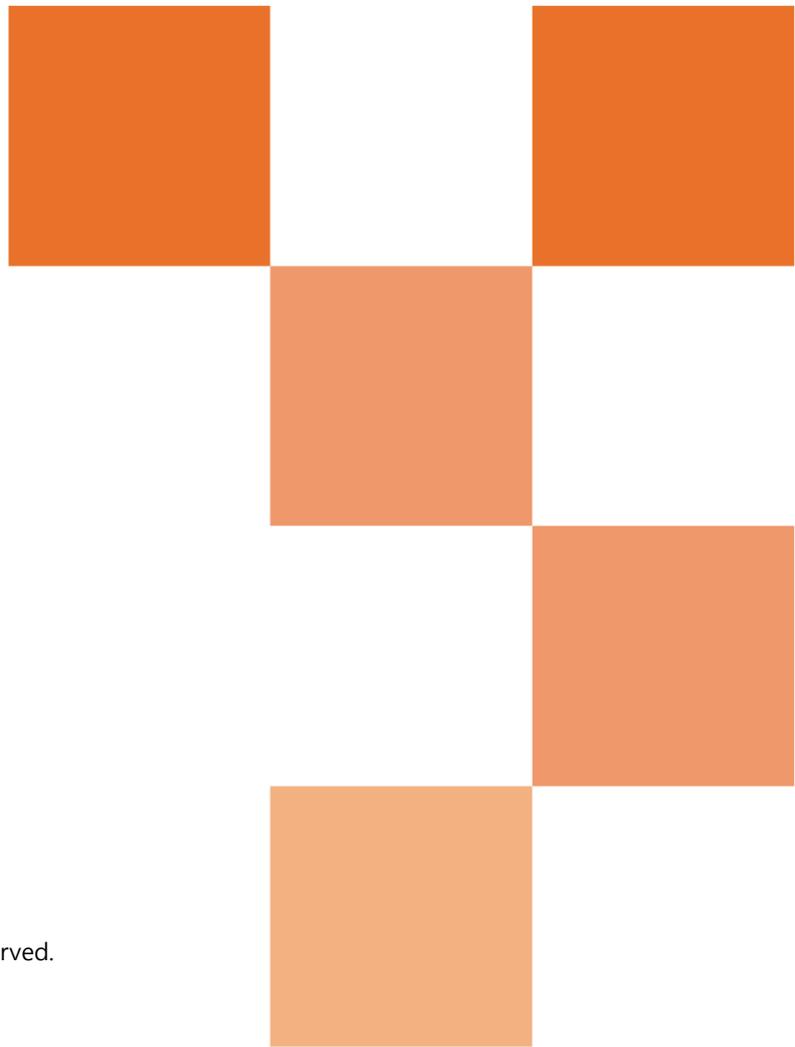


White Paper

AV1 Codec Application

Theory and Practice in Balance

March 2026



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1. Introduction

This white paper presents key indicators for applying codecs such as H.265 and AV1 in security cameras. It demonstrates that codec changes alone do not absolutely determine storage savings or video quality improvements, but rather serve as one of several strategies for bitrate reduction.

AV1 currently stands at a 'technical turning point' in the security market, yet remains in a transitional phase from an infrastructure perspective. Despite widespread adoption by streaming platforms, security infrastructure compatibility and stability have long been validated with H.264 and H.265 codecs. Physical deployment changes require time, making AV1 applicability dependent on existing infrastructure conditions.

The paper provides objective codec data and real-world test results, highlighting essential considerations for future camera selection decisions.



2. Background

High-efficiency video codecs like HEVC/H.265 have been widely adopted in the general video market but consistently faced challenges with high royalty fees. Enterprises bore substantial costs for every video stream transmitted, prompting the development of AV1 as a royalty-free, high-performance codec solution. AV1 represents next-generation technology optimized for high-quality streaming, already embraced by major platforms such as YouTube and Netflix.

Security video applications operate under distinct conditions from general streaming, including 24/7 continuous recording, AI analytics integration, and surveillance system interoperability. HEVC/H.265 delivers approximately 50% better compression efficiency than H.264 and enjoys broad market penetration, yet H.264 persists due to its fast encoding speeds, compatibility with over 90% of cameras and players, and reliable performance on low-spec servers—often used alongside H.265.

Rising storage and network bandwidth costs have heightened demand for advanced codecs, gradually introducing AV1 to security markets. AV1 reportedly offers 20-30% superior compression to H.265, though it demands significantly higher computational resources for encoding and increased power consumption during decoding.

AV1 support emerged in select manufacturers and VMS (Video Management System) platforms from late 2025. Camera-side SoCs enable AV1 encoding, but non-cloud deployments hinge on VMS server and display PC performance for reception and processing. Most current VMS servers rely on CPU processing, leading to overloads, with hardware acceleration limitations suggesting several more years for widespread AV1 commercialization.

Newly released server GPUs (e.g., NVIDIA L4) and Intel's next-gen integrated graphics (Quick Sync) now provide robust AV1 hardware encoding/decoding support. However, broad VMS server adoption will take time, and client PC refresh cycles may further delay field deployments.

Manufacturers must therefore offer detailed guidance on codec and system selection tailored to capture environments (dynamic/static scenes, lighting conditions, AI target density) and infrastructure (cloud vs. on-premises, equipment age, VMS type).



3. Technology Description

Security camera systems consist of image sensors, ISP (Image Signal Processor), codec engines, AI analytics modules, and more, with codecs serving as one critical element in the overall video processing pipeline.

AV1 (AOMedia Video 1) codecs leverage block-based prediction and transform coding to deliver approximately 20-50% higher compression efficiency compared to H.265. However, the elevated complexity of Coding Units (CU) during encoding results in substantial CPU and GPU resource demands for real-time processing. Consequently, embedded AV1 encoders often exclude advanced features to maintain real-time performance, frequently falling short of expected compression gains.

3.1. Technical Differences in Quality Preservation

AV1 does more than simply reduce file size; it employs more intelligent compression techniques, with granular block partitioning and Film Grain Synthesis being its primary features.

Granular block partitioning refers to the way video is segmented for analysis. While H.265 divides video into blocks up to 64x64, AV1 supports up to 128x128, allowing for more efficient processing of large, uniform areas like backgrounds. ¹

Furthermore, **Film Grain Synthesis** addresses the challenge of fine video noise (grain), which is notoriously difficult to compress. AV1 removes the grain during the compression process and synthetically re-applies it during playback. This allows the codec to preserve the original texture while significantly reducing the data required. ²

3.2. AV1 Limitations ("No Free Lunch")

AV1 trades file size for time and resource costs. Its complex analysis algorithms result in encoding times several times longer than H.265. Cameras mitigate this via SoC processing, but AV1 requires dedicated hardware blocks, necessitating new SoC designs unavailable on legacy chips.

AV1's grain handling adds computational overhead by mathematically analyzing noise patterns ("this region's noise follows this pattern"), increasing processing demands.

Hardware compatibility poses further challenges: without acceleration, AV1 playback spikes CPU usage and power draw. Ultimately, AV1 isn't magic—it's smarter data packing at the expense of greater computational power.

¹ Because **specific AV1 implementations** support only up to 64x64, the complexity and characteristics associated with **128x128 Coding Units (CU)** may not apply to all videos utilizing the AV1 codec.

² Since certain **AV1 profiles or implementations** do not utilize **Film Grain Synthesis** parameters, this feature may not be applicable to all AV1-encoded video content.



Security manufacturers pursue high-complexity AV1 for high-resolution and AI analytics demands, alleviating storage risks and bandwidth burdens. Key benefits include:

- **Storage Savings:** 30% capacity reduction vs. H.265 allows more days of footage on the same HDD or fewer drives, cutting installation costs.
- **Bandwidth Reduction:** In large-scale centers with dozens of cameras, AV1 lowers network loads, enabling lag-free remote real-time monitoring.
- **AI Analytics Efficiency:** AV1 preserves critical edges and contours at low bitrates, enhancing object recognition accuracy for people/vehicles.

Paradoxically, cost savings demand upfront investments:

- **Camera Costs:** AV1 encoding requires high-performance SoCs, raising prices over H.265 models; physical hardware changes are mandatory.
- **Server & Recording Infrastructure:** Legacy NVRs/servers lack AV1 recognition, requiring full replacements across recording and control infrastructure. AV1's high computational complexity requires high-performance CPUs and GPUs for server-side processing, especially when performing secondary AI analytics on recorded streams.
- **Client Workstation Upgrades:** A critical but often overlooked cost is the necessity to upgrade or replace monitoring workstations. Efficiently decoding and rendering multiple simultaneous AV1 streams (e.g., in a 16-channel live view) requires modern, high-end GPUs with native AV1 hardware acceleration. For many legacy systems, this upgrade can represent a massive capital expenditure.
- **Mobile Playback:** AV1 is highly optimized for web-based streaming services (e.g., Netflix, YouTube). On mobile devices without dedicated AV1 hardware decoders, software-based decoding can still lead to increased battery drain and potential UI latency during high-resolution playback.

Beyond costs, ecosystem immaturity hinders adoption. Cameras integrate with VMS (Milestone, Genetec, etc.), many of which lack full AV1 support or require paid upgrades. Playback on control PCs or mobile apps risks stuttering or 100% CPU usage without hardware decoding.

Unlike battle-tested H.264/H.265, AV1 carries transitional instability risks. Its precise compression amplifies artifacts from packet loss, demanding more recovery computation.

	H.265	AV1
Compatibility	Near-universal device/software support	Smooth only on latest hardware
H/W Cost	Mass-produced, cost-effective	Higher SoC costs passed to products
System load	Moderate	Requires high-spec PCs for decoding

Table 1: H.265 (Current Mainstream) vs. AV1 (Next-Gen)

At present, AV1 adoption in CCTV resembles future-proofing investment. Short-term compatibility headaches persist, though cloud-based services actively evaluate it.



3.3. Security Industry VMS Landscape

Current VMS (Video Management Software) solutions in security fall into three categories: global open platforms, manufacturer-proprietary systems, and rapidly emerging cloud-native (VSaaS) offerings.

Historically, on-premises deployments dominated for public institutions, large plants, and financial sectors requiring data security and isolated networks—ensuring recording/monitoring during internet outages with full customer data ownership. As of 2026, the market transitions rapidly from traditional on-premises to hybrid cloud models.

Rising cloud VSaaS (Video Surveillance as a Service) suits multi-site enterprises/franchises and cost-sensitive small offices, steadily expanding market share.

Hybrid approaches now prevail during this shift: local recording servers paired with cloud-based control and AI analytics.

AV1 proves a game-changer in cloud environments but remains premature for legacy on-premises setups.



3.3.1. Why Use AV1 in Cloud Services (VSaaS)

In cloud VMS, bandwidth and storage directly translate to costs. AV1 slashes upload data volumes (up to 50% vs. H.265), reducing ISP fees and eliminating stream interruptions from network strain. Developed by Google, Apple, and Microsoft, AV1 plays natively in Chrome, Edge, and Safari without plugins—ideal for web-centric cloud VMS, eliminating user setup hassles. For cloud AI analytics, low-bitrate high-quality streams boost accuracy while cutting transfer costs. Note: Not all AV1 streams guarantee lower bitrates than H.265.

3.3.2. Why AV1 May Be Unnecessary On-Premises

Compatibility with legacy infrastructure poses the biggest barrier on-premises, where AV1's efficiency demands massive computation. Without CPU/GPU hardware decoding, servers/control PCs slow down or glitch.

Most on-premises recorders (NVR or Server based VMS) are optimized for H.264/H.265, ignoring AV1. Gigabit internal networks minimize bandwidth pressures, reducing codec upgrade incentives compared to cloud systems.

Category	Cloud	On-premise
AV1 Necessity	High (bitrate priority)	Low (compatibility priority)
Key Benefits	Data transfer savings, seamless web playback	(Future) Extended storage retention
Current Recommendation	AV1 cameras + cloud VMS	Stable H.265 operations

Table 2: Cloud vs. On-Premise

For existing on-premises users, AV1 doesn't warrant replacements—yet. For new cloud control systems or large-scale (thousands of cameras) projects, AV1 support critically impacts TCO(Total Cost of Ownership).

4. Environment-Based Performance Comparisons

AV1 theoretically excels in bitrate efficiency, but real-world data remains limited—especially since embedded cameras often implement core AV1 features restrictively. Thus, AV1 adoption alone doesn't guarantee lower bitrates.

Hanwha Vision verified that H.265 with AI-based compression achieves lower bitrates than competitors' AV1 while preserving superior video quality. If AV1 strengths stem from CPU-driven ROI (Region of Interest) extraction, equivalent AI ROI on H.265 systems yield similar gains without costly infrastructure overhauls.

The cases below represent measured results under identical conditions (bitrate-reduction presets) and do not generalize to all AV1 cameras.

All comparisons were conducted using the camera's default settings with video compression intensity set to Low.

Bench testing approaches differ depending on requirements. This document follows a defined criteria

4.1. Indoor Evaluation Environment

Hanwha Vision cameras with Wisenet 9 SoC dedicate one NPU to AI-enhanced imaging, minimizing low-light noise for maximal bitrate savings. AI based WiseStream further optimizes for moving objects. Comparing an 8MP P-Series camera against a competitor's AV1 model.

(All comparisons were conducted using the camera's **default settings** with video compression intensity set to Low)

		
	Hanwha Vision	Industry Alternatives
H.265	3.6 Mbps	4.6 Mbps
AV1	-	4.4 Mbps

Table 3: AI Camera Bitrate Comparison (Indoor Scene)

4.2. Outdoor Environment (No Key Objects)

In scenes without any objects of interest for AI-based detection but with relatively high motion in the video, Hanwha Vision’s AI-based bitrate reduction showed a noticeably higher efficiency. Through Hanwha Vision’s AI processing, even when there was non-object-related movement or camera shake, the bitrate did not increase significantly compared with Table 3.



Figure 1: Outdoor scene capture

	Hanwha Vision	Industry Alternatives
H.265	3.9 Mbps	11.12 Mbps
AV1	-	10.5 Mbps

Table 4: Bitrate comparison in a scene with camera shake but no people or vehicles

As shown in the bitrate results from the other solution, switching from H.265 to the AV1 codec reduced the bitrate by about 1%. However, even when using the same H.265 codec, the Hanwha Vision camera demonstrated significantly lower bitrate performance.

Therefore, it can be confirmed that in certain shooting environments, bitrate efficiency is more affected by how AI-based video processing is implemented than by the choice of codec alone.

4.3. High-Target Outdoor (Many Moving People/Vehicles)

As shown in Tables 5 and 6, there is almost no difference in bitrate between day and night scenes under the same conditions for Hanwha Vision cameras.

In low-light environments, conventional cameras typically increase gain to enhance brightness, which often leads to higher bitrate due to noise amplification. However, for cameras equipped with the Wisenet 9 SoC, the measured data confirms that there is no significant increase in bitrate under the same conditions.

In contrast, other manufacturers' cameras showed a noticeable increase in bitrate in darker scenes compared to brighter ones.



Figure 2: Daytime high-target outdoor scene

	Hanwha Vision	Industry Alternatives
H.265	4.1 Mbps	5.7 Mbps
AV1	-	5.8 Mbps

Table 5: High-Target Outdoor Bitrate Differences (Day)



Figure 3: Nighttime high-target outdoor scene

	Hanwha Vision	Industry Alternatives
H.265	4.1 Mbps	8.4 Mbps
AV1	-	9.5 Mbps

Table 6: High-Target Outdoor Bitrate Differences (Night)



5. Conclusion

AV1 represents an advanced codec tailored for cloud streaming, yet this analysis confirms that codec changes alone do not solve bitrate reduction challenges. Moreover, seamless AV1 integration remains difficult in existing video management infrastructures.

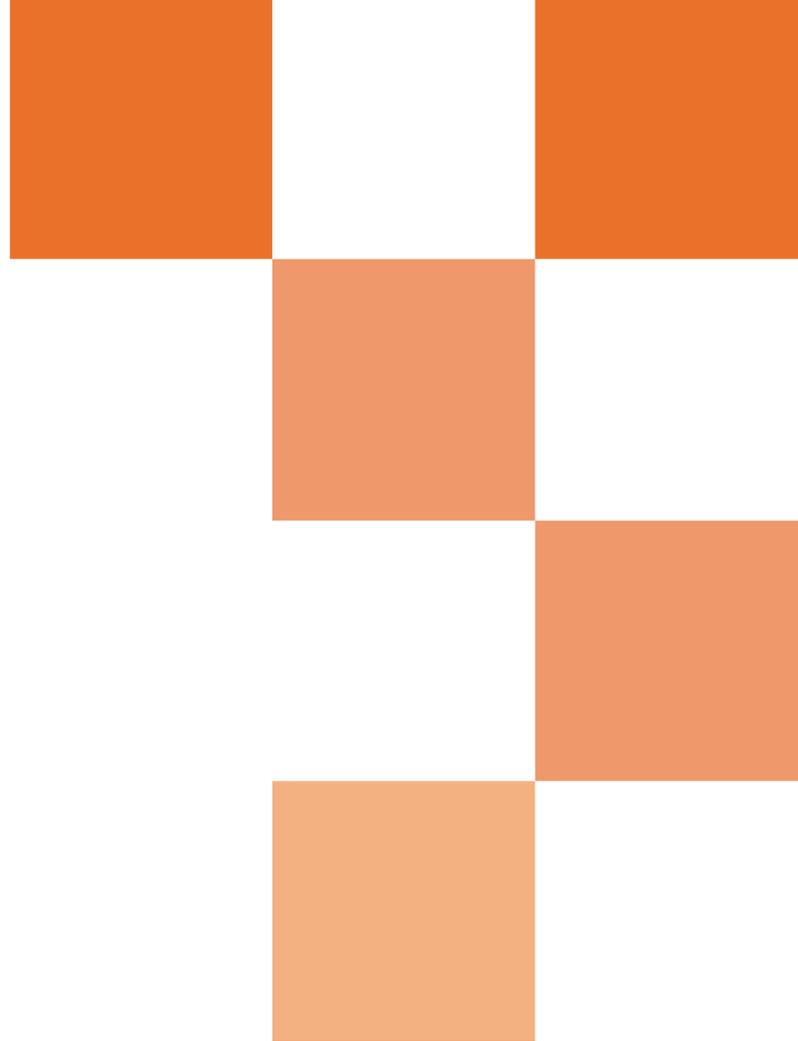
Hanwha Vision demonstrates technical superiority using proven H.265 codecs powered by Wisenet 9's Dual NPU architecture—ensuring infrastructure compatibility alongside reliable bitrate savings.

As AV1 stabilizes across the security market, full-system optimization becomes feasible. All manufacturers should pursue bitrate optimization innovations, extending beyond cost savings for security administrators to broader societal benefits like reduced data center builds and environmental impact.

Rather than fixating on single factors, select products based on objective data—budgets, environments, and capture sites—while scaling infrastructure for stable security deployments.

6. Appendix

Solution	AV1 Support Status	Descriptions
WAVE	X	Supports industry-standard codecs; no AV1 support confirmed even in latest v6.0
NVR	X	Future AV1-capable NVR releases possible
ONVIF Profile S/T	X	Ensures camera-VMS interoperability; H.264/H.265 only officially supported—no AV1 roadmap
Milestone	●	XProtect 2025 R3 adds official AV1 support
Genetec	●	AV1 encoding/decoding from Security Center 5.13.3 (legacy version upgrades may incur costs)
Axis Camera Station (ACS)	●	Axis VMS provides AV1 environment support



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