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Access, Terminals, Transmission and Multiplexing (ATTM); Benefit Analysis of Ethernet and power over coaxial cables - IP Video Surveillance Case Studies

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Traditionally, short- and medium- range Video Surveillance Systems (VSS) have used point-to-point coaxial cables for the transmission of the video signals from the camera to, and the camera control signals from, a monitoring centre with power supplied to the cameras via a separate and local Low Voltage (LV) AC power supply.

Longer transmission lengths and/or the need to support high resolution cameras require the replacement of the coaxial cable with optical fibre cable.

VSS are now able to take advantage of balanced pair cabling and the standards developed by IEEE, ISO/IEC and CENELEC which allow the signals and DC power to be delivered over the same cable, once again on a point-to-point basis.

The provision of signal and DC power within a single cable construction has clear advantages in terms of cost and flexibility of installed configuration, avoiding the need to re-provision LV power and associated infrastructure.

The present document considers the opportunities offered by employing a combined signal and DC powering solution using coaxial cable which not only avoids the replacement of the installed cable but, dependent on the performance of the coaxial cable, can also offer extended distance of support beyond that offered by the balanced cable solution.

Equally importantly, the combined signal and DC powering solution using coaxial cable offers the opportunity to connect multiple cameras in a linear bus configuration.

The present document:

a) presents the basic principles of, and describes in detail the coaxial cabling solution for, Video Surveillance Systems (VSS) using IP technology;

b) describes in detail the implementation of VSS using IP signalling and remote powering using the coaxial cabling solution;

c) provides a benefit analysis (both of cost-of-ownership and environmental impact) of coaxial cabling, balanced cabling and wireless approaches to IP-based VSS;

d) contains a number of use cases for transportation systems and other surveillance applications.

1 Scope

The present document reviews the benefit analyses and environmental impact for selected use cases (such as mass transit systems) of using coaxial cables to support both Ethernet and power over coaxial equipment for IP Video Surveillance Systems (VSS) when:

a) upgrading existing analogue VSS using legacy coaxial cables as compared with installation of alternative transmission media; and

b) building new VSS by installing coaxial cables as compared with other transmission media.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] CENELEC EN 50173-1: "Information technology - Generic cabling systems - General requirements".

[i.2] ETSI TS 105 176-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Ethernet and power over cables; Part 2: Ethernet and power over coaxial cables for IP video surveillance".

[i.3] IEEE 802.3™: "IEEE Standard for Ethernet".

[i.4] IEEE 802.3cg™: "IEEE Standard for Ethernet - Amendment 5:Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors".

[i.5] ISO/IEC 11801-1: "Information technology - Generic cabling for customer premises - General requirements".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 105 176-2 [i.2] and the following apply:

low voltage: voltage exceeding extra-low voltage but not exceeding 1 000 V a.c. or 1 500 V d.c. between conductors, or 600 V a.c. or 900 V d.c. between conductors and earth

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TS 105 176-2 [i.2] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 105 176-2 [i.2] and the following apply:

AC	Alternating Current
DC	Direct Current
E&PoC	Ethernet and Power over Coax(ial cabling)
EMI	ElectroMagnetic Interference
ISM	Industrial, Scientific and Medical
LV	Low Voltage
PSU	Power Supply Unit
QoS	Quality of Service
UPS	Uninterruptible Power System
VDC	Volts Direct Current
VSS	Video Surveillance System
WAP	Wireless Access Point

4 Design solutions for VSS using IP and remote powering over coaxial cables

4.1 General

This clause provides a general description of the Ethernet & Power over Coax (E&PoC) technology which is the subject of the present document.

Clause 4.2 describes the basic principles of the various design solutions for VSS.

For E&PoC solutions:

- clause 4.3 provides further details of the models for remote powering of devices within VSS;
- clause 4.4 addresses the upgrade of VSS constructed from legacy coaxial cabling;
- clause 4.5 addresses the design and installation of new build VSS installations.

4.2 Basic principles

4.2.1 Alternative design solutions

4.2.1.1 Coaxial cabling signal transmission with LV AC power to cameras

Traditionally, VSS have used point-to-point coaxial cables for the transmission of the analogue video signals from the camera to, and the camera control signals from, a monitoring centre with power supplied to the camera Power Supply Unit (PSU) via a separate and local LV AC power supply, typically directly fed by the energy grid.

Figure 1 is a schematic of the basic solution.

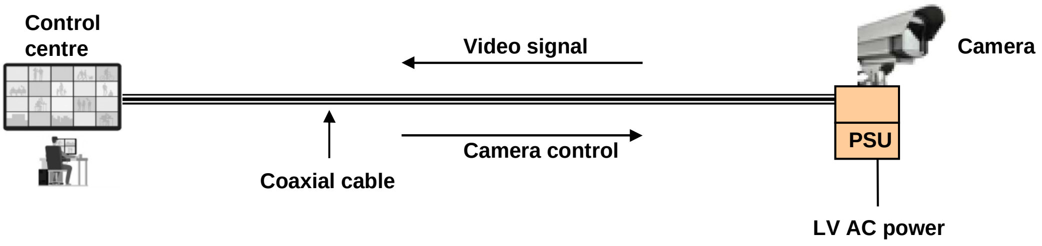

Figure 1: Traditional coaxial cabling solution for video surveillance

The length of coaxial cable is limited by the bandwidth and attenuation of the coaxial cable in relation to the delivery for the required video reception quality.

4.2.1.2 Optical fibre cabling signal transmission with LV AC power to cameras

Where the achievable transmission length using coaxial cable is inadequate, optical fibre may be used in either simplex or duplex mode.

Figure 2 is a schematic of the basic solution.

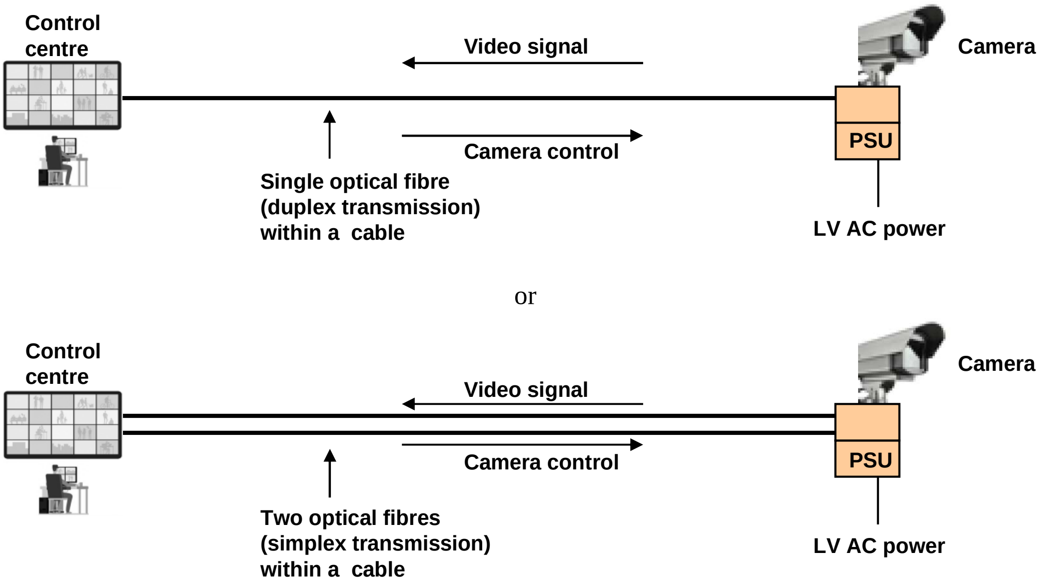

Figure 2:Traditional optical fibre cabling solutions for video surveillance

Depending on the optical fibre technology used (single-mode, multi-mode or plastic) it can offer transmission distances of many kilometres with single-mode optical fibres to just tens of meters with plastic optical fibres.

There may be other technical factors for selecting optical fibre technology in specific situations such as safety and security concerns.

4.2.1.3 Balanced cabling signal transmission and remote powering of cameras

4-pair balanced cabling components of Category 5 and above (as specified in ISO/IEC 11801-1 [i.5] and CENELEC EN 50173-1 [i.1]) enable both the signal transmission (using Ethernet protocols of IEEE 802.3 [i.3]) and the delivery of DC power of up to 90 W to the camera. This allows the replacement of the local LV AC power supply and the associated Power Supply Unit (PSU) with a DC/DC convertor which converts the remote powering voltages to those needed by the cameras (typically 12 V DC). Figure 3 is a schematic of the basic solution.

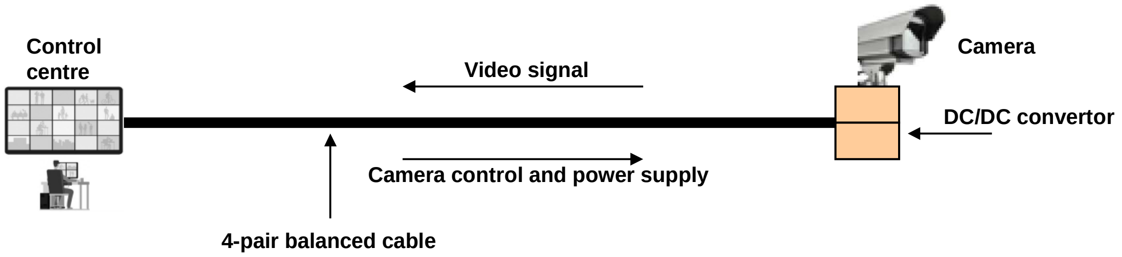

Figure 3: Signal and remote powering provision using balanced cable for video surveillance

The length of balanced cable is limited to approximately 100 m due the maximum distance of support of the transmission protocol and the DC resistance of the cables.

NOTE: IEEE 802.3cg [i.4] is a specification for data transmission and the delivery of lower power (≤ 13 W) using a single pair balanced cable to support lower data rates (10 Mb/s) over distances of up to 1 000 m.

4.2.1.4 Coaxial cabling signal transmission and remote powering of cameras

The focus of the present document is the use of installed coaxial cabling components enabling both the signal transmission using protocols of ETSI TS 105 176-2 [i.2] and the delivery of DC power of up to 90 W towards the camera although the actual power delivered is dependent upon the DC resistance of the coaxial cable and its length.

A DC/DC convertor is used to extract power from the coaxial cable and to convert the voltage to the level needed by each camera. Such convertors include a function that enables power extraction without impairing the signal transmission on the coaxial cable.

Employing a combined signal and DC powering solution using coaxial cable not only avoids the replacement of the installed cable but, dependent on the performance of the coaxial cable, can also offer extended distance of support beyond that offered by the balanced cable solution. For new installations, this allows avoiding costs for providing LV AC powering cabling to each camera. Equally importantly, the combined signal and DC powering solution using coaxial cable offers the opportunity to connect multiple cameras in a linear bus configuration (see clause 5.2.2 and clause 5.3.2).

This architecture also enables development of a system with enhanced availability as it can be protected against a failure of the energy grid supply by using a single Uninterruptible Power System (UPS) function at the Receiver Device (rDEV) location.

This architecture allows two installation implementations:

- point-to-point - where a single camera acting as an Edge Device (eDEV) is connected to a relevant port at an rDEV. The camera is typically, but not always, installed at the end of the cable;
- linear bus - where multiple cameras (eDEVs) can be connected to the same cable via T connections and inserted and removed without functional disruption of the bus. They are connected along the cable route, and may be either scattered along its path or clustered at one point (typically at the end). The bus architecture allows connection of multiple cameras depending upon the powering Class of the rDEV port and the power requirements of the cameras (described in clause 4.3.1). The number of cameras that can be supported is dependent upon the DC resistance of the coaxial cable and the positions of the devices along its length (see clause 5.2.2 and clause 5.3.2).

Figure 4 is a schematic of the basic point-to-point solution.

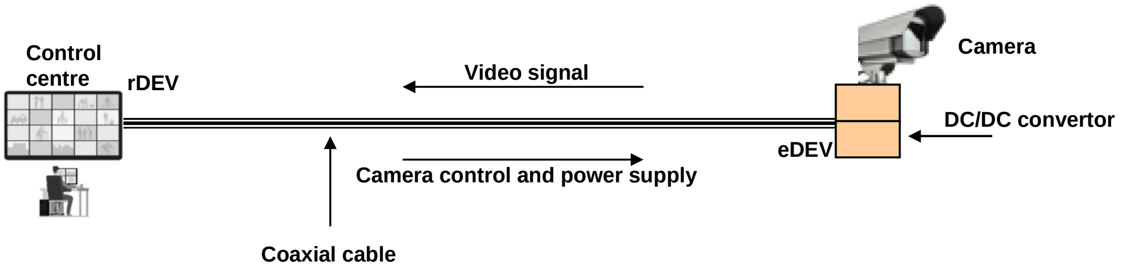

Figure 4: Signal and remote powering provision using coaxial cable for video surveillance (point-to-point)

Figure 5 is a schematic of a linear bus solution.

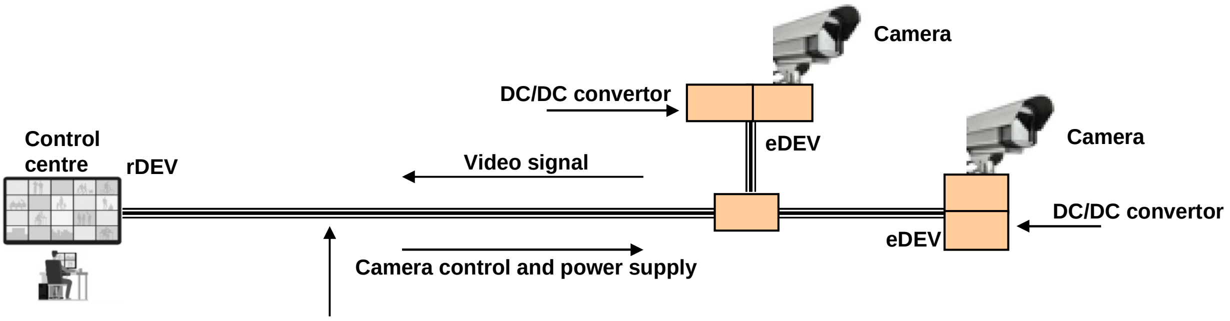

Figure 5: Signal and remote powering provision using coaxial cable for video surveillance (linear bus)

The length of coaxial cables of different DC loop resistance values is addressed in clause 4.3.

4.3 Models for remote powering using coaxial cabling

4.3.1 General

Clause 4.3.2 introduces the Powering Classes of ETSI TS 105 176-2 [i.2].

Clause 4.3.3 considers the requirements for DC loop resistance necessary to deliver the required levels of power to the eDEVs and that information is then used to map sample cable performance values to system design lengths.

4.3.2 Powering Classes

ETSI TS 105 176-2 [i.2] specifies eight Classes of power which are described in terms of the output power at the rDEV (see Table 1).

Although ETSI TS 105 176-2 [i.2] does not define any power for eDEV equipment, the present document adopts the use of power Classes for the eDEV that are aligned with the rDEV power Classes of Table 1.

Table 1: Power Classes of ETSI TS 105 176-2

Class	1	2	3	4	5	6	7	8
rDEV output power (W)	4	7	15,4	30	45	60	75	90
eDEV input power (W) (see note)	3,84	6,49	13	25,5	40	51	62	71,3
NOTE: The minimum received power limit of powered devices of a given Class in IEEE 802.3 [i.3] (taking into account the cable losses) although such devices may consume lower levels of power than that shown.								

The present document considers implementation of end devices of Class 3 and Class 4 (implemented in both a point-to-point and linear bus configuration) and Class 6 and Class 8 (implemented in a point-to-point configuration only).

4.3.3 DC loop resistance

4.3.3.1 Cable DC loop resistance

The DC loop resistance of a length of coaxial cable is not only the DC resistance of the signal conductor which the present document designates as R_1. It is the combined resistance of the signal conductor and the return path i.e. the screen (or shield) of the cable which the present document designates as R_2.

It is not common for the DC resistance of the signal conductor to be specified on a data sheets of coaxial cables and it is even less common for the DC resistance of the screen to be specified. Therefore, in many cases, it is necessary to measure the installed DC loop resistance ($R_1 + R_2$) performance of each cable or a sample, the results of which can be applied to a wider population.

The present document describes implementations based on a number of cable performance values for DC loop resistance per 1 000 m as follows:

- $R_1 + R_2 \leq 18$ Ω/km; RG11 cables with solid copper signal conductors may provide this level of performance;
- $18 < R_1 + R_2 \leq 27$ Ω/km; RG6 cables with solid copper signal conductors may provide this level of performance;
- $27 < R_1 + R_2 \leq 36$ Ω/km.

NOTE: RG59 cables with copper clad (e.g. aluminium- or steel-clad) signal conductors have higher resistance that limits their capability to be efficiently used to provide powering above Class 4.

4.3.3.2 System requirements

In accordance with ETSI TS 105 176-2 [i.2] and as shown in Figure 6, the voltage range at the rDEV is 53,5 - 57,0 VDC and the minimum required voltage at any eDEV is 44,0 VDC.

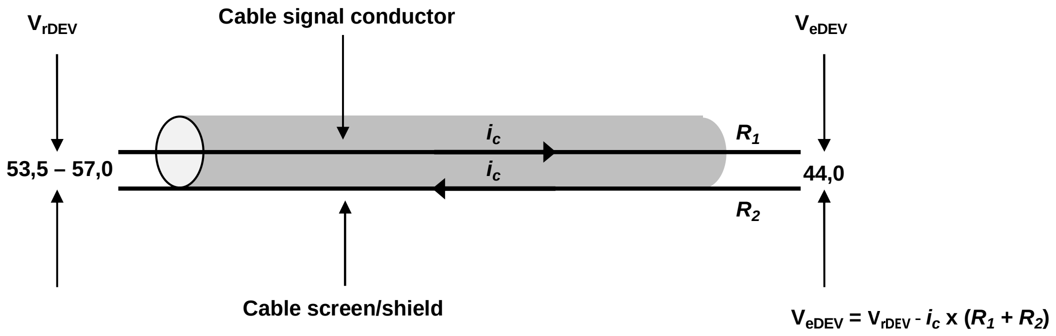

Figure 6: Voltage drops allowance and resistance modelling

Table 2 shows the maximum resistance values ($R_1 + R_2$) which enable the provision of 44,0 VDC to the eDEV for a nominal $V_{rDEV} = 55,25$ VDC.

NOTE: According to ETSI TS 105 176-2 [i.2], an eDEV is required to operate with $V_{eDEV} \geq 44,0$ VDC but may operate with $44,0 > V_{eDEV} \geq 32,0$ VDC.

Table 2: Power delivery parameters for $V_{rDEV} = 55,25$ VDC and $V_{eDEV} = 44$ VDC

Class	1	2	3	4	5	6	7	8
Conductor current (i_c) (A)	0,07	0,13	0,28	0,54	0,81	1,08	1,36	1,63
Maximum resistance ($R_1 + R_2$) (Ω)	160,7	88,8	40,4	20,7	13,8	10,4	8,3	6,9
Min eDEV received power (W)	3,2	5,6	12,3	23,9	35,8	47,8	59,7	71,7

It will be noted that the values for minimum eDEV received power in Table 2 are close to those of the powered devices in Table 1.

Using Table 2 it can be determined that a conservative approach suggests that to deliver:

- Class 3 power, the value of $R_1 + R_2$ is 40 Ω max;
- Class 4 power, the value of $R_1 + R_2$ is 20 Ω max;
- Class 6 power, the value of $R_1 + R_2$ is 10 Ω max;
- Class 8 power, the value of $R_1 + R_2$ is 6 Ω max.

NOTE: If V_{eDEV} = 32,0 VDC is considered, the maximum resistance values ($R_1 + R_2$) double but the eDEV received power falls by approximately 28 %.

Table 3 shows the maximum lengths associated with the maximum DC loop resistance values for remote powering Classes 3, 4, 6 and 8.

Table 3: Maximum lengths at DC loop resistance limits

Class	3	4	6	8
Maximum resistance ($R_1 + R_2$) (Ω)	40	20	10	6
Cable specification (max)				
$R_1 + R_2 \leq 18$ Ω /km	2 200 m	1 100 m	550 m	333 m
$18 < R_1 + R_2 \leq 27$ Ω /km	1 480 m	740 m	370 m	222 m
$27 < R_1 + R_2 \leq 36$ Ω /km	1 100 m	550 m	275 m	167 m

4.3.4 Point-to-point implementations

In a point-to-point implementation, the eDEV is typically connected to the end-point of the coaxial cable. Table 3 indicates the maximum lengths for the various power Classes and reference DC loop resistance values of coaxial cables. The calculations assume all eDEVs at the remote end of the coaxial cable.

However, an eDEV could be connected at any intermediate point of the cable without any detrimental issue to the powering budget, but only causing some variation in the observed data throughput on the cabling due to impairment on the transmission given by the reflections from the stub (the remaining branch of cable).

4.3.5 Bus implementations

The number of eDEVs that can be connected to a bus is limited by the electrical power made available by the rDEV such that:

- a bus fed by a Class 6 rDEV (60 W) can support up to four Class 3 eDEVs or two Class 4 eDEVs;
- a bus fed by a Class 8 rDEV (90 W) can support up to six Class 3 eDEVs or three Class 4 eDEVs;
- a Class 6 and Class 8 rDEV can support many more eDEVs that are less energy demanding e.g. at least ten Class 2 eDEVs or twenty Class 1 eDEVs.

In linear bus installations each powered device can be independently connected, either distributed or clustered, at any position along the length of coaxial cable.

As defined in ETSI TS 105 176-2 [i.2], a linear bus implementation accepts the addition or replacement of an eDEV on any operating network without generating any impairment to the activity of the bus ("hot-plug" capability).

4.4 Upgrade of legacy coaxial solutions

The upgrade of legacy analogue Video Surveillance Systems (VSS) to IP-based VSS takes advantage of the ability to maintain and use the existing cabling and the fixtures where analogue cameras can be directly replaced with IP cameras by avoiding:

- the removal and costly eco-compatible disposal of the existing cabling and associated materials;

- the risks of damage to other cabling (such as that shown in Figure 7) and equipment along the path which, in turn, risks disruption to the other services;
- the procurement, installation and deployment of new cabling, associated materials and equipment (e.g. repeaters).

The latter is important in cases, such as mass transit environments, where the removal and installation of cabling and equipment is not compatible with the service operation. This restricts the length of time when such work can be undertaken.

E&PoC technology ensures safer and more reliable delivery of power to the eDEVs and provides a robust, manageable and interoperable infrastructure. The installation of a centralized UPS serving rDEV equipment enables simple and cost-effective solution providing increased VSS reliability.

Figure 7: Cable congestion under platforms

4.5 "New build" coaxial solutions

Installing a new VSS based on coaxial cable can take advantage of the following:

- extended transmission distances, in some cases beyond 1 000 m, avoids installing multiple rDEVs/repeaters distributed across the area under surveillance;
- simplified installation by removing the need to install an energy cabling along the route of the transmission cables which reduces costs and avoiding the separate management of LV installation operatives in conjunction with those of the VSS;
- improved service availability by the installation of centralized UPS at the rDEV.

As a result, E&PoC technology can offer more reliable delivery of power to rDEV and eDEV equipment - providing a robust, manageable and interoperable infrastructure. In addition, the safety aspects of the VSS is improved since no LV cabling is required.

5 Implementation of VSS using IP and remote powering over coaxial cables

5.1 General

The configuration information of this clause is used in the benefit analysis of clause 6 and the example implementations of Annex A.

5.2 Use case for Class 3 devices

5.2.1 Point-to-point implementation

Installing a Class 3 eDEV in point-to-point configuration can reach very long distances, even exceeding distances found in many VSS applications. It enables using a single rDEV, thus simplifying the overall architecture, minimizing costs and granting high service availability.

According to Table 3, when using low resistance coaxial cable with $R_1 + R_2 \leq 18$ Ω/km, transmission distances exceeding 2 000 m can be achieved. Transmission distances in excess of 1 000 m can even be achieved with cables with $R_1 + R_2 = 36$ Ω/km.

5.2.2 Linear bus implementation

Installing a bus implementation to connect Class 3 eDEVs enables feeding multiple equipment along the path while still compatible with the distances found in many VSS applications It maintains service delivery while reducing cost for procuring and installing additional cables from the rDEV as new cameras are required.

According to Table 3, when using low resistance coaxial cable with $R_1 + R_2 \leq 18$ Ω/km:

- a Class 6 rDEV can support up to four Class 3 eDEVs over a cable length in excess of 500 m (and a lower number of Class 3 eDEVs over a greater distance);
- a Class 8 rDEV can support up to six Class 3 eDEVs over distances of 330 m (and a lower number of Class 3 eDEVs over a greater distance).

5.3 Use case for Class 4 devices

5.3.1 Point-to-point implementation

Installing a Class 4 eDEV in point-to-point configuration can reach very long distances, even exceeding distances found in many VSS applications. It enables using a single rDEV, thus simplifying the overall architecture, minimizing costs and granting high service availability.

According to Table 3, when using low resistance coaxial cable with $R_1 + R_2 \leq 18$ Ω/km, transmission distances exceeding 1 000 m can be attained. Transmission distances of greater than 500 m can even be achieved with cables with $R_1 + R_2 = 36$ Ω/km.

5.3.2 Linear bus implementation

Installing a bus implementation to connect Class 3 eDEVs enables feeding multiple equipment along the path while still compatible with the distances found in many VSS applications. It maintains service delivery while reducing cost for procuring and installing additional cables from the rDEV as new cameras are required.

According to Table 3, when using low resistance coaxial cable with $R_1 + R_2 \leq 18$ Ω/km:

- a Class 6 rDEV can support up to two Class 4 eDEVs over a cable length in excess of 500 m;
- a Class 8 rDEV can support up to three Class 4 eDEVs over distances of 330 m (and a lower number of Class 4 eDEVs over a greater distance).

5.4 Use case (point-to-point) for Class 6 devices

Installing a Class 6 eDEV in point-to-point configuration can reach long distances, compatible with distances found in many VSS applications. It enables a single rDEV to be used, thus simplifying the overall architecture, minimizing costs and granting high service availability.

According to Table 3, when using low resistance coaxial cable with $R_1 + R_2 \leq 18$ Ω/km, transmission distances exceeding 550 m can be attained.

5.5 Use case (point-to-point) for Class 8 devices

Installing a Class 8 eDEV in point-to-point configuration can reach long distances, compatible with distances found in many VSS applications. It enables a single rDEV to be used, thus simplifying the overall architecture, minimizing costs and granting high service availability.

According to Table 3, when using low resistance coaxial cable with $R_1 + R_2 \leq 18$ Ω/km, transmission distances exceeding 330 m can be attained.

6 Benefit analysis overview

6.1 General

This clause analyses the advantages and disadvantages of three solutions for the provision of IP VSS:

- Ethernet & Power over Coax (E&PoC) technology using the implementations of clause 5;
- balanced cabling length with transmission distances limited to 100 m in accordance with the specifications of IEEE 802.3 [i.3] - beyond which repeaters will be required;
- wireless networks, for example Wi-Fi™ implementations operating at 5 GHz - the high throughput involved and the need to minimize disturbances from external networks results in comparatively short reach - requiring the installation of numerous Wireless Access Points (as many as one for every 2 or 3 cameras) together with associated signal transmission cabling and the provision of LV AC power supplies.

NOTE: The present document applies the term Wireless Access Point (WAP) to any device providing a similar network function to a Wi-Fi™ WAP independent of type of wireless network used.

The data of clauses 6.2 and 6.3 show that the points of strength of the coaxial implementation are the extended reach, that avoids costly and complex installation of intermediate rDEVs/repeaters and the bus support that minimizes the amount of cabling and installation needed, while increasing flexibility for future modifications/addition of end-devices.

6.2 Cost of ownership

6.2.1 Factors

For the purposes of this clause, the cost of ownership includes the early phase of design, installation, operation and the maintenance of E&PoC networks.

In addition to the active equipment, this clause evaluates the impact of the passive part of the network i.e. the cabling and installation elements as they have substantive share of the total footprint.

6.2.2 Design

Table 4 in clause 6.2.6 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

The design phase includes a wider set of actions in preparation to the installation of a network. It includes studies, design project definition and procurement decisions regarding equipment and services. Although the material cost and environmental impacts are typically minor, it is a highly time-consuming phase.

6.2.3 Installation

Table 5 in clause 6.2.6 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

When upgrading from an analogue coaxial cabling network, the installation phase includes the costs to dispose of the analogue cameras and the legacy centralized receiver/recorder equipment. As this action applies in the same way to all the networking technologies, it has not been detailed in Table 5 in clause 6.2.6.

However, when the new networking technology is balanced cable or WiFi™, the installation phase includes also the activities to remove and dispose of the legacy coaxial cables. This is technology-specific and is included in Table 5.

6.2.4 Operation

Table 6 in clause 6.2.6 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

The operational phase includes the typical actions on cameras when configuring, testing, restarting (switching off and on) and applying typical operation and management actions.

6.2.5 Maintenance

Table 7 in clause 6.2.6 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

Maintenance of IP VSS includes both the repair actions and any modification/expansion of the cameras and the cabling infrastructure for reasons including:

- moving camera positions to avoid black-spots;
- adapting position to match transmission system reach;
- adding cameras to improve visual coverage of the site;
- adding cameras to extend coverage, etc.

Maintenance activities should minimize disturbances to the proper operation of the VSS.

6.2.6 Results of benefit analysis

This clause includes the tabulated results of the various aspects detailed in clauses 6.2.2 to 6.2.5 applied to the three technical solutions.

Table 4: Cost of Ownership: design phase

	E&PoC (coaxial cable)	Ethernet (balanced cable)	Wireless
Upgrading an existing analogue network	👍 simple and quick as the design phase is limited to the procurement of new active equipment	👍 offers native support of high availability VSS	👍 simple and quick as new active equipment could use the existing LV AC supply
	👍 simple~~r~~ design of camera powering than analogue VSS	👎 redesign of cabling architecture and provision of intermediate switches for extended distances	👎👎 difficulty in planning long-term requirements for the number of WAPs
	👍 offers native support of high availability VSS	👎 surge protection for cabling and equipment for outdoor locations (e.g. surface transportation)	👎 variable wireless coverage and interference from non-licensed ISM bands
	👍 bus structure-supports installation of additional cameras without additional cabling		👎 WAPs (see note) require LV AC cabling
			👎 additional cameras requires additional LV AC cabling
			👎 no support of high availability VSS
Designing a new network	👍 utilizes established specifications for coaxial cable installation	👍 offers native support of high availability VSS	👎👎 design of LV AC cabling required for WAPs (see note) and cameras
	👍 offers native support of high availability VSS	👎 redesign of cabling architecture and possible installation of intermediate switches to extend range	👎👎 difficulty in designing to support long-term requirements for the number of WAPs
	👍 uses LV AC power only at the rDEV location (even for large VSS)		👎 variable wireless coverage and EMI from non-licensed Industrial, Scientific and Medical (ISM) bands
			👎 no support of high availability VSS
NOTE: Unless implemented by remote powering over balanced cabling.			

Table 5: Cost of Ownership: installation phase

	E&PoC (coaxial cable)	Ethernet (balanced cable)	Wireless
Upgrading an existing analogue network	👍👍👍 low cost, only replacing rDEV and cameras 👍 bus structure supports installation of additional cameras without additional cabling 👍 avoids eco-compatible disposal of cables and accumulated coatings of dust, grease and potential dangerous materials and associated safe practices	👎👎👎 installation of balanced cabling and intermediate switches for extended distances 👎👎👎 removal and eco-compatible disposal of the existing coaxial cabling 👎 surge protection for cabling and equipment for outdoor locations (e.g. surface transportation)	👍 simple and quick as replacement cameras can use the existing LV AC supply 👎👎👎 installation of WAPs which require: • signal cabling connecting the WAPs to the control centre; • LV AC (see note) cabling 👎 removal and eco-compatible disposal of the existing coaxial cabling 👎 variable wireless coverage and EMI can require installation of additional WAPs and camera locations 👎 installation of LV AC cabling for WAPs (see note) and additional cameras 👎 obtaining necessary working permits for LV AC equipment impacts installation time
Installing a new network	👍 utilizes established specifications ~~on~~ for coaxial cable installation 👍 offers native support of high availability VSS 👍 installation of LV AC cabling only at the rDEV location, independent of VSS dimensions 👎👎 installation of coaxial cabling	👍 offers native support of high availability VSS 👎👎👎 installation of balanced cabling and intermediate switches for extended distances	👍 simple and quick as no transmission cabling is needed 👎👎👎 installation of WAPs and connection to the control centre 👎👎 installation of LV AC cabling 👎 variable wireless coverage and EMI from non-licensed ISM bands 👎 no support of high availability VSS 👎 obtaining necessary working permits for LV AC equipment impacts installation time

NOTE: Unless implemented by remote powering over balanced cabling.

Table 6: Cost of Ownership: operational phase

	E&PoC (coaxial cable)		Ethernet (balanced cable)		Wireless	
Operating an IP VSS	👍👍	support for Quality of Service (QoS) and infrastructure availability necessary for security services	👍👍	support for QoS and infrastructure availability necessary for security services	👎👎	QoS for some cameras can be impacted by changes to the local EMI environment
	👍	simple, remote and automatic ability to manage cameras and to apply hard reset in case of software issues on remote elements	👍	simple remote and automatic ability to apply hard reset in case of software issues on the camera	👎	privacy and security issues due to perceived weakness of Wi-Fi security
	👍	opportunity for dual camera installation reduces need for urgent intervention	👎	need to operate and manage the intermediate switches and their UPSs	👎	urgent intervention necessary following intentional signal "jamming"
	👍	native encryption preventing unauthorized signal monitoring	👎	EMI from transportation systems can impair QoS and can damage equipment	👎	local intervention to perform hard reset (power cycling) where necessary

Table 7: Cost of Ownership: maintenance phase

	E&PoC (coaxial cable)		Ethernet (balanced cable)		Wireless	
Maintaining an IP VSS	👍👍	no network interruption during general LV AC maintenance procedures	👎👎	if repeaters are used, network interruption during general LV AC maintenance procedures	👎👎	network interruption during general LV AC maintenance procedures
	👍	bus structure supports installation of additional cameras without additional cabling	👎👎	changing a camera position can require~~s~~ the modification of a balanced cable route, or the installation of an additional balanced cable and can require the installation of an additional switch	👎👎	QoS issues caused by local EMI environments are complex to resolve and may require extended periods of service disruption
	👍	hot swap support simplifies operations on cameras installed on the bus structure	👎👎	adding a camera requires the installation of an additional balanced cable and can require the installation of an additional switch	👎	adding a camera or changing a camera position require~~s~~ the extension or modification of the LV AC cabling

6.3 Environmental impact

6.3.1 Factors

For the purposes of this clause, the environmental impact covers material consumption, energy performance and end-of-life of VSS.

6.3.2 Material consumption

Table 8 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

Material consumption analysis is focused on the steps that differentiate the various types of networks (cabling, networking equipment with regard to what can be retained and what has to be removed).

The removal of analogue equipment, the installation of the equipment at control centres and of the cameras have been excluded as they are common to all networking technologies.

Table 8: Environmental impact: material consumption

	E&PoC (coaxial cable)	Ethernet (balanced cable)	Wireless
Upgrading an existing analogue network	👍👍👍 re-use of existing coaxial cables	👎👎👎 installation of balanced cabling and intermediate switches for extended distances	👍👍👍 re-use of existing LV AC cabling
	👍👍 bus structure supports installation of additional cameras without additional cabling	👎 surge protection for cabling and equipment for outdoor locations (e.g. surface transportation)	👎 variable wireless coverage issues and EMI can require the installation of additional WAPs which require: • signal cabling connecting the WAPs to the control centre; • LV AC (see note) cabling
Installing a new network	👍👍 bus structure supports installation of additional cameras without additional cabling	👍 no requirement for LV AC cabling to cameras	👎👎 installation of LV AC cabling to WAPs (see note) and cameras
	👍 no requirement for LV AC cabling to cameras	👎👎👎 installation of balanced cabling and intermediate switches for extended distances	👎 variable wireless coverage issues and EMI can require the installation of additional WAPs which require LV AC cabling
	👍 no requirement for distributed switches, avoiding extra backup systems	👎 surge protection for cabling and equipment for outdoor locations (e.g. surface transportation)	
	👎👎 installation of coaxial cabling		
NOTE: Unless implemented by remote powering over balanced cabling.			

6.3.3 Energy performance

Table 9 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

Energy consumption of cameras is mainly driven by the consumption of their heaters and infra-red lighting. It is expected to be generally similar among the various transmission technologies. As applies in the same way to all the networking technologies, it has not been detailed in Table 9.

Cabled technologies can take advantage on capability of the rDEV to power-off the cameras during the periods when the VSS is not required. Similarly, Wi-Fi cameras could switch off their main functions. However, this is not considered in Table 9 as most applications of VSS require continuous surveillance/monitoring.

Table 9: Environmental impact: energy performance

	E&PoC (coaxial cable)	Ethernet (balanced cable)	Wireless
Energy performance of an IP video surveillance network	👍 the centralized structure (a single rDEV) enables more energy efficient deployment of UPS function to support high QoS 👎 powering losses over the coaxial cabling depend on the DC loop resistance of the cable and are proportional to its length	👎 powering losses over the balanced cabling depend on the DC loop resistance of the cable and are proportional to its length and the presence of repeaters 👎 the limited length of the transmission system requires to install and power intermediate switches to extend range, thus requiring deployment of multiple, less energy efficient UPS to support high availability	👎 variable wireless coverage issues and EMI can require the installation of additional WAPs which increase the overall energy consumption

6.3.4 End-of-life

Table 10 indicates the advantages and disadvantages of the different solutions. The number of 👍 or 👎 symbols indicates the scale of the advantages and disadvantages respectively.

When upgrading from an analogue coaxial cabling network, the removal and disposal of the analogue cameras and the legacy centralized receiver/recorder equipment applies in the same way to all the networking technologies, and it has not been detailed in Table 10.

End-of-life of existing cabling is relatively costly as handling the cabling has to be done with care as it will be coated with dust and pollutants accumulated over the years. They have to be removed by specialists and disposed of in appropriate waste facilities to avoid harm to people and the environment.

When installing a new network, no end-of-life of any element is involved.

Table 10: Environmental impact: End-of-Life

	E&PoC (coaxial cable)	Ethernet (balanced cable)	Wireless
Upgrading an existing analogue network	👍👍👍 no action needed on coaxial cabling 👎 optional removal and eco-compatible disposal of the legacy LV AC cabling	👎👎👎 removal and eco-compatible disposal of the legacy coaxial cabling 👎 optional removal and eco-compatible disposal of the legacy LV AC cabling	👍👍👍 no action needed on powering cabling 👎 removal and eco-compatible disposal of the legacy coaxial cabling

Annex A: Application cases

A.1 General

The application cases of this annex have been developed to compare the delivery of Ethernet signals and DC power using:

a) coaxial cable (E&PoC)

b) balanced cable (using cables of Category 5, and above, in accordance with CENELEC EN 50173-1 [i.1] within which conductors are required to have DC resistance ≤ 9,5 Ω/100 m).

NOTE: The wireless solution has been excluded, as its known weaknesses with regard to EMI and susceptibility to poor mains power quality are not considered acceptable for the service to be supported.

The tables in this annex indicate the main characteristics affecting the installation costs of the networks.

The coaxial cable case assumes half of the cameras are connected on a bus structure supporting three cameras and the other half are connected on a bus structure supporting six cameras. The balanced cable case is limited to a transmission distance of 100 m.

A.2 Underground station implementation

A typical and simple underground station has been considered as shown in Figure A.1. The details of the infrastructure are shown in Table A.1. The comparative network installation characteristics are shown in Table A.2.

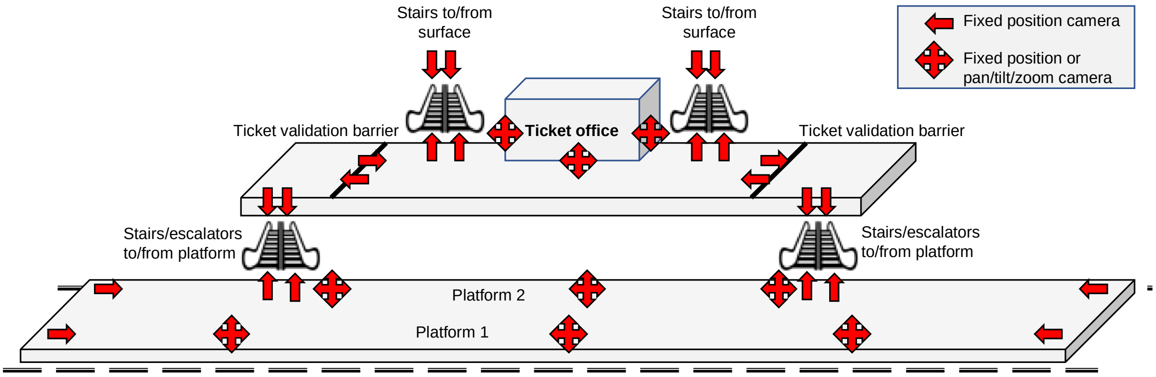

Figure A.1: Underground station example

Table A.1: Underground station infrastructure

Min-max coaxial cable distance of cameras from main receiver station	20 m to 220 m
Average cable distance of cameras from main receiver station	70 m
Platform length	200 m
Number of platforms	2
Camera locations and quantities: 4 entrances (stairs) - 8 cameras ticket office area - 3 cameras 4 stairs/escalators - 8 cameras ticket validation barriers - 4 cameras 2 platforms - 10 cameras	
Total number of cameras	33

Table A.2: Main characteristics affecting the network installation costs

Feature	Model	
	Coaxial	Balanced
Number of ports at the main rDEV	9	23
Number of additional intermediate rDEVs/repeaters, including housing, powering, UPS	-	1
Number of ports at the additional intermediate rDEVs/repeaters	-	10
Total length of the transmission cable	750 m	2 000 m

A.3 Small train station implementation

A typical and simple rural village station has been considered as shown in Figure A.2. The details of the infrastructure are shown in Table A.3. The comparative network installation characteristics are shown in Table A.4.

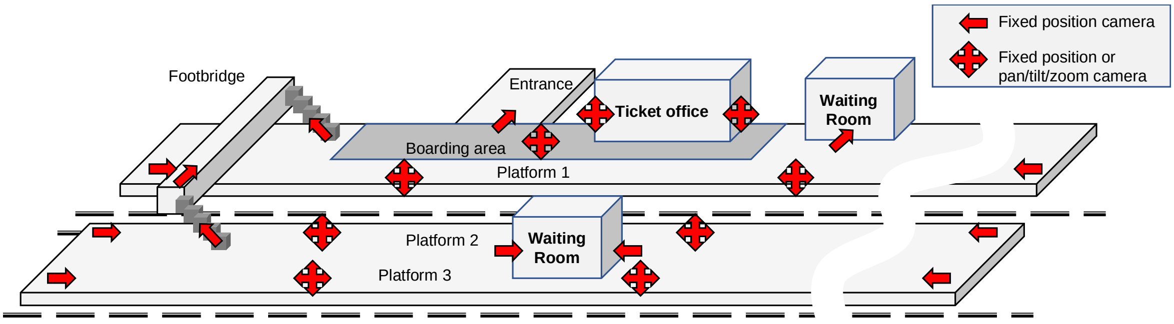

Figure A.2: Rural village station example

Table A.3: Rural village station infrastructure

Min-max coaxial cable distance of cameras from main receiver station	20 m to 240 m
Average cable distance of cameras from main receiver station	100 m
Platform length	300 m
Number of platforms	3
Camera locations and quantities: • entrance - 1 camera • ticket office area - 2 cameras • waiting room - 3 cameras • boarding area - 1 camera • 1 stair/escalator/tunnel - 3 cameras • 3 platforms - 12 cameras	
Total number of cameras	22

Table A.4: Main characteristics affecting the network installation costs

Feature	Model	
	Coaxial	Balanced
Number of ports at the main rDEV	6	10
Number of additional intermediate rDEVs/repeaters, including housing, powering, UPS	-	2
Number of ports at the additional intermediate rDEVs/repeaters	-	12
Total length of the transmission cable	720 m	1 300 m

A.4 Medium-sized train station implementation

A typical train station in a small city and in an urban area has been considered as shown in Figure A.3. The details of the infrastructure are shown in Table A.5. The comparative network installation characteristics are shown in Table A.6.

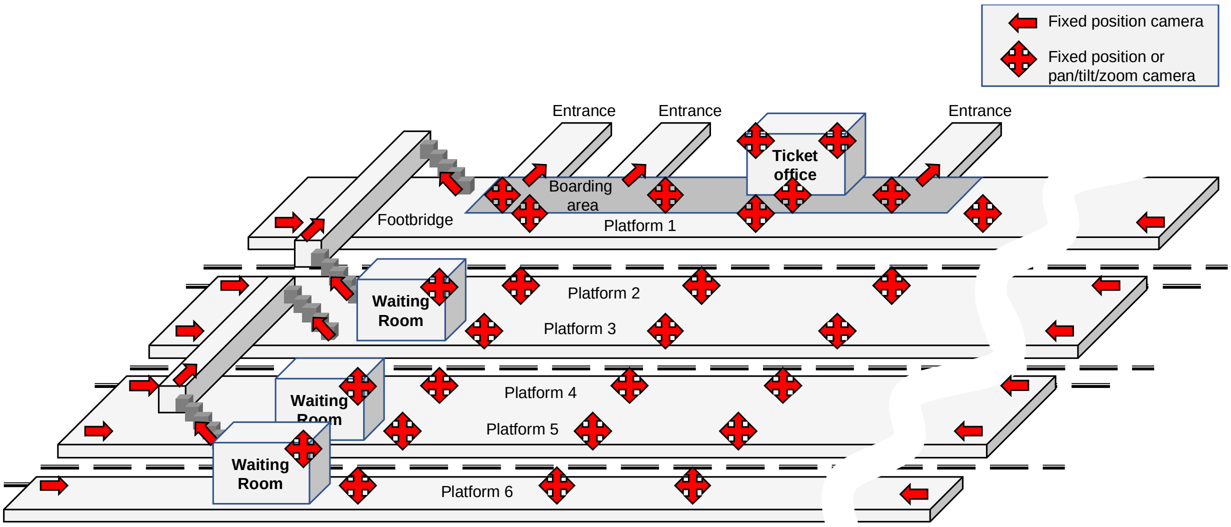

Figure A.3: Medium-sized station example

Table A.5: Medium-sized station infrastructure

Min-max coaxial cable distance of cameras from main receiver station	20 m to 260 m
Average cable distance of cameras from main receiver station	130 m
Platform length	350 m
Number of platforms	6
Camera locations and quantities: • entrances - 3 cameras • ticket office area - 2 cameras • waiting room - 3 cameras • boarding area - 4 cameras • 2 stairs/escalators/tunnels - 6 cameras • 6 platforms - 30 cameras	
Total number of cameras	48

Table A.6: Main characteristics affecting the network installation costs

Feature	Model	
	Coaxial	Balanced
Number of ports at the main rDEV	12	18
Number of additional intermediate r rDEVs/repeaters, including housing, powering, UPS	-	4
Number of ports at the additional intermediate rDEVs/repeaters	-	30
Total length of the transmission cable	1 900 m	2 900 m

A.5 Mass transit - large train station implementation

A typical train station in a large city has been considered as shown in Figure A.4. The details of the infrastructure are shown in Table A.7. The comparative network installation characteristics are shown in Table A.8.

Figure A.4: Large city station

Table A.7: Large city station infrastructure

Min-max coaxial cable distance of cameras from main receiver station	40 m to 600 m
Average cable distance of cameras from main receiver station	160 m
Platform length	450 m
Number of platforms	20
Camera locations and quantities: • entrances - 8 cameras • ticket office area - 6 cameras • shopping areas - 10 cameras • waiting rooms - 8 cameras • boarding area - 10 cameras • 20 platforms - 180 cameras	
Total number of cameras	222

Table A.8: Main characteristics affecting the network installation costs

Feature	Model	
	Coaxial	Balanced
Number of ports at the main rDEV	56	18
Number of additional intermediate rDEVs/repeaters, including housing, powering, UPS	-	8
Number of ports at the additional intermediate rDEVs/repeaters	-	168
Total length of the transmission cable	10 800 m	13 300 m

A.6 Other surveillance applications

Surveillance systems comprise a large variety of purposes and configurations but can be broadly categorized as being one, or a combination, of the following:

- linear (e.g. along a road or in a tunnel);
- dispersed (e.g. covering an area such as a building site, industrial area);
- multi-level dispersed (e.g. covering an area with multiple directly connected floors e.g. multi-level car park or museum).

The ability of the coaxial cabling solutions of the present document to support eDEVs both in point-to-point and linear bus implementations enables community surveillance systems to be installed in the necessary configurations and over extended distance without the need to separately install LV cabling.

Table A.9 shows a "linear" example of a tunnel of length 1 000 m which requires the use of optical fibre, rather than balanced, cabling. This approach will also require LV AC supply to each camera.

Table A.9: Linear example - Tunnel

Configuration and relevant parameters		
Length		1 000 m
No of monitored routes		2
Camera locations and quantities: • entrances - 4 cameras • interior - 20 cameras		
Total number of cameras		24
Main characteristics affecting the network installation costs		
Feature	**Model**	
	Coaxial	**Optical fibre**
Number of ports at the main rDEV	6	24
Total length of the transmission cable	3 600 m	12 000 m

Table A.10 shows a "dispersed" example of an industrial site.

Table A.10: Dispersed example - Industrial site

Configuration and relevant parameters		
Area per level		150 m x 100 m
No of monitored spaces per level		1
Camera locations and quantities: • perimeters and entrances - 14 cameras • interior - 20 cameras		
Total number of cameras		34
Main characteristics affecting the network installation costs		
Feature	**Model**	
	Coaxial	**Balanced**
Number of ports at the main rDEV	9	20
Number of additional intermediate rDEVs/repeaters, including housing, powering, UPS	-	2
Number of ports at the additional intermediate rDEVs/repeaters	-	14
Total length of the transmission cable	1 080 m	2 040 m

Table A.11 shows a "multi-level dispersed" example of a car park with 5 floors.

Table A.11: Multi-level dispersed example - Car park

Configuration and relevant parameters		
No. of levels		5
Area per level		80 m x 50 m
No of monitored spaces per level		1
No of interconnecting stairs per level		2
Camera locations and quantities: • perimeters and entrances - 4 cameras • stairs - 10 cameras • interior - 30 cameras		
Total number of cameras		44
Main characteristics affecting the network installation costs		
Feature	**Model**	
	Coaxial	**Balanced**
Number of ports at the main rDEV	11	30
Number of additional intermediate rDEVs/repeaters, including housing, powering, UPS	-	1
Number of ports at the additional intermediate rDEVs/repeaters	-	14
Total length of the transmission cable	1 320 m	2 640 m

Table A.12 shows a "multi-level dispersed" example of a museum with 4 floors but with many separate spaces each of which requires to be monitored.

Table A.12: Multi-level dispersed example - Museum

Configuration and relevant parameters		
No. of levels		4
Area per level		40 m x 20 m
No of monitored spaces per level		60
Camera locations and quantities: • perimeters and entrances - 12 cameras • interior - 100 cameras		
Total number of cameras		112
Main characteristics affecting the network installation costs		
Feature	**Model**	
	Coaxial	**Balanced**
Number of ports at the main rDEV	28	60
Number of additional intermediate rDEVs/repeaters, including housing, powering, UPS	-	1
Number of ports at the additional intermediate rDEVs/repeaters	-	52
Total length of the transmission cable	2 352 m	6 720 m

History

Document history		
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