Surveillance cards for edge storage

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AXIS
COMMUNICATIONS

Table of Contents

1 Introduction

Axis surveillance cards are industrial-grade SD cards that are specially developed for optimal performance in video surveillance. Compared to ordinary, consumer-grade SD cards, you can keep using a surveillance card much longer and it is ideal for continuous storage. Axis surveillance cards are verified towards video surveillance use cases and equipped with Axis health monitoring functions as well as free returns within warranty time/terms.

This white paper summarizes the benefits and typical use cases of Axis surveillance cards. We also provide a technical background to why they are a reliable and cost-efficient choice.

2 Background: SD cards

SD cards (including SD/SDHC/SDXC) are non-volatile flash memory units based on NAND technology and designed to provide high-capacity storage to portable devices. The lifetime of an SD card depends on many factors, including:

- Type of NAND technology (number of guaranteed P/E cycles)

- Storage size of the card

- Recording settings and encoding efficiency of the device

- Write amplification factor

2.1 P/E cycles

SD cards organize data into blocks, and each block is divided into smaller sections called pages. A storage controller handles writing to and reading from the pages, but it can only erase whole blocks at a time. When you first use an SD card, saving data is quick and easy because all the pages are empty.

However, as the card fills up, the controller must shuffle data around and erase whole blocks to make room for new information. This process of writing and erasing data is known as the P/E cycle (program/erase). Each cycle causes slight physical damage to the card's data cells, and over time, this can lead to errors and eventually make a block unusable.

The endurance of an SD card, that is, its lifespan or how many P/E cycles it can handle before it starts to fail depends on the type of memory cells it uses, their size, and how many bits each cell holds. Cards that store more bits per cell generally endure fewer P/E cycles.

Choosing an SD card with a higher storage capacity can help offset the drawbacks of having fewer P/E cycles. This is because with more space, each cycle lasts a longer time, extending the card's life.

2.2 Types of NAND technology

NAND technology is a type of non-volatile memory used in many flash storage devices. It gets its name from the NOT-AND logic gate, a fundamental component in digital electronics.

There are various types of NAND technology used in SD cards, each differing in cost, capacity, and endurance. The differences depend largely on how many bits of information each cell can hold. Common types of NAND technologies include SLC, MLC, TLC, and QLC.

- **SLC** (single-level cell) NAND stores just one bit per cell, either a 0 or a 1. This simplicity allows for quick data writing and retrieval, offering the best performance and the highest endurance of about 100,000 P/E cycles. However, because it stores so little data per cell, it tends to be expensive if you need a lot of storage capacity.

- **MLC** (multi-level cell) NAND can hold 2 bits per cell. This increased capacity makes it possible to offer large storage sizes at more affordable prices compared to SLC. MLC does have a downside of being more prone to data errors and has a lower endurance of about 10,000 P/E cycles.

- **TLC** (triple-level cell) NAND stores 3 bits per cell, boosting storage capacity and reducing costs even more compared to MLC. It is widely used thanks to its balance of cost and capacity, and it has an endurance of about 3,000 P/E cycles.

- **QLC** (quad-level cell) NAND stores 4 bits per cell, pushing the capacity higher. However, packing more bits into each cell makes QLC more susceptible to data errors and it has a lower endurance of about 1,000 P/E cycles.

Each NAND technology offers different trade-offs between cost, capacity, and endurance. The choice of technology depends on which trade-off is the most suitable for your specific storage needs.

2.3 Write amplification factor

Write amplification factor (WAF) is a metric used in computer storage systems to quantify the efficiency of data writes. It represents the ratio between the amount of data written to the storage medium and the amount of data that the host system intended to write.

Ideally, the write amplification factor should be as close to 1 as possible, indicating that the flash unit is writing only the data that the host system requested without any additional overhead. However, in practice, WAF values are typically greater than 1 due to various factors related to the management and optimization of the flash unit, such as garbage collection, wear leveling, and over-provisioning. Because the memory must be erased before it can be rewritten, rewriting of data results in moving data more than once. Due to the way flash works, much larger portions must be erased and rewritten than actually required by the amount of new data. This multiplying effect increases the number of writes required over the life of the flash unit, which shortens the time it can operate reliably.

High write amplification can negatively impact the performance and lifespan of flash units, as it increases the number of write operations and accelerates the wear-out of NAND flash memory cells. Therefore, minimizing write amplification is an important consideration in flash unit design and usage.

3 Axis surveillance cards

Axis surveillance cards are high endurance microSDXC™ cards that are specially developed to match the typical memory-writing behavior of a surveillance camera. They can be written and overwritten many more times than consumer-grade SD cards can. Thus, the same card can remain in the camera for a longer time without wearing out. Axis surveillance cards come with a 5-year warranty, but versions with 256 GB storage and higher have shown to generally last even beyond 10 years or for as long as you typically use the camera.

Axis surveillance cards are industrial-grade cards resilient to the impact of extreme temperatures and environments. The higher purchasing cost of surveillance cards is balanced by the fact that they provide a cost-efficient recording solution with reduced maintenance costs and superior wear resistance and longevity.

3.1 Use cases

3.1.1 Primary storage

With Axis surveillance cards you can use edge storage as your primary storage, recording high-resolution video directly to the card. You reduce the need for additional servers and recorders and lower the total cost of ownership of the surveillance system.

If you need to retain high frame rate video for very long periods of time, for example in case of incident investigation or due to legal requirements, you might need to transfer or offload data to server-based or cloud storage.

3.1.2 Redundant storage

You can use Axis surveillance cards as redundant storage for high-resolution video. Recording redundancy edge storage works as a complement to central storage. It can record video locally whenever the central system is unavailable or continuously record video in parallel with the VMS (video management software).

Edge storage enables failover recording, which means that video can be temporarily stored on the card during network disruptions or system maintenance. When the network connection has been restored and the system returns to normal operation, the central VMS can automatically retrieve missing video clips from the camera and seamlessly merge them with the rest of the video. This way, you get uninterrupted video recordings even if the network connection is down. System reliability is increased, and system operation safeguarded.

3.1.3 Hybrid solution

You can use a hybrid solution where surveillance card storage is used as a complement to storage in cloud or on server. This is especially useful for installations where network bandwidth is limited or absent, such as on trains and buses. Video can be stored on the card when the vehicle is in operation, and then easily be transferred to the central system when the vehicle stops at a depot. Using a hybrid solution can be flexible and low-cost because you are splitting the storage between surveillance cards, servers, and cloud. You could also run analytics in the cloud but store video locally, on the card.

3.1.4 Analytics

Edge storage, enabled by surveillance cards, is particularly beneficial for analytics. Analytics running on the edge work with uncompressed video, and no information is lost in compression or transmission. This makes the analysis results more accurate.

When quick response to analytics findings is crucial, an edge solution is better than traditional on-premises servers or cloud-based solutions. Edge computing reduces the risk of delays found in centralized systems, allowing timely decision-making and action.

Implementing analytics at the edge allows video transmission only when specific events occur, thereby saving bandwidth. This efficient use of bandwidth is especially useful in places where bandwidth is limited or expensive.

Deploying video analytics at the edge also allows sending only anonymized data or alerts over the network. This helps comply with strict privacy regulations and addresses data privacy concern.

3.2 Endurance

Axis surveillance cards are designed to endure years of continuous recording. They are based on TLC and QLC NAND technology. Their low WAF (write amplification factor) keeps the number of completed P/E cycles down.

Depending on the amount of data you record (depending on recording resolution and bitrate) and on the size of its storage, a card can last 5-10 years or more. This means that you can generally use the same card throughout a camera's whole lifetime. The table below shows simulated expectations of approximate card lifetime.

Table 3.1 Lifetime of Axis surveillance cards in Axis cameras depending on recording resolution and bitrate, based on simulations.

Card size	Resolution, bitrate		
	2 MP, 2.5 Mb/s	5 MP, 3.5 Mb/s	8 MP, 4.5 Mb/s
64 GB	~5 years	~4 years	~3 years
128 GB	~10 years	~7 years	~5 years
256 GB	~20 years	~14 years	~11 years
512 GB	~26 years	~19 years	~15 years
1 TB	~53 years	~38 years	~29 years

Real device data based on billions of operating hours confirms the endurance of Axis surveillance cards. The graph shows a cumulative percentile plot of lifetimes based on real data and estimations of user behavior. It shows that the vast majority of Axis surveillance cards are still functioning properly after five years (96.4% of 64 GB cards, 97.9% of 128 GB cards, and 99.8% of 256 GB cards). Around 85–95% of the cards are still functional even after 10 years.
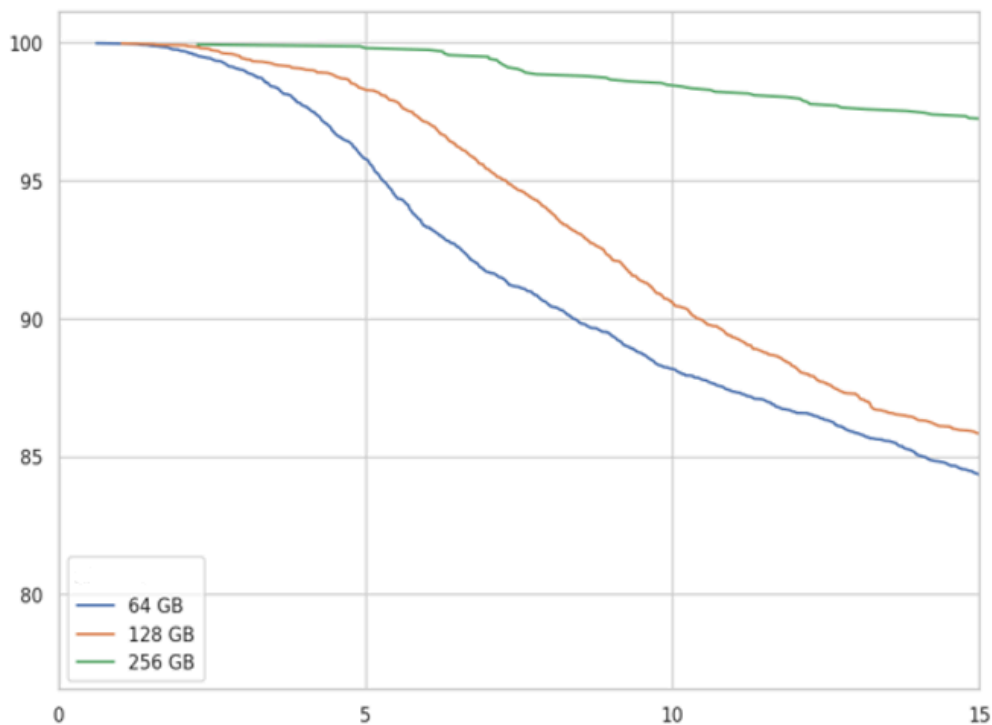
Cumulative percentile plot for surveillance card lifetimes, showing how many percent of cards are still functioning after 0–15 years. Simulation based on real data and estimations.

3.3 Video retention time

The retention time of an SD card is defined as the number of days that the card has stored data before it starts to erase and rewrite data. Some regions require data used for evidence to be stored for between 30 and 180 days, so maximum retention time is an important factor to consider in a recording solution.

Axis surveillance cards offer long maximum retention times even at high frame rates and resolutions, with no compromise on recording quality. The maximum retention time depends on how the camera is configured to record at different frame rates and resolutions, depending on motion detection, alarm events and hours of the day.

For example, the maximum retention time of an Axis surveillance card with 128 GB storage could typically vary from 20 to 215+ days, depending on the camera configurations and resolution required. Even smaller 64 GB cards' maximum retention times can range from 10 to more than 100 days. For larger cards, such as 256 GB and up, maximum retention times will, of course, be much longer.

You can configure the retention time you need in the camera's web interface. If you select, for instance, a retention time of one week, a clean-up operation will remove all recordings older than 7 days. This operation runs once every 60 minutes. There is also an automatic clean-up operation that runs continuously to check that the card has enough space for recording.

3.4 Health monitoring

Axis surveillance cards come with health monitoring, which is a data-driven service that keeps track of the wear and tear of the card. Thanks to this sophisticated data monitoring based on card usage, you can be notified months in advance if you need to replace the card.

3.5 File system for reduced risk of data loss

Axis recommends you use the file system ext4 for surveillance cards. This is a journaling file system, which employs a journal — a specific type of data structure — to record changes as they happen. Should there be a system crash or power outage, this kind of file system can be restored more swiftly and is less prone to corruption, thereby reducing the risk of losing data. This feature can be especially important in environments where power sometimes goes down, for example for devices installed on buses or trains, but also devices in regions with unreliable power supply.

3.6 Encryption

Safeguarding stored data from unauthorized access is crucial for maintaining data security and protecting sensitive information. Axis cameras offer an encryption feature that you can enable for the surveillance card within the device. When you have applied encryption, unauthorized individuals who remove the surveillance card cannot access the data.

The encryption feature supports the following encryptions:

- AES-CBC 128-bit for all devices with AXIS OS 5.80.1 or later

- AES-CBC 256-bit for all devices with AXIS OS 8.40.1 or later

- AES-XTS-Plain64 (AES-XTS-512 256-bit) for newer devices with AXIS OS 8.30.1

3.7 Warranty

SD cards sometimes come with warranty that does not cover surveillance use cases. Axis surveillance cards, however, are custom-made for surveillance and verified against surveillance use cases. They come with 5-year warranty and free support, repair, and replacement (RMA) for defective units during that period.

About Axis Communications

Axis enables a smarter and safer world by creating solutions for improving security and business performance. As a network technology company and industry leader, Axis offers solutions in video surveillance, access control, intercom, and audio systems. They are enhanced by intelligent analytics applications and supported by high-quality training.

Axis has around 4,000 dedicated employees in over 50 countries and collaborates with technology and system integration partners worldwide to deliver customer solutions. Axis was founded in 1984, and the headquarters are in Lund, Sweden

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