

# Wideband RF Record & Playback for EMSO



A complete, standards-compliant signal capture and replay system for electronic warfare test and evaluation using Moku:Delta with Gigabit Streamer.

<b>80 Gbps</b> Max Streaming Rate	<b>6 Ch</b> Simultaneous Streams	<b>2 GHz</b> Real-Time Bandwidth	<b>VITA 49.2</b> DIFI Compliant
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## The Challenge

Modern electromagnetic spectrum operations (EMSO) demand the ability to capture, store, and replay wideband RF signals with deterministic timing and high fidelity. Traditional approaches rely on proprietary record and playback systems costing \$100K–\$200K+ that perform a single function, use locked storage formats, and offer no path to real-time signal processing during capture.

Defense test engineers need a flexible, standards-compliant platform that can record wideband threat environments, replay modified scenarios for receiver validation, and integrate with existing test infrastructure—without six-figure procurement cycles for single-purpose hardware.

## The Solution

The Moku:Delta platform with Gigabit Streamer provides a complete wideband RF record and playback system over standard Ethernet infrastructure. Using **DIFI-aligned VITA 49.2 packet streaming over UDP/IPv4**, sample data flows at deterministic rates from Moku:Delta to any standards-compliant host—no proprietary drivers, no vendor lock-in.

The Gigabit Streamer streams two channels of real-valued samples at up to 5 Gbps per SFP port or four channels at up to 80 Gbps, with support for simultaneous transmit and receive on the same port. In Multi-Instrument Mode, up to six concurrent high-rate channels are available across both SFP and QSFP interfaces.

### Gigabit Streamer+ for Higher Throughput

For ultra-high-speed capture, the Gigabit Streamer+ operates through the QSFP interface at up to 80 Gbit/s (4 channels). It uses the same DIFI-aligned VITA 49.2 packet structure. Note: the Gigabit Streamer+ may be subject to export control and restrictions.

## System Architecture

The diagram below shows a full Multi-Instrument Mode configuration with all three Gigabit Streamer slots active, connected to a verified Minisforum MS-A2 host workstation via direct-attach copper (DAC) cables.

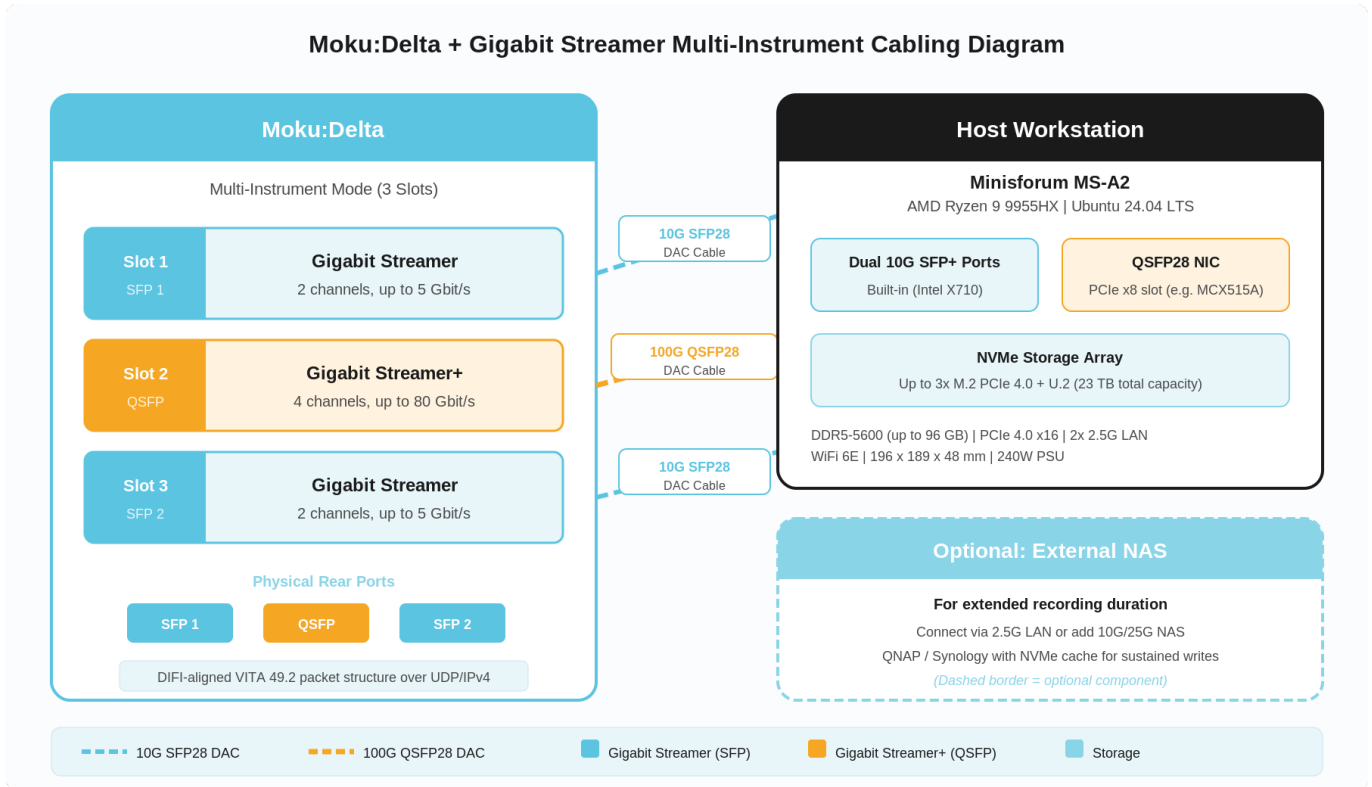


Figure 1: Full multi-instrument cabling configuration with verified host workstation

### Connection Summary (3-slot Multi-Instrument Mode)

Slot	Instrument	Moku Port	Cable	Host Port
Slot 1	Gigabit Streamer	SFP 1	10G SFP28 DAC	MS-A2 SFP+ Port 1
Slot 2	Gigabit Streamer+	QSFP	100G QSFP28 DAC	PCIe NIC (x8 slot)
Slot 3	Gigabit Streamer	SFP 2	10G SFP28 DAC	MS-A2 SFP+ Port 2

#### Important: Network Configuration

The Gigabit Streamer uses static IP addressing on dedicated point-to-point links. No DHCP or ARP is used. FEC must be disabled on QSFP interfaces. MTU must match between Moku and host (max 1500 bytes).

## Verified Host Workstation: Minisforum MS-A2

The following workstation has been verified for sustained data streaming with Moku:Delta Gigabit Streamer. Its built-in dual 10G SFP+ ports, PCIe expansion, and NVMe storage make it ideal as a compact bench or field companion.

Component	Specification
<b>Processor</b>	AMD Ryzen 9 9955HX (16C/32T, up to 5.4 GHz)
<b>Memory</b>	Up to 96 GB DDR5-5600 (2x SO-DIMM)
<b>Network (built-in)</b>	Dual 10G SFP+ (Intel X710) + 2x 2.5G RJ45 + WiFi 6E
<b>PCIe Expansion</b>	1x PCIe 4.0 x16 (x8 bandwidth), splittable to 2x PCIe 4.0 x4
<b>Storage</b>	3x M.2 PCIe 4.0 + 1x U.2 NVMe (up to 23 TB total)
<b>Operating System</b>	Ubuntu 24.04.3 LTS (Noble Numbat) — verified
<b>USB</b>	2x USB 3.2 Gen 2 Type-A, 2x USB-C (DP Alt Mode), 2x USB 3.2 Gen 1 Type-A
<b>Display</b>	HDMI 2.1 (8K60) + 2x USB-C DisplayPort 2.0
<b>Form Factor</b>	196 x 189 x 48 mm   1.5 kg   240W PSU
<b>QSFP Capability</b>	Install QSFP28 NIC (e.g. MCX515A-CCAT) in PCIe x16 slot
<b>Cost</b>	Under \$1,200 USD

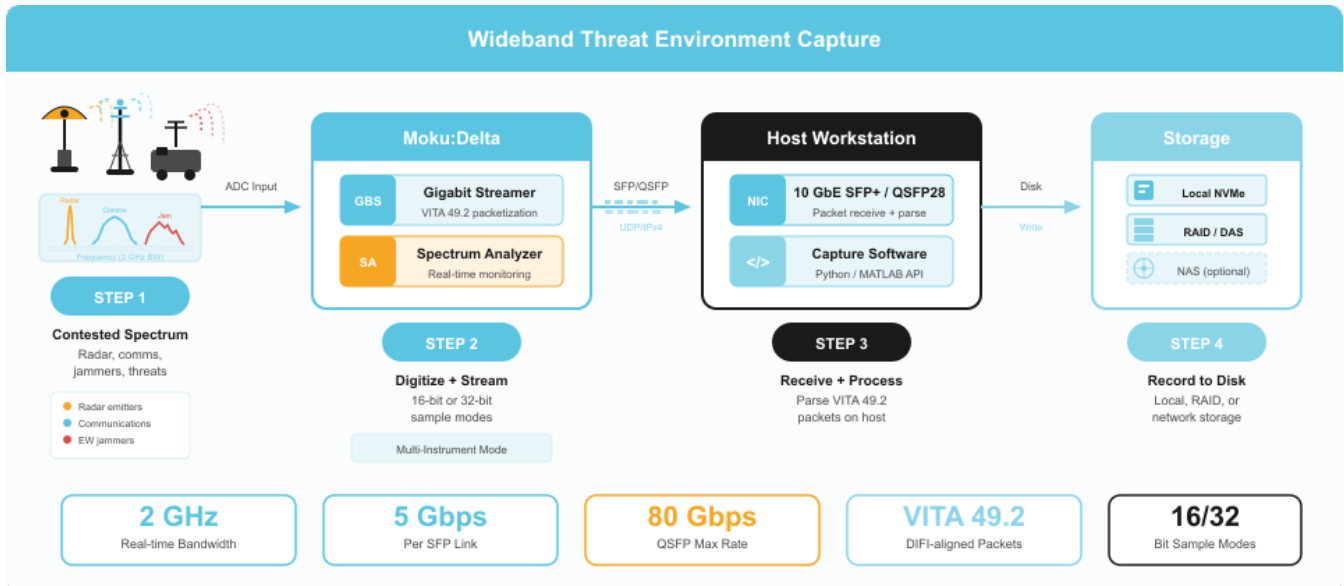
### More verified configurations coming soon.

The Gigabit Streamer works with a variety of PC workstations that meet the performance requirements for high-speed data streaming.

## EMSO Record & Playback Workflows

The Gigabit Streamer enables several critical electronic warfare test workflows. Each leverages the deterministic VITA 49.2 streaming architecture and Multi-Instrument Mode for real-time signal processing during capture or playback.

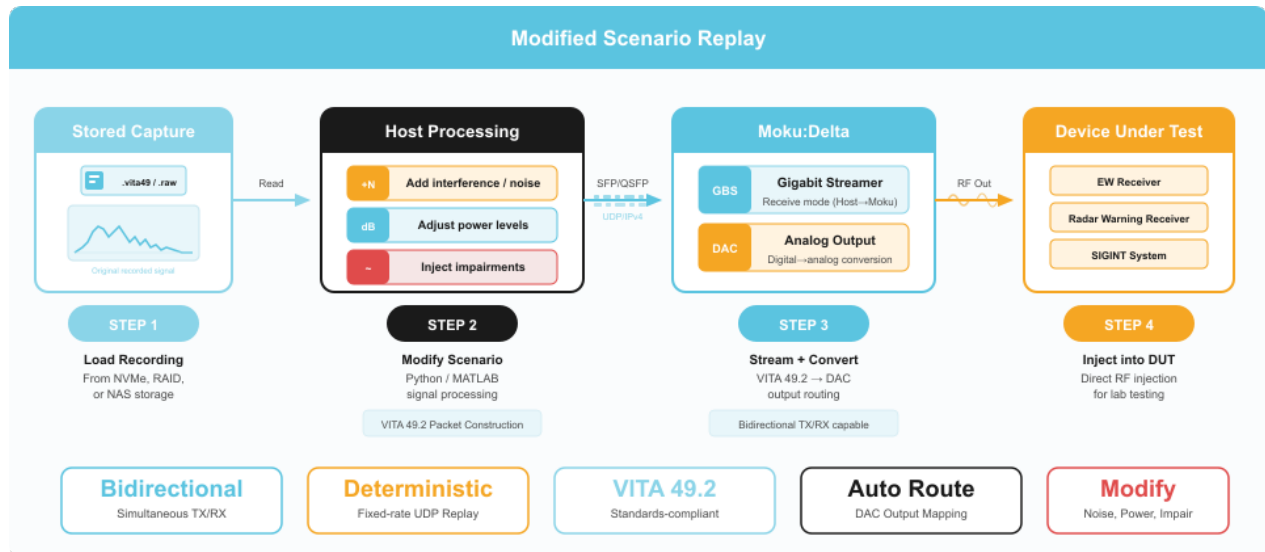
### Wideband Threat Environment Capture



Record the electromagnetic environment in the field or lab at full bandwidth for offline analysis and scenario development. The Gigabit Streamer transmits sample data as a continuous stream of DIFI-aligned VITA 49.2 packets over the dedicated SFP or QSFP link.

- **Up to 2 GHz real-time bandwidth** (2 channels at 5 GSa/s via dual SFP)
- **16-bit (Normal) or 32-bit (Precision)** sample modes with configurable decimation
- **Simultaneous Spectrum Analyzer** via Multi-Instrument Mode for real-time monitoring during capture

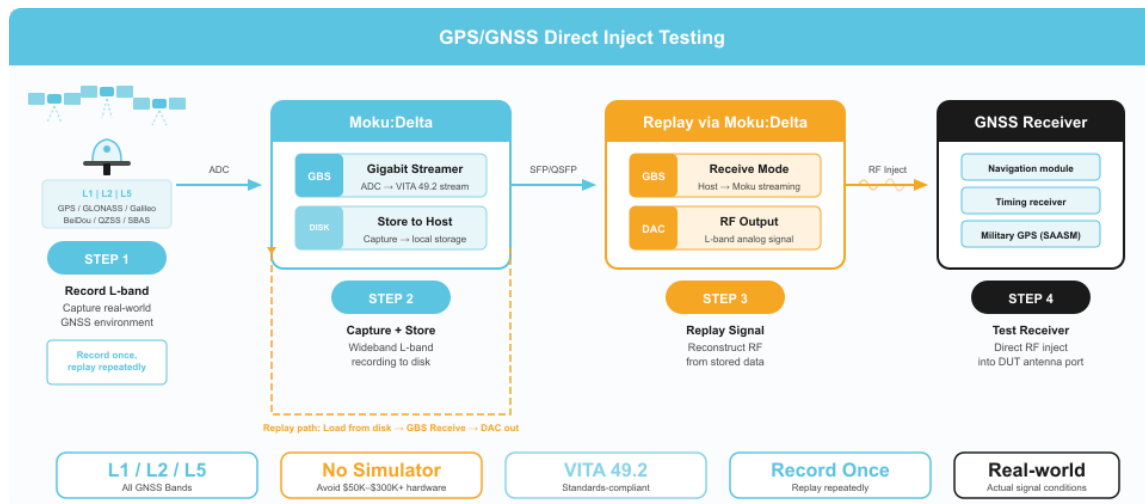
## Modified Scenario Replay



Capture, modify (add interference, adjust power levels, inject impairments), then replay through the Gigabit Streamer in Receive mode. Moku:Delta converts the digital stream to analog output through its high-speed DACs for direct injection into the DUT.

- **Bidirectional:** Simultaneous transmit and receive on the same port for closed-loop testing
- **Host-to-Moku playback:** Construct VITA 49.2 packets matching the configured sample rate for deterministic replay
- **Automatic output routing:** Streamer outputs connect to DAC and analog ports based on vector size parameter

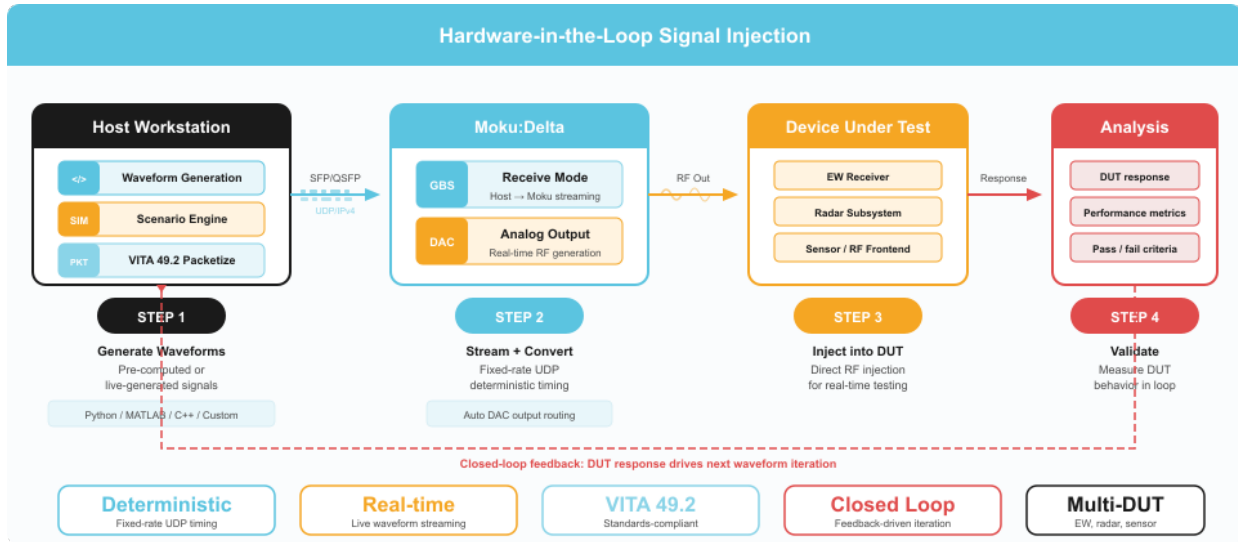
## GPS/GNSS Direct Inject Testing



Record real-world L-band GNSS signals (L1/L2/L5) via the ADC, store the wideband capture, then replay through the DAC directly into a GNSS receiver's RF input—a cost-effective alternative to dedicated constellation simulators.

- **Record once, replay repeatedly:** Capture real-world signal environments and reproduce them precisely in the lab
- **No dedicated simulator required:** Avoid \$50K-\$300K+ GNSS constellation simulator hardware for record/replay use cases
- **Simulate via MATLAB:** Create GNSS constellations via MATLAB to replay through Moku:Delta as an alternative

## Hardware-in-the-Loop Signal Injection



Stream pre-computed or live-generated waveforms from the host into Moku:Delta for real-time DAC output. The fixed-rate UDP transport ensures deterministic timing for HIL applications including EW receiver testing, radar environment emulation, and sensor simulation.

## Gigabit Streamer Specifications

Parameter	Specification
<b>Streaming Interface (GBS)</b>	2x SFP (SFP+ / SFP28 DAC)
<b>Streaming Interface (GBS+)</b>	1x QSFP (QSFP28 DAC)
<b>Max Data Rate (SFP)</b>	Up to 5 Gbit/s per port
<b>Max Data Rate (QSFP)</b>	Up to 80 Gbit/s (standalone) / 4 channels in MIM
<b>Channels per Instance</b>	2 (Gigabit Streamer on SFP) or 4 (Gigabit Streamer+ on QSFP)
<b>Max Concurrent Channels</b>	6 using Multi-Instrument Mode
<b>Packet Protocol</b>	DIFI-aligned VITA 49.2 over UDP/IPv4
<b>Sample Modes</b>	Normal (16-bit real)   Precision (32-bit real, block-averaged)
<b>Decimation</b>	Powers of 2 (1, 2, 4, ...) or multiples of 16 (16, 32, 48, ...)
<b>Transmit / Receive</b>	Simultaneous on same port
<b>Network Addressing</b>	Static IP (no DHCP/ARP); unicast and multicast (receive)
<b>MTU</b>	Up to 1500 bytes
<b>Host NIC Requirement</b>	SFP+/SFP28 (PCIe Gen3 x4+) or QSFP28 (PCIe Gen3 x8+)
<b>Software APIs</b>	Python, MATLAB, REST; Moku Cloud Compile
<b>Platform</b>	Moku:Delta (2U, DC-2 GHz, 5 GSa/s ADC, 10 GSa/s DAC)



## Why Moku:Delta for EMSO

### 16 Instruments in one 2U box

Record, analyze, generate, and process signals simultaneously. Replace entire test benches with a single reconfigurable platform.

### Standards-compliant streaming

DIF-compliant VITA 49.2 packets over standard UDP/IPv4. Integrate with any VITA 49-compatible infrastructure or COTS storage.

### Open APIs & FPGA flexibility

Full automation via Python, MATLAB, and REST. Deploy custom DSP on the FPGA via Moku Compile.

### Compact, cost-effective system

A complete Moku:Delta + host workstation starts at a fraction of the cost of dedicated proprietary recorders, with far more capability.

## Getting Started

Setting up a Moku:Delta Gigabit Streamer system for EMSO record and playback:

1. **Connect hardware:** Attach SFP28 DAC cables from Moku:Delta SFP ports to the host's SFP+ ports. For QSFP, install a compatible NIC and connect via QSFP28 DAC.
2. **Configure network:** Assign static IPs on the same subnet. Disable FEC on QSFP. Set MTU to 1500.
3. **Deploy instruments:** Place Gigabit Streamer in correct MIM slots (Example for 3-slot mode: 1 = SFP1, 2 = QSFP, 3 = SFP2). Configure stream parameters in the Moku App.
4. **Start streaming:** Use the Moku App, Python API, or MATLAB API to begin capture. Verify link and monitor.

### Ready to build your EMSO test bench?

Contact us at [sales@liquidinstruments.com](mailto:sales@liquidinstruments.com)

[liquidinstruments.com/products/integrated-instruments/gigabit-streamer](https://liquidinstruments.com/products/integrated-instruments/gigabit-streamer)