

# Planning of Video Surveillance for Electrical Substations

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## EXAMENSARBETE

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### Abstrakt

Detta examensarbete är gjort till Vasa Elnät och handlar om kameraövervakning till deras elstationer. I detta projekt behandlas främst två stycken så kallade pilotstationer för att se hur bra kameraövervakningen fungerar. Tanken var att om kameraövervakningen fungerar bra, skall även de andra elstationerna få kameraövervakning. Syftet med detta arbete är att förbättra säkerheten vid elstationerna samt att förhoppningsvis undvika vandalism med hjälp av kameraövervakning.

I arbetet undersöks analoga och digitala system samt deras fördelar och nackdelar. Utmaningar som kommit emot i arbetet är i huvudsak den begränsade fiberbandbredden till elstationerna. Även lagar om kameraövervakning samt registerbeskrivning har blivit undersökta och adapterade till detta projekt.

Vid pilotstationerna installerades två stycken kameror samt lagringsutrymme för inspelade händelser. Resultatet blev ett fullt fungerande system samt ett delvis fungerande system. Det delvis fungerande systemet saknade endast förbindelse till kontrollrummet.

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Språk: engelska

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**Abstract**

This thesis was done for Vasa Elnät. The thesis is about camera surveillance for their electrical substations. This thesis is focusing on the two first pilot substations to see how well the camera surveillance system works. If the system is working fine, the surveillance system will be installed on all Vasa Elnät's substations. The idea with the camera surveillance is to increase the safety and hopefully keep vandalism away from the station.

In the thesis, analog and digital systems are investigated as well as their advantages and disadvantages. A challenge with the project was the limited bandwidth from the control room to the substations. The laws regarding camera surveillance and registration descriptions have been applied to this project.

At the pilot substations, two cameras were installed as well as a video recorder to store the events. The work resulted in a fully functioning system as well as a partially functioning system. The partially functioning system only lacked the connection to the control room.

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Language: English

Key words: Video surveillance, Electrical substation

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# **1 Introduction**

This thesis is made for Vasa Elnät during autumn 2017 and spring 2018. The thesis is about a camera surveillance system for substations. The surveillance system will monitor Vasa Elnät's electrical substations. The surveillance system will improve the safety as well as hopefully keep intruders away from the substation area.

The camera surveillance system will include a couple of IP cameras as well as a NVR, network video recorder, which will contain the events that have been recorded. The stored events and live streams will be accessible for the employees at Vasa Elnät's who are handling the surveillance system. This system will improve the monitoring and safety at the substations.

## **1.1 Vasa Elektriska**

This thesis is made for one of Vasa Elektriska's subsidiaries, Vasa Elnät, at the measurement department. Vasa Elektriska Ab was founded 1892 and it is owned by the city of Vasa with a majority of 99,9%. Vasa Elektriska is a parent company with three subsidiaries. Vasa Elnät Ab, Oy Ravera Ab and VS Vindkraft Ab. The whole group of companies have about 170 employees, with a turnover of 141 million euros in 2016. The company group does also have a district heating network with a total length of 238 kilometer as well as about 3200 customers using it. [9]

## **1.2 Vasa Elnät**

Vasa Elnät have the liability of transferring and distributing electricity as well as providing related services to their customers. The electrical grid has a length of about 6830 kilometers and a distribution area of about 3400 square meters. Vasa Elnät have about 30 employees and 71000 customers, mainly located in Vasa, Korsholm, Laihela, Malax, Korsnäs, Vörå and Närpes. [10]

## **1.3 Ravera**

Ravera was founded in 2006. It is a company specialized in building, repairing power grids, road and street lighting networks and other cable networks. The construction may include planning, building, material delivery and necessary excavation work. Ravera have about 60 employees. [8]

## **1.4 VS Vindkraft**

VS Vindkraft is Finland's first windmill park. The park was built in 1991 and is located in Korsnäs. The park is producing about 1300 MWh each year. The park is now out of service and is about to be torn down/deconstructed during 2017-2018. [11]

## 2 Purpose and challenges

The purpose of this thesis is to improve Vasa Elnät's surveillance at their substations. As it is now, employees have to inform Vasa Elnät when they are entering or leaving the substation area. This system works quite well, but there have also been times when people have forgot to inform when they have arrived or left. This is a problem, since this may cause suspicion of accidents when workers are entering the substation but are never leaving.

With camera surveillance, it is possible to see if anyone is at the substations area. Another benefit with the surveillance is that it may also help to keep intruders away. There have been persons painting graffiti on some of the substations. This might stop when the intruders see the camera surveillance equipment. A camera inside the substation may also be useful for safety when an employer is working inside the station.

The main challenge in this thesis is the bandwidth between the stations and the server at Vasa Elnät. The bandwidth is limited to 4 Mbit/s of which 1 Mbit/s is reserved. This may affect the data traffic between the station and the server.

### 2.1 Bandwidth

The bandwidth between the server and the substations is now limited to 4 Mbit/s. This will lead to issues when sending data from the station to the server, since the bandwidth is limited. Below is a calculation of how much bandwidth a single camera needs. The settings of the camera are given in the calculation.

The camera is shooting 20 frames per second, having a resolution of 1920 x 1080P with 24 bits of color depth. The compression factor is a reference from a calculator found at stardot.com. This creates an average frame size of about 50 kB. This will give us the following calculation. The division of 8 is used for getting the bits to byte and 1024 to get byte to kilobyte. [21]

$$\left( \frac{\text{width pixels} * \text{height pixels} * \text{color depth}}{8 * 1024} \right) / \text{compression factor} = \text{kB per frame}$$

$$\left( \frac{1920 * 1080 * 24}{8 * 1024} \right) / 120 = 50,6 \text{ kB}$$

How much data per second.

$$50,6kB * 20 fps = 1012 kB/s$$

To get kilobytes to bytes a multiplication with  $2^{10}$  or 1024 is preformed:

$$\frac{1012 kB}{s} * 2^{10} = 1036288 Bytes/s$$

To get bytes into bits, multiply with 8 since in a single byte is 8 bits.

$$1036288 Bytes/s * 8 = 8290304 bits/s$$

To convert it into Mbit/s, divide it with  $2^{20}$  or 1048576:

$$\frac{8290304 bit/s}{2^{20}} = 7,9 Mbit/s$$

For sending the recording live to the server from a single camera the bandwidth speed from the station to the server would have to be a minimum of 7,9 Mbit/s. This is not the case since the connection to the station is limited to 4 Mbit/s, of which 1 Mbit/s is reserved for other software.

A simple solution for this would be to increase the bandwidth making it possible sending and receiving data fast enough.

$$2 * 7,9 \frac{Mbit}{s} + 1 \frac{Mbit}{s} = 16,8 Mbit/s$$

Another solution would be using cameras and software supporting dual streaming. Dual streaming means that it is possible to set up a main stream and a sub stream. The main stream can be configured to use higher resolution, frames per second, as well as only start recording when motion is detected, making it more suitable for capturing higher quality recordings on the NVR.

Meanwhile the sub stream is configured to use lower resolution and not to record events to the NVR at all. Making it more suitable for live view. The lower quality makes the data transferred to the monitoring device smaller, allowing a smaller bandwidth. See the example below.

The sub stream is configured to have the following settings: 15 frames per second, resolution 640 x 480P with 24 bits of color depth. This creates an average frame size of about 7,5 kB. This will give us the following calculation. The division of 8 is used for getting the bits to byte and 1024 to get byte to kilobyte.

$$\left( \frac{\text{width pixels} * \text{height pixels} * \text{color depth}}{8 * 1024} \right) / \text{compression factor} = \text{kB per frame}$$

$$\left( \frac{640 * 480 * 24}{8 * 1024} \right) / 120 = 7,5 \text{ kB}$$

Data per second:

$$7,5 \text{ kB} * 15 \text{ fps} = 112,5 \text{ kB/s}$$

To get kilobytes to bytes a multiplication with  $2^{10}$  or 1024 is performed:

$$\frac{112,5 \text{ kB}}{s} * 2^{10} = 115200 \text{ Bytes/s}$$

To get it into bits multiply with 8 since in a single byte there are 8 bits.

$$115200 \text{ Bytes/s} * 8 = 921600 \text{ bits/s}$$

To convert it into Mbit/s, divide it with  $2^{20}$  or 1048576:

$$\frac{921600 \text{ bit/s}}{2^{20}} = 0,88 \text{ Mbit/s}$$

This will generate a total required bandwidth of:

$$0,88 \frac{\text{Mbit}}{s} * 2 + 1 \frac{\text{Mbit}}{s} = 2,76 \text{ Mbit/s}$$

This makes it possible to use the limited 4 Mbit/s of which 1 Mbit/s is reserved and still have the possibility to add a camera in the future.

## 3 Theory

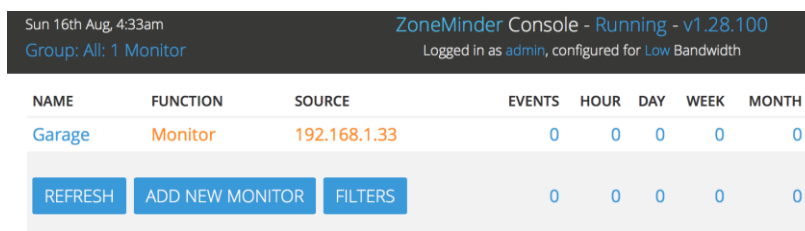
This chapter contains all the theory about the thesis. A couple of surveillance programs will be presented as well as analog and digital surveillance systems. The chapter also describes how the Finnish laws are applied to the thesis.

### 3.1 Surveillance programs

Here are some of the surveillance systems that were investigated during this thesis. There are many different software with own interfaces that offer different user experiences as well as advantages and disadvantages.

#### 3.1.1 ZoneMinder

ZoneMinder is a free open source surveillance software for Linux distributions. It supports several different cameras and does not have a maximum amount of cameras setup. The program is quite CPU friendly and needs much resources. There are many ways to configure the recording software and it have all the basic modes such as record on motion and email alarm. ZoneMinder also have a big community and forum where it is possible to search for guidance and submit questions about ZoneMinder. However, it may need some terminal experience and certain cameras to work properly. [26]

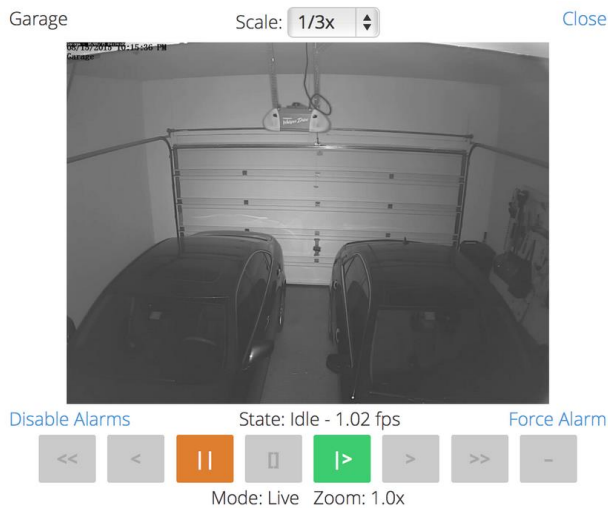


The screenshot shows the ZoneMinder Console interface. At the top, it displays the date and time (Sun 16th Aug, 4:33am) and the system status (ZoneMinder Console - Running - v1.28.100). Below this, it shows the user is logged in as 'admin' and configured for 'Low Bandwidth'. The main part of the interface is a table with columns: NAME, FUNCTION, SOURCE, EVENTS, HOUR, DAY, WEEK, and MONTH. There is one monitor listed: 'Garage' with function 'Monitor' and source '192.168.1.33'. All event counts are 0. At the bottom, there are buttons for 'REFRESH', 'ADD NEW MONITOR', and 'FILTERS'.

NAME	FUNCTION	SOURCE	EVENTS	HOUR	DAY	WEEK	MONTH
Garage	Monitor	192.168.1.33	0	0	0	0	0

Below the table, there are buttons: REFRESH, ADD NEW MONITOR, and FILTERS. The counts for EVENTS, HOUR, DAY, WEEK, and MONTH are all 0.

Figure 1: ZoneMinder's user interface



**Figure 2: ZoneMinder's monitor view**

### 3.1.2 Blue Iris

Blue Iris is a camera surveillance software for Windows. The software requires a yearly bought license. There are two versions of the license a LE version and a full version. The LE version supports a single camera and costs about \$30. The full version supports up to 64 cameras and costs about \$60. It supports several different cameras and the software have all the basics modes and settings, such as dual streaming and record on motion detection. The program is easy to install and quite user-friendly. It is possible to have unique configurations for each camera. When trying out the free trial version it used about 14 % CPU in standby with a single camera configured to use motion detection. When the camera noticed movements, the CPU usage increased to about 26%. When two cameras where configured with motion detection the CPU in standby was 16,5 %. When both cameras were recording at the same time, the CPU usage increased to about 34,5 %. [5]



**Figure 3: Blue Iris user interface**

### 3.1.3 TruVision Navigator

TruVision Navigator is a surveillance software for windows platforms made by Interlogix. Interlogix is a surveillance company, which manufactures surveillance equipment such as cameras, NVR's and their surveillance software Navigator. Navigator is a free program to handle your camera recordings and live views. The software is easy to install and have a quite user-friendly interface. It supports several different cameras and the software have all the basics modes and settings, such as dual streaming and record on motion detection. There is also an application for android and IOS making it easy to monitor your cameras and recordings with a phone or tablet. [22]



**Figure 4: Truvision Navigator user interface**

## 3.2 Analog and digital systems

This chapter describes the analog and digital surveillance system. What is different between the two systems as well as what are their advantages and disadvantages. In the end of this chapter there is a comparison between the systems.

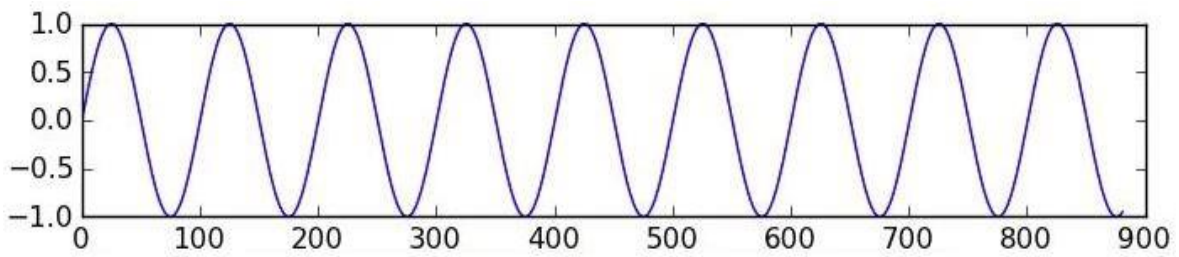
### 3.2.1 Analog systems

#### Analog cameras

Analog cameras have been around for a long time and have been used in surveillance systems. Analog cameras are more sensitive to noise and interference. This is affecting the video quality of the camera. The analog camera is connected with a power adapter and a coaxial cable to transfer the data to a DVR, digital video recorder. In the DVR the analog signal from the camera is converted to digital data and the recordings are stored on the DVR's hard drive. [1], [7]

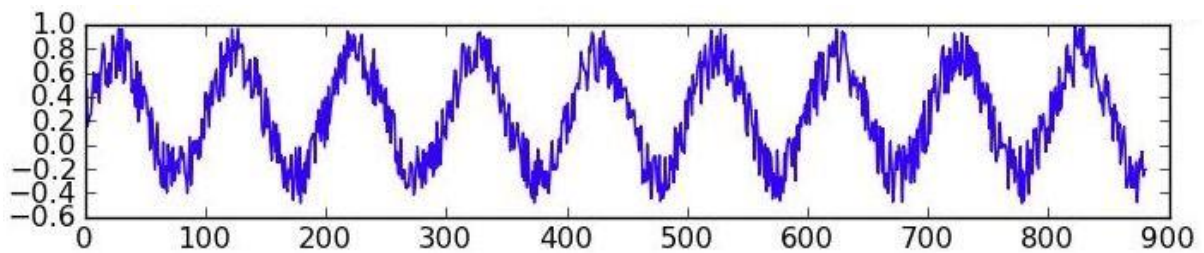
#### Analog signal quality

The signal in an analog system looks like a sine wave. The wave can have several different values depending on the time. Below is an example of an analog signal wave.



**Figure 5: Analog signal, with no noise.**

When the signal is sent from the camera to the DVR some noise will affect the wave. Noise may appear from poor wiring, electrical interference or other devices. This might lower the amplitude and make the signal more irregular than the original signal. The figure below shows the same analog signal with noise. The signal wave will have decreased quality compared to the original signal in Figure 5.

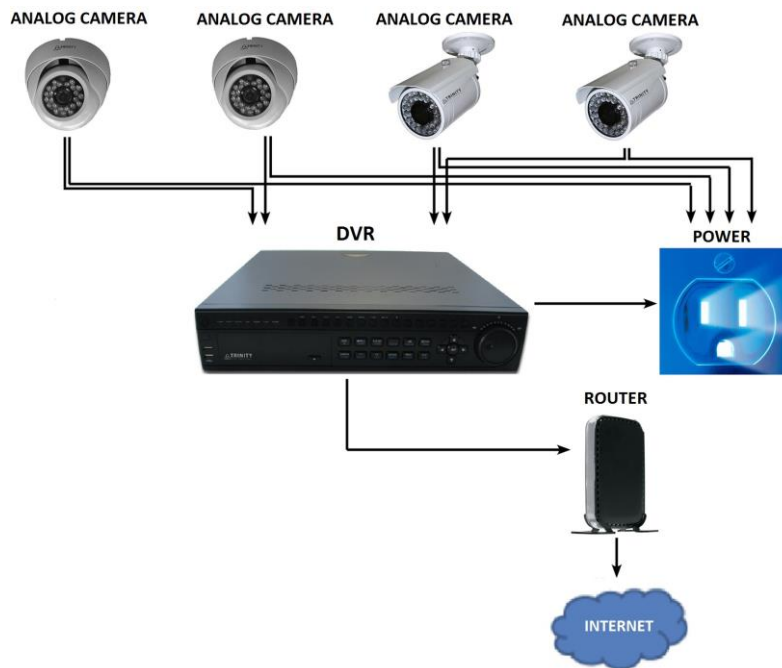


**Figure 6: Analog signal, with noise.**

The noise may make the video look blurry, as well as decrease the audio quality. This is one of the main disadvantages with analog surveillance systems. [4], [20]

### **Flexibility**

The flexibility is a small drawback in analog systems. Each camera needs a separate power cable as well as a connection to the DVR with a coaxial cable. This is not flexible since there needs to be a power outlet close to the camera. There is also another disadvantage with the analog system. The DVR's have limited video input ports, meaning there is a limit of maximum cameras that can be added to the system, usually there are about 4 – 24 video input ports on a DVR. The figure below shows a connection diagram of an analog system.



**Figure 7: Analog system, connection diagram**

The system is remotely accessible from anywhere with an Internet connection and the right authentication. The live view from the cameras are accessible as well as the recorded events on the DVR's hard drive. [1], [7]

### **Video analytics**

The DVR software in analog systems makes it possible to analyze the data received from the cameras. Depending on the DVR's software it is possible to setup different settings/modes when to record, how long to store recordings etc. A common feature that is most likely to be included in the software is a record on motion mode. This mode will analyze the data from the cameras and when there is enough movement in the surveilled area, the DVR will start recording. This feature will save space on the hard drive, since the DVR is not constantly recording. Another common feature is the alarm feature, which will send an email or text message to notify the persons supervising the system. This feature will quickly update the persons that something has occurred at the surveilled area.

### **3.2.2 Digital systems**

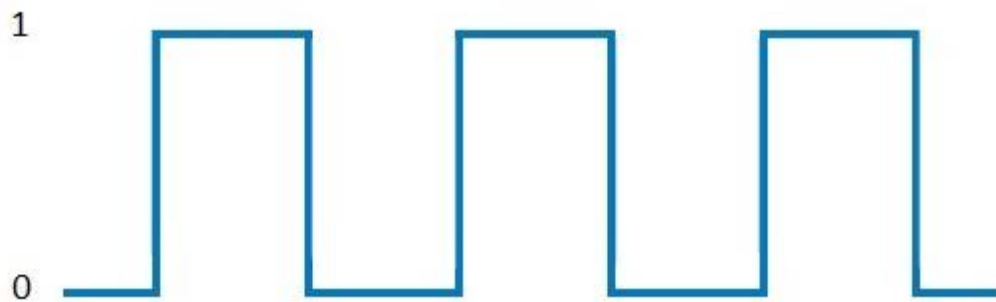
#### **Digital cameras**

Digital IP cameras are the most common cameras for surveillance today. With the possibility to send and receive data from the cameras as well as high resolution and flexibility. The cameras can be installed anywhere and only requires a single PoE, power over Ethernet cable

connected to the camera and the switch or NVR, network video recorder. The streams and recordings are accessible from anywhere when accessing the network. [7]

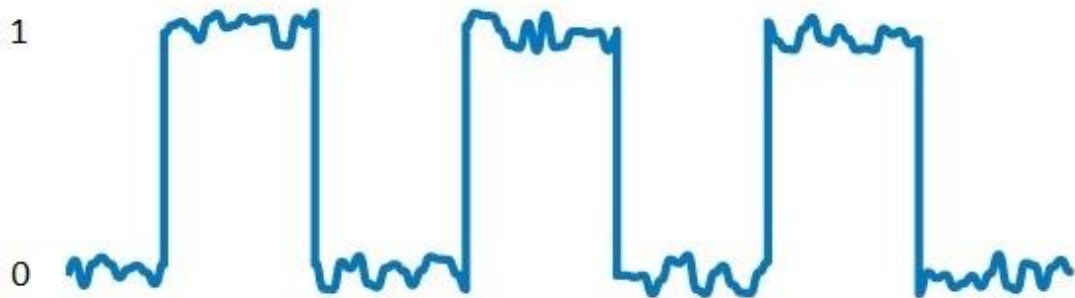
### Digital signal quality

The signal quality is a good example of the benefits with a digital system. A digital signal can only have two different values, 1 or 0. This makes it easier to detect the correct value at a given time. Below is a figure showing a digital signal without any noise or interference. As mentioned, it is very easy to determine the values at a certain time, since it may only have a high or low value, 0 or 1.



**Figure 8: Digital signal with no noise.**

Noise will also affect the digital wave, making it harder to analyze the values and therefore lower the signals quality. However, a digital signal with noise is still quite easy to analyze thanks to the limit of values it may have. Below is a figure showing the digital signal with some noise. The signal quality is one of the main advantages of digital systems. [4]

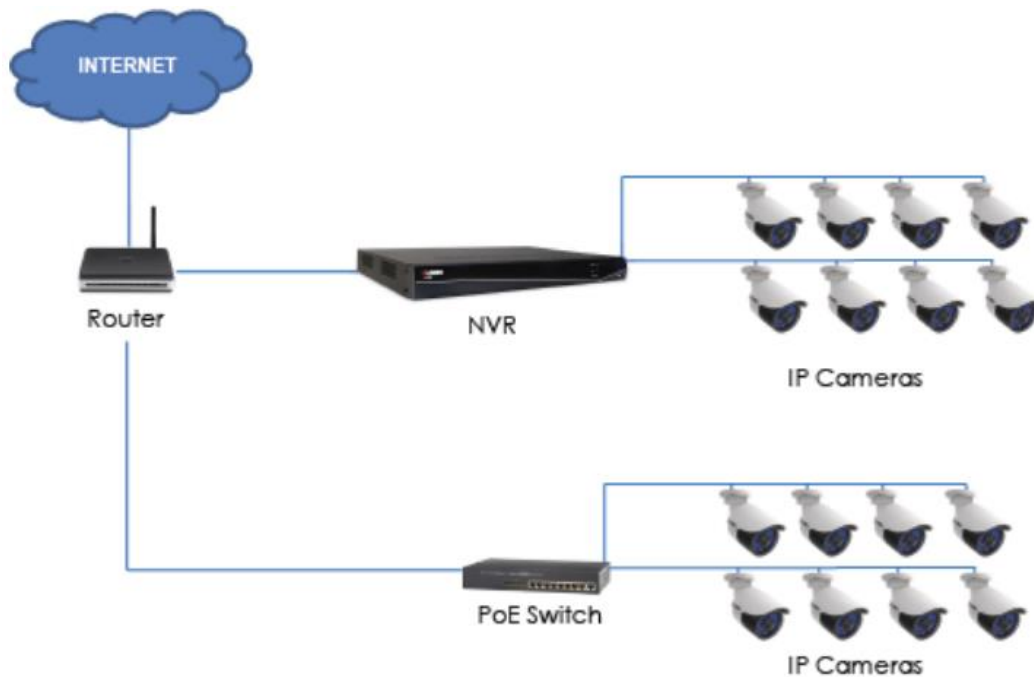


**Figure 9: Digital signal with noise.**

### Flexibility

The flexibility with a digital system is very good and gives the possibility to expand your system easily. The system can be easily accessible from anywhere with an internet

connection and the right authentications with a phone, tablet or computer. A simple digital system consists of cameras, a switch, a router and a NVR, network video recorder. The figure below shows how to connect the components.



**Figure 10: Digital surveillance system, connection diagram.**

As shown in Figure 10, it is possible to connect cameras to a switch that is on the same network as the NVR. This makes it very easy to expand the system just by adding another switch. This flexibility is another advantage of digital systems. [7], [18]

### **Video analytics**

The NVR software in digital systems makes it possible to analyze the data received from the cameras. Depending on the NVR's software it is possible to setup different settings/modes when to record, how long to store recordings etc. A common feature that is most likely to be included in the software is a record on motion mode. This mode will analyze the data from the cameras and when there is enough movement in the surveilled area, the NVR will start recording. This feature will save space on the hard drive, since the NVR is not constantly recording. Another common feature is the alarm feature, which will send an email or text message to notify the persons supervising the system. This feature will quickly update the persons that an event has occurred at the surveilled area.

### 3.2.3 Comparing analog and digital systems

Both analog and digital surveillance systems are similar to each other. The main difference of these systems is the flexibility, where the digital system has an advantage. The ability to easily expand the system is a huge plus, as well as the convenience of only needing a single PoE cable to connect your camera to the switch or NVR. Another advantage with the digital systems is that the signal is not as fragile to noise and interference. There is also no need to convert the signal type in the NVR, only compress the data to a smaller file size. [2], [3], [7]

## 3.3 Legal obligations

This chapter describes how the Finnish law was applied to the thesis when it comes to camera surveillance and handling person data. When recording video or audio in a way that a person can be identified there are certain legal obligations to fulfill.

There is an obligation to have a registration description containing a clear intention and motivation why the system is needed, as well as who is responsible of the recorded data and contact information. Another important part in the registration description is if the data is transferred to another company and if so, why.

A person who have been recorded have the rights to see the recorded data. A personal visit to the company or a written request with a specific date and time of the recorded event. If the request is denied the person can turn to the data protection supervisor for further steps. The surveilled area must openly inform that there is a camera surveillance system, this can be done with e.g. signs at the entry to the area. The data recorded must be destroyed immediately when the data is no longer relevant or serves any purpose and no later than 1 year after the data was recorded. [6], [17], [19]

## 3.4 Codecs

The following chapters contains information about codecs. What is a codec and why they are needed. The codecs that the chapter will mainly focus on the H.264, H.265 as well as Huffman coding. There will also be a simplified explanation on how they work.

### 3.4.1 Definition of a codec

The word codec is a blend of the words compression and decompression, which also describes what they do. A codec is a software that compress and shrink a file without affecting the quality that much. There are several reasons why compression techniques are needed. In this project the main reason is due to the limited bandwidth and limited storage capacity in the substations NVR. By reducing the bit rate of a video stream, it is possible to use the limited bandwidth more efficiently to transfer data. Below is a simple example using the Huffman coding technique. Uncompressed the text “Hello World “ would need 8 bits per character when using ASCII, making the total bits  $12 \times 8 = 96$  bits. When compressing the text with the Huffman coding the number of bits is reduced to 35 bits, as shown in the example. That is a result of 36,5% of the uncompressed number of bits. The figure below shows a Huffman coding tree, which is used to compress the data. The “Hello World“ text written in bits would look like this: 11001101101000111011000011110010111.

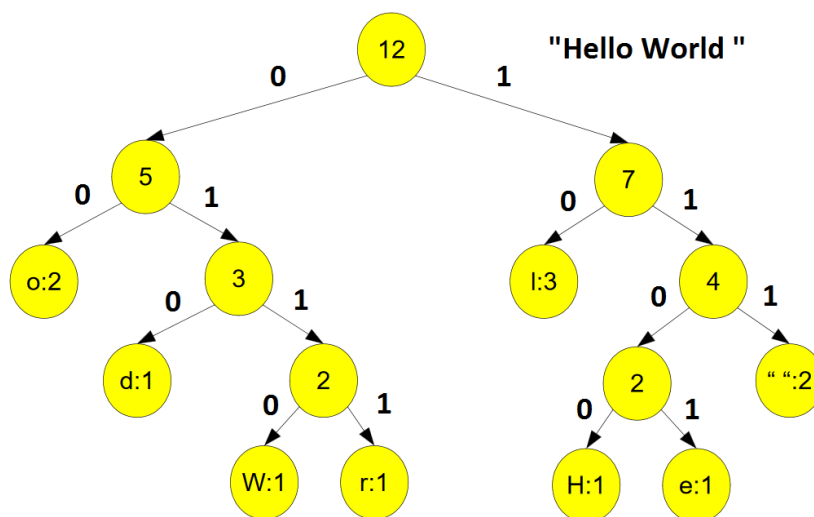


Figure 11: Huffman coding tree example

When using Huffman coding, the tree will also be sent to the decoder. Or else, the decoder would not know how to decode the bitstream. [16], [25, p. 3-4], [25, p. 30-31]

But there are not only benefits and advantages with compression. Compressed data is more sensitive to errors than uncompressed data. A single bit error may have a huge impact when decoding the data.

The same text is used to demonstrate how sensitive the Huffman coding is to bit errors. By inverting the first bit value of the original “Hello World “ written in bits.

Original: 1100 1101 10 10 00 111 0110 00 0111 10 010 111 = “Hello World “.

Error at first bit: 010 0110 1101 00 0111 0110 00 0111 10 010 111 = “dWeorWorld “.

As shown, there were some typos in the compressed text with the bit error. Not all codecs are this sensitive to bit errors like the Huffman coding.

When compressing video, it is important to use the same codec for encoding and decoding the data. Else the data might end up with compression artifacts. Below is a figure of an compression artifact. Artifacts will most likely appear when using a big compression factor in order to achieve a lower bit rate. [23] [25, p. 31]



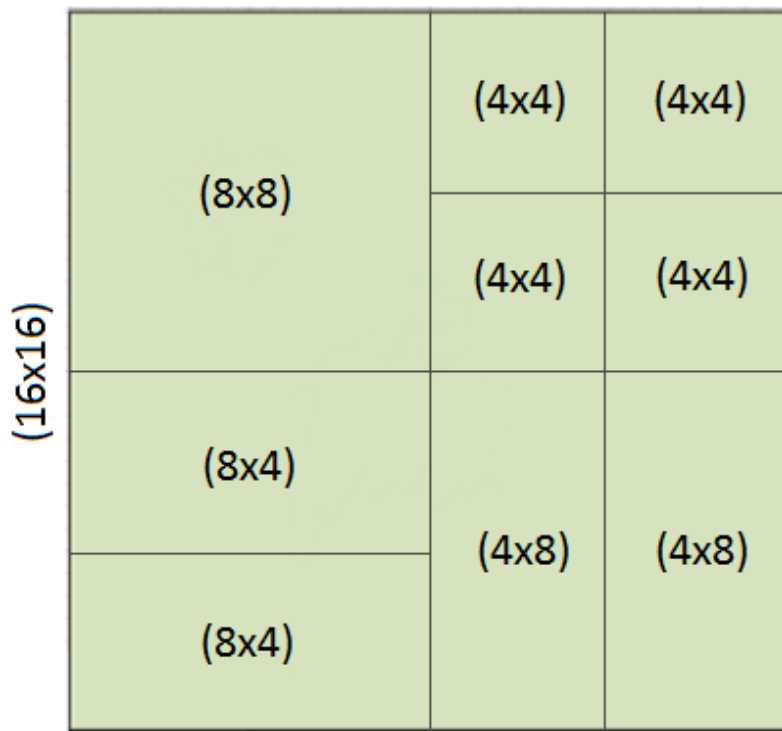
**Figure 12: Example of compression artifact**

Although compression is very important and brings many benefits it should not be used if it's not necessary and when used compress the data as little as possible to achieve the best result. When used only be used when needed and compress the data as little as possible to achieve the best result. [25, p. 32-33]

### **3.4.2 H.264**

The H.264 is a video codec and was included in the ISO-standard 2003. The codec is also called AVC, Advanced Video Coding or MPEG-4 part 10. The H.264 codec was mainly created to provide high-resolution 1080P video content at lower bitrate than previous standards. H.264 is used in HDTV, Blue-Ray, flash and media players such as VLC. There is also an open source version called x264. The H.264 codec is one of the most used codec today. [12], [24]

The H.264 works by creating several 16 x 16 pixel squares called macroblocks of each frame. These blocks can then split in various ways shown in the figure below. These blocks known as sub-blocks can have a minimum size of 4 x 4 pixel squares.



**Figure 13: Different ways of splitting a 16 x 16 pixels macroblock**

Each frame splits the screen into these macroblocks. Then the macroblocks / sub-blocks will compare the next frame's macroblocks / sub-blocks. If the blocks have not changed since the previous frame, it will use the same values for the macroblocks. For the macroblocks that have changed and therefore cannot use the previous macroblock's values, will get new values for that frame. The example below will show how this works. In the example there is three frames of a car driving down the street and the resolution is 1280 x 720P. This means that there are a total of  $1280/16 = 80$  macroblocks on the width and  $720/16 = 45$  macroblocks on the height.

During the first frame shown in Figure 14 all macroblocks and sub-blocks will get their values. In the second frame shown in Figure 15, all macroblocks and sub-blocks will be compared to the blocks in the previous frame. This means that all the blocks compared in the background have the same values. Meanwhile the blocks around the car does not have the same values, since the car have moved. Therefore, the macroblocks and sub-blocks around the car will get new values for that frame. Now the macroblocks from the second

frame will be compared with the macroblocks in the third frame shown in Figure 16. The result is the same, all macroblocks in the background have the same values, and the macroblocks around the car needs new values. This will limit the data needed to create the frames, since many macroblocks can use the same values in many frames. [13], [24]



**Figure 14: First frame**



**Figure 15: Second frame**



**Figure 16: Third frame**

### 3.4.3 H.265

H.265 is a quite new codec and a successor to H.264. The H.265 became an ISO-standard 2013. The codec is also called HEVC, High Efficiency Video Coding. The goal with this codec is to keep the same quality at half the bit rate to the previous standard, in this case H.264. When the goal is reached, it would mean that it is possible to stream Full-HD or Ultra-HD video content over the internet with half the bandwidth when using H.265 instead of H.264 codec. [13], [14]

The H.265 works quite similar to H.264. Instead of using macroblocks, it is using a new block called CTU, coding tree units. A single CTU can have a size of 64 x 64 pixels, compared to macroblocks 16 x 16 pixels. A max sized CTU is 16 times larger than a max sized macroblock. This makes it possible to save less number of blocks with data and therefore reduce the file size. The figure below shows an example of how a CTU can be further split into smaller blocks, with a minimum block of 4 x 4 pixels.

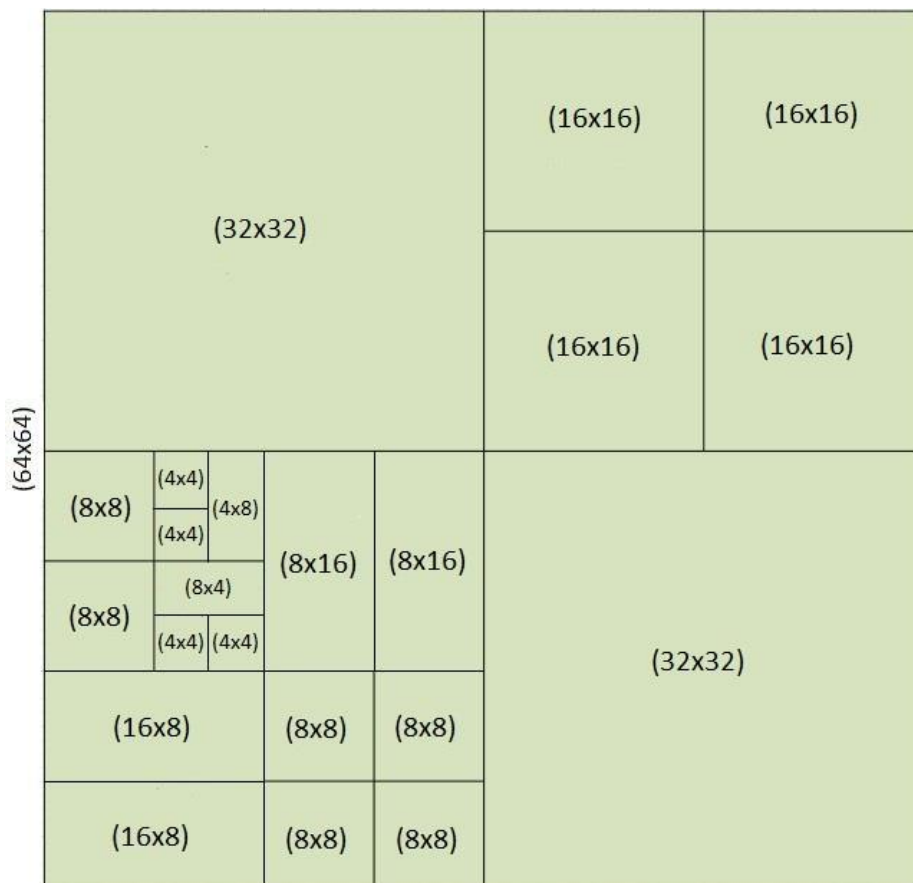


Figure 17: Different ways of splitting a coding tree unit.

### 3.4.4 Comparison

Below are two figures showing how the codecs are splitting a frame into blocks. The H.264 is splitting the frame into macroblocks. The H.265 is splitting the frame into CTU's. As the figures clearly shows, the number of blocks is more in Figure 18 comparing to Figure 19. This is due to the maximum size of a macroblock is limited to 16 x 16 pixels compared to the maximum size of a CTU's block, which is 64 x 64 pixels. With bigger blocks it is possible to compress the data more efficiently. This is because bigger blocks can be represented by fewer bits than if each pixel were represented individually. This is one of the main reasons that H.265 is able to make smarter compression and smaller file size of the same video compared to H.264. A disadvantage is that the H.265 requires more CPU power than the H.264 codec. [14], [15]



**Figure 18: H.264 Macroblocks**



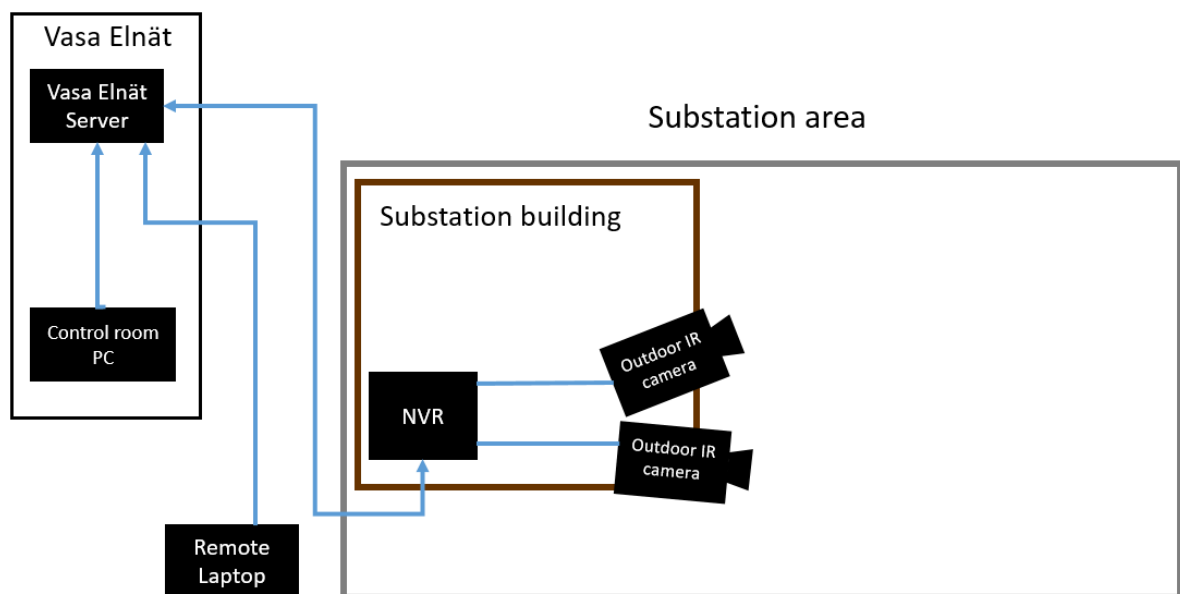
**Figure 19: H.265 CTU, coding tree units**

## 4 Planning and execution

The following describes how the surveillance system is planned to work, how many cameras are needed, where to position them, how long the recordings needs to be saved and how to access them remotely. This chapter will also include how the project was executed.

After further investigation, the ideal plan is to have two infrared IP cameras per substation. Both cameras will be placed outdoor at the roof corner of the building. The cameras will be facing the transformer with different angles to cover as much area as possible. The cameras will be connected with PoE cables to the NVR. The station has fiber connection from Vasa Elnät, making it possible for the supervisors in the control room to watch live streams from the cameras or the recorded files stored in the NVR.

It will also be necessary for the supervisors to have remote access to the surveillance system, in case of alarms. The Figure 20 shows the connection diagram of a single substation and the connections at Vasa Elnät.



**Figure 20: Surveillance system connection diagram.**

## 4.1 Components and software

After reviews of several offers, a company called Avarn security were chosen to supply Vasa Elnät with the needed cameras and NVR's for this project. The components' manufacturer is a company called Interlogix. Interlogix make surveillance components with the brand Truvision. The software that will be used for this system is Navigator v7, made by Interlogix.

This NVR have 4 channels and 4 PoE ports, making it easy to setup the planned system. With 4 channels it is possible to expand the system with 2 additional cameras. The NVR supports the H.264 video codec and have a storage of 2 Terabyte.



**Figure 21: Truvision's 4 channel NVR**

The Truvision infrared IP camera have a resolution of 2 megapixels and have a view angle of about 60°. The camera is suitable for outdoor environment since it has an environment rating of IP66. It is a fixed type of camera, meaning it may not be rotated with the use of software. The camera supports the H.264 video codec as well as dual-streaming.



**Figure 22: Truvision's Bullet IR camera**

The Navigator software is well compatible with these components, since they have the same manufacturer and brand. The software has a discovery tool, which will detect devices on the network. This will make it easy to connect the cameras to the Navigator software.

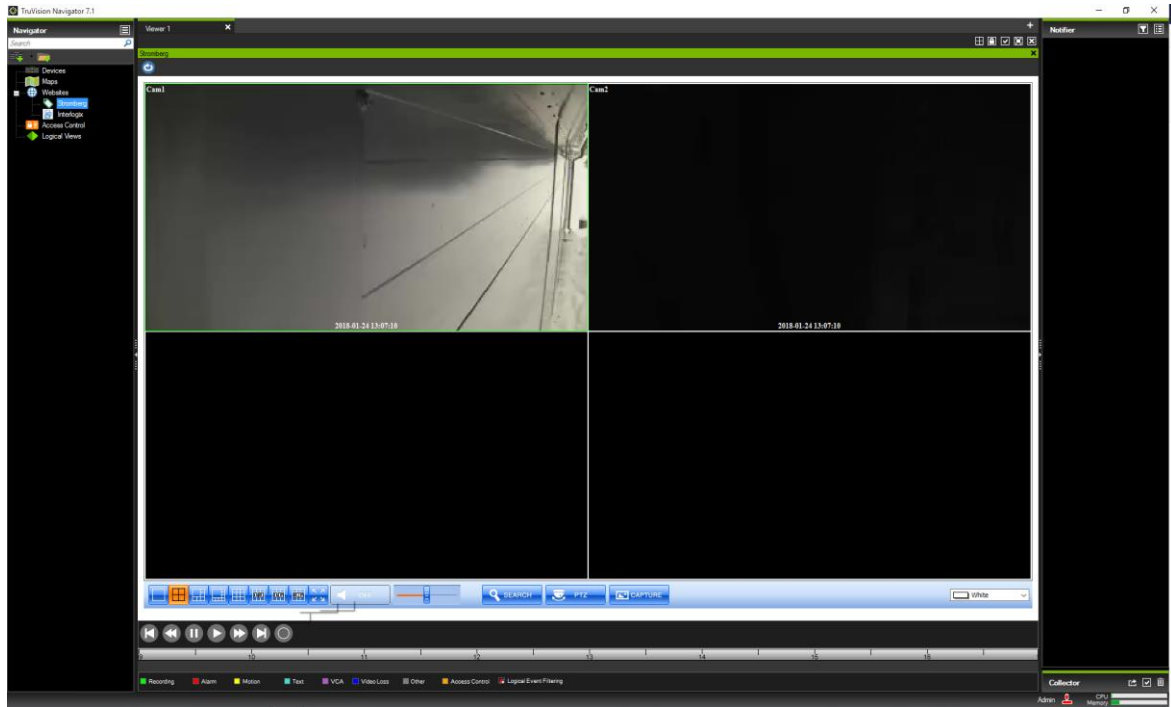


Figure 23: User interface of Navigator, showing a web view of a station.

## 4.2 Execution

The Alskat substation was the first station to get its cameras and NVR installed. Both cameras were installed in a corner of the station, with one of the cameras monitoring the doors and the second camera monitoring the transformer. The transformer camera needed to get a bit higher for a better view. To achieve this the camera was installed on the end of a pipe. Cat 6 ethernet cables with extra interference protection were used to connect the cameras to the NVR. Below are a couple of pictures of the camera setup.



**Figure 24: Installation at Alskat substation.**



**Figure 25: Cameras installed.**

After the cameras and the NVR have been installed at the station, it was possible to configure the NVR using a mouse and a monitor. After the configurations, the system was up and running and recording on motion. Everything was working except for the connection from the office.

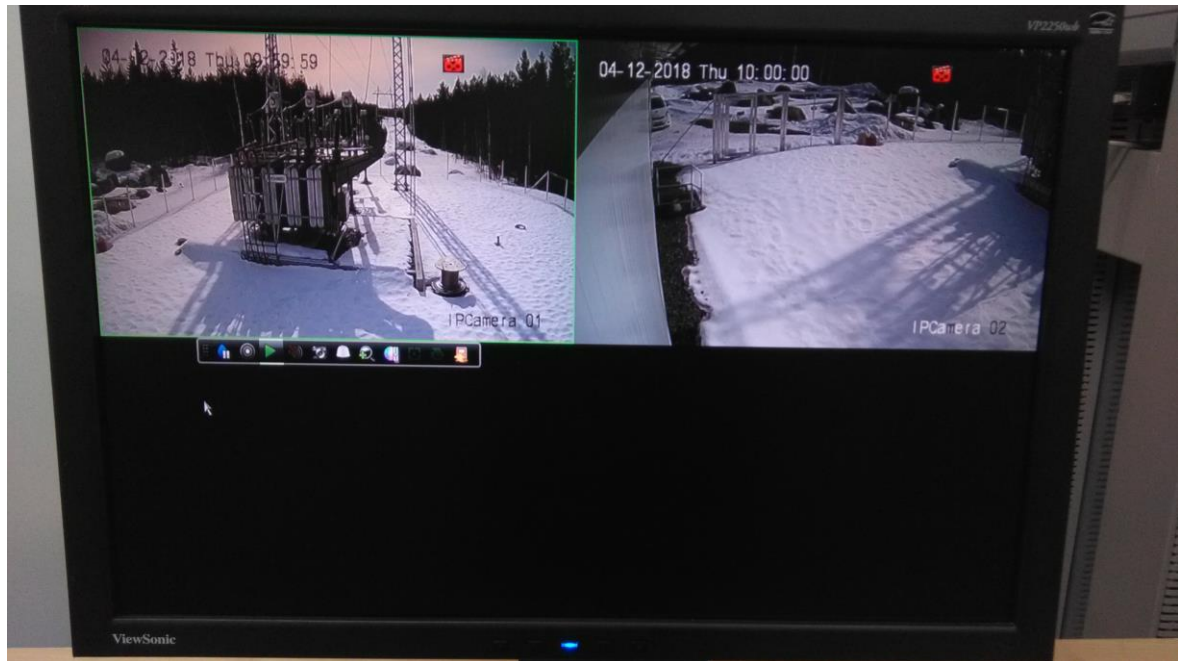


Figure 26: Camera view at Alskat substation.

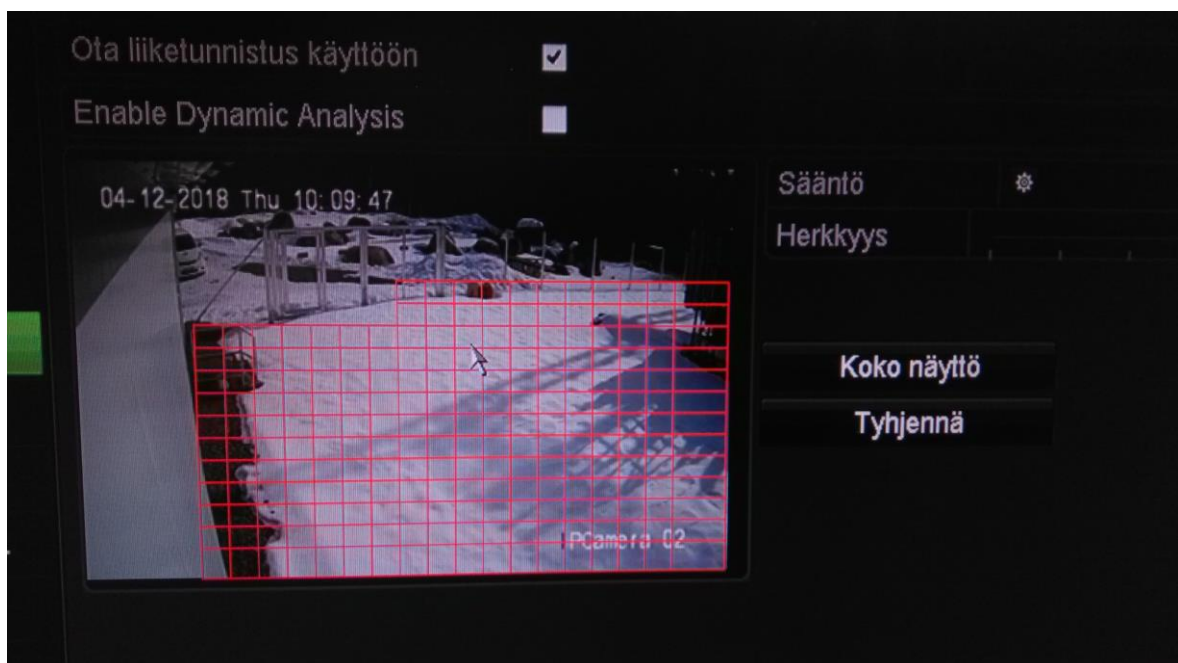


Figure 27: Area to check for motion.

To keep order in Vasa Elnät's network system, a subnetwork for the camera surveillance was created. This network would only be accessible by certain people. At this network, it

was possible to connect to the stations' NVR using the Navigator software. At first, Navigator could only connect to the NVR, but got immediately disconnected after the login succeeded. This was due to the firewall only allowed Navigator to use one of its three needed ports. After allowing Navigator to use all these ports, Navigator was setup correctly. Now it is possible to watch the live-view as well as the recorded events on the NVR.

## **5 Result**

### **The Strömberg substation**

At the Strömberg substation there is an analog system installed. The system is fully functioning but has different components compared to the Alskat substation. By logging in via Navigator's web view it is possible to access and configure the system at the station. In the web view it is possible to watch the cameras' live view with four frames per second at 480P resolution. The stored events are recorded with high quality and are accessible from the web view. The cameras have the possibility to rotate 360 degrees and it is possible to do so remotely. Both cameras are set up with a record on motion functionality to save space on the DVR hard drive.

### **The Alskat substation**

At the Alskat substation there is a digital system with the components mentioned in the previous chapter. The cameras are mounted on the substation building with a static view, meaning they cannot be rotated using the software. The cameras have wide view monitoring both the entrance and the transformer. Both cameras are set up with a record on motion functionality to save space on the NVR hard drive. The events will be recorded with 720P resolution. The connection to the station from the office is currently not set up. This is due to a third party. Because of that it is not possible to test the cameras live view from Navigator at the office. Except from the connection, the system is working. The cameras are recording when detecting motion and storing the data.

Neither stations have an alert system set up.

## **6 Discussion**

I personally think that this bachelor's thesis went quite well, although the planned result was not completely achieved. Both the analog and the digital surveillance systems with their different components had to be reviewed and analysed to determine which system would benefit Vasa Elnät the most. Some drawbacks with the thesis were the limited time I had to work with the project as well as the time it took to make certain necessary decisions in order to continue with the project.

### **Strömberg**

At the Strömberg substation the system is up and running but the email alert functionality is not yet set up. Some feedback that I have gotten is that both of the analog cameras that came with the Strömberg substation have already had to be exchanged for new ones due to some image errors. I was quite surprised to hear that both of the cameras already had to be changed, although the system had only been up and running for a short while.

### **Alskat**

At the Alskat substation the surveillance system is up and running but is lacking the email alert as well as the connection from the office at the moment. Therefore, I could not test and configure the live stream from the substation. The connection not being set up, was due to a third party.

The surveillance system will now be tested for a while, before the other stations will add the same setup as the Alskat substation. In the end it is planned to change the components at the Strömberg substation to the same components as in the Alskat substation.

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