

Axis' Zipstream technology

- More video, less storage

2015 - Introduced to the market

2016 - Enhanced with PTZ camera functionality

2016 - Enhanced with dynamic frame rate



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1. Introduction

Most networked video surveillance systems today are limited by the amount of video that can be stored for later use. Camera technologies such as sensors, optics and embedded image processing have evolved rapidly over the last 10 years, resulting in video with higher resolution, frame rate and dynamic range, capturing more details of a scene. The development has improved the quality of video evidence and forensic analysis such as face identification, but only when it is possible to retrieve the video from the right place, at the right time and with the right quality. A high quality video source is of no value if storage was limited and the system was configured to remove valuable information before it was needed.

There are various methods to limit storage requirements by reducing the video bitrate, such as limiting the storage retention time, saving video in a lower resolution, constantly reducing the frame rate and increasing compression. In all these methods, information about something critical might be missing when really needed.

Optimized for video surveillance, Axis' Zipstream technology is a radically more efficient H.264 implementation, lowering bandwidth and storage requirements by an average 50% or more. Axis' Zipstream technology adds a module inside the video compression engine of the network camera that ensures that important details in the image get enough attention in the video stream while unnecessary data can be removed. Axis' Zipstream technology cuts the storage requirement without costly and complicated integration. It is provided free of charge in the latest Axis network cameras, including pan/tilt/zoom (PTZ) cameras.

See Section 3.6, for more information on PTZ cameras.

Zipstream also contains the dynamic Frames Per Second (FPS) algorithm that is especially useful in use cases where there is an extra demand for storage reduction.

2. Background

Before video from surveillance cameras can be efficiently stored on any media it has to be processed to fit into the allowed space. To fit video with high resolution and full frame rate onto SD^{TM1} cards, which are the most popular and cost-efficient media for embedded applications, the original information has to be encoded. This is done using video compression algorithms that encode video data by reducing and removing redundant information.

See Section 7. 'Useful links', 'Video compression', for more information on video compression.

2.1 Video compression algorithms

Video compression algorithms are used to find regions in the video that already have been transferred and do not need to be sent again in the next image frame. Another task for the algorithm is to identify where in the video details can be removed without reducing the visual quality.

State-of-the-art video compression methods that function well together are grouped into an international standard, which is a video stream syntax created for storing, sharing and viewing video. Today, the most used video compression standard is called H.264, which is a method that is efficient enough to reduce several days of surveillance video onto one single SD card.

The solution used to compress video according to H.264 is not part of the standard, only the syntax and the method to perform playback is standardized. This enables improved H.264 encoding solutions to be created while keeping the file format for interoperability (decoder compatibility).

Axis' Zipstream technology is a more effective implementation of an H.264 video encoder for surveillance applications. It includes various surveillance-unique methods that enable networked cameras to produce video with significantly lower bitrate.

3. How does Axis' Zipstream technology work?

Axis' Zipstream technology is a collection of algorithms in the camera that analyzes the video stream in real-time. Interesting details and motion are preserved with the given video quality while the Axis-unique module can filter other areas harder to optimally use the available bandwidth.

Axis' Zipstream technology is not in any way a replacement for High Efficiency Video Coding (HEVC)/ITU Telecommunication Standardization Sector (ITU-T) H.265, which was jointly developed by ISO/IEC Moving Picture Experts Group (MPEG) and ITU-T Video Coding Experts Group (VCEG). Zipstream is a video coder enhancement, which can be applied on many video compression standards with minor adaptations.

3.1 Configuration options

Axis' Zipstream technology adapts the compressed video stream based on four factors:

- > Scene motion
- > Scene content
- > Ambient light level
- > Configuration options

Configuration options that affect Zipstream:

- > Compression parameter
- > Group of Pictures (GOP) length
- > Frame rate
- > Strength parameter
- > Dynamic GOP parameter
- > Dynamic GOP limitation parameter
- > Dynamic FPS parameter

The effort level for Zipstream is defined by the strength parameter, as follows:

Strength parameter	Effort level	Explanation
Off	Off	Disabled
10	Low	No visible effect in most scenes
20	Medium	Visible effect in some scenes: less noise, and slightly lower level of detail in regions of lower interest
30	High	Visible effect in many scenes: less noise, and lower level of detail in regions of lower interest
40	Higher	Visible effect in even more scenes: less noise, and lower level of detail in regions of lower interest
50	Extreme	Visible effect in most scenes: less noise, and lower level of detail in regions of lower interest

All strength parameter settings are compatible with all existing software applications, while still reducing the bitrate.

Dynamic GOP parameter:

Dynamic GOP parameter	Explanation
Off	Dynamic GOP adjustments, disabled
On	Dynamic GOP adjustments, enabled

Dynamic GOP limitation parameter:

Dynamic GOP limitation parameter	Explanation
Actual value	Maximum allowed dynamic GOP length

Dynamic FPS parameter:

Dynamic FPS parameter	Explanation
Off	Dynamic frame rate adjustments, disabled
On	Dynamic frame rate adjustments, enabled

By default, networked cameras supporting Axis' Zipstream technology are configured with the strength parameter set to 10 and dynamic GOP/FPS disabled. The default setting is compatible with all existing applications, while still reducing the bitrate.

3.2 Bitrate reduction

The bitrate reduction can be derived from either the dynamic Region of Interest (ROI) of Zipstream or its dynamic GOP or dynamic FPS.

Dynamic ROI

The dynamic ROI optimizes bandwidth in real-time by analyzing where available bits will give the maximum benefit from a forensic perspective. This process is performed for all image content, resulting in a totally flexible dynamic ROI. This dynamic ROI automatically expand, shrink, change shape, split, merge, disappear and reappear depending on content, for the benefit of tuning the instant bandwidth.

Since it is unknown in which parts of the image relevant information may appear, Zipstream prepares the system for unexpected events. This dynamic automatic ROI is much more convenient than other traditional ROI implementations where the region is set manually.

Dynamic GOP

The dynamic GOP reduces the bitrate by avoiding storage consuming I-frame updates. Typical surveillance scenes with limited motion can be compressed to an extremely small size without any loss of detail. This algorithm makes a real-time adaption of the GOP length on the compressed video according to the amount of motion. All clients or Video Management System (VMS) solutions may not support smooth playback of video with this algorithm enabled even though the compressed video stream conforms to the H.264 standard.

Dynamic FPS

The dynamic FPS reduces the bitrate by avoiding unnecessary encoding of video frames. This is done by omitting them from the stream. A static surveillance scene will be encoded with radically reduced frame rate even though the camera is capturing and analyzing video at full frame rate. Since scene motion is used as a control variable, a small moving object far away may not render at full frame rate. Objects approaching the camera increase the frame rate to capture every important detail. The number of delivered frames per second is restricted automatically by the camera, which will save a substantial amount of data in many scenes.

Some VMS solutions may not support smooth playback of video with dynamic frame rate even though the compressed video stream conforms to the H.264 standard. Legal requirements may prevent the use of dynamic frame rate in some cases.

3.3 Expected reduction rates

Axis' Zipstream technology reduces the average bitrate by using real-time scene information. One method to estimate total savings is to look at the bitrate savings from each method independently and combine the reduction factors.

Zipstream method	Bitrate reduction	Influenced by
Dynamic ROI	10-50%	Zipstream strength parameter, scene motion and content
Dynamic GOP	0-50%	Scene motion
Dynamic FPS	0-50%	Scene motion

The example in Figure 1 plots the instant bitrate from a video with four different motion scenarios A, B, C and D, with two different Zipstream configurations compared when Zipstream is disabled. All streams are Variable Bitrate (VBR) streams with GOP length=32. Each I-frame update is clearly visible as bitrate spikes and the instant bitrate can be read on the vertical axes.

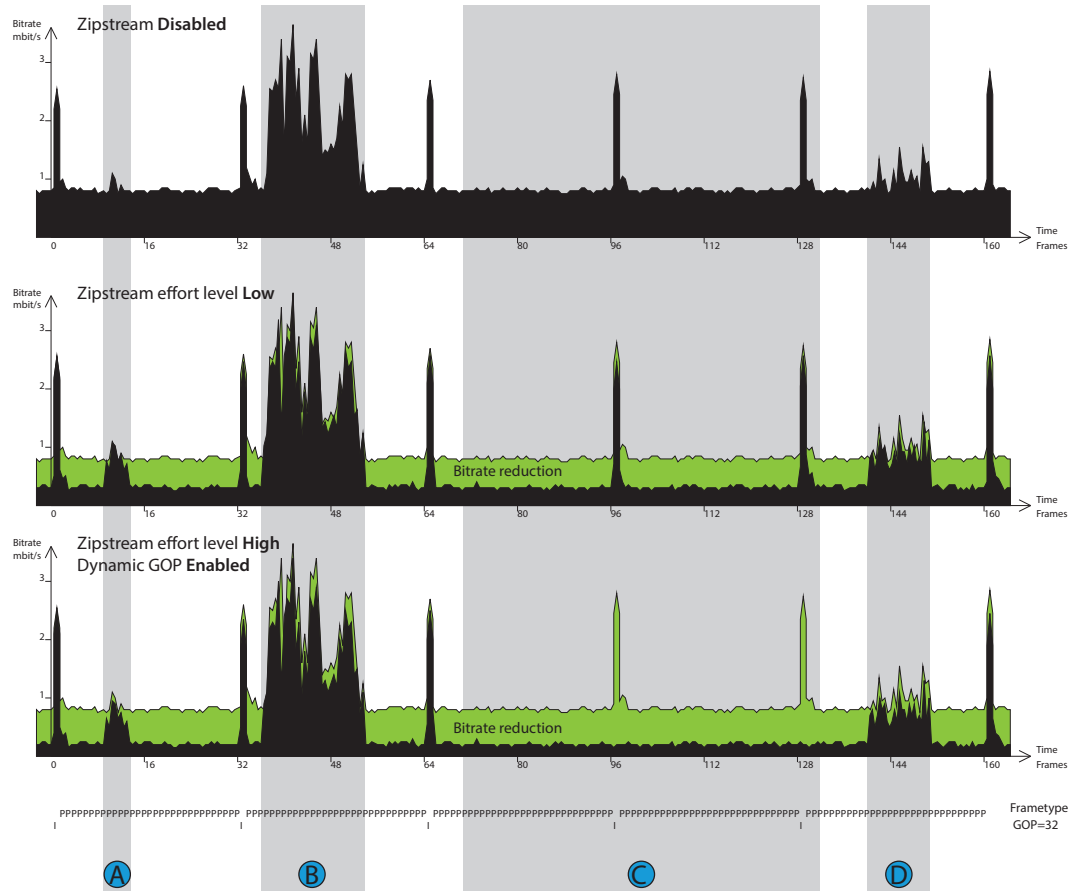


Figure 1: Illustration of instant bitrate in four different scenarios.

This example has been created to highlight the behavior of Axis' Zipstream technology under different conditions:

- A. Time period with short small motion. The small motion is detected, and adding bits in that region can preserve the quality of the moving part of the video.
- B. Period with large longer motion needs more space but still it is possible to save storage during this motion, since the dynamic ROI detects areas where non-prioritized information can be removed.
- C. Periods without motion are detected and the dynamic GOP algorithm removes unnecessary I-frame updates.
- D. Period with small longer motion.

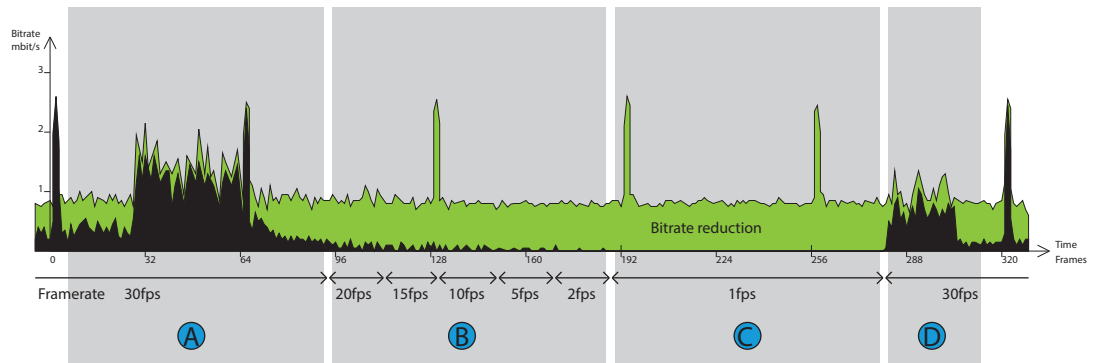


Figure 2: Illustration of instant bitrate and dynamic frame rate for dynamic FPS.

This example has been created to highlight the behavior of Axis' Zipstream technology under different conditions when dynamic FPS is enabled.

- A. The camera produces data at 30 fps because there is motion in the scene.
- B. When the motion decreases, the frame rate drops substantially. The bitrate decreases when the frame rate is reduced since less data is transferred.
- C. During a period without any motion in a completely static scene, the frame rate decreases to almost zero between I-frames. Sparse, spread I-frame updates is the only bitrate source.
- D. The camera immediately returns to 30 fps when motion is detected.

3.4 Parameter settings

The original compression parameter is still used when Axis' Zipstream technology is enabled. This parameter controls the amount of compression applied to important forensic details. Compression is usually set to 30 and this value is recommended also when Zipstream is enabled.

The bitrate controller built into the encoder can be combined with Zipstream to enforce a Maximum Bitrate (MBR) limit. MBR is a VBR configuration that includes an upper limit to protect the system from temporary bandwidth spikes. However, the MBR limit must be sufficient to capture the details of moving objects in the scene to enable the full potential of Axis' Zipstream technology and VBR.

To limit the bitrate for increased storage time, cloud-connected cameras or cameras using edge storage should be configured with the strength parameter set to 30 (effort level High) and dynamic GOP enabled. This setting is suitable to combine with motion detection triggering and/or MBR systems where the bitrate is allowed to adapt to changes in complexity. Edge storage is a development in Axis network cameras and video encoders that enables video recording directly to an onboard SD card or a Network-attached Storage device (NAS).

See Section 7. 'Useful links', 'Edge storage', for more information on edge storage.

The dynamic GOP and the dynamic FPS algorithms of Zipstream can be used to compress low motion scenes. When using dynamic GOP, the GOP length will vary, which might pose a problem for some VMS and other types of client software. When using dynamic FPS, the frame rate will also vary, affecting some VMS and client software. To improve support in existing software solutions that do not optimally implement playback of H.264 video with dynamic GOP, either a shorter maximum GOP length could be selected or dynamic GOP could be disabled. Dynamic GOP and dynamic FPS can be combined and used simultaneously for an even greater bitrate reduction.

3.5 Comparison measurements

Figure 3 shows examples of surveillance scenes where Axis' Zipstream technology can reduce storage needs. The table shows the Zipstream strength value and whether dynamic GOP was enabled, as well as the total bitrate reduction.

	Retail: Well-lit indoor detailed scene, sparse medium-sized movements.		
Zipstream strength: Low	Dynamic GOP: Off	Total bitrate reduction: 25%	
	City surveillance: Daytime overview, many small car movements most of the time.		
Zipstream strength: High	Dynamic GOP: On	Total bitrate reduction: 50%	
	Constant recording: Nighttime overview, very noisy scene with sparse small and fast car movements.		
Zipstream strength: High	Dynamic GOP: On	Total bitrate reduction: 90%	
	City surveillance: Continuous surveillance of scenes with limited motion.		
Zipstream strength: Extreme	Dynamic GOP: On Dynamic FPS: On	Total bitrate reduction: 73%	
	Constant recording: Nighttime constant recording of scenes without motion or with very small and sparse motion.		
Zipstream strength: Extreme	Dynamic GOP: On Dynamic FPS: On	Total bitrate reduction: 99.7%	

Figure 3: Examples of surveillance scenes where Zipstream can reduce storage needs.²

3.6 Zipstream for PTZ cameras

Axis' Zipstream technology also reduces bandwidth and storage for PTZ cameras. While a PTZ camera is not moving or zooming, Zipstream processes the video exactly as it would process video from any other Axis' network camera, that is, with the same bitrate reduction results as described earlier in this document.

The algorithm for PTZ cameras enables Zipstream to reduce bitrate even when the camera is panning, tilting, or zooming. The algorithm reduces bitrate in real-time by automatically updating the dynamic ROI that is used to preserve important image details. To further improve PTZ usability and reducing system requirement, a dynamic bitrate controller has been added to reduce the bitrate peaks caused by the PTZ camera moving.

Zipstream for PTZ cameras has been optimized to drastically reduce bandwidth peaks when the camera is moving. It does this by reducing the general video quality while still preserving reference points used by the operator for navigation. During fast camera movements, it is important that the operator does not miss tracking important objects and lose orientation.

3.6.1 Enhanced dynamic ROI

Dynamic ROI, one of the core algorithms of Zipstream, compensates for both scene motion and camera motion simultaneously. This algorithm reduces bitrate with the same method while the camera is panning, tilting, or zooming. During camera movements, some areas of the video are identified as more important and prioritized, while other areas are compressed more to reduce bandwidth usage. This part of the algorithm reduces the average bandwidth and storage, while still keeping forensic details.

3.6.2 Dynamic bitrate controller

Even with the enhanced dynamic ROI enabled, a panning, tilting and/or zooming camera require more bandwidth than a fixed camera. This extra bandwidth is required since a lot of new information is captured at a very high rate during quick repositioning of the camera. A dynamic bitrate controller automatically adjusts the video quality and reduces bandwidth peaks triggered by camera-motion, allowing the user to use less expensive network equipment and transmission channels.

When the PTZ camera moves, motion blur occurs. Since the video quality is reduced anyway because of motion blur, the algorithm is designed on purpose to ignore video information by reducing the bitrate when the camera is moving. Avoiding bandwidth peaks is typically more important than avoiding artifacts in the video during fast PTZ movements. This means that the generated video bitrate does not increase uncontrollably, while the camera still preserves good operator awareness. A PTZ camera typically performs panning, tilting, and zooming within a fraction of a second. As soon as the camera stops again, the bitrate controller immediately restores the bitrate to deliver optimal video quality.

3.6.3 Reduced bandwidth peaks

The dynamic bitrate controller eases requirements on the entire system, such as transmission equipment (switches and routers), storage (recording servers and disk size), and viewing devices (computers and decoders). This means that remote PTZ cameras can be operated using a less complex transmission channel, while still preserving their benefits and flexibility.

The example in Figure 4 plots the instant bitrate from a video with four different motion scenarios A, B, C and D, with a configuration with Zipstream for PTZ enabled compared to when Zipstream is disabled. All streams are VBR streams with GOP length=32. The instant bitrate can be read on the vertical axes.

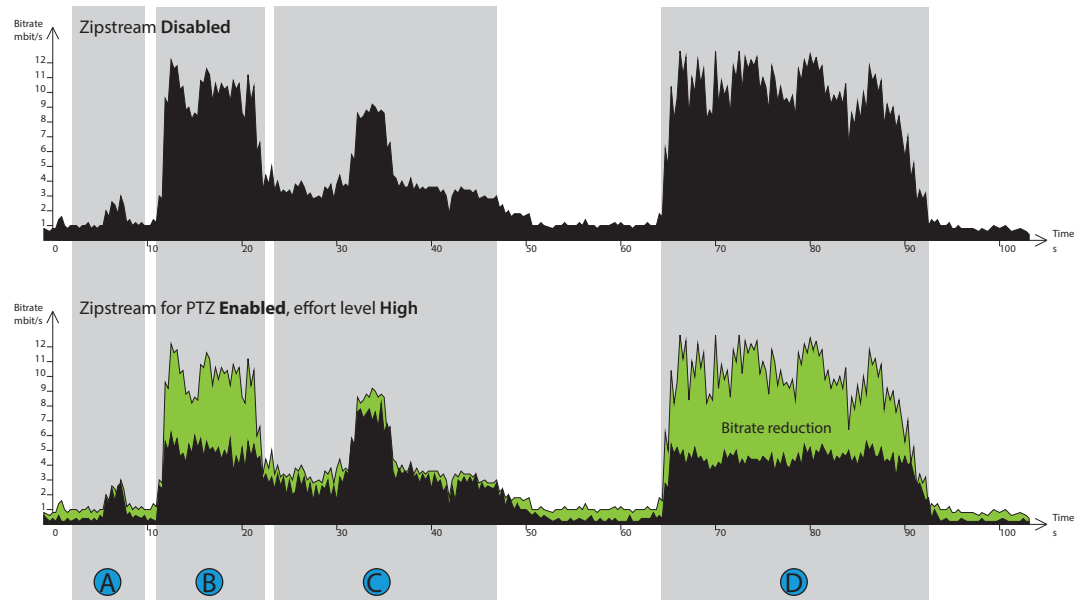


Figure 4: Illustration of instant savings in a PTZ scenario.

- A. Initially, the PTZ camera is motionless in its overview position. The standard Zipstream algorithm is saving considerable amounts of storage since the camera is completely still. Suddenly the PTZ camera captures a small suspect motion.
- B. The operator pans and zooms the PTZ camera to get higher resolution footage of the event. During fast motion, the dynamic bitrate controller achieves a substantial bitrate reduction.
- C. The PTZ camera is recording the event in high quality video. The standard Zipstream algorithm automatically saves bitrate in non-prioritized areas of the image.
- D. After the event, the operator pans and tilts to view a larger area to search for similar events. The video quality is automatically adjusted to match PTZ movements.

4. Application areas

In professional VMS systems, bitrate reduction is desirable while the image quality must be kept for operations on critical sites around the world. These systems must detect even the smallest threat, and enable advanced forensic work after any incident. Axis' Zipstream technology enables high security systems to use continuous recordings due to the low bitrate used for static scenes.

When using AXIS Camera Companion an even lower bitrate is desired, since system cost and easy installation is a priority. The aim is to store video of sufficient quality on cost-efficient edge storage. However, video quality should be decreased in a controlled manner, in order to easily find and understand the course of events. Zipstream reduces the amount of missed triggers by allowing longer recording segments for each motion-triggered event without generating excessive data.

Axis Zipstream technology is relevant for all users that wish to reduce the cost of storage or network load. In any video surveillance system, reducing storage needs directly results in lower total cost independent of system size or storage solution. With Zipstream, less storage is needed per recorded minute. This enables increased retention time, resolution, or number of cameras without increased storage space.

4.1 Forensic details

Axis recommends using networked video with VBR where quality is adaptive to scene content in real-time. Using Constant Bitrate (CBR) as a storage reduction strategy is not recommended, since cameras delivering CBR video may have to discard important forensic details in critical situations due to the bitrate limit.

Axis' Zipstream technology makes it possible for the system installer to continue using VBR for optimum video quality while reducing the storage requirements. This way the surveillance system can keep delivering high quality video. Important forensic details such as faces, tattoos and clothing patterns are isolated and preserved, while irrelevant parts such as white walls, lawns and vegetation are smoothed out.

If a storage solution or the network requires an absolute upper bandwidth limit, Zipstream is compatible with MBR, a method which protects the system from temporary bandwidth spikes.

5. Conclusion

Optimized for video surveillance, Axis' Zipstream technology is a radically more efficient H.264 implementation, lowering bandwidth and storage requirements by an average 50% or more for many common 24/7 surveillance use cases.

Axis' Zipstream technology makes it possible to use higher resolution and increase forensic detail, while reducing storage cost and enabling longer recordings.

Zipstream is available for H.264-based products but there is nothing in the technology that prevents the solution from migrating to H.265 encoders when that is technically possible.

6. Acronyms and abbreviations

CBR	Constant Bitrate
FPS	Frames Per Second
GOP	Group of Pictures
HEVC	High Efficiency Video Coding
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
MBR	Maximum Bitrate
MPEG	Moving Picture Experts Group
NAS	Network-attached Storage
PTZ	Pan/Tilt/Zoom
ROI	Region of Interest
SD	Secure Digital
VBR	Variable Bitrate
VCEG	Video Coding Experts Group or Visual Coding Experts Group
VMS	Video Management System

7. Useful links

For more information, see the following links:

Axis Communications – 'Axis' Zipstream technology': www.axis.com/technologies/zipstream

Axis Communications – 'Video compression': www.axis.com/products/video/about_networkvideo/compression.htm

Axis Communications – 'Edge storage': www.axis.com/products/video/about_networkvideo/edge_storage/

Axis Communications – 'PTZ Cameras': www.axis.com/products/ptz-cameras

About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to customers through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 2,100 dedicated employees in more than 50 countries around the world, supported by a global network of over 80,000 partners. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ Stockholm under the ticker AXIS.

For more information about Axis, please visit our website www.axis.com.