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ABSTRACT

Recent years have shown an increase in arson, theft, and vandalism committed in educational facilities resulting in a need for managers to formulate security policies. This document provides technical advice and guidance on policy for the design, specification, installation, maintenance, operation, and management of closed circuit TV (CCTV) systems in all types of educational facilities. It also includes case studies and gives elemental costs which allow estimates to be made. The appendix examines CCTV system hardware, including cameras and lenses, monitors, cabling and wiring, and types of video recorders. (GR)

Closed Circuit TV Surveillance Systems in Educational Buildings

CRIME PREVENTION IN SCHOOLS

Crime prevention in schools

Building Bulletin 75
Architects and Building Branch

DES
THE DEPARTMENT OF EDUCATION & SCIENCE

Crime Prevention in Schools

Closed Circuit TV Surveillance Systems in Educational Buildings

London: HMSO

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Introduction

1 In recent years there has been an increase in acts of arson, theft and vandalism committed in educational establishments which has resulted in the need for managers to formulate security policies. The Department of Education and Science (DES) has produced a video entitled *Schoolwatch UK* which analyses criminal threats and suggests crime prevention measures. It has also published the series called Crime Prevention in Schools with titles such as *Practical Guidance* and *Specification, Installation and Maintenance of Intruder Alarm Systems.*[1] This bulletin in the series covers closed circuit TV (CCTV) systems. It aims to provide technical advice and guidance on policy to help those responsible for design, specification, installation, maintenance, operation and management of the CCTV systems in schools, colleges, polytechnics and universities.

2 Most acts of arson, theft and vandalism occur when an establishment is unoccupied. However, security lighting and/or intruder alarms usually provide adequate protection. Security lighting deters intruders and can be a most cost-effective form of defence because often the capital cost can be partially offset against the cost of necessary outside amenity lighting.[2] Intruder alarms are a complementary form of defence during out-of-use hours.

3 CCTV systems will not normally be required in a property protected by security lighting and intruder alarms. However, where there are continuing problems and where conventional intruder alarms have not been a sufficient deterrent, CCTV systems are worth consideration.

4 The CCTV option should always be available at the earliest stage of planning to the person using the risk assessment, not only after other attempts have failed. In some cases CCTV may be considered to be the most cost-effective solution on its own or in conjunction with other systems.

5 While few schools and colleges are currently protected by CCTV, experience indicates that their presence in certain circumstances is justified and proves cost effective. Evidence suggests that, very soon after a CCTV system is installed, there are fewer criminal incidents. It seems that CCTV systems are a very good deterrent.

6 CCTV systems are now commonplace throughout the commercial sector with the smallest systems costing less than £1,000 (at 1991 prices). From the vast range of readily available equipment it is possible to provide an optimum amount of protection for any establishment at a reasonable cost.

7 A well-planned CCTV system can, in conjunction with other methods, help to provide 24-hour protection. By monitoring vulnerable parts of the premises, it can give evidence in the form of a videotape recording of the crimes taking place; staff or police may then be able to identify those who committed the crimes.

[1] Building Bulleting 67 (HMSO, 1987) and Building Bulletin 69 (HMSO, 1989).

[2] The DES is in the process of producing guidance on security lighting in educational establishments.

8 CCTV enables an area to be viewed from a remote location. The basic components of any CCTV system are the camera, the monitor and an interconnecting medium such as a cable. The camera looks at a scene and converts the picture it sees into an electrical signal which it transmits through the interconnecting medium to the monitor. The monitor receives the electrical signal and converts it back to a picture which is displayed on the screen.

9 The simplest system comprises a single black-and-white camera and monitor, but it can be made more complex by adding further cameras and monitors and incorporating additional facilities. The following paragraphs briefly describe the more common additions, which are discussed in more detail in the Appendix together with other less common facilities.

10 A **camera switching (sequencing) unit** receives the electrical signals from a number of cameras and allows the selection of the camera picture to be displayed on the screen. This can be done automatically in a sequence **(sequence switcher)** and/or manually.

11 A **time-lapse video-recorder** records the picture transmitted by the camera(s) for future review. These are very similar to domestic video-recorders except that, by not recording continuously and allowing a time-lapse between each recorded picture, the normal three-hour length of a tape can be extended to up to 480 hours (or 20 days).

12 A **video multiplexer** can be used to transmit the signals from up to 16 cameras along a single cable or to display a number of pictures on a monitor at the same time which can be simultaneously recorded.

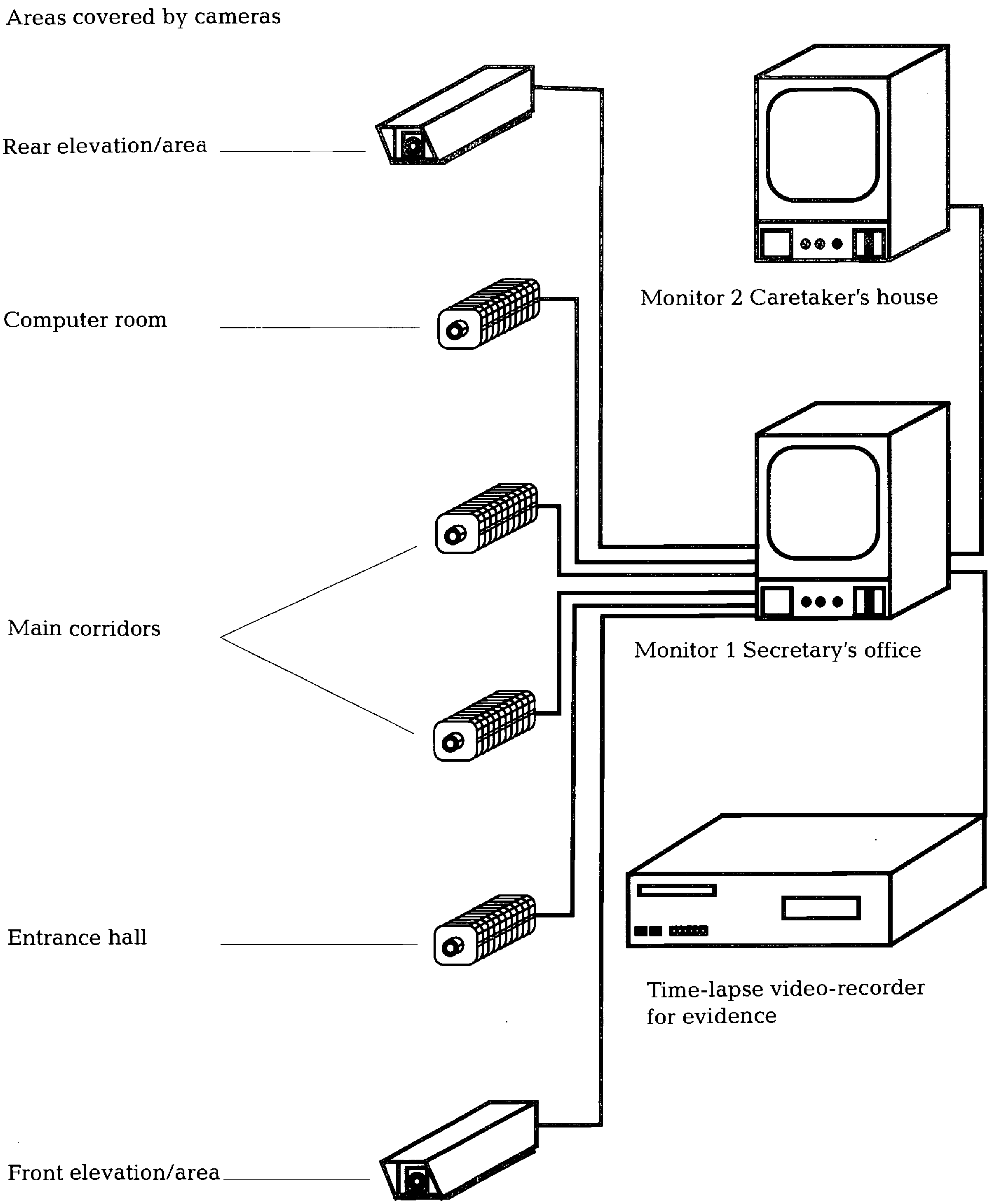
13 A **slow scan TV** system is a way of transmitting the picture seen by a camera along an ordinary telephone line to be displayed on a remote monitor.

14 A **video motion detection system** compares the picture being displayed with a record of a standard picture of the scene. Any differences produce an alarm signal which can be used to alert monitoring staff, and/or switch the recorder to real time (continuous) mode recording of the alarm scene, and/or initiate slow scan TV transmission to the remote monitoring centre wherever it may be located.

15 In general the CCTV industry produces two types of system, namely packaged systems for up to eight cameras and custom-designed systems for larger installations or those with more complex requirements.

16 The packaged systems are ideal for most sites. Figure 1 shows such a system where the desk-top monitor contains all the system controls, including power for the line-fed cameras. The only connections required are a single co-axial cable connection to each camera, the second monitor and the video-recorder.

Figure 1 A typical small CCTV system



Planning policy

17 A CCTV system is one option in an overall security policy.[3] It can be used as a deterrent, an alternative to guard patrols and for distinguishing between the nuisance and true alarms of a conventional intruder alarm system.

18 Usually CCTV systems will be targeted at high risk sites where other security measures have not provided adequate protection. One way to determine the level of risk is to carry out a risk analysis audit.[4]

19 If equipment within a local education authority (LEA) or group of educational buildings is compatible, then it will be possible to relocate equipment as the levels of risk change at different locations.

20 The need for expensive monitoring equipment such as time-lapse video-recorders, movement detection systems and slow scan TV should be carefully evaluated. For some systems their inclusion will be a costly over-provision; in others their omission may render the system virtually useless in its objectives.

21 While relatively expensive at present, there may be situations where the use of mobile systems is appropriate. One authority is developing a portable CCTV system which can be installed quickly as the need arises and then be easily relocated to meet changing needs and priorities. There is scope for establishments in the same area, which purchase and operate their own equipment, to share mobile facilities.

3 For further advice on the overall policy see *Crime Prevention in Schools: Practical Guidance* and *Crime Prevention in Schools: Specification, Installation and Maintenance of Intruder Alarm Systems.*

4 *Crime Prevention in Schools: Practical Guidance* deals with risk assessment methodology in detail.

22 Traditionally CCTV systems have been installed in commercial premises such as retail multiples where standard layouts are sometimes replicated. This approach to design is not suitable for educational buildings. Factors such as site layout, patterns of occupancy and local risk assessments are the main design criteria.

23 In order to ensure cost-effectiveness the decision to install CCTV should be based on priorities determined by a security audit. The design engineer should study the audit findings and liaise closely with the principal or headteacher, school-keeper and the local crime prevention officer. This process will help determine the most advantageous locations for cameras and the siting of monitoring equipment.

24 This liaison will allow the performance requirements to be jointly assessed. The following check-list will help in this assessment.

System design performance check-list

- What areas are to be covered, for what period (for example, 24 hour, dusk to dawn, etc.) and what degree of picture detail is required (for example, presence only or for identification)?
- What is the range of operational lighting levels (for example, day, night, indoor, outdoor, etc.), what additional lighting is required and should infra-red lighting be used?
- If there is an intruder alarm system, can the CCTV system be usefully linked to it?
- What are the physical limitations affecting the position of cameras such as the height of poles, intrusion into neighbours' privacy, dazzle from lights, the sun's arc, etc?
- How is the system to be monitored, by whom, where and when?
- What procedure is to be followed in the event of an incident?
- What will the maintenance and repair arrangements be?
- What scope is there for system expansion to provide extra functions?

25 The CCTV system must be designed to meet the essential surveillance and monitoring requirements of the establishment. Each possible additional facility of a system should be carefully evaluated. Unnecessary inclusion will result in inflated system costs, which may stop the scheme; exclusion may result in the system failing to meet its objectives.

26 In most CCTV installations the monitor screens are observed on site. Depending on local conditions it may be possible to install viewing monitors and CCTV controls inside the premises with a duplicate monitor at the school-keeper's house which can be used when the building is unoccupied. Much will depend on the geography of the site and its proximity to the school-keeper's house.

27 Remote monitoring using slow scan TV can be useful at sites suffering repeated attacks during holidays and other unoccupied periods. The high capital and recurrent costs involved can probably be justified for only those sites at exceptional risk. However, when a CCTV system is designed the possible need to add a slow scan transmitter should be considered.

28 Unless the display is continually viewed to pick up an incident, it will be detected after the event and a recording will be useful in identifying the culprit and possibly allowing action. Therefore, a video-recorder may be essential.

29 Even with continuous viewing, a person cannot concentrate for long periods. Tests have suggested that the period of concentration may be as short as 20 minutes. Consequently some method of drawing attention to an incident will be required, possibly using the intruder alarm or a video motion detection system. This can also be used to switch the video-recorder to continuous, real-time recording.

30 Despite the technical variations of CCTV systems, selecting equipment and cable terminations to ensure compatibility can improve cost-effectiveness. Purchasers should try wherever possible to standardise their CCTV design and use a few proprietary systems of both package and

custom-designed types. This will ensure competitive procurement while maintaining a degree of standardisation that will allow flexibility and the relocation of items of equipment as local levels of risk change.

31 In a typical small, packaged-type CCTV system the master monitor will contain the camera power supplies, a sequential switcher, manual switching facility and outputs to supply a second monitor and a video-recorder. A single co-axial cable is the only connection required to each line-fed camera.

32 Many CCTV systems will have input for local alarms. Detectors, either discrete or part of an intruder alarm system such as door contacts, can be wired into the system to activate the nearest camera and display it on the monitor. Some systems incorporate a multiplexer which can present all pictures simultaneously on the monitor screen. In the event of a possible security exposure the system operator can select the single picture to be displayed on the monitor screen. Figure 2 shows the operator position of a typical system with multiplexer, switcher and camera remote controller, and a time-lapse video-recorder.

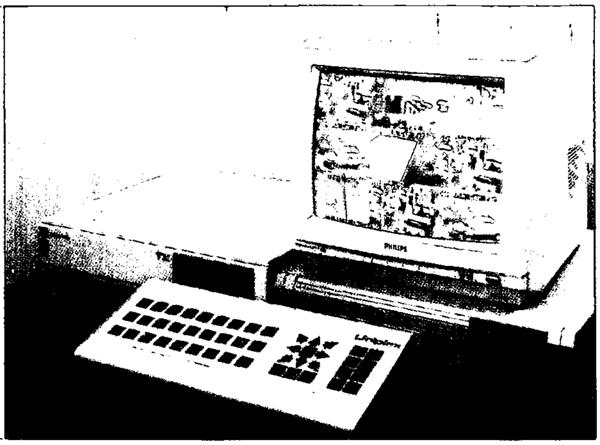


Figure 2 Operator position of a typical system

33 Custom-designed systems are more complicated and require expert design. Monitors, sequential switchers, cameras and all other system components are generally specified as separate items. In these systems the camera power supply will not normally be combined with the camera video signal. Each camera is likely to require a local mains or extra-low voltage power supply. A central extra-low voltage A.C. supply can be distributed, but care must be taken to limit voltage drop. It is recommended that all components of a CCTV system are supplied from the same phase of the electrical supply.

34 Systems can be further complicated where there is a requirement for central control of camera operation including focus, pan and tilt or a zoom lens. However, these features are not normally necessary for school and college applications. External camera locations can add requirements for a weatherproof camera housing with integral heater, washer and wiper. These additional features can add to the amount of wiring from the control position to a local relay assembly fixed close to the camera. Connections are taken from the relay assembly to the camera zoom lens and any other additional controls. The economics of providing a larger number of less expensive fixed view cameras instead of fewer mobile cameras should always be considered.

35 When designing a CCTV system thought should be given to the vulnerability of cameras. A range of casings is available to protect cameras against, for example, vandals and weather. The recently introduced Charge Coupled Device (CCD) cameras are increasingly taking the place of conventional tube cameras because of their compact size and low maintenance. Conventional tubes need replacing regularly due to progressive deterioration whereas, being electronic devices, CCD cameras do not require such a high level of maintenance. Some of these CCD cameras are weatherproof and do not need special housings for external installation.

36 The positioning of cameras both inside and out is an important part of the system design. For example, a camera located in the main entrance can be a valuable deterrent. Realistic dummy cameras can be included in installations to increase the deterrent effect of operational cameras. They can also be substituted to disguise the fact that real cameras have been moved.

37 Installation is generally carried out by CCTV equipment distributors or security system installation contractors.

38 Purchasers of multiple systems should ideally develop and maintain expertise in system design and equipment selection, together with a standard CCTV installation specification in which standards of workmanship and materials are clearly defined. The specification should be readily adaptable to accommodate particular requirements of individual CCTV installations.

39 However, keeping up-to-date in such a high technology field is time consuming and unlikely to be practical for purchasers of single systems. Therefore, purchasers may wish to invite system proposals and priced schedules of works and equipment from different suppliers. Basic performance requirements would need to be stipulated and a drawing indicating areas requiring observation together with intended monitoring arrangements should be included. This method allows suppliers to offer up-to-date technology which would then be evaluated by professional staff, including the system's capacity for expansion. The selected system proposal may then form the basis of the installation contract.

40 The most economic installation arrangement may be by outright purchase and not tied to a rental agreement or exclusive maintenance contract. Outright purchase allows the buyer to employ a contractor other than the installing contractor to carry out later alterations or maintenance. With this in mind prospective CCTV equipment suppliers should confirm that they make spare parts available to their competitors who may maintain systems of various manufacture.

41 However, purchasers may be able to secure economic long-term rental agreements which will allow the system to be up-dated, either in line with technological developments or when equipment becomes obsolete. Life cycle costings should be prepared to evaluate the economics of the options.[5] In such cases it is sensible to make provision in the contract for taking over ownership of the cable installation in case the agreement is terminated. It is essential that the cable installation satisfies the requirements of the equipment of a number of suppliers in case of a later change.

42 The completed CCTV system should be functionally and technically tested in full to ensure compliance with design intentions. Signal levels should be monitored and control voltages confirmed to be within the ideal working parameters of cameras and other equipment. Devices are available to help with the specification of equipment and to verify actual coverage after initial installation and during later maintenance.[6] The contract should require that the installing contractor provide all testing equipment and fully instruct the users of the system in its operation. Detailed maintenance and operating documents should be provided before the installation is accepted as handed over.[7]

43 The effectiveness of a CCTV system should be monitored after its installation. Some LEAs have formed security liaison groups, which include the education department, treasurer's department, property services, the LEA's insurance company and local police. One function of these groups has been to monitor the effectiveness of intruder alarms and other measures. CCTV can be monitored in the same way, but its particular ability to reduce crime when the building is both occupied and empty should be taken into account.

5 *Maintenance and Renewal in Educational Buildings: Maintenance of Mechanical Services*, Building Bulletin 70 (HMSO, 1990).

6 See *The Rotakin: A Test Target for CCTV Security Systems*, Police Scientific Development Branch, Publication 16/89.

7 See *Maintenance and Renewal in Educational Buildings: Maintenance of Mechanical Services.*

Maintenance policy

44 CCTV systems are used more intensively than domestic television sets. Poor quality pictures cannot be tolerated so replacements are necessary as components deteriorate. Monitor screens and camera tubes can become ineffective before they fail completely. Typically camera tubes need to be replaced every one or two years (an average life is 12,000–14,000 hours with 24-hour operation) and screens every five to seven years. There is a growing trend away from tube cameras to the more recently introduced CCD cameras which are solid state devices and have a much longer life expectancy (an average life is 100,000 hours with 24-hour operation). Although most CCTV and ancillary equipment is highly reliable, periodic checks and adjustments are necessary to maintain the optimum operating standards and prevent deterioration which would make the system ineffective.

45 The level of maintenance must be appropriate to the technical sophistication of the equipment installed. It is important to be able to get maintenance on competitive terms. Tender documents should list the CCTV equipment at the various locations and specify the level of maintenance and service required. The maintenance and operating documents received before hand-over will help. Typically there will be two service visits a year to check and adjust the system. After such a visit the service company should issue a report of recommendations for equipment which is deteriorating. Records should be kept of faults so that fault rates can be calculated and preventative maintenance can be planned. If records of failures are supplied to a national organisation or user group then the information can be usefully shared.

46 In case of a camera failure, it may be advisable to keep a spare which can be installed by a semi-skilled person. Spare cameras and monitors should be energised from time to time, for example for 24 hours every six months, to prevent deterioration.

47 Tender documents should include a schedule of rates covering all engineer call-outs, typical repairs and all replaceable items such as monitor screens and camera tubes. Tenderers should then complete the schedule of rates with their own proposed charges. The response time for emergency maintenance should also be stated in the tender return.

48 If extensive CCTV provision is planned, the tender package should be subdivided into groups of establishments with CCTV. This division will allow different groups to tender at different times and for comparisons to be made between service companies.

49 The tender documents should also make clear the level of on-site support available to the service contractor. For example, a service contractor may be unwilling to provide basic equipment such as step-ladders or other access items. Also contractors may refuse to work on cameras or other equipment above a specified height. Such exclusions must be known before a contract has been signed. Therefore, the contractual terms of the tender documents must be specific on all points. Some companies wrote their own terms on a 'take it or leave it' basis, but with the increase in competition they are now willing to provide the customer's required level of service.

Budget costs

50 The following prices give an indication of costs in 1991.

Monochrome camera without lens		Monitor	£200 – 600
$^1/_2$" CCD	£400 – 1,200	Video-recorder (domestic type)	£500
$^2/_3$" CCD	£400 – 1,000	Time-lapse video-recorder	£2,000
with $^2/_3$" Vidicon tube	£300 – 800	Camera switcher (sequencer)	£450
with $^2/_3$" Newvicon tube	£650 – 1,500	Camera controller (of pan, tilt, zoom) – eight-way	£550 – 700
with Silicon Intensified tube	£3,000	Video motion detection system	£1,000 – 6,000
$^1/_2$" fixed lens	£ 50 – 300	Slow scan transmitter	£3,400 – 7,500
$^2/_3$" fixed lens	£ 50 – 400	Slow scan receiver	£5,500 – 8,000
Zoom lens (motorised)	£600 – 2,000	Cabling	
Static mounting and housing	£250 – 600	co-axial	£30 per 100m
Mobile mounting and housing	£500 – 1,500	20 core control cable	£50 per 100m
		ducting	£300 – 1,000 per 100m

Typical cost of a simple external system comprising

four CCD cameras with fixed lens and external housings
four-way camera switcher (sequencer)
monitor
cabling — £1,200 – 2,500 per camera

Typical cost of a complex external system comprising

four CCD cameras with
- external housings with pan and tilt
- zoom lens
- telemetry receivers
- infra-red lighting

monitor
camera controller and switcher (sequencer)
time-lapse video-recorder — £3,500 – 10,000 per camera

Comprehensive annual maintenance (excluding camera tubes, infra-red lamps and video-recorder heads)

for simple system described above — from £120 per camera per annum

for complex system described above — from £350 per camera per annum

Case study 1

51 A primary school for 346 pupils in an urban area suffered badly from out-of-hours arson, vandalism and break-ins. The LEA decided to install a CCTV system in an attempt to reduce these incidents. Since installing the system two years ago, incidents of vandalism and theft have stopped completely.

52 The system consists of six mains voltage auto-iris cameras in protective housings. The cameras are mounted at a high level and cover all external facades on the building. The layout is shown in Figure 3.

53 All signals are sent to a remote switcher mounted on the roof. From here the monitor signal and switcher control cables are fed to the headteacher's study. In the study, the video signal passes via a time-lapse video-recorder onto a monitor. At this point, the system is powered, which gives overall control to the headteacher.

54 The system was installed on a lease/purchase basis. It will cost the authority £4,450 each year for five years, but this sum also includes regular maintenance. After five years, the system belongs to the school.

55 Tables 1 and 2 show an economic evaluation of the costs for both an outright purchase with separate maintenance and lease purchase which includes maintenance for the first five years and has separate maintenance for later years.

56 The costings have been prepared for an 11-year period, based on the 100,000 hour expected life of a CCD camera and a test discount rate (d) of five per cent.

Table 1
Case study 1: Life cycle cost (in pounds) of installation purchase

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	**Total**
Capital cost (Cp)	16,450	–	–	–	–	–	–	–	–	–	–	**16,450**
Maintenance cost (Mp)	2,060	1,961	1,868	1,780	1,695	1,614	1,537	1,464	1,394	1,328	1,265	**17,966**
Running total	**18,510**	**20,471**	**22,339**	**24,119**	**25,814**	**27,428**	**28,965**	**30,429**	**31,823**	**33,151**	**34,416**	**34,416**

Table 2
Case study 1: Life cycle cost (in pounds) of installation lease/purchase

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	**Total**
Lease/purchase cost (Lp)	4,450	4,238	4,036	3,844	3,661	–	–	–	–	–	–	**20,229**
Maintenance cost (Mp)	–	–	–	–	–	1,614	1,537	1,464	1,394	1,328	1,255	**8,602**
Running total	**4,450**	**8,688**	**12,724**	**16,568**	**20,229**	**21,843**	**23,380**	**24,844**	**26,238**	**27,566**	**28,831**	**28,831**

Figure 3 Camera layout for case study 1

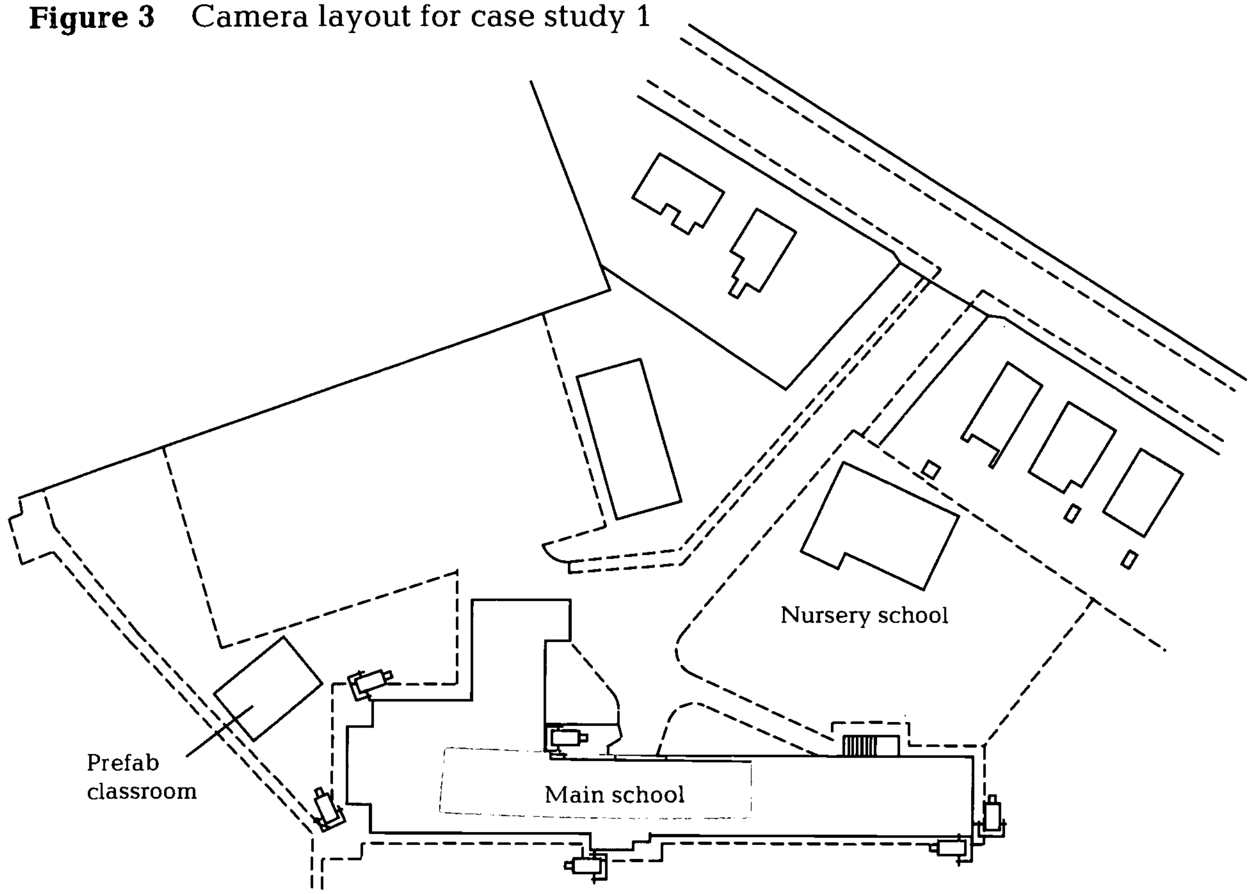
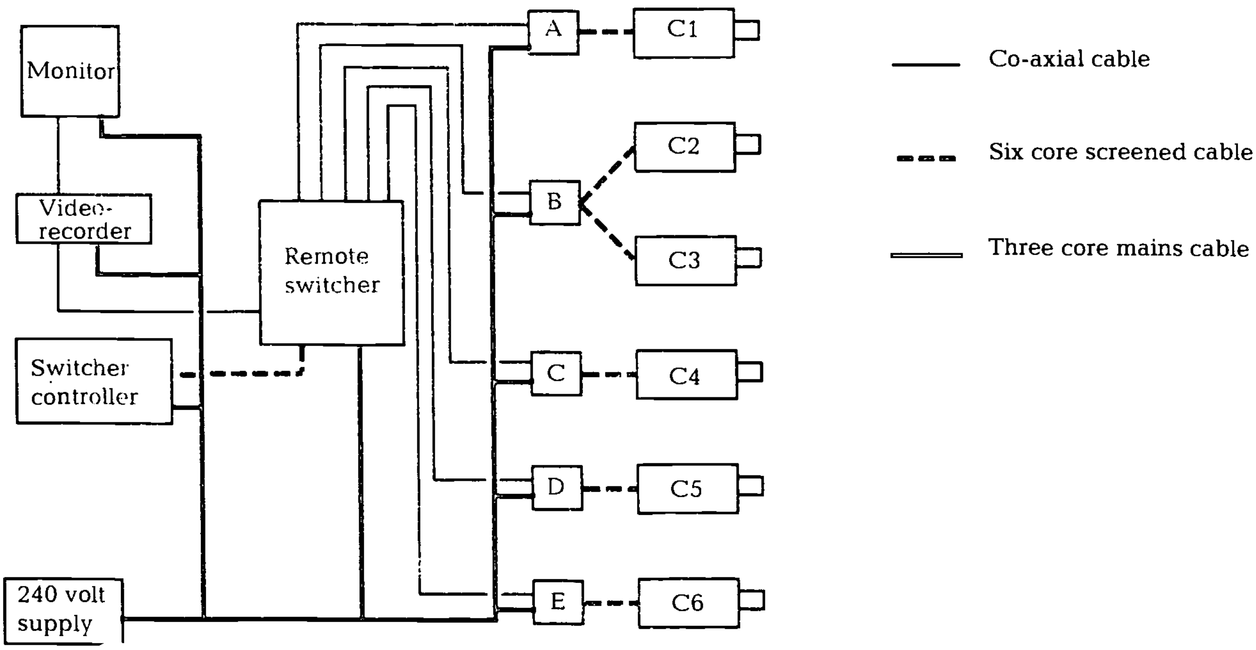


Figure 4 Schematic diagram of the system in case study 1



Case study 2

57 This case study describes a large secondary school in the north-east with 730 pupils on the roll. The school is close to a shopping centre and a public house, and has public footpaths on two sides.

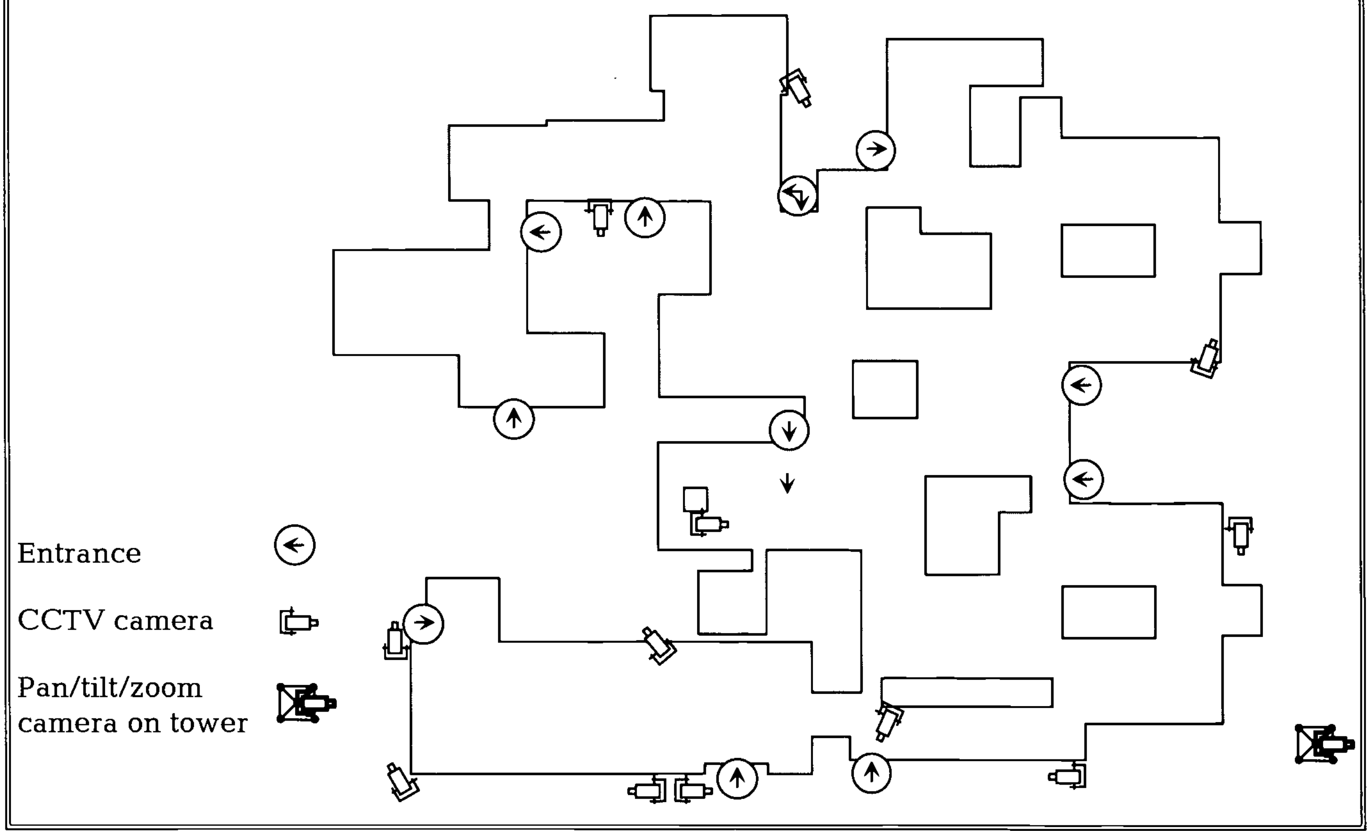
58 The school suffered regular acts of vandalism. In a seven-month period before the installation of CCTV, the estimated cost of vandalism was in excess of £8,700 and included the replacement of about 100 broken windows.

59 The original CCTV system comprised eight CCD auto-iris cameras fitted with infra-red floodlighting and four dummy cameras. Monitoring is carried out via an eight-way multiplexer, monitor and a time-lapse video-recorder with time and date generator which is located in the caretaker's store.

60 Incidents of vandalism have been virtually eliminated since the installation. In the first 12 months only six windows were broken and two of these accidentally during school hours; the total cost of repairs was about £300.

61 One problem persisted. Cars left in the car-park, particulary at night by evening class students, were still being damaged or broken into which affected attendance at classes. To overcome this and improve site security generally, a fully functional camera with pan, tilt and zoom facilities was erected on a tower at the east end of the building adjacent to the car-park. A monitor together with the pan, tilt and zoom controls were located in the caretaker's office and this equipment allows the duty caretaker to watch the site and take action as necessary. Since the installation of the camera, which is in full view of all visitors to the school, theft of and from cars and damage to them is almost nil.

Figure 5 Camera layout for case study 2



62 The cost of the installation was as follows.

Original system	£15,586	Annual maintenance	£1,510
Additional fully functional camera complete with tower, civil engineering and electrical works	£ 4,588	Annual maintenance	£ 402
Total	**£20,174**		**£1,912**

63 Using the estimated cost of vandalism for the seven-month period, it is expected that the original system will have paid for itself in less than two years. Data for the losses in the car-park which prompted the installation of the additional camera are not available.

64 While it was immediately apparent that this system would be cost effective, others may not be so and some analysis will be needed. Tables 3 and 4 show an economic evaluation of the system.

The evaluation in Tables 3 and 4 is based on the following assumptions:
annual floodlighting energy charge = £560
annual re-lamping costs = £400
annual costs of repairs due to vandalism
with CCTV = £300
without CCTV = £14,914 (£8,700 ÷ 7 x 12)
life of installation is 11 years (based on 100,000-hour CCD camera life)
the test discount rate (d) is five per cent.

Table 3
Case study 2: Life cycle costs (in pounds) with CCTV

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	**Total**
Capital cost (Cp)	15,586	–	–	–	–	–	–	–	–	–	–	**15,586**
Energy cost (Ep)	560	533	508	484	461	438	418	398	379	361	344	**4,884**
Maintenance cost (Mp)	1,510	1,438	1,370	1,304	1,242	1,183	1,126	1,073	1,022	973	927	**13,168**
Repair cost (Rp) (lamps, etc.)	400	381	363	346	329	313	298	284	271	258	246	**3,489**
Vandalism cost (Vp) (with CCTV)	300	286	272	259	247	235	224	213	203	193	184	**2,616**
Running total	**18,356**	**20,994**	**23,507**	**25,900**	**28,179**	**30,348**	**32,414**	**34,382**	**36,257**	**38,042**	**39,743**	**39,743**

Table 4
Case study 2: Vandalism costs (in pounds) without CCTV

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	**Total**
Vandalism cost (Vp) (without CCTV)	14,914	14,204	13,527	12,883	12,270	11,686	11,129	10,599	10,094	9,614	9,155	**130,075**
Running total	**14,914**	**29,118**	**42,645**	**55,528**	**67,798**	**79,484**	**90,613**	**101,212**	**111,306**	**120,920**	**130,075**	**130,075**

Cameras

There are two types of camera available; the vacuum tube type and the more recent charge coupled device (CCD) solid state type. Both types are available for black-and-white or colour operation. Colour is not recommended because a high level of lighting is needed and, therefore, it cannot be used to best effect for night-time surveillance unless expensive floodlighting of good colour rendering is also provided. Bad colour rendering can be misleading and infra-red lighting cannot be used to enhance night-time performance as is often done with black-and-white cameras.

Cameras are available in various formats (1 inch, $^2/_3$ inch and $^1/_2$ inch) offering a wide range of performance to suit various applications. Generally the larger the format the higher the resolution and the greater the amount of picture detail. However, current technology has resulted in the $^1/_2$ inch CCD camera equalling the picture quality of the larger tubed cameras and it is therefore the leading camera for security applications. The $^2/_3$ inch CCD camera can be good value because it has a larger range of lenses.

While the capital cost of CCD cameras is greater than that of their tubed equivalent, they have lower running costs because they do not need tube replacements and they have lower power consumption. Technical developments and increasing market share should reduce capital costs further. Other advantages over tube cameras are:

- their small size
- their long life of more than seven years
- that they are much less sensitive to vibration
- that they are not affected by external magnetic fields
- their short warm-up time of 0.5 seconds
- that there is no smearing when the camera is panning
- that there is no blooming, lag or burn-in
- that they are not damaged by hot-spots.

Cameras should have the correct specification for the variation in lighting levels in which they are to be used (namely daylight, lowlight, moonlight or starlight). The light levels on site should be measured throughout the required operating hours before cameras are selected. Figure 7 shows the typical lighting levels in which different camera types will operate.

Infra-red cut filters can be used in conjunction with CCD cameras to improve resolution, grey scale and contrast under daylight conditions. However, the amount of infra-red cut will need to be carefully controlled if the camera is to be operated at night with infra-red illumination.

Cameras may be fixed with a single view or mobile where they are mounted on a bracket which rotates in both the horizontal (pan) and vertical plane (tilt). Fixed view cameras are more common because they are simple and therefore more reliable.

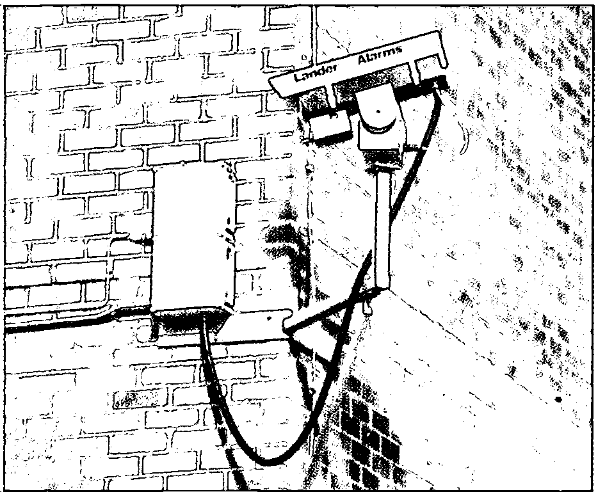
The height of the camera is important to the field of view and every effort must be made to mount the camera at the specified height. Pole-mounted cameras are often needed for perimeter surveillance. However, for ease of maintenance it is better if they can be mounted on flat roofs provided they are out of reach of intruders. Poles should preferably be of the tilt over type which allows maintenance from ground level.

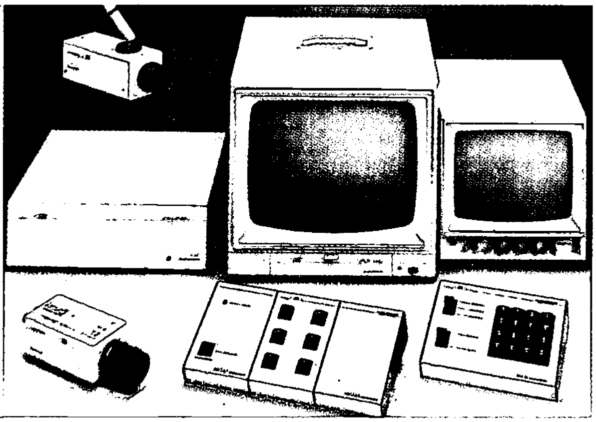
For interior applications it is often difficult to find a suitable mounting point which will give full coverage, even using a wide-angle lens.

Tube cameras on a single fixed view can retain images. This condition is sometimes referred to as burn-in and it results in a partial loss of picture in the affected area making regular tube replacement necessary. The interval between replacement ranges from six to nine months for the cheaper Vidicon cameras and up to 36 months for the more expensive Ultracon or silicon diode cameras. Ideally, where practical and where suitable staff are available, fixed cameras should be interchanged regularly to minimise burn in and maximise tube life.

Figure 6 Typical system hardware

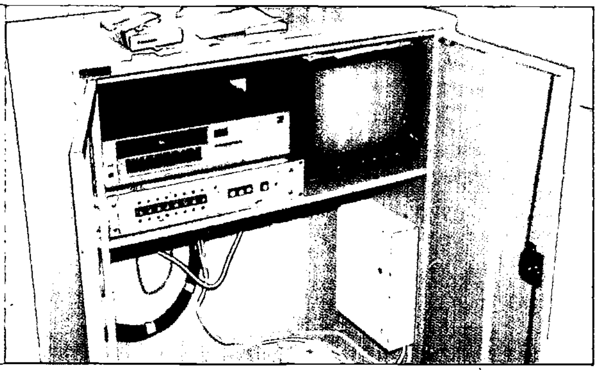
External camera with pan and tilt



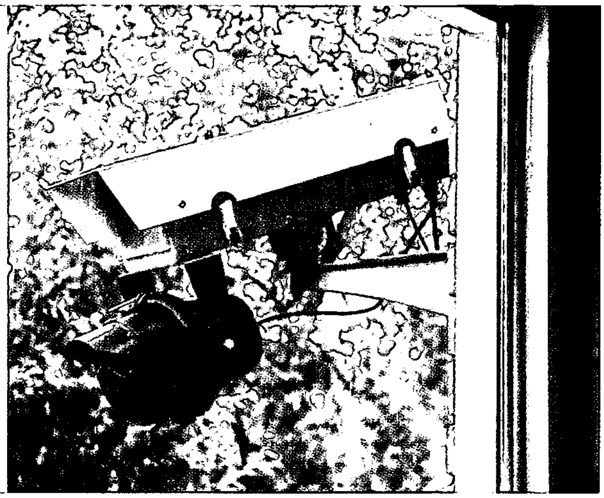


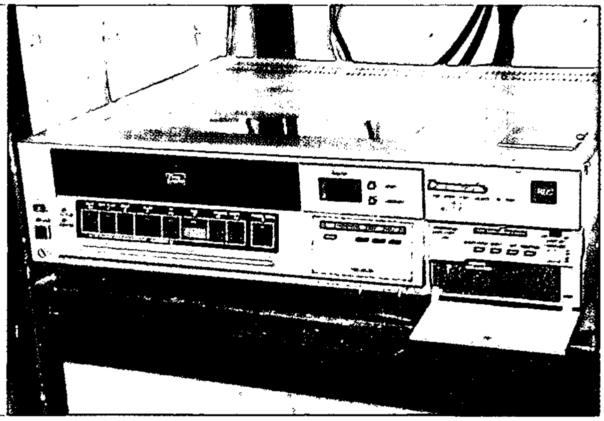
Internal cameras, monitors and switchers

Monitoring equipment in secure cabinet



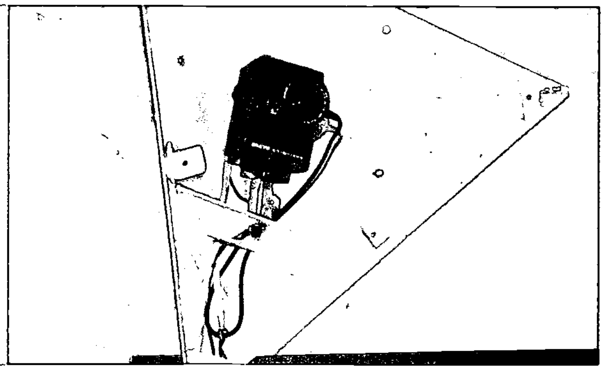
External camera with infra-red lighting





Time-lapse video-recorder

CCD camera in vandal-proof housing (cover removed)



Tube cameras can be affected by intense light sources such as car headlamps and direct or indirect sunlight which can cause hot-spots. Hot-spots are where the light blinds the camera causing the surrounding area to appear black. If they exceed the dynamic range of the camera they can cause bloom (a spreading patch on the screen) or may cause burn marks on the tube. If the bright light is just outside the picture, flaring may occur which is a patterned haze across the picture. Eclipsers are white light limiters/inverters which can be used to electronically block out the hot spot from a monitor, but their use will not prevent burn marks on the camera tube. Lens coatings, hoods, sun shields and filters may be used to prevent hot-spots, but it is best to eliminate these problems by locating equipment and lighting sensibly, including extra background light and multiple light sources.

Care should be taken to avoid direct sunlight falling on the lens.

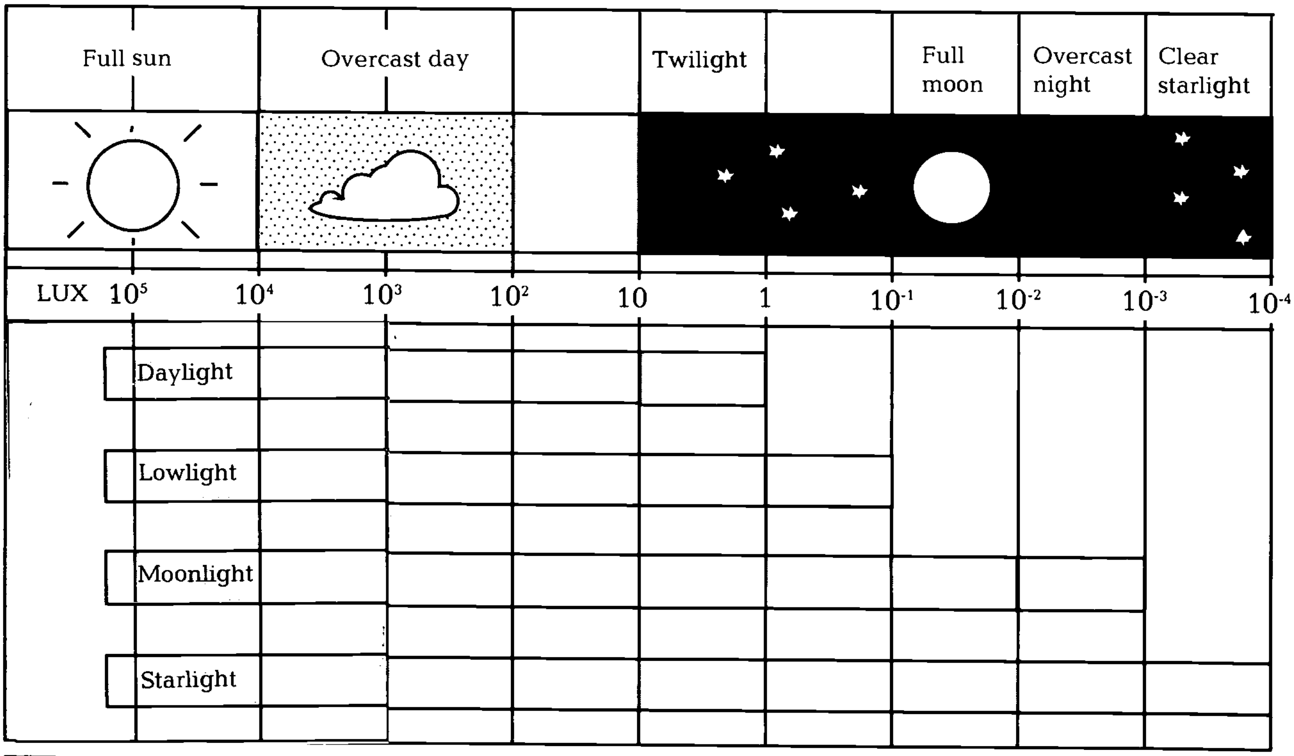
Lenses

The most important part of the design is to ensure that the correct lens is chosen for the field of view required. Also the depth of focus should guarantee that the whole field of view is in focus under all conditions. Figure 8 shows varying fields of view for different lenses.

Two classes of lenses, the fixed and zoom lens, are available. Both types allow control of both focus and iris. All adjustments can be either manual or motorised via remote control. Zoom is normally remote-controlled.

Pin-hole lenses are available in straight and right-angle versions for hidden cameras. They have a very small aperture and can

Figure 7 Relative typical operating light levels of various camera types

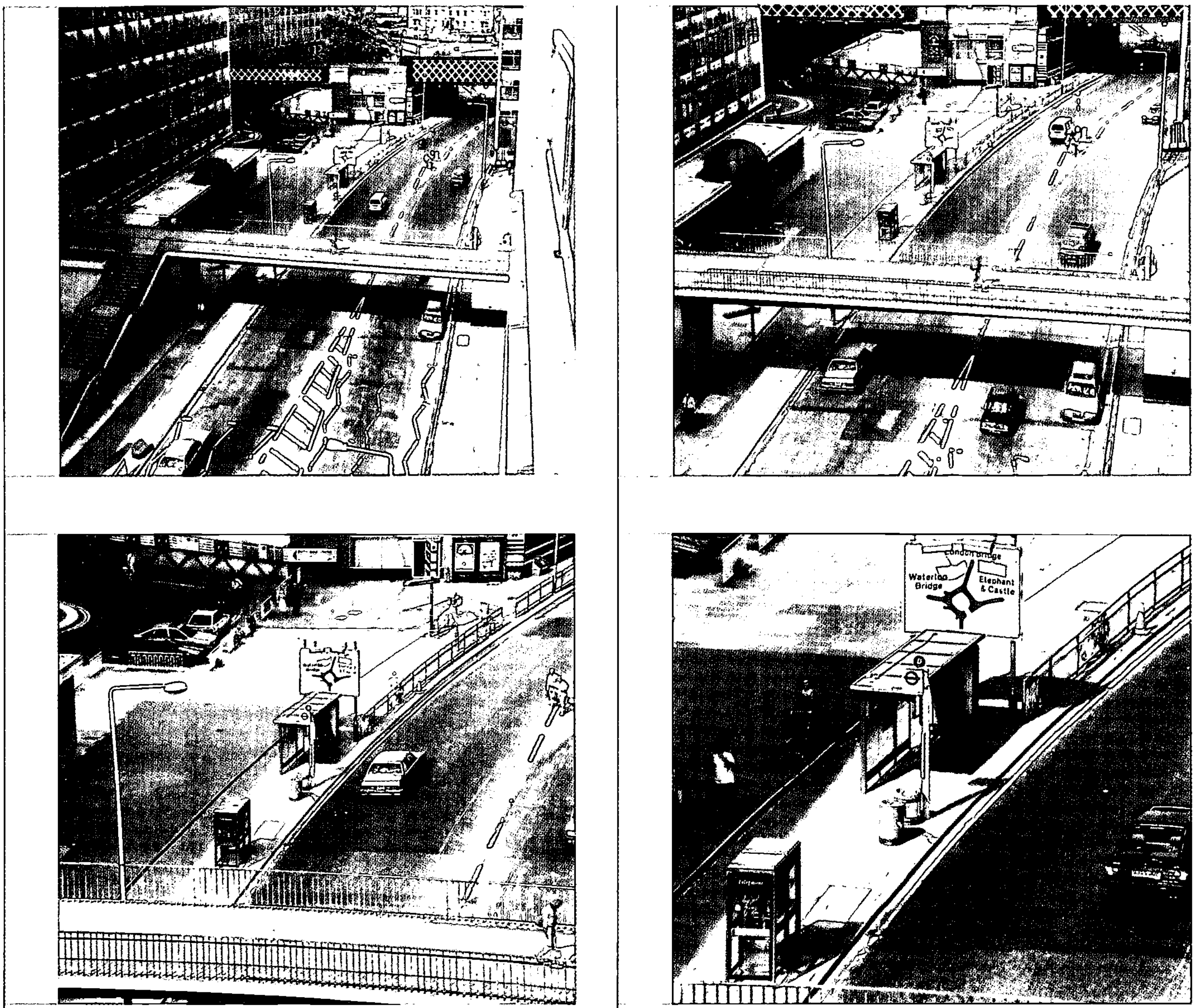


Normal operating range for good picture

Limit of operation

LUX Light level measured at tube faceplate

Figure 8 Effect of lens focal length on field of view



therefore be easily hidden. However, light absorption is small and it may be necessary to use a lowlight camera.

Lighting

Artificial lighting is normally available for cameras located inside. Additional lighting will normally be needed for exterior cameras and of a higher level than is required for security lighting. The higher the level of lighting the less sensitive the camera needed for 24-hour monitoring. Figure 7 indicates typical lighting levels required for different cameras. Camera sensitivity may vary with the type of light source. For example, a silicon tube is much more effective under incandescent than high pressure sodium light. Infra-red light to which cameras are sensitive may be used, but people's eyes do not compensate for infra-red and, without care, injuries can happen. Infra-red lighting is useful because it allows the discrete enhancement of lighting for CCTV without raising the level of visible lighting. Allowance should be made at the design stage for extra costs due to any additional lighting needed whether visible or infra-red.

Monitors

Monitors convert the video signal from a camera into a picture on screen. The video signal can be in various formats depending on the system type and manufacturer. Two types of video signal synchronisation are used. The first is fully synchronised (or 2:1 interlaced), which is used on broadcast television and the more sophisticated systems, and the second is random interlaced which is slightly inferior to the fully synchronised, but saves money on electronic circuitry and is used in the simpler systems. Cameras, monitors, transmission cables and other equipment such as video switchers must use compatible signal formats.

Composite video inputs should provide for 75 ohm termination. Black-and-white monitors should have standard 625 vertical line resolution (that is, 585 picture lines) to allow cameras of different manufacture to be used on the same system and so give some scope for their relocation.

Horizontal resolution varies and is at best 700–800 lines. Resolution may be different across the screen, but as long as monitor resolution is better than camera resolution this need not be considered when choosing a monitor. It is recommended that a video output and termination switch be provided on the monitor.

A problem similar to camera burn in happens to monitors and, where fixed view is required, arrangements should be made to alternate monitors at monthly intervals.

Cabling

Systems normally use co-axial cables. With amplified signals these can be used for distances up to 1.5 kilometres, but over this an alternative means of transmission must be used. Exceptionally, twisted pair cables may be used where long cable lengths exist (that is, 0.5–1 kilometres long). In some simple systems one cable is used for both the video signal from the camera and the power supply to the camera.

Special attention must be given to cable routes longer than 200 metres. In such cases line amplifiers and signal correction equipment will usually be needed to increase and improve the quality of the signal. Also, more expensive high quality co-axial cable can be used to increase permitted cable length. Cables may require physical protection like those for intruder alarm systems.

Wireless signal communication

For applications where hard-wiring is impractical or undesirable, the camera signals may now be transmitted as electromagnetic radiation of various types including infra-red, microwave or laser links. These methods avoid running cables between buildings by overhead catenaries or underground ducts. Careful positioning of the transmitter and receiver is required to avoid obvious problems from birds and other obstructions and to ensure a clear line of sight.

Camera switchers (sequencers)

Camera switchers, sometimes referred to as sequencers, are used to switch sequentially a number of cameras to one or more monitors, to a video-recorder or via a slow scan transmission system to a remote monitoring station. The switching can be manual, automatic or on receipt of an alarm or control signal. If the switcher has alarm inputs these can be used to control a switcher from a remote monitoring station. Remotely sited switching units can save on cabling costs by transmitting pictures from different cameras in turn down a single cable.

Video multiplexers

Using a multiplexer the signals from up to 16 cameras can be simultaneously transmitted down one cable and recorded on a video-recorder which ensures that no camera activity is missed. Multiplexers are also used in order to display simultaneously up to 16 remote cameras on a monitor in a permutation of full size and compressed pictures.

Time-lapse video-recorders

It is now possible to record and play back single frames which carry time and date information. A time-lapse video-recorder should provide the following facilities:

- three-hour continuous recording with audio track
- various time-lapse modes of between 24, 48, 72, 120, 240 and 480 hours
- each frame accurately identified by an internal time and date generator
- the ability to start and stop automatically for a period of up to one week
- an external alarm input which, when triggered during time-lapse recording, will put the video-recorder into continuous real-time recording mode
- built-in rechargeable batteries to maintain time and date during a power failure
- replay in still field to allow examination of single frames without appreciable noise.

While still being cost-effective, LEAs could own a small number of these units and use them in schools where levels of risk are highest or where crime has suddenly increased. Time-lapse video-recorders are like domestic video-recorders in as much as they are easy to disconnect and set up at another location. Video-recorders need to be protected against theft.[8]

Video motion detection systems

A change in the picture when compared with the image stored is used either to cause an alarm and start a video-recorder or to transmit the appropriate zone picture to a monitor. Some video motion detection systems have proven unreliable when used outside because of the high rate of false alarms caused by animals, birds and rapid changes in light levels. If the clothing of an intruder is the same colour as the background the detection capability of the system may be unsatisfactory. Their use indoors is more expensive than employing conventional intruder alarms to trigger a camera. The system is not generally recommended for use in educational establishments.

Slow scan transmission system

Slow scan transmission is a way of sending TV pictures to a remote monitoring station via an ordinary telephone line. A sequence of still pictures is provided at regular intervals and the pictures are stored digitally at both transmitter and receiver ends. An auto-dialler is used and the video signal is converted to a telephone signal on site and back to video at the remote station. Pictures of a reasonable 300-line definition can be obtained depending on transmission speed. An efficient auto-dialling and answering system is required. Connection to a telephone company circuit should only be made using an approved interface. The slow scan system cannot replace conventional intruder alarm systems, but may be used as a source of verification and for remote patrolling.

Slow scan transmitters, used to deliver the picture signal to the telephone line, have an installed cost of approximately £3,000 with top of the range versions costing as much as £7,500. At the remote monitoring station the receiver will cost between £5,000 and £10,000. Private monitoring stations charge approximately £10 per camera each month for monitoring a slow scan installation. This price (in 1991) includes the cost of the receiver but not the cost of any additional telephone line, if required, nor the standing and unit charges. This facility is not recommended for use in educational establishments.

Where it is thought necessary and where purchasers already own and operate their own central monitoring facility for intruder alarms, it may be more cost-effective to add a slow scan receiver and monitoring screen at the existing monitoring facility. In other instances purchasers should ask for competitive quotations from private monitoring companies. Transmitters and receivers must be completely compatible. Industry standards vary and it is essential to use a proprietary slow scan transmitter that is acceptable to the proposed monitoring station. Slow scan transmitters must be approved by the appropriate telephone line

8 See *Crime Prevention in Schools: Practical Guidance.*

company. Where slow scan transmitters are incorporated into a CCTV system, the scheme should be designed to facilitate on-site real time monitoring simultaneously with slow scan remote monitoring.

Continuous remote monitoring would mean excessive telephone costs. Therefore, slow scan transmission needs to be initiated by the local intruder alarm, video motion detection system or the remote monitoring station.

Systems should allow for easy removal of the slow scan transmitter to another site in line with varying levels of risk. In this event close co-ordination with the monitoring station is required to ensure that they are fully aware of the changed site, system, telephone numbers and so on.

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Schoolwatch UK
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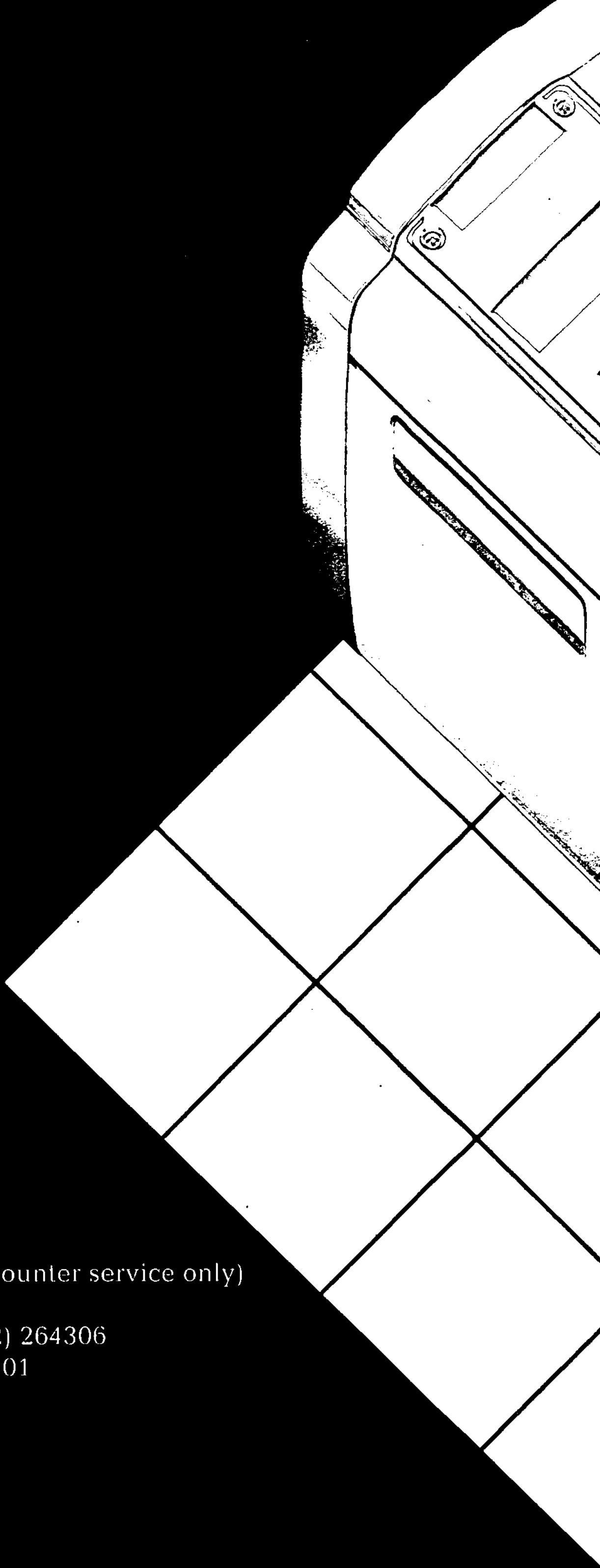
Watching What's Yours
(Police Scientific Development Branch) is a video produced to help users understand the operational requirements of CCTV systems. It is available for sale at £26.27 from Look It Up Limited (tel. (0969) 40437).

Acts of arson, theft and vandalism committed in and around educational establishments have increased in recent years. The Department of Education and Science has produced a series of publications called Crime Prevention in Schools which advises on security measures.

This bulletin gives guidance to those who are considering installing closed circuit TV surveillance systems. It also provides information to those responsible for the design, specification, operation, maintenance and management of such systems in educational establishments. The bulletin includes case studies and gives elemental costs which allow estimates to be made.



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