The Role of Modern Hardware in ELINT Operations

Harnessing CPUs, GPUs, and FPGAs for Real-Time Electronic Intelligence

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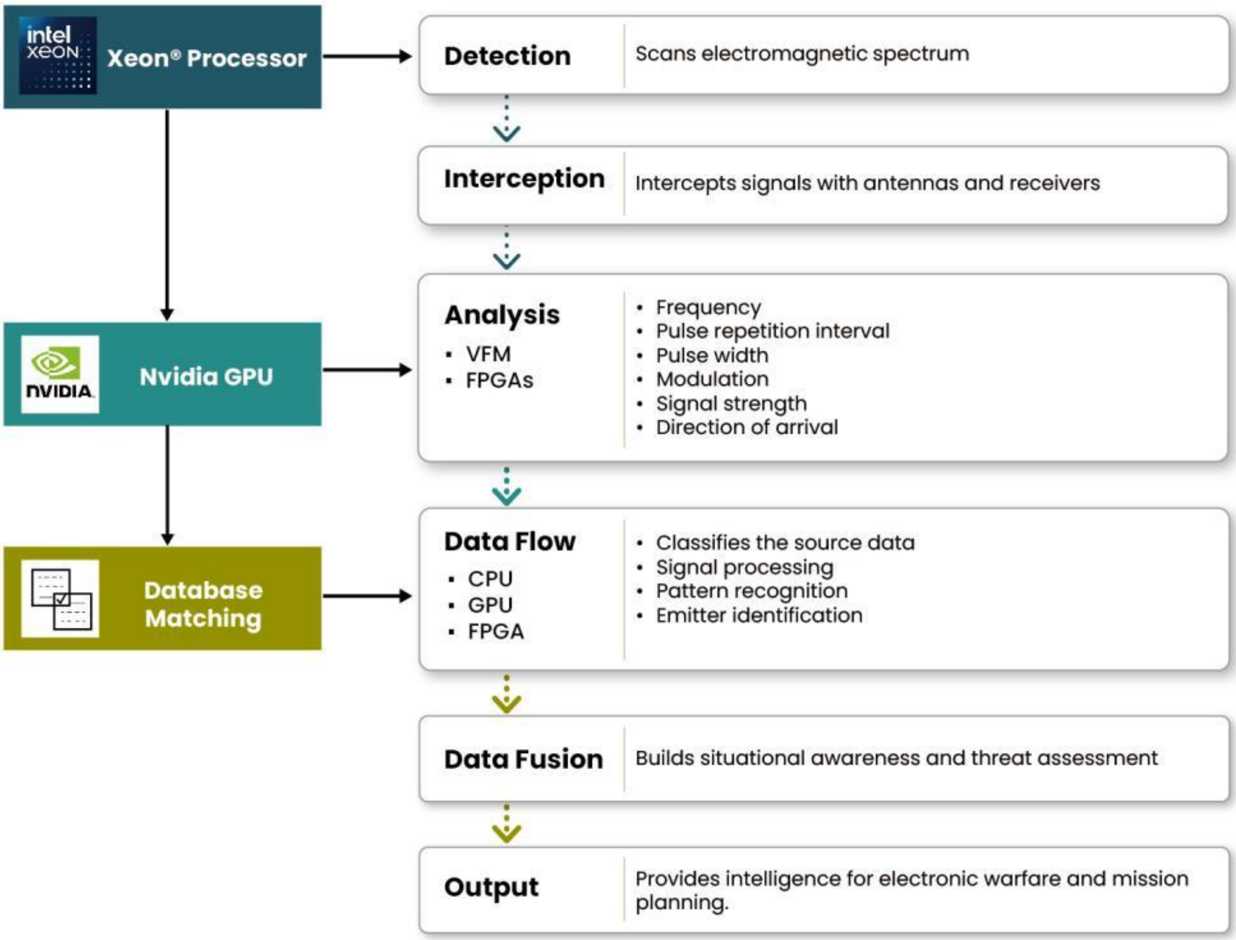
1 Executive Summary

Electronic Intelligence (ELINT) plays a vital role in modern defense and electronic warfare (EW), enabling the detection, analysis, and geolocation of hostile electromagnetic emissions. As threats become more dynamic and signal environments more congested, the need for real-time, edge-level processing has become critical. With advancements in hardware technologies—such as Intel® Xeon® CPUs, NVIDIA GPUs, and FPGAs—today's ELINT systems have become faster, more accurate, and capable of real-time signal processing at the edge.

Intel® Xeon® CPUs manage system orchestration and high-throughput data processing, while NVIDIA GPUs accelerate AI and machine learning algorithms used for signal classification and threat identification. FPGAs provide ultra-low-latency processing for tasks such as pulse detection and PDW extraction. This combination enables ELINT systems to efficiently handle complex, high-density signal environments, ensuring timely and accurate intelligence delivery across air, land, sea, and space domains. This white paper explores how these cutting-edge technologies are transforming ELINT capabilities, with real-world use cases that highlight their operational impact.



2 Unveiling the Electromagnetic Spectrum - How ELINT Works

Electronic Intelligence (ELINT) systems operate by scanning the radio and microwave frequency spectrum to detect non-communication signals, such as radar emissions. Once detected, the signals are intercepted using specialized receivers placed on various platforms like aircraft, ships, or satellites. These signals are then analyzed for technical attributes such as frequency, pulse width, modulation, and direction. The system classifies the signal source (e.g., air defense or missile radar), determines its location using methods like triangulation, and compares its characteristics with a database of known emitters. The resulting intelligence is then delivered to military personnel for applications in electronic warfare, mission planning, and threat evaluation.

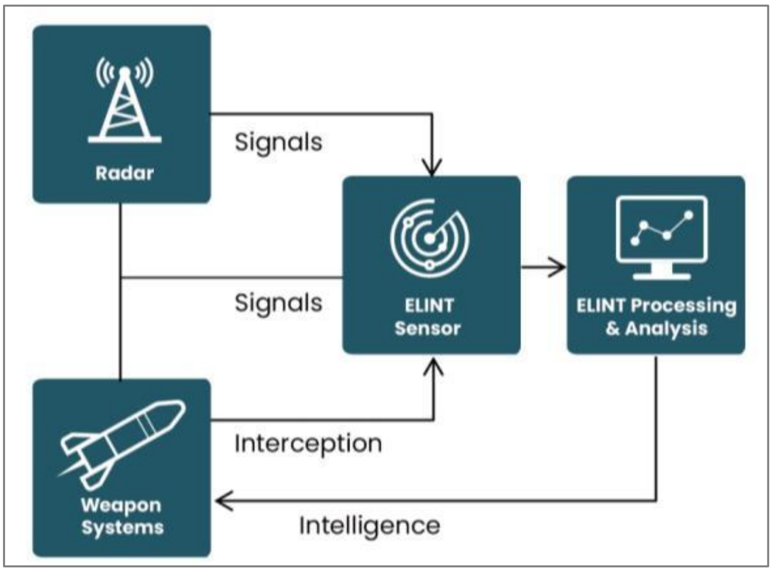
2.1 Detection

ELINT systems scan the electromagnetic spectrum, usually in the radio frequency (RF) and microwave ranges, for emissions that aren't part of normal communications (i.e., not voice, video, or data links).

2.2 Interception

Once a signal is detected, the ELINT system intercepts it using specialized antennas and receivers. These can be ground-based, airborne (e.g., in aircraft or drones), sea-based, or satellite-based.

2.3 Analysis



The intercepted signals are analyzed for:

- Frequency
- Pulse repetition interval (PRI)
- Pulse width
- Modulation
- Signal strength
- Direction of arrival

2.4 Classification

Based on the analysis, the system classifies the source — for example, determining if it's a radar used for air defense, missile guidance, or target acquisition.

2.5 Geolocation

Using triangulation or time difference of arrival (TDOA) from multiple ELINT sensors, the location of the emitter can be pinpointed.

2.6 Database Matching

Signal characteristics are compared against a database of known emitters to identify and catalog the system.

2.7 Output

Intelligence is passed to military operators or analysts for use in electronic warfare (EW), mission planning, or threat assessment.

3 Use Cases: ELINT in Action

ELINT plays a pivotal role in military and intelligence operations. Below are key scenarios where ELINT, powered by modern hardware, provides strategic advantages:

3.1 Detecting and Avoiding Enemy Radar Systems

Challenge: Stealth aircraft and reconnaissance drones must evade detection by enemy radar.
Solution: ELINT systems scan for radar emissions, classify threats, and provide real-time avoidance routes.
Hardware Role:

- FPGAs perform ultra-low-latency spectrum scanning.
- NVIDIA GPUs accelerate radar signature recognition using deep learning.
- Xeon® CPUs manage mission-critical decision-making.

3.2 Mapping Enemy Air Defenses (SAM Sites)

Challenge: Surface-to-Air Missile (SAM) systems pose a lethal threat to aircraft.
Solution: ELINT sensors detect and geolocate radar emissions, creating a real-time threat map.
Hardware Role:

- FPGAs preprocess raw signal data for rapid analysis.
- GPUs compute triangulation (TDOA) for precise emitter location.
- Xeon® CPUs integrate multi-sensor data for battlefield awareness.

3.3 Supporting Stealth Aircraft Operations

Challenge: Stealth platforms must remain undetected while identifying hostile radars.
Solution: ELINT systems onboard stealth aircraft classify radar threats and recommend countermeasures.
Hardware Role:

- FPGAs handle high-speed signal interception.
- GPUs run AI models for adaptive jamming strategies.
- Xeon® CPUs coordinate with onboard EW systems.

3.4 Developing Countermeasures (Jamming & Spoofing)

Challenge: Adversaries employ advanced radar systems with frequency agility.
Solution: ELINT-driven Electronic Attack (EA) systems generate deceptive signals to mislead enemy sensors.
Hardware Role:

- FPGAs generate real-time jamming waveforms.
- GPUs optimize countermeasure algorithms.
- Xeon® CPUs manage system-wide coordination.

4 How ELINT Works: A Hardware-Centric Workflow

From initial signal detection to final intelligence delivery, each stage of the ELINT process is supported by a combination of high-performance computing components—FPGAs for real-time signal interception, CPUs for control and coordination, and GPUs for advanced analytics and AI-based classification. This section outlines a typical ELINT workflow, highlighting how each hardware element contributes to turning raw RF emissions into actionable insights for mission planning and threat response.

Step	Stage	Key Tasks	Hardware Role
1	**Detection**	Monitor RF/microwave bands for non-communication signals.	**FPGA**: Real-time spectrum scanning with low latency.
2	**Interception**	Capture signals via ground/air/sea/space platforms.	**FPGA**: High-speed digitization. **Xeon® CPU**: Data orchestration.
3	**Signal Analysis**	Extract frequency, PRI, modulation, direction.	**NVIDIA GPU**: FFT, spectrograms, AI-based modulation recognition. **FPGA**: Preprocessing.
4	**Classification**	Identify emitter type (e.g., radar, missile guidance).	**GPU**: Neural networks for pattern matching. **CPU**: Multi-sensor fusion.
5	**Geolocation**	Triangulate emitter location using Time Difference of Arrival (TDOA).	**GPU**: Parallelized geolocation algorithms. **CPU**: Data correlation.
6	**Output & Intel® Delivery**	Generate reports for EW and mission planning.	**Xeon® CPU**: Report formatting, database integration. **GPU**: Real-time visualization.

5 The Hardware Advantage in ELINT

Modern ELINT systems demand high-speed processing, real-time analysis, and seamless data fusion across multiple domains. To meet these requirements, cutting-edge platforms leverage a heterogeneous hardware architecture that combines the strengths of CPUs, GPUs, and FPGAs. Each component plays a distinct role in delivering performance, flexibility, and reliability in mission-critical environments. We breaks down how Intel® Xeon® CPUs, NVIDIA GPUs, and FPGAs collectively power the next generation of ELINT operations from system orchestration to AI-driven signal classification and ultra-low-latency RF processing.

Intel® Xeon® CPUs: The Orchestrator

- Role: Manages system control, data routing, and multi-sensor fusion.
- Strengths: High core count, reliability, and seamless integration with GPUs/FPGAs.

NVIDIA GPUs: The AI & Signal Processing Powerhouse

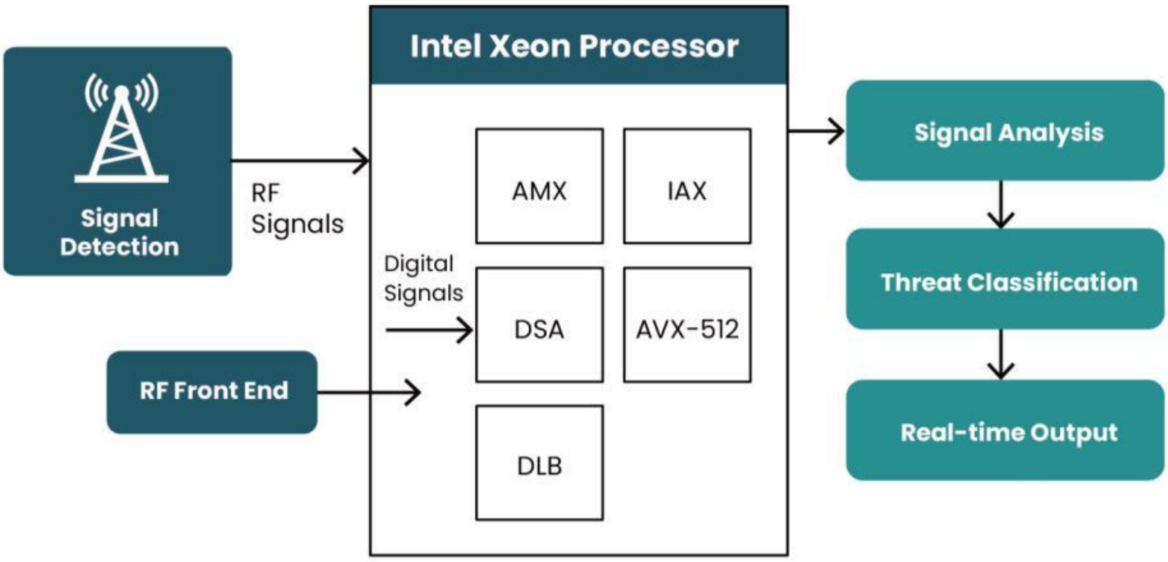
- Role: Accelerates deep learning for signal classification, FFTs, and geolocation.
- Strengths: Massive parallel processing for real-time analytics.

FPGAs: The Real-Time Signal Interception Experts

- Role: Handles ultra-fast RF scanning, digitization, and preprocessing.
- Strengths: Low latency, reconfigurability, and high throughput.

6 Combined Advantages of Intel® Xeon® D & GPU

Using an Intel® Xeon® D processor in combination with an NVIDIA GPU significantly optimizes the performance of an ELINT system because each component complements the other's strengths for processing large volumes of real-time signal data.



6.1 Intel® Xeon® D: Edge-Class, Multi-Core CPU for Real-Time Tasks

Low Power, High Performance: Xeon® D is designed for edge computing and embedded systems — ideal for ELINT platforms like drones, ships, or mobile units.

Multithreading: Handles concurrent tasks like signal detection, preprocessing, and network communication.

I/O Bandwidth: Excellent for integrating high-speed ADCs (Analog-to-Digital Converters), RF front-ends, and data buses (e.g., PCIe, Ethernet).

Deterministic Response: Important for real-time control of signal scanning, routing, and prioritizing threats.

6.2 NVIDIA GPU: Parallel Signal Analysis and Machine Learning

Massive Parallelism: Ideal for processing thousands of signal pulses per second, including complex radar signal parameters (PRI, frequency hopping, pulse width, etc.).

FFT and DSP Acceleration: Speeds up Fast Fourier Transforms and filtering, essential in spectral analysis.

AI and Pattern Recognition: Useful for automatic emitter classification using machine learning models (e.g., CNNs trained to detect specific radar signatures).

CUDA Ecosystem: Mature libraries for signal processing, including cuFFT, cuBLAS, and custom signal-processing kernels.

6.3 Combined Advantages for ELINT

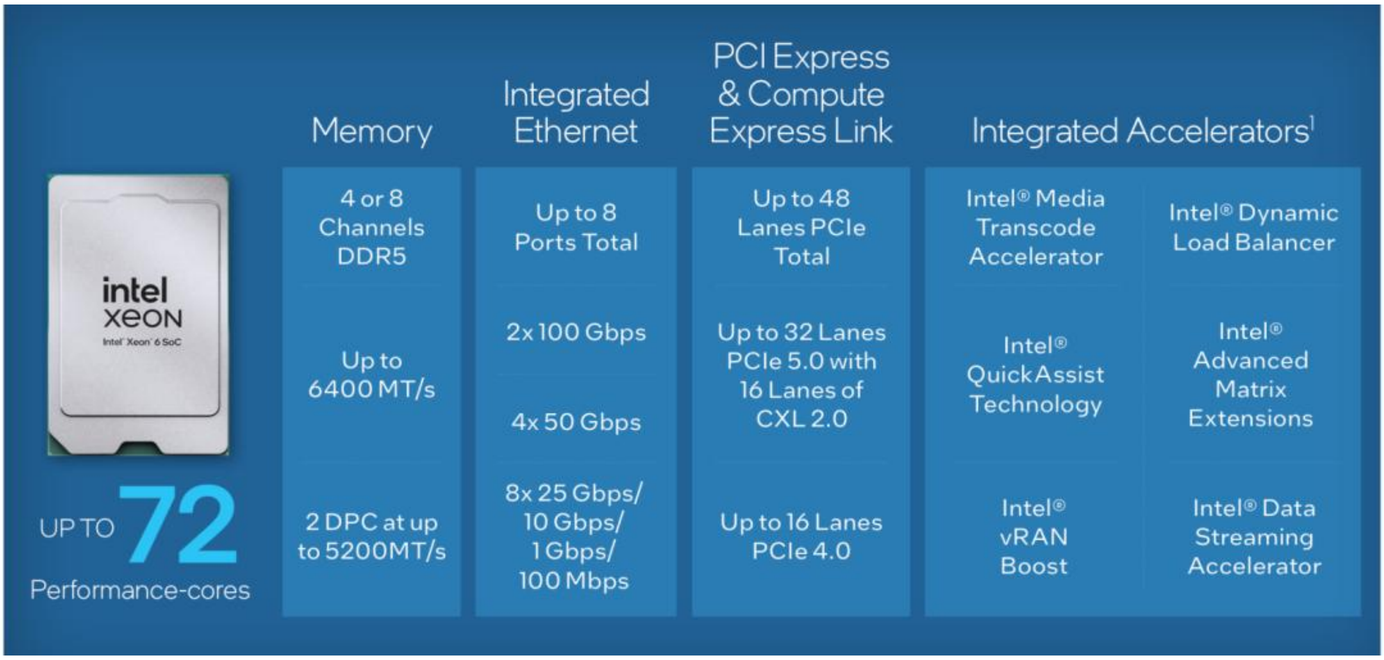
Task	Xeon® D (CPU) Role	NVIDIA GPU Role
Signal Detection	Orchestrates antennas, ADCs, preprocessing	—
Signal Analysis	Manages flow, scheduling	Performs FFT, filtering, clustering
Threat Classification	Logic-based comparison with database	Deep learning, pattern matching
Geolocation (TDOA*, AoA*)	Coordinates timing and sensor fusion	Accelerates correlation calculations
Real-Time Output	Communicates results to operator/system bus	—

*TDOA (Time Difference of Arrival): Determines the emitter’s location by analyzing time delays between signal arrivals at multiple spatially separated sensors.
*AoA (Angle of Arrival): Identifies signal direction using antenna arrays and estimates the source position by triangulating angles from multiple observation points.

The Intel® Xeon® D provides a strong foundation for deterministic, multitask control and system orchestration, while the NVIDIA GPU delivers the raw computational power needed for high-speed signal analysis and machine learning. Together, they enable faster, more accurate and more automated ELINT operations, critical for both defense and intelligence missions.

7 Breakthrough Features of Intel® Xeon® 6 SoC (Granite Rapids-D)

The **Intel® Xeon® 6 SoC** (System on Chip) is exceptionally well-suited for **ELINT (Electronic Intelligence)** systems, especially those operating at the edge (airborne, naval, ground-mobile). Here's how its **hardware features** directly support ELINT capabilities:



7.1 Intel® Xeon® 6 SoC XCC Scalable Up to 72 Cores

- **Use in ELINT**: Parallel processing of multiple RF channels, simultaneous signal stream handling.
- **Benefits**:
  - Enables **multi-threaded signal processing** pipelines (e.g., PRI detection, FFT, TDOA)
  - Supports **multi-mission** workloads on a single chip (e.g., SIGINT + radar detection + EW coordination)
  - Facilitates **AI/ML inference** for signal classification in real-time

7.2 High-Speed PCIe Lanes: 48 Total

- **32x PCIe 5.0, 16x PCIe 4.0**
- **Use in ELINT:**
  - Interface with high-speed ADCs, RF front ends, GPUs, FPGAs, or storage
  - Connect external accelerators for DSP or machine learning
- **Benefits**:
  - **Low-latency communication** with capture boards or GPU accelerators (e.g., NVIDIA)
  - Enables **simultaneous multi-antenna data capture** and storage
  - Flexible modularity for mission-specific payloads

7.3 200 Gbps Ethernet I/O Bandwidth

- **Use in ELINT**:
  - Real-time streaming of signal data to/from remote sensors, command centers, or other platforms
  - Inter-platform coordination for triangulation, emitter tracking
- **Benefits**:
  - **High-throughput, low-latency networking** for distributed ELINT operations
  - Supports **mesh coordination** between drones, satellites, ships, etc.
  - Real-time integration into **C4ISR** systems

7.4 DDR5-6400 Memory Support

- **Use in ELINT**:
  - Holding large buffers of IQ data from RF digitizers
  - Storing signal history for burst/event analysis
  - Feeding ML classifiers with structured signal features
- **Benefits**:
  - **High memory bandwidth and speed** ensures smooth processing of high-volume signal data
  - Reduces **latency in FFT, filtering, and pattern matching**
  - Supports **edge caching** of threat databases

7.5 Integrated AI, Security, and Telemetry Support

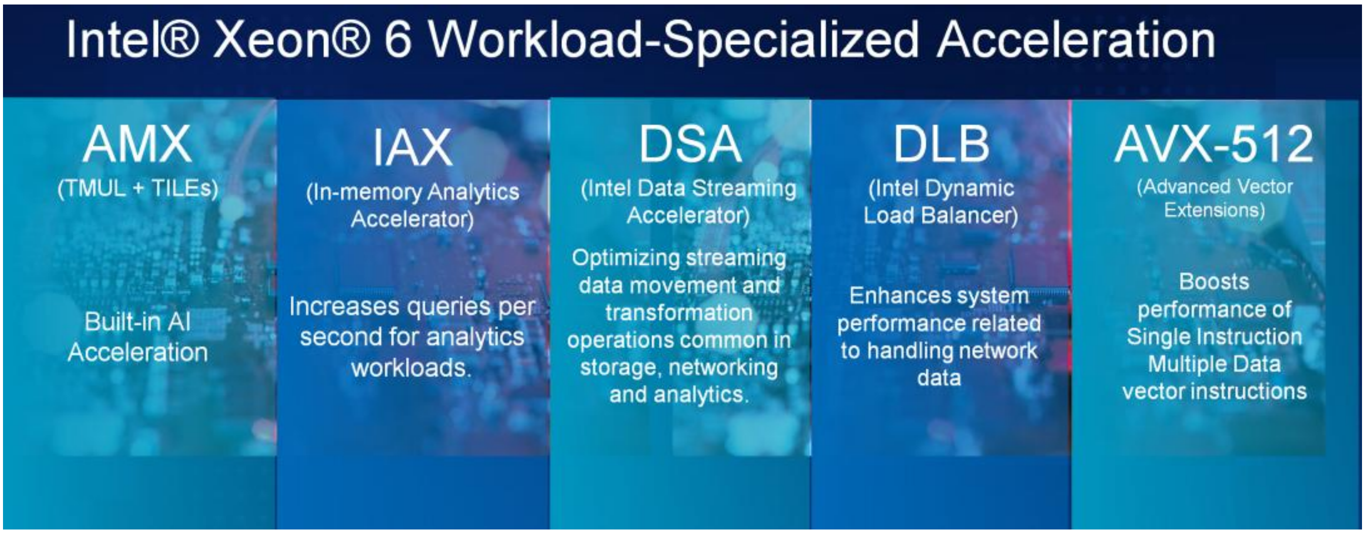
- Built-in **telemetry and security** features allow for:
  - Secure, tamper-resistant data handling
  - In-band telemetry monitoring of signal health and processor load
- Embedded **AI acceleration** enables fast classification of unknown signals or threat prioritization.

Intel® Xeon® 6 SoC (Granite Rapids-D) Feature vs. ELINT Utility

Xeon® 6 SoC Features	ELINT Benefit
Up to 72 Cores	Concurrent signal stream handling, real-time AI/ML
48 PCIe Lanes	Modular sensor, GPU, FPGA expansion
200 Gbps Ethernet	Real-time multi-platform sensor data exchange
DDR5-6400 Memory	Low-latency, high-bandwidth signal buffering
Integrated Security	Secure data chain, mission integrity
Embedded AI/Telemetry	Adaptive threat classification and diagnostics

8 How Intel® Instruction Set Support ELINT Tasks

Intel's advanced instruction sets and accelerators like **AMX**, **IAX**, **DSA**, **DLB**, and **AVX-512** can significantly enhance ELINT performance by accelerating compute-heavy signal processing and system-level data management. Here's how each supports ELINT tasks:



8.1 AVX-512 (Advanced Vector Extensions 512-bit)

Role in ELINT:

- High-throughput vector and matrix math for DSP (Digital Signal Processing)
- Enables wide SIMD (Single Instruction, Multiple Data) operations on radar signal data

Example ELINT Tasks:

- Fast Fourier Transform (FFT)
- Filtering and decimation of wideband signals
- Pulse analysis**:** Pulse width, repetition interval (PRI), and frequency estimation
- Angle-of-arrival (AoA) and direction-finding algorithms

8.2 AMX (Advanced Matrix Extensions)

Role in ELINT:

- Accelerates matrix-intensive operations like those in AI-based threat classification and signal correlation
- Optimized for machine learning workloads

Example ELINT Tasks:

- Running neural networks that classify radar emitter types
- Matrix convolution in synthetic aperture radar (SAR) imaging or multi-channel signal correlation
- Real-time pattern recognition of unknown emitter signatures

8.3 IAX (Intel® Accelerator Engines)

Role in ELINT:

- Custom accelerator interface to offload specific ELINT workloads from the CPU
- Used for signal correlation, packet pre-processing, or compression/decompression of raw signal logs

Example ELINT Tasks:

- Correlating intercepted pulses across multiple antennas
- Fast interference pattern detection and signal clustering
- Real-time spectrum monitoring with low CPU overhead

8.4 DSA (Data Streaming Accelerator)

Role in ELINT:

- Moves and transforms large volumes of data efficiently across memory and peripherals without CPU involvement
- Supports streaming I/O, vital for handling raw RF data from ADCs

Example ELINT Tasks:

- Ingesting and routing real-time IQ (in-phase/quadrature) data
- Offloading signal buffer management and movement between memory banks
- High-speed telemetry and metadata tagging from multi-sensor sources

8.5 DLB (Dynamic Load Balancer)

Role in ELINT:

- Manages event queues and distributes workloads efficiently across CPU cores or processing units
- Reduces latency spikes in multi-threaded signal analysis

Example ELINT Tasks:

- Balancing signal processing across cores for real-time emitter detection
- Load distribution for multi-channel direction-finding arrays
- Handling bursts in signal capture events (e.g., radar scans or missile launches)

Intel® Xeon® 6 SoC Instruction Set V.S. ELINT Benefit

Feature	Accelerates	ELINT Benefit
AVX-512	Vector math, DSP	FFTs, pulse analysis, AoA
AMX	Matrix ops, AI	Emitter classification, ML
IAX	Custom workloads	Signal correlation, preprocessing
DSA	Data movement	Low-latency I/O for RF signals
DLB	Task scheduling	Real-time load balancing

9 Case Study: AV800-H32 in ELINT Applications

Powered by Intel® Xeon® SoC and NVIDIA RTX Ada 5000m GPU, the AV800-H32 is a rugged, conduction-cooled military server built to deliver real-time spectrum analysis for ELINT and ESM missions. Designed for use in harsh and mobile environments, it provides the computing power and reliability needed to detect, analyze, and respond to electromagnetic threats as they happen. With advanced edge AI acceleration and real-time RF signal processing capabilities, the AV800-H32 enables military intelligence and electronic warfare teams to operate with speed and precision in dynamic spectrum environments.

Purpose-built for time-sensitive operations, the AV800-H32 plays a critical role in identifying and classifying signals across the electromagnetic spectrum. Its ability to process large volumes of RF data instantly ensures rapid situational awareness and informed decision-making in the field. Whether deployed on airborne, naval, or ground platforms, the AV800-H32 delivers the consistent, real-time performance required for modern ELINT systems operating in today's complex battlefields.

IP65 Military Xeon® 6 GPU Server AV800-H32

- Intel® Xeon® 6 Granite Rapids D processor 6546P-B, 32 Cores 2.3/3.5 GHz, 195W
- NVIDIA RTX Ada 5000m GPU 9728 CUDA cores
- DDR5 up to 6400MT/s, 64GB RDIMM, up to 512GB
- 4 x 2TB U.2 NVMe SSD Storage
- 18-36 VDC PSU
- 1 x QSFP28 100GbE, 1 x SFP28 50GbE 2 x SPF28 25GbE , 1GbE-T share with IPMI
- Operating Temperature: -20°C to 60°C
- IP65 Sealed with External Cooling Blade

10 Case Study: HORUS560 High-Performance Edge System

The HORUS560, a 4U 19" Rugged Military Server, is engineered for demanding signal processing tasks in ELINT applications. Equipped with dual Intel® Xeon® 6 Granite Rapids Scalable processors and DDR5 6400MT/s Up to 2TB, it delivers high-throughput parallel processing and low-latency performance required for real-time RF spectrum analysis. The server supports dual FPGA up to 650W and four NVIDIA RTX 5000 ADA, providing flexibility for compute-intensive workloads such as real-time spectrum analysis, pulse and modulation analysis, and digital signal classification. This architecture ensures rapid detection and decoding of RF signals from diverse antenna and sensor arrays in operational environments.

To support continuous data capture and storage for real-time recording and post-mission analysis, the HORUS560 features 8 x hot-swappable 3.5" NVMe U.2 bays, enabling ultra-fast data ingestion and streaming to disk. The integrated Intel® VROC RAID controller offers hardware RAID levels 0/1/5/10 for performance, redundancy, or a balance of both, essential for handling mission-critical datasets. The HORUS560 is ruggedized to meet MIL-STD-810 standards for wide temperatures, shock and vibration, making it ideal for mobile or field-deployed ELINT platforms. The rugged server supports functions such as real-time RF spectrum monitoring, activity dashboards, emitter detection, and database interfacing, ensuring rapid situational awareness and actionable intelligence in tactical environments.

4U 19" Military GPU Server HORUS560

- Dual Intel® Xeon® 6th Granite Rapids Scalable Processor
- DDR5 6400MT/s Up to 2TB
- 8 x U.2 NVMe with RAID 0/1/5/10
- Dual FPGA up to 650W
- 4 x NVIDIA RTX 5000 ADA
- 2 x 100GbE QSF
- MIL-STD-810 for wide temperatures, anti-shock and vibration
- MIL-STD-461 EMI Filter

11 7STARLAKE Roadmap: The Future of Xeon® SoC ELINT Systems

7STARLAKE brings extensive expertise in designing and manufacturing rugged, high-performance GPU servers built for mission-critical ELINT and signal intelligence applications. Supporting all generations of Intel® Xeon® D processors, from Broadwell DE and Skylake D to Ice Lake D, we now proudly embrace the latest Xeon® 6 Granite Rapids D platform.

Engineered for real-time, compute-intensive tasks in extreme environments, our next-generation edge platforms, including flagship models like the Thor11-H20, Thor11-X6, and AV800-H32, leverage Xeon® 6 to deliver breakthrough performance, enhanced AI/FPGA integration via advanced PCIe expandability, and ultra-fast networking capabilities.

Designed for deployment across UAVs, naval vessels, and mobile ground units, 7STARLAKE's rugged Xeon® servers offer the compute density, thermal resilience, and mission-ready durability essential for today's complex electronic warfare environments.


Intel® Xeon® D Military Server Roadmap
Broadwell DE
Skylake D
Ice Lake D
Granite Rapids D
D-1500
D-1700
D-2100
D-2800
HCC Xeon® 6
XCC Xeon® 6
NVIDIA A10
THOR11-H20
THOR11-X6
NVIDIA MXM
AV710-X3
THOR200-D17
SR800-D21
AV800-D27
SR800-H20
AV800-H32
NVIDIA TESLA
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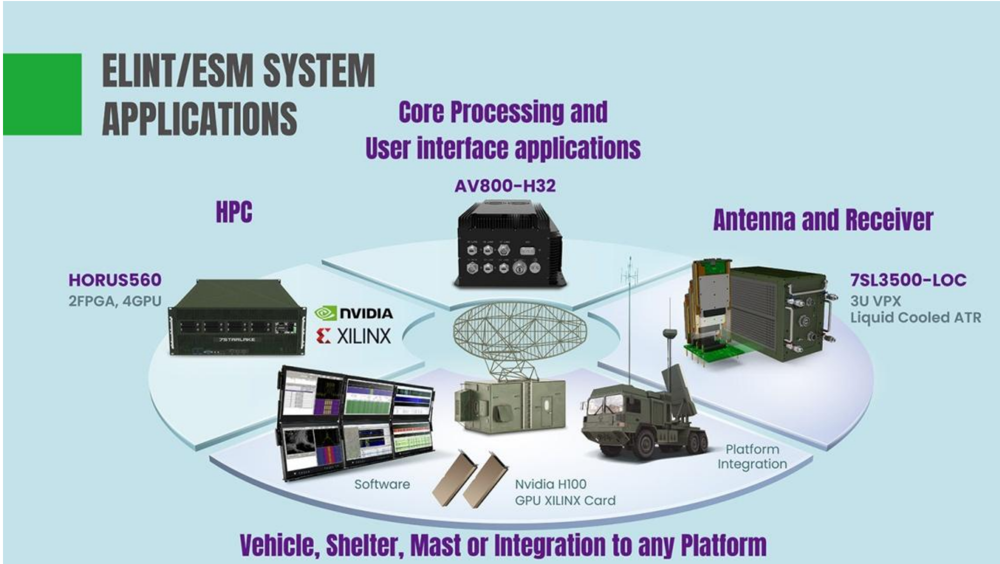
SR800
HORUS200
THOR11-D27
7STARLAKE

Conclusion



Modern ELINT systems harness the combined strengths of **Intel® Xeon® CPUs, NVIDIA GPUs, and FPGAs** to enable real-time signal processing and actionable intelligence. From radar threat detection to stealth and countermeasure support, these hardware advancements ensure ELINT systems can adapt rapidly to evolving threats and remain a critical pillar of electronic warfare. Xeon® processors handle system control, high-throughput data, and multithreaded workloads; GPUs accelerate AI-based tasks such as pattern recognition and spectral analysis; and FPGAs deliver ultra-low-latency, deterministic processing for time-critical functions like pulse descriptor word (PDW) extraction and radar signal decoding. Together, they ensure ELINT platforms to quickly detect, classify, and respond to complex signal environments across the electromagnetic spectrum.

As electronic threats continue to grow in complexity, ELINT hardware must evolve to keep pace—driving innovation in defense technology. At 7STARLAKE, we are advancing next-generation ELINT platforms by leveraging the combined strengths of Intel® Xeon® SoCs, GPU acceleration, and FPGA integration. With ongoing breakthroughs in AI, 5G, and edge computing, and as Intel® pushes the boundaries of Xeon® architecture, we remain committed to embedding these advancements into our rugged server solutions. These advancements empower ELINT systems with accelerated processing, robust security, and enhanced mission agility, ensuring mission readiness in the dynamic landscape of modern electronic warfare.

Recommendation: Future ELINT systems should leverage AI-enhanced GPU processing, FPGA-based adaptive RF front ends, and scalable CPU architectures to sustain a tactical advantage.

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