settings. Without tools that reflect real-world workflows but run on affordable, accessible platforms, this potential remains underutilized.

The result is a persistent gap between classroom learning and operational readiness. Students struggle to translate theory into practice, and operators lack flexible ways to maintain and expand skills outside structured training events.

3. CURRENT STATE OF PRACTICE

A variety of tools and approaches are used today to address the training and education gap in spectrum operations. Each has strengths but none provide a complete pathway that combines accessibility, scalability, and operational relevance.

- **Open-Source Ecosystems:** GNU Radio, Scapy, and Wireshark provide powerful building blocks for signal processing, packet inspection, and protocol experimentation. They are flexible and respected in research communities, but new learners face steep setup challenges and require expert guidance to use them effectively in structured lessons.
- **Vendor SDR Software:** Many SDR manufacturers supply companion software tailored to their devices. These environments are approachable for demonstrations and introductory labs but are tied to specific hardware and lack flexibility for broader training.

- **Proprietary Defense and Commercial Systems:** Large organizations use advanced platforms that integrate sensing, analytics, and effects. These systems offer strong capabilities but remain closed, costly, and inaccessible to universities, small teams, or individual learners.
- **Online Tutorials and Lessons:** A growing number of online courses and reference materials cover SDRs, wireless protocols, and cybersecurity. While useful for background learning, they are often disconnected from hardware and operational workflows, leaving learners with fragmented skills.
- **Academic Labs:** Some universities integrate SDRs, networking equipment, or cybersecurity environments into their coursework. These labs vary in scope and often focus on isolated demonstrations rather than a structured progression from fundamentals to advanced applications.

Despite this diversity, common challenges remain. Learners are often left to assemble multiple tools on their own with little guidance on integration. Access and exposure vary widely between programs, leaving many without practical experience. Few options provide continuity from classroom exercises to operationally relevant workflows.

The current state of practice is a patchwork of useful but disconnected resources. What is missing is a unified, open framework that brings together software, hardware, and workflows to support comprehensive training and education.

4. SOLUTION: FISSURE FRAMEWORK

FISSURE provides an open-source, modular framework that makes advanced spectrum operations accessible for both students and professionals. It runs on commercial off-the-shelf (COTS) hardware and software-defined radios, enabling users to explore the full chain of RF, EW, and cyber experimentation. By combining hands-on experimentation with realistic workflows, FISSURE bridges the gap between learning and operational practice.

Technical Focus Areas Enabled by FISSURE

FISSURE integrates a wide range of technical domains into one coherent environment, allowing learners to develop skills across disciplines that are often taught in isolation:

- Radio Operation and RF Fundamentals
 - Tuning and configuring SDRs.
 - Testing and comparing antennas.
 - Sampling, modulation, and digital communications.
 - Exploring electromagnetic concepts through direct signal capture.
- Signal Visualization and Processing
 - Real-time signal visualization and spectrum analysis.
 - In-phase and quadrature (IQ) data manipulation for protocol exploration and replay.
 - Digital signal processing techniques, including filtering and feature extraction.
 - Audio signal handling and real-time playback.
- Networking and Communications
 - Understanding wireless protocols and network communications.

- Practicing with systems such as Meshtastic, Wi-Fi HaLow, and other COTS radios.
- Observing how data flows across layers of communication stacks.
- Exploring cyber-physical systems where RF and networking intersect.
- Cybersecurity and Exploitation
 - Packet crafting, fuzzing, and protocol disruption.
 - Vulnerability exploration tied to real RF and networking environments.
 - Safe red/blue team training scenarios that combine RF and cyber.
- Programming and Software Development
 - Practical experience with Python for signal analysis, networking, and automation.
 - Exposure to GUI development with Python Qt (PyQt) and other frameworks.
 - Learning open-source development practices such as version control, modular design, and community contribution.
- Data Science and Machine Learning
 - Feature extraction from signals and datasets.
 - Training and testing machine learning models for classification and anomaly detection.
 - Applying AI to real-time spectrum operations.
 - Leveraging FISSURE's plugin system and online signal archive for dataset-driven experimentation.
- Integration and System-Level Skills
 - Multi-sensor fusion, combining RF with GPS, acoustic, or visual data.
 - Real-time processing pipelines for operationally relevant scenarios.
 - Distributed computing across multiple nodes.
 - Interoperability with common systems such as TAK for situational awareness.

A Unified Environment

Each of these technical focus areas exists in today's landscape, but they are scattered across disconnected tools and platforms. FISSURE unifies them in one framework that runs on COTS devices and open-source software, lowering barriers while preparing learners for real-world tasks. Students can move from tuning an SDR to training a machine learning model, all within a single system that mirrors the workflows used in both educational and operational environments.

5. DEPLOYMENT SCENARIOS

FISSURE's flexibility makes it well suited for a variety of training and education environments. Its modular architecture supports lightweight setups in classrooms, advanced exercises for operational teams, and distributed collaboration across remote learners.

In academic programs, FISSURE provides students with access to the fundamentals of radio operation, digital communications, and cybersecurity in a hands-on way. Universities can apply it in

undergraduate labs, senior projects, or graduate research, where students progress from visualizing signals to experimenting with machine learning models for classification. Because it runs on COTS hardware and integrates with widely used open-source software, institutions can scale programs without the prohibitive costs of proprietary systems.

In defense and industry training, FISSURE offers a practical way to create realistic exercises that blend RF and cyber elements. Red and blue teams can use it to rehearse detection, spoofing, or protocol disruption in controlled environments, while C-UAS training can simulate drone-based emitters and teach countermeasure tactics. Operators are no longer limited to formal ranges or specialized facilities; with portable nodes and low-cost radios, they can practice workflows at home or in distributed groups, gaining repeatable experience that reflects operational conditions.

In research and workforce development, FISSURE provides a platform for experimentation with new algorithms, data analysis techniques, and distributed architectures. National labs, government programs, and private industry can use it to reskill personnel or train the next generation of engineers and analysts. Because the framework supports feature extraction, dataset building, and AI-driven classification, learners can develop cutting-edge methods while building intuition about signals and systems.

Online and remote learning is also supported through the FISSURE Challenge capture-the-flag (CTF) site and distributed sensor nodes. Students and professionals can collaborate across geographies, practice skills in a safe environment, and share results through the integrated database. This enables continuous training opportunities outside the classroom and supports a global community of learners.

Taken together, these scenarios show how FISSURE can be adapted to meet the needs of students, operators, researchers, and organizations. Its ability to scale from individual learners to distributed teams makes it an effective foundation for training and education across multiple domains.

6. KEY BENEFITS

FISSURE provides a set of advantages that make it uniquely suited for training and education in spectrum operations:

Open-Source and Extensible: Students and educators can use, modify, and extend the framework without vendor lock-in. This supports new radios, effects, and datasets while introducing learners to common practices in open-source software development.

Low-Cost and Scalable: Runs on COTS hardware and general-purpose computers, making it practical for classrooms, labs, and workshops. The same system can scale to multi-node setups for advanced training.

Hands-On Learning: Learners gain direct experience with SDRs, Linux environments, data management, and programming. They can capture real signals, analyze protocols, and test their solutions on devices.

Continuity from Classroom to Field: The same framework that introduces students to RF fundamentals also supports advanced operator training, ensuring skills are directly transferable.

Data-Driven Practice: FISSURE's plugin system and online signal archive allow learners to access shared datasets and

recorded signals even when hardware is limited. This supports repeated analysis, experimentation, and machine learning workflows.

Cross-Disciplinary Exposure: Connects RF, networking, cybersecurity, and AI in one environment, preparing students for multi-domain challenges.

Teaching Efficiency: Instructors can design repeatable scenarios, use the GUI for visualization, and guide students from fundamentals to advanced exercises without switching tools.

Career Alignment: Students gain experience with open-source tools, SDR workflows, and programming practices that are directly valued by employers in defense, government, and industry.

7. RELEVANT EXPERIENCE

FISSURE has gained traction across both academic and professional settings, where it has been applied in learning, demonstration, and skill development. Its use in education and training highlights how the framework adapts to different audiences and environments while maintaining continuity between classroom exploration and operational practice.

In academia, FISSURE has been used for senior projects that allow students to investigate spectrum operations through hands-on experimentation. It has also been introduced in classroom settings to teach the automotive industry about RF attacks, demonstrating its value in specialized training programs that extend beyond traditional coursework.

The framework has been showcased at major conferences including DEF CON and the GNU Radio Conference, where it reached diverse technical communities and encouraged engagement from both practitioners and researchers. Educational video series have also featured FISSURE in summer learning initiatives, giving students and professionals an accessible entry point into spectrum experimentation.

Competitive environments have further demonstrated the framework's potential. FISSURE has been used in capture the flag events focused on RF and cyber challenges, and the FISSURE Challenge now operates as a continuously available environment where learners can practice spectrum analysis, protocol exploration, and cybersecurity skills at their own pace.

FISSURE has also been presented at technology expos, career fairs, and operator-focused demonstrations. These venues give audiences a direct view of the framework in action and reinforce its role as a bridge between academic study, professional training, and real-world readiness.

8. CONCLUSION

Training and education in spectrum operations continue to face a gap between what learners study in theory and what they can practice in reality. Many students finish programs without meaningful experience in configuring SDRs, analyzing RF protocols, or applying open-source tools. Operators often lack ways to rehearse skills outside structured facilities. Existing resources provide pieces of the puzzle but remain scattered, forcing learners to assemble toolchains without a clear pathway from fundamentals to advanced applications.

FISSURE addresses this challenge by bringing radios, sensors, programming, visualization, and data analysis together in one open framework. Learners can progress naturally from visualizing

signals to building machine learning models, from tuning radios to exploring real-time network communications. These experiences prepare students and professionals not only to understand the spectrum but also to act within it.

Accessibility is at the heart of this approach. FISSURE runs on COTS devices, integrates with open-source software, and supports both in-person and remote learning. Educators can design repeatable scenarios, students can practice independently, and operators can maintain readiness beyond formal training events. The same framework that introduces fundamentals in a classroom can extend into advanced experimentation and operational practice.

By combining accessibility with operational relevance, FISSURE is positioned as a cornerstone for spectrum education and training. Its open foundation, technical depth, and proven applications across academic, industry, and community settings show that it can meet the needs of today's learners while preparing tomorrow's workforce. FISSURE ensures the next generation of spectrum professionals can learn, innovate, and contribute with confidence.