

Cognitive Area and Border Control

Introduction and concept

Modern border control agencies and area security forces face an electromagnetic threat landscape of unprecedented complexity. Adversaries, smugglers, and hostile actors exploit a growing array of radio-frequency technologies — from encrypted push-to-talk radios and commercial drones to sophisticated GNSS jammers and illicit cellular devices. Conventional spectrum monitoring tools are no longer sufficient to address these threats.

Effective area and border security demands the ability to detect, classify, and precisely geolocate RF emitters across a wide frequency range — in real time, 24 hours a day, without constant human supervision. It demands intelligence, not just observation.

The cognitelligent systems from YOTASYS address this challenge directly. The Y9827A Inception Spectrum Analyzer combines the proven RF measurement performance of an Anritsu MS27201A spectrum analyzer with embedded NVIDIA Jetson Orin NX edge AI processing, TDOA/POA passive geolocation, LSTM-based anomaly detection, and an Agentic AI control layer — delivering a fully autonomous RF monitoring platform designed for the most demanding field and infrastructure deployments.



The system continuously monitors the radio spectrum from 9 kHz to 54 GHz, covering all relevant communication bands used by border threat actors: VHF/UHF PMR radios, mobile networks (2G–5G), Wi-Fi, Bluetooth, LoRa, ISM devices, and drone control links. Multiple Y9827A units can be networked as a passive sensor array, enabling precise geolocation of active RF emitters through Time Difference of Arrival (TDOA) techniques — pinpointing a transmitter's position on a map without any cooperative signal from the target.

Highlights

- Broadband RF monitoring from 9 kHz to 54 GHz (based on Anritsu MS27201A analyzer)
- AI signal classification: CNN-based recognition of modulation, protocol, and device type
- LSTM anomaly detection: pattern-of-life baseline learning with automatic deviation alerting
- TDOA passive geolocation: sub-metre to tens-of-metres accuracy depending on signal bandwidth
- POA geolocation and hybrid TDOA/POA fusion for narrowband and single-receiver scenarios
- Agentic AI: natural language operator interface for instrument control and reporting
- Node-RED programmable workflows for rapid integration into C2 and GIS systems
- Autonomous 24/7 operation with watchdog-supervised auto-restart

Applications and use cases

- Land border monitoring: detection and geolocation of VHF/UHF radios and smartphones
- Coastal and maritime surveillance: identification of dark vessels via VHF transmissions
- GNSS jammer and spoofer detection: continuous monitoring of GPS/Galileo frequency bands
- Critical infrastructure protection: perimeter spectral awareness across all relevant bands
- Spectrum occupancy measurement in accordance with ITU-R SM.2154

Product Y9827A Inception Spectrum Analyzer

The Y9827A Inception is a rack-mounted, full-spectrum RF monitoring instrument designed for continuous, unattended operation in demanding field and infrastructure environments. It is built on a stacked architecture that combines the proven RF front-end of the Anritsu MS27201A with YOTASYS Inception Technology™: an integrated NVIDIA Jetson Orin NX processor running Ubuntu Linux, Node-RED, ONNX inference libraries, and the full Y9800A software suite.

At the computational core sits the NVIDIA Jetson Orin NX GPU module — delivering 157 TOPS (INT8) of AI inference performance in a power-efficient, thermally optimised form factor. This brings cloud-class neural network processing directly to the field sensor, eliminating latency, bandwidth consumption, and the data security risks associated with remote server or cloud-based AI architectures. CNN inference, LSTM anomaly scoring, and TDOA cross-correlation all execute locally in under one millisecond per analysis cycle.



Agentic AI: The Intelligent Operator

The most significant innovation in the Y9827A is the Agentic AI layer — a Large Language Model (LLM) that acts as an intelligent co-analyst, accepting natural language instructions, orchestrating instrument control, and synthesising results into structured operational reports.



Traditional spectrum analyzers require operators to navigate complex menus and write precise SCPI command sequences, creating a knowledge barrier accessible only to experienced RF engineers. The Agentic AI removes this barrier entirely. An operator types a plain-language directive such as "Scan the 380...400 MHz PMR band and identify any non-standard emitters" — and the system autonomously configures the analyzer, captures IQ data, runs the CNN classifier, computes a TDOA position fix if multiple nodes are available, and returns a human-readable report with geolocation coordinates in under 30 seconds.

The agentic architecture is compatible with locally hosted LLM deployments for fully air-gapped, classified environments, meeting the data security requirements of government and defence customers.

AI Signal Classification: CNN-Based Recognition

At the core of the Y9827A signal intelligence capability is a Convolutional Neural Network (CNN) that processes RF signals as spectral images or time-frequency representations, recognising the unique characteristics of each signal type — even in congested, low-SNR environments. The CNN identifies modulation schemes, protocol-specific patterns, device-specific RF hardware fingerprints, drone RF signatures, and anomalous emissions that deviate from expected signal profiles.

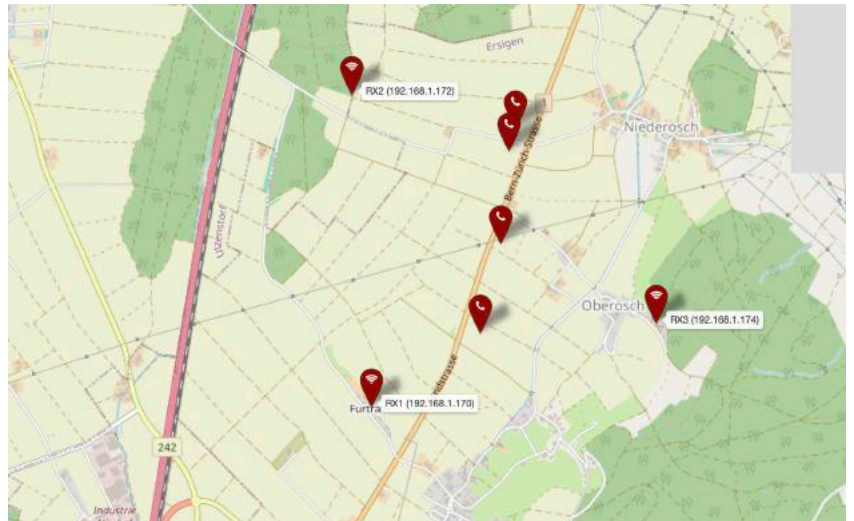
Classification models are delivered as software library modules under the Y9800A designation, covering modulation analysis, drone and pilot detection, jammer detection, mobile network identification, IoT/ISM band devices, and more. Custom models can be trained using the YOTASYS Y9900A Training System, allowing organisations to develop proprietary CNN models from their own captured signal environments.

TDOA/POA Geolocation and Hybrid Fusion

Time Difference of Arrival (TDOA) geolocation is the most accurate passive positioning method available for RF emitters. When a transmitter emits a signal, it arrives at spatially separated Y9827A receivers at slightly different times. Each pair of receivers generates a TDOA measurement defining a hyperbolic locus of possible transmitter positions; three or more receivers provide intersecting hyperbolas whose intersection pinpoints the transmitter in two or three dimensions.

At the nominal 200 MSPS operating point, the timestamped IQ stream provides a 5 ns timing grid. Sub-sample interpolation via correlation procedures achieves effective timing resolution of 0.25–0.5 ns at SNR above 15 dB — equivalent to 8–15 cm range resolution — using only a genius GPS IQ signal data timestamp for synchronisation. For the most demanding applications, White Rabbit PTP synchronisation (below 1 ns inter-node) is supported, enabling centimetre-level positioning with 5G NR waveforms.

For narrowband signals or single-receiver deployments where TDOA precision is limited, Power-of-Arrival (POA) geolocation provides a complementary capability with 50–500 m accuracy. The YOTASYS platform implements a minimum-variance hybrid fusion architecture that adaptively combines TDOA and POA estimates in real time as a function of signal bandwidth, synchronisation quality, and measured SNR - always delivering the best achievable position fix from available data.



LSTM Anomaly Detection: Pattern-of-Life intelligence

Beyond individual signal classification, effective border monitoring requires understanding what is normal in a given RF environment — and detecting immediately when something deviates. Long Short-Term Memory (LSTM) neural networks continuously analyse the time-evolving spectrum occupancy of a monitored area, building a robust statistical model of normal RF behaviour - the "pattern of life" - and generating alerts when observed activity diverges from this learned baseline.

Unlike threshold-based monitors that generate excessive false alarms and miss low-and-slow anomalies, YOTASYS LSTM models flag deviations regardless of absolute signal level. A signal 10 dB below the noise floor that arrives at an unexpected time or frequency is detected because it deviates from the learned temporal pattern. Initial training requires 24..72 hours to establish the site-specific baseline; the model then updates continuously in the background.

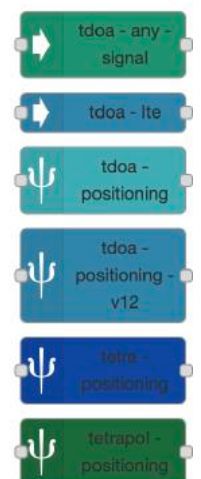
Node-RED programmability

The Y9827A comes pre-installed with Node-RED and the full YOTASYS Y9800A library of instrument control, spectrum acquisition, and AI inference nodes.

Operators construct, modify, and deploy sophisticated surveillance workflows visually - without requiring specialist software engineering skills. Example border security workflows include:

- spectrum scan → CNN inference → TDOA positioning → MQTT alert to C2 → map update
- jammer detection → LSTM anomaly flag → operator alert with frequency, bearing, and estimated EIRP and multi-node TDOA network coordination with KML position output to GIS platforms

Integration with external systems is supported via MQTT, REST API, KML/GeoJSON, ASTERIX format, SNMP, and TCP/IP — enabling the Y9827A to participate in broader C2 networks and Common Operating Picture (COP) environments.



Technical specifications

RF specifications (based on Y9827A)

Parameter	Value	Unit	Comment
Frequency range / bandwidth	9	kHz	RX lower frequency limit
	up to 54	GHz	RX upper frequency limit (see datasheet)
	2 .. 150	MHz	Realtime / IQ Bandwidth
Antennas	1		RX Antenna on front connector N(f) for <20GHz or K(f) for <43.5GHz and V(f) for <54GHz
Sampling rate	200	MSpS	ADC/DAC sample rate at 32bit resolution
Signal Bandwidth	0.036..150	MHz	
Bit resolution	8, 10, 16 or 32	bit	
Trigger source	Free run External 1/2 Video		
Capture Memory	2	TB	Internal at Y9827A
GNSS Antenna	1		RX Antenna on front connector SMA(f)

The RF specifications are depending on setup and configuration of Anritsu MS27200A.

Disclaimer

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YOTASYS AG

Aarbergstrasse 46
CH-2503 Biel/Bienne
Switzerland

www.yotasys.com
info@yotasys.com