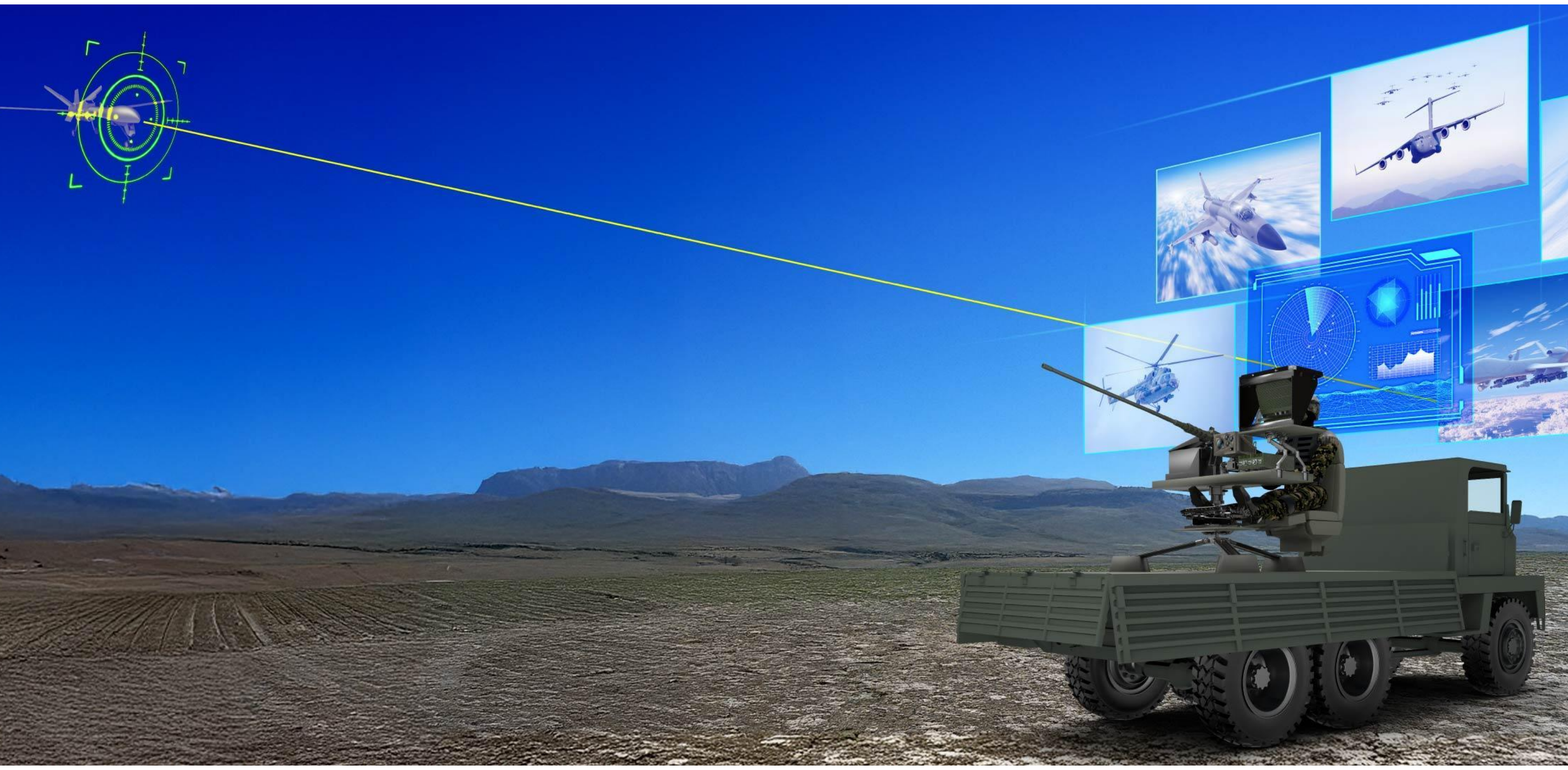

Integrated Anti-Drone System

Powered by EO/IR Sensors, AI Processing, and C2 with Fire Control Integration

7STARLAKE Whitepaper July 11th, 2025

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Executive Summary

The proliferation of commercial and military-grade drones presents a growing threat to critical infrastructure, military installations, and sensitive areas. As drone technology advances in autonomy, maneuverability, and payload capabilities, traditional air defense systems often struggle to detect, track, and neutralize these small and agile threats.

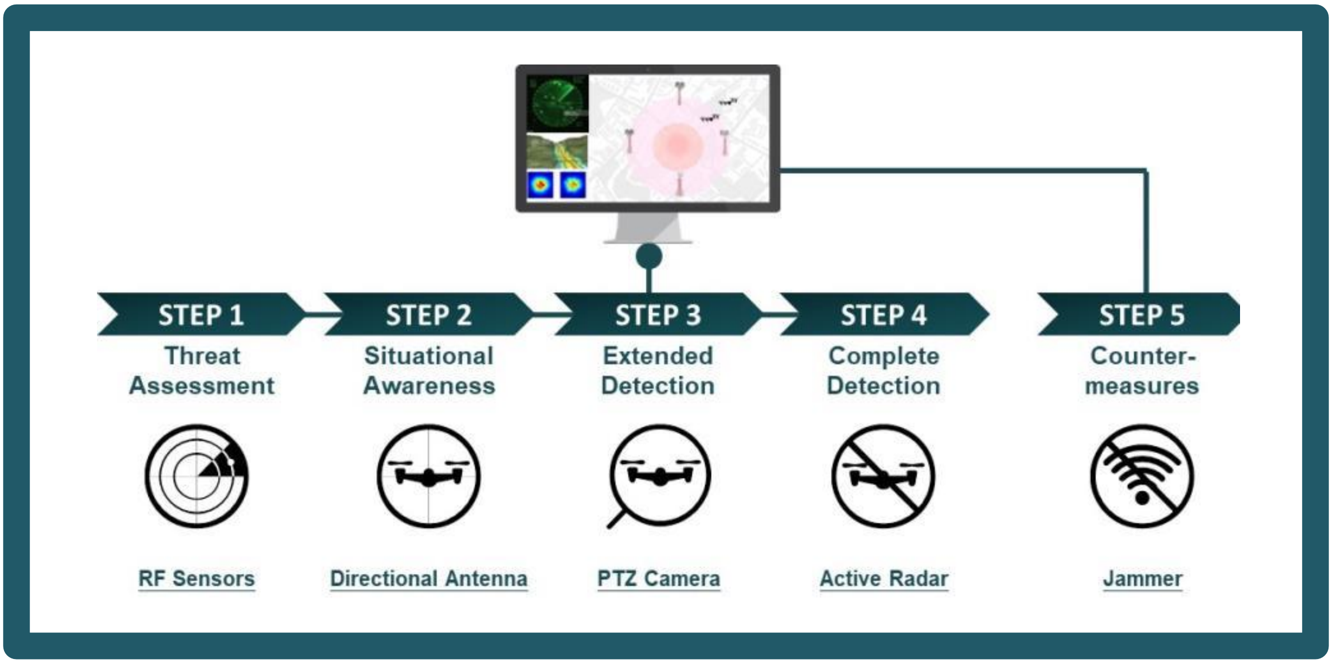
This white paper outlines a modular and effective Anti-Drone System that leverages four key components: **Electro-Optical/Infrared (EO/IR) sensors**, **GPU-based AI computing**, **rugged military-grade displays**, and a **Command & Control (C2) system integrated with fire control**. Together, these components enable real-time detection, classification, tracking, and neutralization of drone threats.

Backed by years of experience in defense-grade computing and ruggedized system design, 7STARLAKE offers fully integrated Anti-Drone solutions tailored to mission-specific requirements. Our in-house expertise in AI computing, sensor integration, and military standard platforms enables us to deliver end-to-end systems optimized for harsh and dynamic environments, whether deployed at forward operating bases, naval vessels, or critical infrastructure sites.

System Architecture Overview

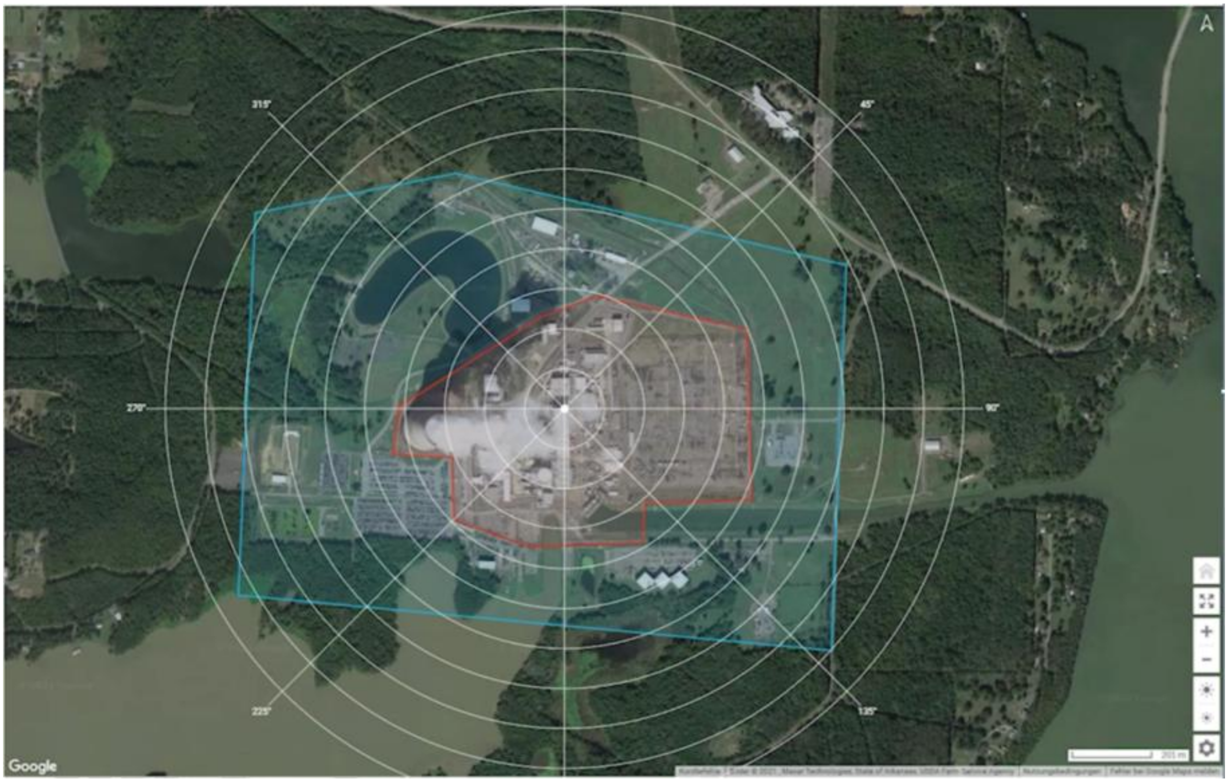
The Anti-Drone System operates through a seamless data flow architecture designed for rapid detection, analysis, and response. It integrates four key components to ensure efficient threat mitigation and situational awareness:

- **EO/IR Sensor Unit**: Captures real-time visual and thermal imagery.
- **GPU Computer (AI Processor)**: Performs high-speed processing and AI-driven threat analysis.
- **Military Display Terminal**: Provides tactical visualization for field operators.
- **Command & Control (C2) with Fire Control Integration**: Centralizes decision-making and coordinates automated or manual countermeasures.



This system outlines the architecture and operational flow of a modern C-UAV system, highlighting a four-step process: **Threat Assessment**, **Situational Awareness**, **Extended Detection**, and **Counter-Measures**. Each step integrates advanced technologies and sensor fusion to ensure a robust and responsive defense against unauthorized drone activity.

1. Threat Assessment: RF-Based Detection and Analytics



The first line of defense in any Counter-UAV system is early threat detection. This stage relies heavily on **Radio Frequency (RF) sensors** which scan the electromagnetic spectrum for signals associated with UAV activity.

RF Spectrum Monitoring:

RF sensors continuously monitor for command and control (C2) links, video downlinks, or telemetry signals commonly used by commercial and DIY drones.

Unmanned Aerial Vehicles (UAVs) frequently utilize communication frequencies such as **800 MHz (telemetry and analog video)**, **2.2 GHz (command and control links)**, and **5.8 GHz (HD video downlinks via FPV)**. To detect these signals in real time, RF monitoring systems leverage both **omnidirectional (360°) antennas** for broad coverage and **directional antennas** for accurate geo-location through angle-of-arrival (AoA) detection.

At the compute level, the brain of RF Antenna Tower Unit is the Intel® Xeon® D CPU, which features a one-package design with integrated AI, security, advanced I/O, and Ethernet, plus dense compute, to deliver high data throughput and address key edge requirements. To broaden the range of usage models, the Xeon® system-on-a-chip (SoC) is available in two distinct packages: the high-core-count Xeon® D-2700 processor, optimized for performance, and the Xeon® D-1700 processor, which is optimized for cost and power consumption. With options ranging from 4 to 20 cores, the Xeon® D-2700 processor is suited to demanding workloads, such as handling high data-plane throughput, making it more suitable for multi RF spectrum monitoring.

Intel® Xeon® D-1700/D-2700 processors, with integrated support for **Intel® AVX-512 instructions**, play a critical role. These 512-bit vector operations processes more RF signal data per clock cycle than prior vector instruction sets, enabling the rapid execution of complex digital signal processing (DSP) tasks such as **fast Fourier transforms (FFTs)** and **spectral correlation** across multiple bands simultaneously. This is especially vital for **multi-band radio workloads** that must parse gigahertz-wide channels with high temporal resolution.

Object Classification:

Using machine learning algorithms, the system analyzes the RF signature to differentiate drones from other radio-emitting devices.

Once an RF signal is identified, the system uses **machine learning and pattern recognition algorithms** to classify the source—differentiating between consumer drones, military UAVs, or benign RF devices. The **Intel® Xeon® D-1700/D-2700's AVX-512 capabilities** boost preprocessing throughput by efficiently handling matrix operations and vectorized calculations necessary for feature extraction in RF signal analysis.

The RF signature—including **modulation type**, **frequency spread**, and **temporal burst pattern**—is then passed to AI inference models running on **high CUDA core GPUs**. These GPUs enable rapid execution of convolutional and recurrent neural networks to generate real-time classifications, distinguishing UAV signals from environmental noise and other non-drone transmitters. After identifying RF emissions, the system classifies them using **machine learning algorithms** that analyze modulation type, burst patterns, and spectral characteristics. **Xeon® D-1700/D-2700 CPUs**, with AVX-512 extensions, handle real-time signal preprocessing and mathematical operations for feature extraction.

The **Quadro RTX GPUs**, equipped with powerful **Tensor Cores and high memory bandwidth**, handle real-time inference using deep neural networks. These models distinguish between drones and other RF sources such as IoT devices or microwave communications by comparing signal patterns to a database of known drone signatures.

Additionally, the Quadro RTX's robust compute architecture supports **sensor fusion**—integrating RF signals with **EO/IR imagery**—so classification algorithms benefit from both thermal/visual data and RF emissions, increasing the system's ability to confirm drone presence with minimal false positives

For enhanced accuracy, RF-based classification is fused with **EO/IR sensor inputs**, allowing cross-validation between **thermal/visual imagery** and **RF emission behavior**—delivering higher confidence levels in drone identification, especially in cluttered RF environments.

Threat Profiling

Detected UAVs are profiled based on signal type, frequency, duration, and movement pattern to assess the threat level.

Once a UAV is classified, the system builds a behavioral profile by analyzing its **signal type**, **frequency agility**, **flight pattern**, and **engagement behavior**. UAVs using encrypted or spread-spectrum control on unusual frequencies, or exhibiting evasive maneuvers, are flagged as higher threats.

Intel® Xeon® D-1700/D-2700 processors, optimized with AVX-512, execute threat correlation logic efficiently across large time-series datasets, while the **Quadro RTX GPU Series** supports real-time model inference for behavior analysis and intent prediction using AI models such as LSTMs or graph-based neural networks.

The large **VRAM capacity** of Quadro RTX GPUs allows them to handle extensive RF logs, EO/IR imagery, and real-time video feeds simultaneously. This ensures smooth performance even during multi-drone incursions or spectrum-saturated conditions. Moreover, the **visualization capabilities** of the Quadro RTX line help analysts interpret signal trajectories, geo-location estimates, and fused sensor data in an intuitive, interactive interface.

2. Situational Awareness: Localization and Tracking

Upon detecting a potential UAV threat, the system rapidly transitions to building situational awareness through precise localization and continuous tracking. Leveraging multi-sensor fusion, it synthesizes RF signals with radar and acoustic sensor data to accurately triangulate the drone's position. This enables real-time monitoring of the UAV's trajectory, velocity, altitude, and heading. Geo-fencing integration further enhances security, automatically triggering alerts and activating response protocols when a drone breaches predefined no-fly zones.

Multi-sensor Fusion:

RF data is combined with radar and acoustic sensors to accurately triangulate the drone's position.

Real-time Tracking:

The system continuously updates the drone's trajectory, speed, altitude, and heading.

Geo-fencing Alerts:

Integration with pre-defined no-fly zones triggers alerts and activates the next level of response protocols.

3. Extended Detection: Electro-Optical/Infrared (EO/IR) Verification

Visual confirmation is essential to avoid false positives. **Electro-Optical (EO)** and **Infrared (IR)** cameras provide this critical optical verification.

Target Identification:
EO/IR systems lock onto the UAV for visual or thermal imagery to verify the object.

Electro-Optical/Infrared (EO/IR) systems depend on real-time visual and thermal imaging to identify and track unmanned aerial vehicles (UAVs). With high-performance GPU servers equipped with multi-core **Intel® Xeon®** processors and **NVIDIA HIGH CUDA CORE** GPUs, vast streams of EO/IR data can be processed concurrently. Xeon® CPUs handle the initial task scheduling, I/O management, and preprocessing pipelines for raw sensor data, while the **HIGH CUDA CORE GPUs** accelerate convolutional neural network (CNN) inference models, enabling rapid identification of UAV shapes, thermal signatures, and movement patterns. This parallelism is critical in scenarios involving multiple UAVs or high-frame-rate video feeds from multi-sensor arrays.

Day/Night Capability:
IR sensors enable reliable tracking in low-visibility or nighttime conditions.

Infrared (IR) imaging requires processing low-signal thermal data, especially during nighttime operations or in obscured environments (fog, smoke, etc.). The **combination of multi-core Xeon® CPUs** and **NVIDIA HIGH CUDA CORE GPUs** excels in noise reduction, contrast enhancement, and thermal pattern recognition under these challenging conditions. HIGH CUDA CORE GPUs, with their Transformer Engine and tensor cores, support advanced deep learning models that can distinguish subtle thermal variations, ensuring reliable tracking. Meanwhile, Xeon® processors manage concurrent sensor fusion tasks (e.g., combining IR with visible light data) to maintain situational awareness in real time, regardless of lighting

Automated Image Analysis:

AI-based tools analyze the captured images for model recognition and threat validation.

Massive volumes of imagery generated by EO/IR systems are analyzed using AI-driven image recognition and threat detection algorithms. The HIGH CUDA CORE GPU's **massive memory bandwidth** and **AI-specific acceleration** allow real-time processing of high-resolution frames, 3D object detection, and segmentation models, while the Xeon® CPUs manage orchestration, load balancing, and storage I/O for large datasets, including radar and multi-modal inputs. Together, they enable fast and accurate classification of objects, distinguishing hostile UAVs from benign ones, and provide actionable intelligence instantly to operators or automated counter-UAV systems.

4. Counter-Measures: Soft and Hard Kill Options

Once a threat is confirmed, the system initiates **counter-measures** to neutralize the UAV. These are broadly classified into **soft kill** and **hard kill** strategies.

Soft Kill Methods

Soft kill methods focus on disrupting or manipulating the drone's communication, navigation, or control systems without causing physical damage, rendering it ineffective or forcing it to retreat. One of the most common methods is RF jamming, which interferes with the radio frequency signals between the drone and its operator, potentially forcing the UAV to return to base or hover aimlessly. RF jamming is particularly effective in scenarios where minimizing collateral damage is a priority, such as in urban environments or near critical infrastructure.

Another powerful soft kill technique is GNSS spoofing, which involves transmitting false GPS signals to deceive the drone's onboard navigation system. This can divert the drone from its intended path, force it to land in a designated area, or cause it to become lost. Additionally, protocol manipulation exploits vulnerabilities in a drone's firmware or communication protocols, to take control of the drone or force it to shut down. These non-kinetic countermeasures are crucial for dealing with drone threats in a controlled and reversible manner, allowing authorities to neutralize hostile UAVs without creating safety risks from falling debris or unintended damage.

RF Jamming:

Disrupts the C2 link between the drone and its operator, causing the drone to lose communication or return to base.

GNSS Spoofing:

Sends false GPS signals to misguide the UAV's navigation system.

Protocol Manipulation:

Exploits firmware vulnerabilities in commercial drones to gain control or disable them.

Hard Kill Methods

Hard kill methods physically disable or destroy hostile drones through direct engagement. These include kinetic options such as anti-drone guns, shotguns, and even trained birds of prey that intercept UAVs mid-air. More advanced approaches utilize Directed Energy Weapons (DEWs), including high-energy lasers and microwave systems, to disable drone electronics with precision and minimal collateral damage. Additionally, net guns and drone-on-drone interception use interceptor drones equipped with nets to capture and neutralize threats. Hard kill techniques are essential when immediate, decisive action is required, particularly in high-risk or densely populated areas.

Kinetic Solutions:

This includes anti-drone guns, shotguns, or even trained birds of prey to physically disable the UAV.

Directed Energy Weapons (DEWs):

High-energy lasers or microwave weapons can disable drone electronics without collateral damage.

Net Guns & Drone-on-Drone Interception:

Specialized interceptor drones equipped with nets capture and neutralize hostile UAVs.

Step-by-Step Operational Workflow

Step 1: Drone Detection via EO/IR and Sensor Fusion

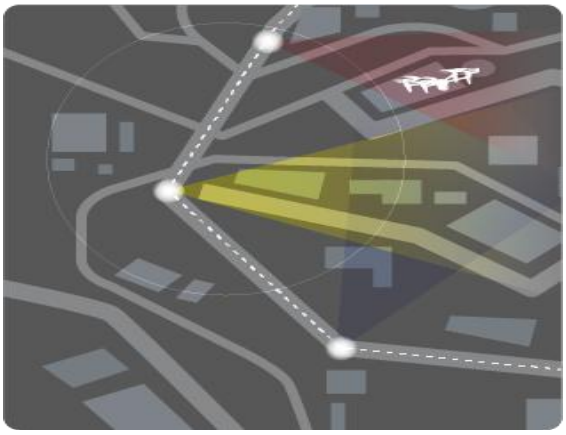
UAVs excel through sensor fusion, a vital component for intelligence in challenging environments. This fusion of multiple sensors enhances UAV capabilities in motion control, tactical missions, and crucial intelligence gathering

The **EO/IR sensor** scans the sky for anomalies, identifying potential drones based on thermal signatures (IR) and optical recognition (EO).

Simultaneously, data from other sensors (e.g., radar, RF detectors) is fused to enhance target validation and eliminate false positives.

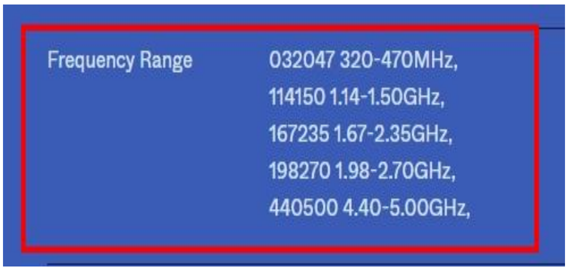
The fused data is passed to the **GPU Computer** for AI-based processing.

1. Data Acquisition:



Armed with cameras and advanced sensors, UAVs excel in collecting mission-critical intelligence. From capturing detailed images of buildings to reading car plates, the fusion of sensor data empowers UAVs with the capability to gather precise information. When coupled with AI technology, UAVs can perform real-time object detection, further elevating their capabilities in data acquisition.

2. Data Link:



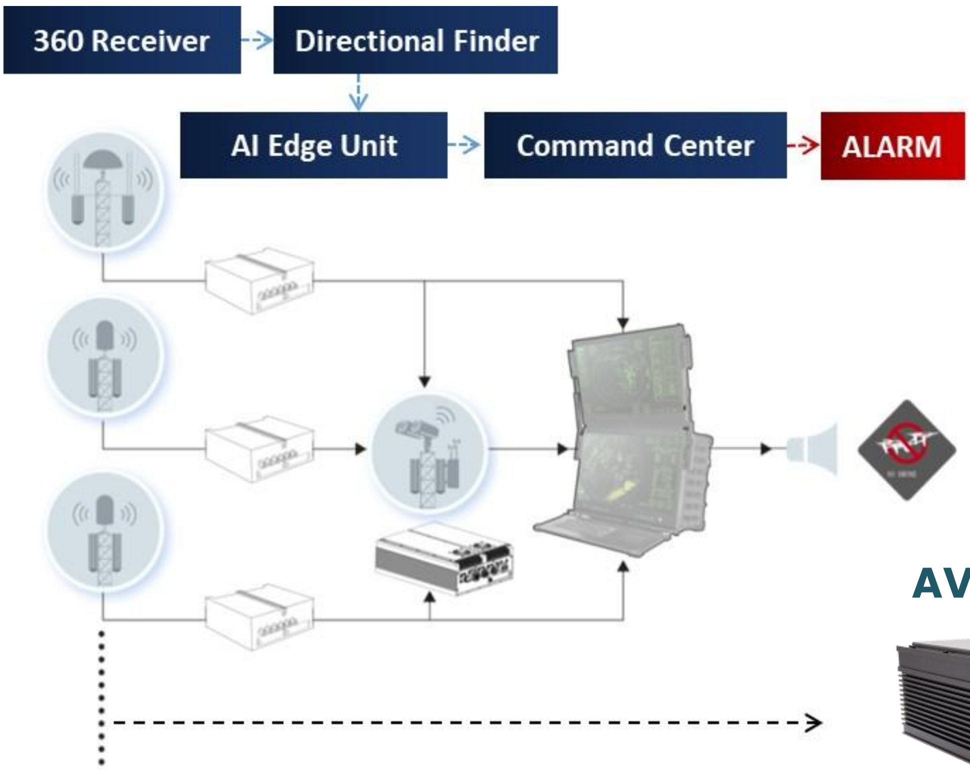
Addressing the diverse communication requirements of UAVs, the integration of Software-Defined Radio (SDR) technology becomes paramount. SDR enables adaptability to different frequency bands and communication standards, establishing an agile and reliable Data Link between the UAV and the control station. This seamless communication is fundamental for successful UAV missions.

3. Data Transmission:

The optimization of UAV roles relies on the efficient transmission of valuable frontline data back to the control station in real-time. This ensures a live visual feed, enhancing decision-making and responsiveness, especially in critical applications like surveillance and reconnaissance. Data transmission completes the loop, allowing operators to act swiftly based on the information gathered by the UAV.

Step 2: AI-Based Tracking and Localization Using GPU Computing

- The **GPU Computer**, running advanced **AI algorithms** such as Convolutional Neural Networks (CNNs) and object tracking models, processes incoming data to:
    - **Classify** whether the object is a drone.
    - **Track** its movement in real time, even under cluttered or obscured conditions.
    - **Locate** its precise coordinates (geo-location) and predict trajectory.
- The GPU Computer is linked to the **Command & Control system (C2)** and transmits real-time data for **threat evaluation and fire control decision-making**.



AV600-RH-A45

Drone Annalistic Ground Station:

PS2

Integrate computer vision and spectrum analysis data for object detection and tracking of flight trajectories. Massive data is optimized for decision analysis on a portable server with dual GPUs.

Step 3: Visual Confirmation and Engagement on Military Display

- All processed data, including video feed and target telemetry, is sent to the military-grade display.
- The ruggedized display presents:
  - Visual tracking of the drone on map and live feed.
  - Status indicators for tracking confidence, threat level, and system readiness.
  - User interface for the commander to confirm and authorize neutralization.
- Once a threat is confirmed, the C2 with fire control initiates the engagement sequence, launching countermeasures (e.g., jamming, lasers, or kinetic interceptors).

Key Components Description

EO/IR Sensors

EO/IR sensors are advanced electro-optical systems that deliver high-resolution visual and thermal imaging for enhanced surveillance and targeting. With Pan-Tilt-Zoom (PTZ) capabilities, they provide wide-area coverage and reliable performance in day, night, and all-weather conditions—making them ideal for detecting and tracking drone threats in complex environments.

NEPTUS (EXAVISION)

NEPTUS is a military targeting system designed for 20mm firing turrets, delivering precise long-range observation and targeting capabilities. Engineered to perform reliably in harsh maritime environments, it supports remote weapon stations with enhanced accuracy and situational awareness.

- MIL-STD-810 qualified and waterproof solutions
- Multi spectral sensors + LRF
- Easy to integrate on third-party system and platform
- Laser Range Finder ensuring ranges beyond 1NM (nautical mile)
- High performances in compact and lightweight mechanical assemblies

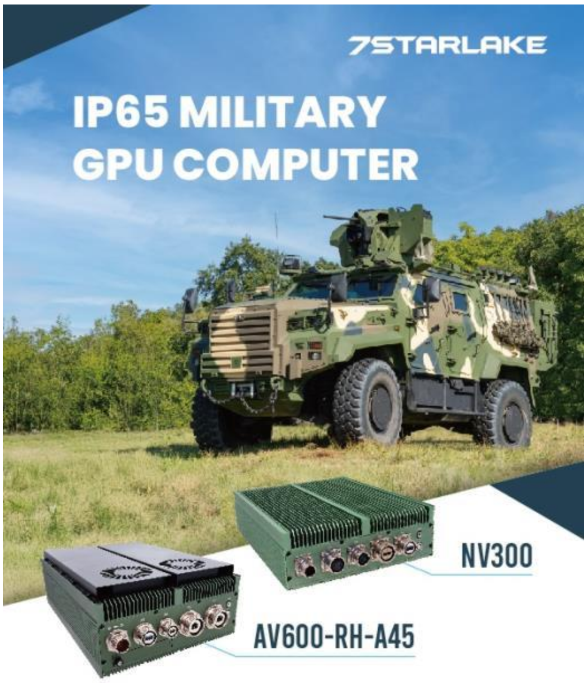
SPYNEL-X (HGH Infrared Systems)

SPYNEL-X is a proven InfraRed Search & Track system equipped with a 360° panoramic camera, delivering real-time infrared monitoring and tracking of threats across land, sea, and air. Its advanced capabilities provide essential situational awareness and force protection.

- 120Mpix day/night panoramic video in total darkness in any weather conditions
- Cooled MWIR thermal sensor
- Human, vehicle, RHIB or UAV detection capabilities
- Automatic tracking and classification of any ground/sea/air threats
- Undetectable, no EM disturbance
- Motorized tilt for fine-tuned installations

GPU Computers

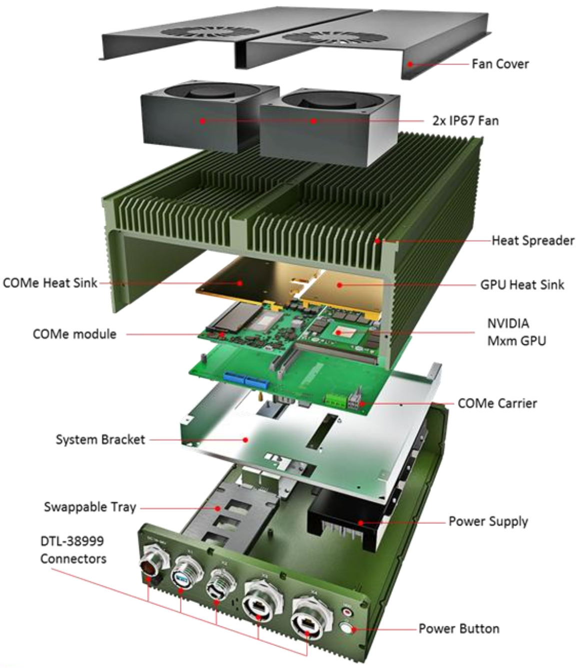
Military GPU computers act as powerful counter-drone processing platforms, enabling real-time threat detection and response through multi-source sensor fusion, AI-driven analytics, and high-performance computing. Engineered for mission-critical applications across defense, government, and critical infrastructure, these systems support rapid data processing and visualization in dynamic operational environments.



AV600-RH-A45 (7STARLAKE)

Built for demanding operational conditions, **the AV600-RH-A45** is ideal for AI-enhanced object recognition and 3D rendering large capacity storage up to 16TB for extended mission data recording.

- Full IP65 sealed enclosure for harsh, wet and dusty environments.
- 8 x Channel 3G-SDI Frame Grabber with low latency
- Intel® 13th Raptor Lake-H, Core™ i7-13800HE/HRE, 14C, 20T, 5.0Ghz
- NVIDIA® Quadro MXM RTX A4500 (16GB GDDR6, 5888 CUDA)
- Large capacity storage up to 16TB
- Extreme temperature: -40°C to +60°C
- Designed to meet MIL-STD-810 for anti-shock and vibration



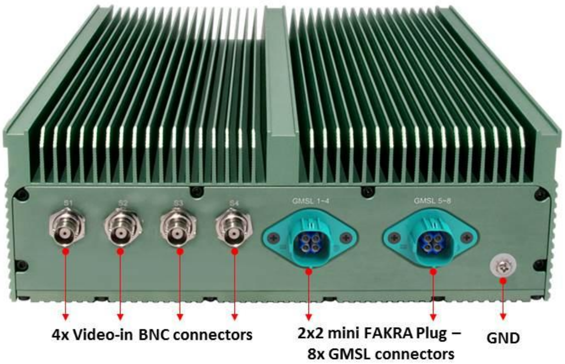
MIL-STD 810 Rugged Standards

- MIL-STD-810 Vibration Method 514.6: ◎Acceleration: 5.0 Grms
- MIL-STD-810 Vibration Method 514.6: ◎PSD: 0.01257 g2/Hz
- MIL-STD-810 Shock Method 516.6: ◎Wave Form: Half shine wave
- MIL-STD-810 Shock Method 516.6: ◎Acceleration: 75G

NV300 (7STARLAKE)

Designed with an ultra-compact and lightweight form factor, **the NV300 Military AGX Orin Computer** is a counter UAV visualization platform supporting multi-sensors data fusion.

- NVIDIA Jetson AGX Orin 32G/64G LPDDR5 DRAM
- Data fusion: 4 CH 3G-SDI NVENC H.264 low latency
- Data input: 1 x 10G SFP+ 2 x LAN , 8xCH GMSL 2.0
- Connectivity: CAN Bus+ 1 x RS232/422/485 support
- IP65 Classified with DTL38999 connector
- DC-DC 18V~36V, Options with MIL-461 EMI Filter
- Designed to meet MIL-STD-810 for shock and vibration



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- MIL-STD-810 Shock Method 516.6: ◎ Wave Form: Half shine wave
- MIL-STD-810 Shock Method 516.6: ◎ Acceleration: 75G

Edge AI Platform

SFF & SWaP

Open Modular Architecture

MIL-STD 810 Rugged

Military Displays

Rugged military displays provide a durable, touch-screen interface optimized for harsh military environments. Supporting multiple display modes including thermal, visual, and fused imaging, they enable real-time threat visualization. With secure network connectivity to the Command & Control system and GPU modules, these displays ensure seamless operator interaction in mobile, naval, and fixed-site anti-drone deployments.

SKY15-P20 (7STARLAKE)

The SKY15-P20 is a next-generation rugged UAV display for artillery targeting, designed to enhance precision and withstand the rigors of the battlefield.

- Sunlight readable 1000 Nits
- Anti-reflection/anti-glare (AR/AG) coating
- Anti-shock: 20mm cannon shock resistance
- Extended temperature -40°C to 60°C
- MIL-STD-810 Vibration Method 514.6: ◎Acceleration: 5.0 Grms
- MIL-STD-810 Shock Method 516.6: ◎Acceleration: 40G
- IP65 Sealed with DTL38999 connector
- Military ground vehicle targeting display

Command & Control with Fire Control

Seamlessly integrated with the Command and Control interface, the gun control system serves as the central processing hub of the anti-drone platform. It orchestrates coordination across all system modules, delivering real-time decision support for threat evaluation, engagement rules, and weapon activation. Designed for versatility, the system supports seamless integration with both kinetic and non-kinetic effectors, ensuring rapid, precise responses to dynamic aerial threats.

Intel® Xeon® 6 SoC Tactical Edge Solutions

Powered by the next-gen Intel® Xeon® 6 SoC, the 7STARLAKE Tactical Edge Solution delivers high-performance, rugged edge computing. Featuring PCIe 5.0 for high-speed data throughput, DDR5 memory, and support for extended temperature ranges, it's purpose-built for multi-sensor surveillance and air domain awareness at the tactical edge.

	7SL-XR600-4P	7SL-XR600-3P	7SL-XR600-2P
CPU	4 x 6th Xeon® SoC 42C	3 x 6th Xeon® SoC 36C	2 x 6th Xeon® SoC 20C
TDW	6726P-B (235W)	6553P-B (215W)	6516P-B (145W)
Clock	3.5 Ghz	4.0 Ghz	3.5Ghz
NIC	8 x 100G (SFP+)	6 x 100G (SFP+)	4 x 100G (SFP+)
GPU	N/A	2 x NVidia L4	2 x Nvidia H100
NVMe	On board M.2	6 x E1.S SSD	On Board M.2

Applications

As drones become more accessible and capable, the risk of malicious or unauthorized UAV activity continues to rise across both military and civilian domains. Anti-drone systems play a critical role in safeguarding airspace, personnel, and strategic assets by detecting, tracking, and neutralizing drone threats in real time. These solutions are essential for protecting sensitive locations, maintaining operational security, and ensuring public safety across a wide range of scenarios.

- Military bases and forward operating posts
- Airports and urban critical infrastructure
- Border surveillance and homeland security
- Naval vessels and maritime patrol zones
- Air defense radar stations and missile silos
- Nuclear power plants and energy infrastructure
- Combat convoys and mobile command units
- Embassy compounds and diplomatic missions
- Disaster relief zones
- VIP event protection

Conclusion

In an era where unmanned aerial threats are becoming increasingly sophisticated and accessible, the modern battlefield demands agile, intelligent, and multi-layered defense systems. From protecting frontline troops and strategic installations to safeguarding urban infrastructure and critical civilian zones, the need for reliable anti-drone capabilities has never been more urgent. Scenarios such as swarming drone attacks on military convoys, surveillance UAVs breaching restricted airspace, or weaponized drones targeting command centers illustrate the diverse and growing risks that defense forces must counter. In such complex threat environments, real-time detection, precise tracking, and rapid neutralization are essential for mission success and personnel safety.

7STARLAKE's integrated Anti-Drone System addresses these evolving challenges through a cutting-edge combination of EO/IR sensors, AI-powered GPU processing, and C2-ready rugged military-grade interfaces. Its modular and scalable design ensures adaptability across both fixed and mobile deployments, enabling seamless integration with existing defense systems. Whether deployed at a remote military base, mounted on an armored vehicle, or installed to protect critical infrastructure, the system delivers enhanced situational awareness and decisive response capabilities. By bridging advanced technology with operational readiness, 7STARLAKE provides a future-proof defense solution for securing high-risk airspace in modern and asymmetric warfare environments.

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