



# The VEC500 and 4K 60fps Compression in Defense Applications

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## Executive Summary

A 4K 60 fps sensor with 4:2:2 10-bit color produces roughly 10 Gbps of raw video. The best tactical datalinks top out under 300 Mbps. That gap is the entire problem.

Delta Digital Video's VEC500 is an OEM encoder module that compresses 4K 60 fps video using H.264, H.265, or optionally JPEG-XS, multiplexes STANAG 4609-compliant KLV metadata, encrypts the transport stream with AES-256, and does it all on a 3.6-ounce board that draws 10 watts. It accepts SDI or MIPI CSI-2 input and outputs over standard Ethernet with SRT and RIST support.

This paper is for sensor OEMs, platform integrators, and video architects working on any system that carries an EO/IR payload and needs STANAG-compliant 4K encoding over constrained links. That includes UAS across all group categories, manned ISR platforms, ground vehicle sensor suites, counter-UAS detection systems, and network video distribution architectures.

## The Raw Data Problem

A 4K frame contains 3840 by 2160 pixels, roughly 8.3 million per frame. At 60 frames per second with 4:2:2 chroma subsampling and 10-bit depth, the baseband payload is approximately 9.95 Gbps. With transport overhead and interface formatting, the total approaches the 11.88 Gbps line rate of 12G-SDI.

No tactical datalink comes close. The Common Data Link family tops out at 274 Mbps. TCDL runs 10 to 45 Mbps. Even the upper end of CDL is more than an order of magnitude below what the sensor produces. Sustained multi-gigabit transmission over SATCOM is economically prohibitive and spectrally impractical.

Compression is not optional. The question is which codec, at what bitrate, with what latency penalty, and with what consequences when the link degrades.

# Why 4K at 60 Frames Per Second Matters

## Target Discrimination at Range

An analyst identifying vehicle types, distinguishing civilian from military equipment, or reading markings on a structure needs pixel density on the target. As the standoff distance increases, the number of pixels on the object of interest drops. Higher sensor resolution preserves discrimination capability at distances where closing to shorter range introduces unacceptable risk. For high-altitude ISR and long-range reconnaissance, resolution is the difference between actionable intelligence and ambiguous imagery.

## Temporal Resolution and VMTI

Video Moving Target Indication algorithms depend on frame-to-frame coherence to detect, track, and classify moving objects. Higher frame rates reduce inter-frame motion displacement, improving tracking stability and reducing track loss. Over complex urban terrain or against high-speed targets, the difference between 30 fps and 60 fps determines whether tracks survive in clutter or break.

## Metadata as the Intelligence Layer

Under STANAG 4609, video is imagery fused with time-synchronized geospatial and platform metadata encoded in KLV format per MISB specifications. MISB ST 0601 defines the UAS Datalink Local Set, which covers platform position, sensor pointing, field of view, and slant range. MISB ST 0603 defines precision time stamping. Together, these enable geolocation, coordinate handoff for targeting, and fusion with other intelligence sources.

If your metadata is wrong, late, or missing, your coordinates and weaponeering are wrong. An operator cueing a precision strike relies on geolocation accuracy measured in meters, not tens of meters. At 60 fps, metadata updates twice as often, tightening geolocation and timing error bars across the exploitation chain.

## Codec Comparison for ISR Applications

Three codecs dominate the current defense video trade space. The following table summarizes the key differences, followed by a detailed discussion of each.

Attribute	H.264 (AVC)	H.265 (HEVC)	JPEG-XS
Bitrate efficiency at 4K 60fps	Baseline; requires the highest bitrate for equivalent quality	~50% reduction vs. H.264 at equivalent quality	Low; 2:1 to 10:1 compression only
Typical 4K 60fps operating range	20-50+ Mbps depending on scene and quality target	8-25 Mbps, depending on scene and quality target	1-2 Gbps (visually lossless)

Codec latency	1-2+ frames (GOP-dependent)	1-2+ frames (GOP-dependent)	Sub-millisecond (line-based)
Error propagation	High; lost I-frame corrupts all frames until next IDR	High; similar GOP dependency to H.264	None; intra-frame only, no inter-frame dependencies
STANAG 4609 status	Endorsed, Edition 3+	Endorsed, Edition 4	Not currently specified in STANAG 4609
Best-fit use case	Legacy interoperability with fielded PED systems	Primary codec for new ISR builds on bandwidth-constrained links	Intra-platform low-latency feeds, sensor control loops, ST 2110-22 distribution
VEC500 support	Baseline, Main, High to Level 5.1	Main, Main 10 to Level 5.1	Optional, 4:2:2 8/10-bit

## H.264

H.264 remains the most widely fielded codec in ISR systems because of broad interoperability. Most ground stations, exploitation workstations, and ROVER terminals across the coalition inventory decode it natively. STANAG 4609 explicitly endorses it. The downside is the bitrate. H.264 is hungry compared to newer codecs, and its inter-frame prediction using I/P/B-frame Group Of Pictures (GOP) structures makes it fragile on degraded links. A lost I-frame propagates artifacts across every subsequent frame until the next I-frame resets the decoder. On a high-BER tactical link, video quality collapses faster than the raw bitrate would suggest.

## H.265

H.265 delivers roughly 50% bitrate savings over H.264 at equivalent perceptual quality. STANAG 4609 now supports it, and it is becoming the default specification for new ISR encoder procurements. For 4K 60 fps, H.265 can meet quality targets at bitrates that fit within tactical link budgets, whereas H.264 cannot. The tradeoff is computational complexity. Real-time 4K 60fps H.265 encoding demands significantly more processing power, which matters for module size, power draw, and thermal management on airborne platforms. Error propagation characteristics are similar to H.264, and careful GOP configuration is still required to keep end-to-end latency under 200 milliseconds.

## JPEG-XS

JPEG-XS does not compete with H.264 or H.265 for the RF link. It solves a different problem. The codec operates line-by-line with no inter-frame prediction, delivering sub-millisecond encoding and decoding latency. It achieves compression ratios of 2:1 to 10:1 while maintaining visually lossless quality. There is no error propagation

because there are no inter-frame dependencies. A corrupted slice stays corrupted. The next frame is clean.

The practical architecture: H.265 handles the constrained RF downlink for maximum bitrate efficiency, while JPEG-XS runs inside the platform or across 10 GbE and ST 2110-22 networks for low-latency distribution where sub-millisecond delay matters. Sensor control loops on remotely piloted aircraft, real-time targeting overlays, and cockpit display feeds are the primary use cases. JPEG-XS compresses that ~10 Gbps stream to 1-2 Gbps, which fits on 10 Gigabit Ethernet but is still far too high for a tactical radio link.

For applications that require JPEG-XS at high throughput and 10 GbE transport, Delta's 5480E, with its SFP+ optical interface, supports up to 10 Gbps. The VEC500 is the SWaP-optimized edge encoder for platforms where H.264 or H.265 over 1 GbE is the primary output path.

## VEC500 Architecture

The VEC500 is an OEM encoder module, not a standalone appliance. It is a board-level component for sensor manufacturers and platform integrators.

### Form Factor and Environment

- 3.03 x 2.36 x 0.84 inches
- 3.6 ounces
- 10 watts typical
- Operating temperature: -40 to +71 degrees C (industrial configuration)

On any platform where encoder SWaP is constrained, those numbers matter. An encoder that draws 40 or 50 watts and weighs two pounds changes the payload integration math in ways that ripple through endurance, thermal management, and available margin for other subsystems.

### Input Interfaces

- SDI (SMPTE, up to 4K 60fps) via MCX connector
- MIPI CSI-2 via multi-pin header for direct sensor connection
- 4:2:2 chroma at 8-bit and 10-bit color depth
- Auto-detect for format, resolution, and frame rate

MIPI CSI-2 allows direct connection to an image sensor without intermediate format conversion, eliminating parts, power, and board space in compact sensor heads.

### Compression

- H.264: Baseline, Main, High profiles up to Level 5.1 (4:2:2, 8-bit)
- H.265: Main, Main 10 profiles up to Level 5.1 (4:2:2, 8/10-bit)
- JPEG-XS (optional): 4:2:2, 8/10-bit, visually lossless

## Transport

- MPEG-2 Transport Stream over RTP/UDP or raw UDP
- SRT and RIST for forward error correction on lossy links
- Unicast and multicast
- 64 Kbps to 1 Gbps over 10/100/1000 Mbps Ethernet
- Product literature indicates SMPTE ST 2110 support within the broader feature set

## Metadata and Timing

- KLV metadata multiplexing per MISB and STANAG 4609
- Metadata input via RS-232, Ethernet, or SDI VANC
- On-the-fly KLV encoding or passthrough from upstream sources
- Time sync: GPS, IRIG-B, PTP (IEEE 1588), NTP

## Security and Control

- AES-128 and AES-256 transport stream encryption
- External key management for platform COMSEC integration
- Configuration via web GUI, Telnet, SSH, HTTPS, SNMPv3, or serial

## Design Example:

### Group 2 UAS Downlink

To make the codec and transport tradeoffs concrete, consider a Group 2 UAS carrying a 4K EO/IR gimbal with a MIPI CSI-2 output.

The sensor feeds raw 4K 60 fps video to the VEC500 over MIPI CSI-2. The VEC500 encodes H.265 at Main 10 profile, targeting 8 to 15 Mbps depending on scene complexity and quality requirements. It multiplexes MISB ST 0601 KLV metadata received from the gimbal controller over RS-232 and applies AES-256 encryption. The output is an MPEG-2 Transport Stream over RTP/UDP at the configured bitrate, fed to the platform's datalink transmitter over GbE.

On the ground, the receiving terminal ingests a STANAG 4609-compliant stream that compatible exploitation workstations can decode, geolocate, and fuse without custom integration. The entire encoding chain from raw sensor to compliant transport stream runs within a 3.6-ounce, 10-watt payload budget.

If the same platform also requires a low-latency sensor-control feed for the pilot station, the optional JPEG-XS codec can provide a parallel sub-millisecond stream over the onboard Ethernet backbone, while H.265 handles the downlink. That dual-codec architecture is where the VEC500's optional JPEG-XS capability earns its value.

## Operational Context

### Small UAS Sensor Integration

Group 1 and Group 2 platforms under 55 pounds are proliferating across infantry, reconnaissance, and special operations units, and increasingly carry EO/IR sensors with 4K resolution. The constraint is not whether 4K sensors exist. They do. The constraint is turning that 4K stream into a STANAG-compliant, metadata-rich transport without exceeding the payload's SWaP budget. The VEC500's OEM form factor and MIPI CSI-2 input allow sensor manufacturers to embed encoding directly, rather than build a custom compression board.

### Counter-UAS Detection Systems

C-UAS sensors face the inverse problem. They must detect, track, and classify small drones at extended range in cluttered environments. Higher-resolution imagery improves classification accuracy and reduces the false positive rate that overwhelms operators. A tower-mounted C-UAS system with a 4K EO/IR tracker needs ruggedized, low-power, metadata-compliant encoding without occupying significant rack space or thermal budget.

### JADC2 and Network Video Distribution

JADC2 concepts require sensor data that is tagged, indexed, discoverable, and transportable across heterogeneous networks with classification metadata. For ISR video, that means encoders at the tactical edge must produce standards-compliant MPEG-2 Transport Stream with synchronized KLV from the point of capture. Encoding correctly at the sensor eliminates format conversion downstream and reduces latency in the distribution chain.

## Standards Compliance as a Procurement Gate

STANAG 4609 and MISB compliance are not features. They are requirements. Video that does not conform cannot be ingested by most U.S. and NATO exploitation systems without custom integration, which incurs time, money, and operational risk.

STANAG 4609 mandates the MPEG-2 Transport Stream as the container, approves H.264 and H.265 as codecs, and requires KLV metadata per SMPTE ST 336, with a mandatory MISB ST 0601 payload for UAS feeds. The standard is codec-agnostic at the transport layer, so switching from H.264 to H.265 changes the bitrate but does not change how metadata is handled.

The Joint Interoperability Test Command certifies video systems for STANAG 4609 compliance through a formal process that typically requires twelve to eighteen months and significant investment. The VEC500 is an OEM module, not a standalone certified system. It is built on Delta Digital Video's encoder product line, which includes JITC-certified systems such as the 6805R and 6820R. That shared architecture provides a foundation for manufacturers pursuing certification of integrated platforms. The VEC500 inherits proven engineering from certified

products, but any system incorporating the module would pursue its own certification path appropriate to its target program.

## The Risk of Non-Compliant Encoding

Integrators sometimes use commercial off-the-shelf video encoders in ISR systems because they are inexpensive and readily available. That choice introduces serious interoperability risk.

Most commercial encoders lack KLV metadata support, do not implement STANAG 4609 transport stream profiles, and do not support military time synchronization or encryption requirements. Retrofitting metadata onto a consumer encoder introduces engineering risk, schedule delay, and certification complexity that frequently exceeds the cost of a purpose-built defense encoder.

The failure mode is specific and common. The video looks great on a bench monitor and is completely unusable in the kill chain. Ground stations reject the stream. Exploitation tools cannot extract metadata. The sensor works perfectly as a camera and is worthless as an intelligence source. Procurement specifications increasingly require encoder compliance verification before platform acceptance testing for exactly this reason.

The VEC500 avoids this by design. KLV multiplexing, STANAG 4609 transport formatting, military time synchronization, and AES encryption are native capabilities. An integrator building around the VEC500 starts with a compliant foundation rather than spending months forcing a consumer product to do something it was never built for.

## Conclusion

The core problem in defense ISR video is straightforward: 4K 60fps sensors produce data at rates that exceed tactical link capacity by one to two orders of magnitude, and the video is operationally useless unless it arrives at exploitation systems with accurate, time-synchronized metadata in a standards-compliant transport format.

The VEC500 addresses that problem with a 3.6-ounce, 10-watt OEM module that supports H.264, H.265, and optional JPEG-XS compression, with native KLV metadata multiplexing, STANAG 4609 transport formatting, and AES encryption. Its SDI and MIPI CSI-2 inputs, combined with SRT/RIST-capable Ethernet output, enable integration with a range of sensor platforms, from small UAS to ground-based C-UAS systems, without requiring custom encoding hardware.

No encoder module eliminates the need for system-level video architecture design, link budget analysis, or operational concept work. What the VEC500 does is remove the encoding layer as a design risk. For programs where 4K ISR video, metadata compliance, and tight SWaP constraints intersect, the alternative is typically a custom build, a non-compliant commercial encoder, or a heavier purpose-built

system. Each of those paths carries cost, schedule, or interoperability consequences that the VEC500's architecture is specifically designed to avoid.