

# Modern Solutions of CCTV Systems Used in Rail Transport

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## Summary

The paper presents the issues related to CCTV systems. The devices included in their composition were showed and characterised. Modern solutions (both in the field of CCTV systems and ICT safety), which are currently being implemented in these systems, were presented.

**Keywords:** CCTV systems, transport, virtual private networks

## 1. Introduction

According to the Government Centre for Security in the Republic of Poland, the critical infrastructure consists of 11 systems. They were characterised in the paper entitled „National Programme for Critical Infrastructure Protection”. These systems play a key role in safety of the country and its citizens. They also ensure efficient functioning of the public administration bodies as well as institutions and entrepreneurs. The critical infrastructure includes the following systems [2]:

- energy supply, energy sources and fuels,
- communications,
- ICT networks,
- financial,
- food supply,
- water supply,
- health care,
- transport,
- rescue,
- ensuring continuity of the public administration operation,
- production, disposal, storage, and the use of chemicals and radioactive substances (including pipelines of hazardous substances).

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Among these systems, transport has a vital role. It is the movement of people, freight (the subject of transport) in the space using the appropriate means of transport. The movement of goods, people and services is one of the basic characteristics of modern economy and society. Therefore, a well-functioning transport system is one of the pillars of the modern country. Thus, it is very important to ensure an appropriate level of safety to objects (both stationary and mobile), used in the transport process [15]. To that end, a variety of technical and organisational solutions are used.

The full risk alarm system (i.e. the electronic protection alarm system) is formed with the following systems distinguished depending on the detected threats, as systems of [1, 4]:

- intrusion and panic alarm,
- fire alarm,
- access control,
- CCTV,
- external sites protection.

The protection resulting from operation of these systems can be supplemented by systems of:

- health condition and personal threat alarm,
- environmental threat alarm,
- anti-theft,
- voice alarm systems,
- car protection against burglary and abduction.

Among interchangeable systems, the CCTV system is one of the most important and often preventively used. It allows to observe places and areas which are investigated as particularly important from the safety point of view (both people and continuity of transport systems operation). For this reason, there are many structurally different designed CCTV systems on the railway area which is included in the group of extensive systems.

CCTV systems belong to the group of elements constituting the transport telematics systems [11, 14]. They operate then the service of ensuring safety of travelling, which is one of the services provided by these systems [12, 13]. It is implemented, among others, by the systems installed both in permanent facilities of the airports, railway stations, logistics bases, loading terminals, as well as in mobile objects (e.g. vehicles). Thanks to this, a level of safety of both travellers and transported cargoes increases. In the paper, an analysis of modern electronic solutions of the CCTV systems, used in rail transport, was conducted.

## 2. CCTV systems

CCTV systems are a set of technical and programme measures designed for observing, detecting, recording, and signalling unusual conditions indicating the existence of danger. They may include (depending on configuration) the following basic devices [3, 5, 7, 8]:

- cameras with appropriately selected lenses,
- transmission media with interfaces,
- recorders (among others, digital video recorders, network recording servers),
- monitors,
- power systems,
- emergency power systems,
- protection systems of the power systems (including, e.g. protection against overvoltage),
- others (e.g. additional lighting systems, processing devices).

Figure 1 shows the simplest CCTV system that is often called the surveillance system. It usually consists of several cameras (generally 4), as well as a sequential switcher and a monitor. The disadvantage of this solution is the lack of possibility to extend it, and the advantage is the low cost of this set. If a number of cameras is greater, then a video splitter is applied. It allows to display on the monitor the images of all cameras at the same time (usually divided into 4, 9 and 16 fields). There is also the possibility of using 2 monitors (usually one larger and one smaller). The monitor of a greater diagonal size displays images divided into 4, 9 or 16 fields showing individual cameras. The monitor of a smaller diagonal size allows to preview the image of a single camera. This type of solution was presented in Fig. 2. The disadvantage of both presented solutions is the lack of event recording with a view to their subsequent use (e.g. as evidence in lawsuits, or as a source of information about the perpetrators of terrorist attacks).

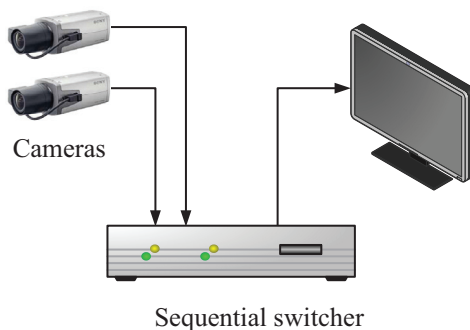


Fig. 1. Surveillance set

Video recorders were used in order to record images of the cameras. Currently, they are specialised electronic devices that analyse the images and save them digitally in hard drives. This type of solution was presented in Fig. 2. A digital video recorder most often serves as: a sequential switcher, video splitter, event recording system with motion detection in order to optimise the image recording. Mostly, at the observation position, there are two monitors working like in the system shown in Fig. 3.

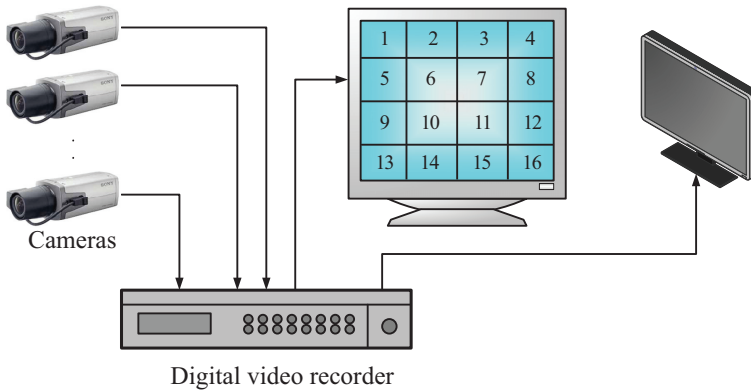


Fig. 2. The system contains 16 cameras and a digital video recorder

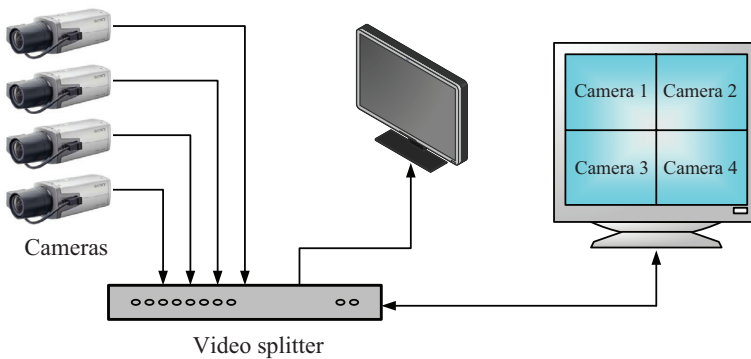


Fig. 3. A set with the video splitter and two monitors

Currently used digital video recorders have the following characteristics [9]:

- mode of operation: triplex (allows to play back without interrupting recording images from cameras),
- watermark (in English: *watermark* – putting a special tag in the recorded material, preventing modification of recordings),
- mirror recording (in English: *mirror recording* – a function that makes it possible to record the material on two drives at the same time – the archive safety in case of failure of one of the media),

- network interface using the TCP/IP protocol,
- controlling rotary heads and speed dome cameras (PTZ),
- the possibility of putting a recorder in the hard disk or (and) DVD-R/RW or Blu-Ray burner,
- USB port,
- memory slot e.g. MicroSD,
- the opportunity to work with wireless devices.

The construction of large CCTV systems (especially related to stationary railway facilities, e.g. railway stations) requires very good content-related preparation from the designer, and appropriate financial contribution from the investor. In new systems, digital transmission as well as video signal processing, also in a digital way, are used.

The video signal transmission usually takes place in the following way:

- coaxial cable,
- twisted-pair cable type,
- microwave transmission or transmission on radio frequency,
- transfer with the use of infrared or laser,
- fibre optic cable,
- transmission through a public or private telephone network or via a data transmission network (e.g. Intranet, Internet).

Recently observed development of modern information technologies enabled the direct connection of cameras with CCTV systems to computer networks. To that end, the TCP/IP protocol is used. This solution allows to view events from cameras installed in different locations of protected facilities on a computer with appropriate software connected to the computer network. The camera has a built-in network video server, and its own assigned IP address. In small, local CCTV systems (due to the cost of such a solution), the systems based on digital video recorders using coaxial cables will continue to be used. In distributed facilities and buildings with modern telecommunication system structure, CCTV systems using the TCP/IP networks are more frequently used now. Such systems are shortly called CCTV IP (in English: *Closed Circuit Television Internet Protocol*). Devices for video signal processing have their own IP addresses. It is also possible to use existing analogue system elements of installation, such as e.g. cameras through the use of video servers. Recording a signal may occur in traditional video recorders as well as in network video recorders.

CCTV IP systems offer functions which are not available in analogue solutions:

- transmission of video signals over long distances does not cause deterioration of the image quality,

- recording and multiple copying the same material does not cause deterioration of the quality of recorded images,
- the once generated video signal in the camera can be used many times and in many places,
- the possibility of two-way communication with the camera, not only in terms of configuration, but also in terms of implementation of the utility functions (e.g. smart cameras),
- the possibility to implement a function of the motion detection and alarm functions on the camera (smart cameras),
- the possibility to cache data containing images in the camera,
- the possibility to power the IP camera via the Ethernet port (PoE, in English Power over Ethernet).

The development of new algorithms for the image analysis enabled more powerful searching and detection of dangerous situations [6, 10]. This is done either on the basis of recorded video material using the software installed on the server or local computers, or directly in the camera or digital video recorders.

### **3. Modern solutions in CCTV systems**

Among the electronic safety systems, the CCTV systems are one of the fastest developing systems. A lot of modern solutions, both in the field of cameras themselves and their sensors, as well as software for the image analysis, are implemented in them.

A modern solution used in cameras is implementation of the 360° panoramic camera, commonly referred to as a fisheye, (other names are hemispherical, omnidirectional camera). The most important element is a lens that allows to transfer the image to the photosensitive material (optical-electrical transmitter). These types of lenses are characterised by large, uncorrected barrel distortion. It allows to get a panoramic or hemispherical image. In order to make an analysis of the obtained image by the operator of the CCTV system, among other, the virtual PTZ function is applied. It allows to navigate the image in the traditional manner, despite the fact that it was obtained as a result of application of one or two sensors and a fisheye lens. This type of solution enables to reduce a number of installed cameras in the protected facility.

Another solution implemented in CCTV systems is the use of sensors with a growing number of mega pixels. It gives the possibility to obtain an image of increasing resolution, and therefore, more accurately reproducing the details.

Many companies implement more and more sophisticated microprocessor systems in the subsequent generations of cameras. At the same time, they allow

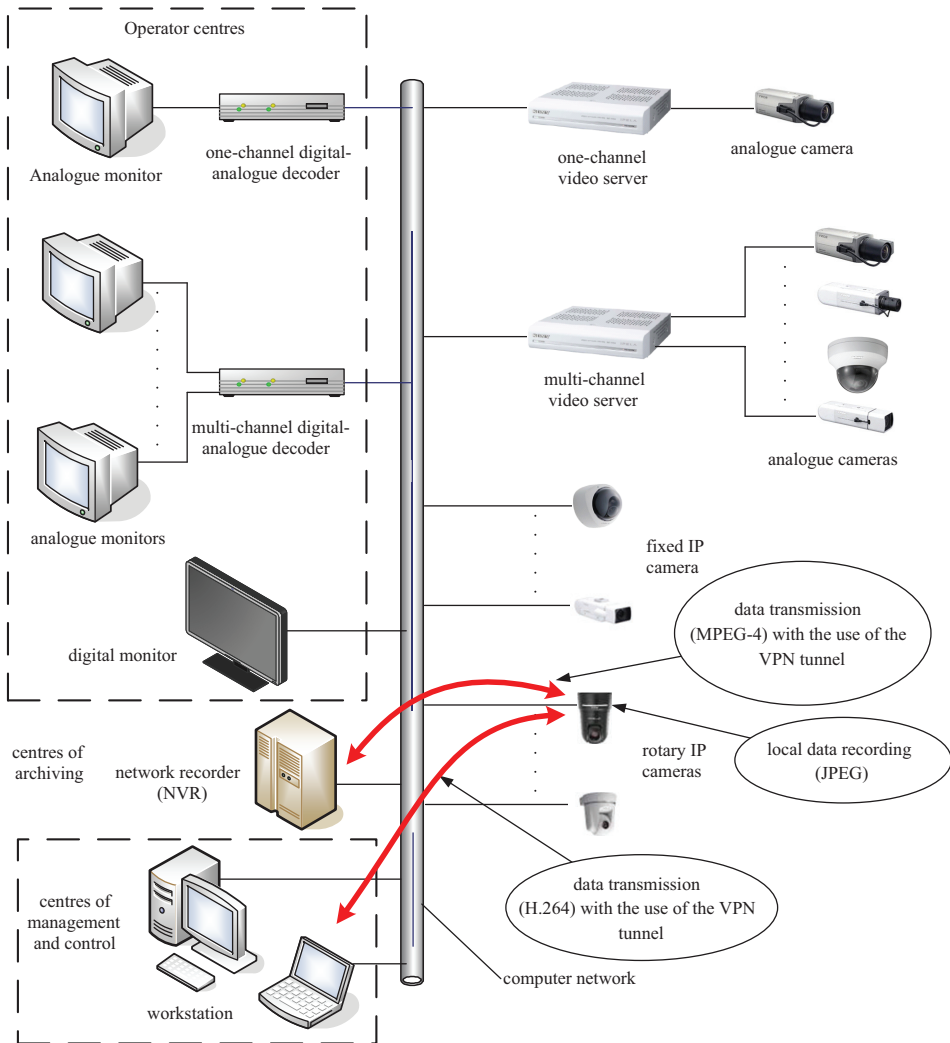


Fig. 4. General diagram of the CCTV system

to encode the image using different codecs (H.264, MPEG-4, JPEG) and send them, with the use of a computer network, to different locations. Until now, the compressed material has been sent to two locations (in English: *dual streaming*), and currently there are cameras that send images to three locations (in English: *triple streaming*), and each of them may be subject to compression using another encoding format. The use of this type of cameras makes the local (on hard drives of the HDD cameras) video data archiving, with the use of the JPEG encoding, possible. At the same time, the video data can be transmitted to the centre of management and control (H.264 encoding) and the centre of archiving (MPEG-4 encoding). Shown in Figure 4. In order to secure data transmission the VPN tunnel

(in English: *Virtual Private Networks*) was used. It allows to provide confidentiality and authenticity of data globally transmitted using the Internet or other public networks.

Virtual Private Network, often shortly called VPN, to the data sending can use the public telecommunications infrastructure, which through the use of a tunnelling protocol and safety procedures preserves confidentiality of data. The infrastructure can be a backbone network of the telecommunications operator (e.g. Frame Relay or ATM). It involves creation of dynamic, virtual connections between a sender and a receiver with the use of the data transmission network, but the transmission route and throughput of the transmission band for the connection are set dynamically. According to the assumption, the VPN network should provide: confidentiality, integrity and authenticity of transmitted data.

Figure 5 shows a general wiring diagram of the CCTV system. IP cameras are attached to the managed switches using the screen twisted pair of the 5e category. They are powered directly from the switches thanks to the HPoE function. The switches were connected with each other and the router using a transmission medium, which is the fibre optic. It provides high throughput, and at the same time, resistance to electromagnetic interference, which is significant in the rail transport environment. Recording of video data takes place in the network recorders.

## 4. Conclusion

In this paper, the issues related to CCTV system, which can be used in the widely understood transport, were presented. These solutions can be used in the rail transport, because due to the nature of operation, it should ensure safety (among others, especially of passengers). Therefore, it is necessary to implement innovative solutions that will allow to increase effectiveness of the CCTV systems operation. At the same time, it is necessary to ensure confidentiality, integrity and authenticity of data transmitted from these systems. It can be achieved through the use of virtual private networks (e.g. with the aim of configuration of the individual devices included in the electronic safety systems).

Presented solutions of the CCTV system of public safety usually constitute an open IT system, which allows to spatial expansion in the future, i.e. it is possible to gradually enter more and more controlled facilities into the system and to increase the controlled area in a given facility. It also allows, without the necessity to introduce significant changes in the logical and functional architecture, to launch the new system functions.



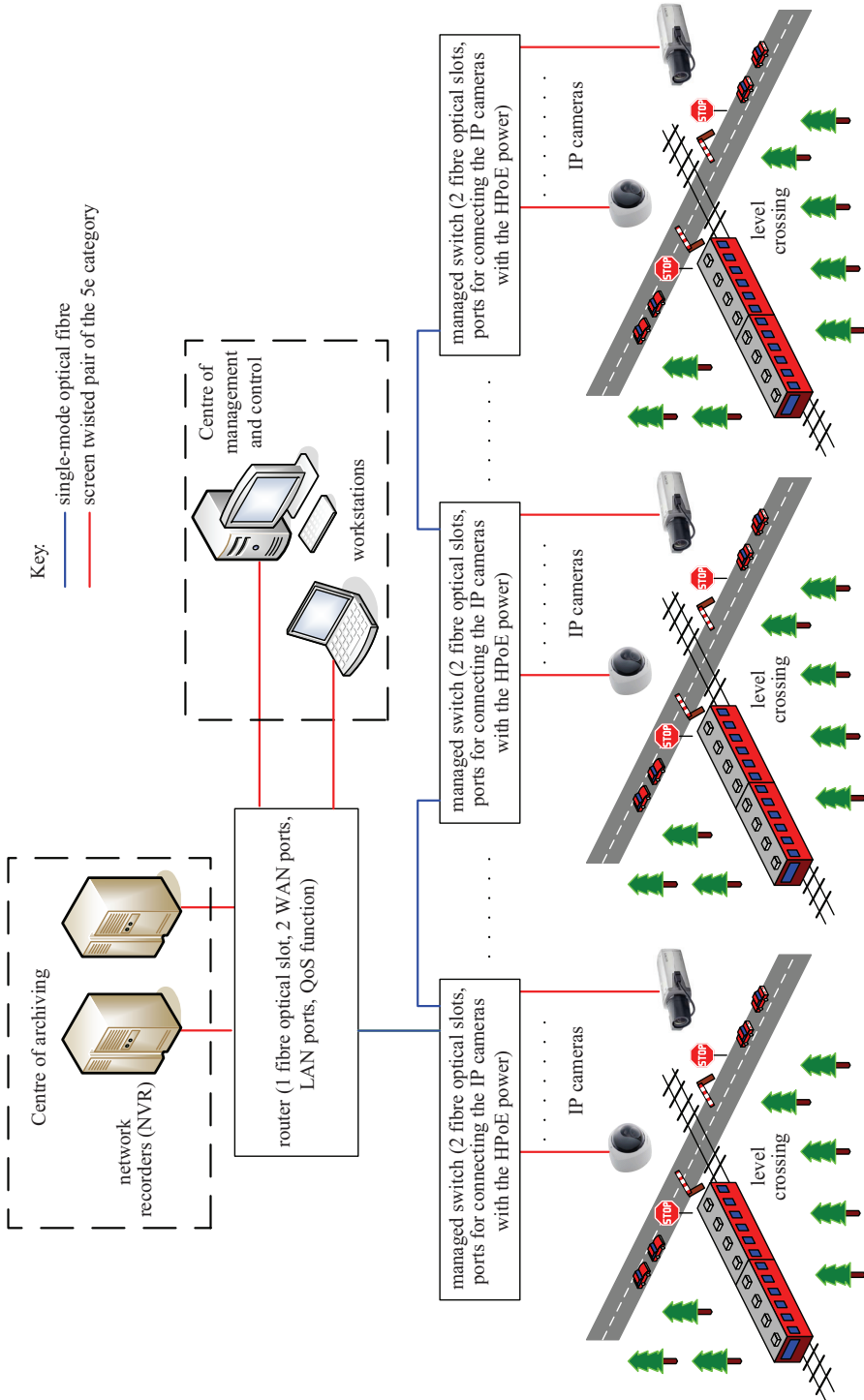


Fig. 5. General wiring diagram in the CCTV system

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## **Nowoczesne rozwiązania systemów monitoringu wizyjnego stosowanych w transporcie kolejowym**

### **Streszczenie**

W artykule zaprezentowano zagadnienia dotyczące systemów monitoringu wizyjnego. Ukazano i scharakteryzowano urządzenia wchodzące w ich skład. Przedstawiono także nowoczesne rozwiązania, zarówno z zakresu systemów monitoringu wizyjnego, jak i bezpieczeństwa teleinformatycznego, które są obecnie wdrażane w tych systemach.

**Słowa kluczowe:** systemy monitoringu wizyjnego, transport, wirtualne sieci prywatne

## **Современные решения систем видеонаблюдения в железнодорожном транспорте**

### **Резюме**

В статье представлены проблемы связанные с системами видеонаблюдения. Указаны и охарактеризованы входящие в их состав устройства. Представлены также современные решения (как в области систем видеонаблюдения, так и безопасности телеинформационных сетей), которые внедряются в сегодняшнее время.

**Ключевые слова:** системемы видеонаблюдения, транспорт, виртуальные частные сети