4.2.6 Maximum Lens Aperture

This characteristic of cameras and camcorders tells something about how good the lens is. The better a lens is, the faster it gathers light for conversion into electrical signals and the easier it is for the rest of the camera or camcorder to maintain a noise-free image, since there is more light coming from the scene than there would have been with a slower lens. If most of the perceived applications involve nighttime or twilight conditions, it is important to obtain the fastest lens available (within the established budget).

Most cameras/camcorders have the maximum aperture marked on (or near) the lens as an "f-number." It may be shown, for example, as "f/1.4," "1:1.4," or simply "1.4." Speed in a lens, as determined by the aperture, provides an indicator of how long it takes to expose the video pick up (or any type of film). With an f/1.4 lens, the light can be one-eighth as bright as with an f/4 and still allow the same length exposure. For the same brightness of light on the subject, the shutter speed can be shortened by a factor of eight. For the police photographer, lens speed is of the greatest value in a covert surveillance situation where there is little natural light and supplementary illumination cannot be used. A lower f-number may be the difference between getting a picture and not getting it.

Table 10 lists standard f-numbers and compares the relative brightness requirements of each. The table uses f/1.4 as a typical "best" limit for lenses, however, some cameras offer an f/1.2 lens. An f-number of 1.0 is the theoretical lower limit for standard lenses.

Table 10. f-Numbers and Light Brightness

f-number	1.4	2.0	2.8	4.0	5.6	8.0	11	16	22
Relative Brightness Required	1	2	4	8	16	32	64	128	256

For most surveillance cameras, it is fairly easy to cover applications involving different lighting conditions by buying more than one lens. Lenses can be switched on and off the camera body, even in the field. Camcorders are not so flexible. The lens that comes with the camcorder cannot normally be removed.[7] If two camcorders are essentially the same except for the maximum aperture, it may be prudent to choose the one with the lower f-number, especially if both show the same lux specification.

4.2.7 Minimum Focusing Distance

Almost all of today's common camera and camcorder lenses focus as close as 2 1/2 feet to 3 feet. This is suitable for satisfying most needs of law enforcement and corrections, except for acquiring some forensic footage. If there is a need to record extremely close footage of an object that will serve as evidence, the 'macro' function of the lens should be engaged, if available. This effectively switches the lens into another mode that has a focusing range from about 2 1/2 feet right down to zero – which is right at the lens. In this mode, focusing is typically accomplished with the zoom controls and with more difficulty.

4.2.8 Zoom

Although such a function is considered a "special" lens on a photographic camera, it is the norm for video cameras and camcorders. Usually a lens will come with the unit and be designated, for example, an "8:1" zoom. This means that if the lens is zoomed to its wide-angle limit (that which makes the subject look the farthest away), then zoomed to the other end (as close as possible), the subject will appear eight times as close. This extreme is called "telephoto." While not true for all lenses, in most camcorders, zooming to the telephoto end of the lens also reduces the light transmission (i.e., f-rating) through the lens. In spite of this restriction, having a zoom feature means the camera or camcorder can be used in a wider range of situations than would otherwise be the case.

[7] It is true that "wide angle" and "telephoto" lenses can be mounted in front of the camcorder's permanently mounted lens, increasing the range of situations in which the device can be used. These lenses do, however, generally reduce the amount of light reaching the lens by one or two f-stops.

When zoom functionality is solely dependent on the lens, it is considered an optical zoom. Some of the new digital camcorders have a digital zoom feature in addition to the optical zoom, in which they use a subset of the elements of the CCD video pick-up device and enlarge that subset to cover the full screen. When reporting zoom ranges, manufacturers typically multiply the optical zoom and the digital zoom features. For example, a camcorder with a 12x optical zoom lens and a 5x digital zoom feature would be touted as a 60x zoom. That is, the image of an object fully zoomed in (magnified) will appear 60 times larger than if the camera were fully zoomed out. Remember, however, that much of the increase was due to sampling a subset of the CCD, thus reducing the overall resolution of the image.

4.2.9 Autofocus

A number of consumer-grade cameras and camcorders on the market offer the user the choice of either manually focusing on a subject or allowing the video device to automatically focus. In some cases, the user has no choice – the equipment comes with only a manual or auto-focus lens. Whether the auto-focus is optional or mandatory, it is important to realize what its capabilities (and limitations) are before making a selection.

Two methods are typically used in auto-focus cameras and camcorders – contrast-maximization and infra-red ranging. These methods are described below.

<u>Contrast Maximization (CM)</u>

Imagine, as in the discussion on resolution, a series of vertical lines alternating between pure black and pure white. If this scene is viewed with a lens system that is in focus, the boundaries between the two types of regions will be distinct. If the eye scans from left to right, it sees light levels alternating in sequence between a very low light level (a black region) and a very high light level (a white region). If the lens is completely out of focus, all that will be seen is a large area of uniform medium gray (a medium light level). In fact, for any given scene, the lens setting that is in focus also produces the maximum contrast in light levels. Cameras scan pictures as described above but see pictures in terms of electrical levels. A camera can find the best focus by changing the lens until the difference between the highest voltage and the lowest voltage in a scene is maximized. This principle has been exploited to allow camcorders to find the "best" focus automatically and is called "contrast maximization."

<u>Infrared Ranging (IR)</u>

In this radar-like system, an infrared emitter, typically located next to the camcorder's lens, transmits a pulse of light that is not in the range visible to humans. An infrared light sensor then waits for a reflection of the original pulse and notes how long it took for the reflection to return. Knowing how fast the pulse travels, the system then calculates the distance to the object that reflected the light pulse and adjusts the lens apparatus accordingly. These calculations and adjustments are done from 5 to 10 times per second.

In implementing both the CM and IR methods, engineers had to answer many questions. For example, in the case of the CM camcorder, the true focus could be anywhere in the range of the lens (or too close). While sweeping from nearest to farthest, the contrast might not simply increase until focus is attained, but instead, it may increase a little, then decrease, and then increase a lot. How should the camcorder decide whether to find an even greater contrast, or to stand pat on its current decision? If it stays where it is, it might not be in focus, and then just stay there, out of focus, forever. If it is in focus but goes hunting for a better focus, it might simply waste time, losing valuable information by recording out of focus until it comes back or stays elsewhere incorrectly.

In the case of the IR focusing camcorder, the pulse should spread as it travels outward, away from the camera and toward the subject to be videotaped. If it does not spread but stays thin as a pencil, it could focus, for example, through to the other side of library bookshelves (when there is an opening through and things and people on the other side can be seen) when the books are the intended subject. If the beam is too wide, the camera could focus on the books, when it is the people on the other side who should be monitored. In another scenario, what if the user of the camcorder is by a chain-link fence, and something else is on the other side? Should the point of focus be the chain-link fence or the object on the other side? Both cases are possible, but how does the user inform the camera what's on his/her mind? He/she does not with auto focus! Manufacturers made decisions for the user.

Regardless of how the manufacturers ultimately decided, it is imperative that the user understand what they decided to do and how that impacts the effectiveness of auto-focus for certain video applications. Some of the advantages and disadvantages of the two technologies are given below:

IR focuses on glass, whether you want to or not. This makes observation of people in houses and vehicles very difficult.

CM looks for the greatest difference between black and white. If the room is relatively dark, it takes longer to decide that a given lens setting is right or wrong. It could take up to 30 s to focus in a well-lit indoor room when the subject is of low contrast already.

IR systems can focus perfectly on a subject even if there is absolutely no visible light. This does not mean the camera can operate and/or record images in pitch black surroundings. This means the camera can be focused and ready to go, and once the light level reaches the minimum illumination the camera requires, it will operate. An IR autofocus camera, then, could be placed in a dark room and record happenings when a lamp was turned on or some sunlight shone in. From bright light to little light, the IR focusing ability is not progressively diminished as the light grows dimmer.

CM uses only the center third of the frame when calculating focus; therefore the zoom interacts with the auto-focus. CM maintains focus when moving from wide-angle to telephoto but loses it badly in the other direction.

Regardless of whether the auto-focus mechanism is CM or IR, depending on the particular camera, the auto-focus can be swift or slow. The swift ones tend to hunt indecisively once they get close to focus, whereas the slow ones take longer to get there but are very accurate and stable once they decide they are focused.

Linked in with all of this is the auto-iris, the part of the camera that adjusts for changing light levels. As the iris opens and closes, the depth of field will change, making parts of the scene that are not at the same distance as the subject go in and out of focus. While the CM types will be affected by this, the IR types do not appear to be.

4.2.10 Shutter Speed Control

The fact that most video devices in the United States produce frames at the rate of 30 per second means that if a subject moves considerably in 1/30 second, it will appear blurred under normal circumstances. One of the features available (with the proper device) that can solve this problem is shutter speed control. Just as with a photographic camera, higher shutter speeds reduce the amount of time the shutter is open and decrease the blur seen during that time. The payback is the faster the shutter speed, the more light that must be available; however, with a subject illuminated by full sunlight, shutter speeds of one 0.0001 second are possible with uncompromised quality.

5. The Ergonomic Aspects of Equipment

One of the experiences people have had with new video equipment is they could not get it to work. No, this is not another story relating to poor workmanship, missing parts, or bad information from the salesman! In the vast majority of cases, there was nothing wrong (theoretically) with the equipment. Problems arose because users did not know what to do; the equipment was not straightforward to operate; technical manuals were incomplete, misleading, or confusing; or the equipment controls could not physically be moved or positioned. These were all ergonomic problems. (Ergonomics is the science concerned with the characteristics of people that need to be considered in designing and arranging things. That is, how should something be made so that people will interact with it effectively?) A video product can have the best specifications and features in the world, but if no one can easily use it, it has no real practical value.

This section addresses a few of the "nitty-gritty" items that may be forgotten during the selection process for video surveillance equipment. If specifications, features, and cost all fall out as about equal, one of these items may be the deciding factor. Even if the video units mentioned below did not have any drawbacks in specific categories, it still would be prudent to look at those kinds of categories when actually contemplating a purchase.

5.1 Time Needed to Learn Basic and Advanced Operations

With a technical manual as a guide, it only took about 5 or 10 min for ordinary people (non-experts) to get the various video units described in this guide working. (That is, if the batteries came already fully charged with the camcorders). The Sony DXC-M7 camera took somewhat longer because it is a more complex piece of equipment (e.g., more function switches, feature controls, and connectors). An officer who had never used a camera or camcorder before would be ineffective if forced to use one "cold" in a pressure situation, but 2 h of use over a couple of days probably would allow that officer to use all of the basic features adequately and to record valuable information. To learn and use advanced features, such as toggling sensitivity gain and autofocus, adjusting white balance, connecting a 10 W lamp to the camcorder, and using the macro feature of the lens, some weeks of use would be required. In addition, there are some things an artist can do with skillful control of the camcorder that your average operator will never be able to do. This personal element is no more of a problem with certain officers than trying to photograph evidence with a standard 35 mm single lens reflex camera, however.

5.2 Controls – What Kinds are Better?

This subject is general to cameras, camcorders, televisions, monitors, and VCRs. Even in this realm, things have changed a lot since the days when TVs were powered on with a loud mechanical click. This is mostly due to solid state electronics, but also to materials science. Since silicon switches use so little energy, it is not uncommon now for a part of an electronic instrument to remain on even when it has been turned off. Turning it back on consists of moving a switch that closes an electrical contact that tells the part of the instrument that remains on to turn on the rest of the instrument. Since the switch is just a contact, it can be made quite small. Unfortunately, some manufacturers have gotten overzealous in their desire to show off just how small they can make their switches, and the result is full-size camcorders that have switches that are too small to use comfortably with just fingers, not to mention gloves.

The most common types of controls are buttons, sliders, knobs, and switches. (See figs. 3, 9, 10, and 11.) Switches are generally of the variety that can be in one of two positions and stay there. More popular than switches are buttons, knobs, and sliders. Buttons most often are just electrical contacts that electronically toggle functions: the first time you press it the auto-focus turns off; the next time it turns back on. Of course, if these toggle buttons are too large, it becomes possible to bump them when it is not desirable to do so. It could be disastrous if such a button controlled the power for the entire camcorder or for the cassette eject mechanism. These functions are usually protected by a slider, the function of which is invoked by moving a spring-loaded control to the side momentarily for electrical contact. Sliders return themselves to a home position upon release. Since pressure straight upon their surfaces does not bring them to operation, they are safe for the more important functions. Knobs are most commonly used to allow the user to select one of many options. One example of this is the power-on knob of the Sony DCR VX-1000. This knob allows selection of VCR or camcorder mode, as well as various levels of automation.

An example of a more complicated control that can be found on some devices is the power control on the Sony CCD-V99 camcorder. It has a center position and slides to one side to use the device as a camcorder or to the other side to use it as a VCR. Before moving it from its center position, however, a tiny green button in the middle of the sliding switch must be depressed to unlock it. It has proven to be a formidable task even with bare fingers.

Even simple controls like buttons can be made difficult to operate by placement. Many times frequently used controls are placed behind covers or doors. This slows access to those controls. One extreme example of poor placement are the menu controls on the Sony DCR VX-1000. These controls are behind the battery compartment door, on the side closest to the hinge. This makes the buttons awkward to reach without the added complication of having to hold the camcorder at eye level to see the menu in the viewfinder and having the battery door continually bumping into your chin.

Monitors and televisions are used almost exclusively indoors or at least not in sub-zero outdoor weather. Since they are relatively large, there does not seem to be a leaning by designers to give them unnaturally small switches. Operation is rarely an ergonomics problem.

In general, understand that modern equipment will have many controls to maximize functionality, and they may need to be somewhat small to fit them all logically onto a control panel. Beware of controls that are smaller than they need to be – especially if you may need to use the equipment with gloves or in tight places.

5.3 Camcorder Use with Gloves and Other Heavy Clothing

Most of the hand straps that come manufactured with camcorders can be adjusted to fit large hands, even ones sporting gloves that are not too thick (e.g., driving gloves or work gloves). Shoulder supported camcorders (most standard size VHS units) and cameras may not have a hand strap but an area built through the device that is intended for use as a grip. The size of this grip may not be adjustable, and this should be taken into account when considering purchase. The low end of the operating temperature range is usually specified to be above the freezing point of water (32 °F)anyway, and extremely thick and heavy gloves probably would not be needed at this temperature. The other consideration when using thick, heavy gloves is the size of the buttons and knobs on the unit. This should not be a problem either if gloves are not too thick, given the typical button and knob size.

5.4 Weight and Handling Versus Steadiness When Operating

Weight is mostly irrelevant when dealing with devices intended to sit on a shelf, such as most VCRs and monitors. Some monitors can be transported between sites, but system design options should not include having a monitor strapped to a human assistant. For cameras, portability, weight, and handling are a significant issue, because manufacturers always try to compromise between quality, manufacturing cost, and consumers’ desires for something small and easy to operate. This is even more true when you try to design a tape recorder into the same small enclosure as the camera. Such a device is called a camcorder. As far as weight goes, it is desirable to keep it low, but stability will suffer if weight is insufficient to keep the camcorder steady when the operator moves. Muscles sometimes shake a little when asked to remain perfectly still. At the other end of the extreme, even aside from the obvious discomfort of carrying around a camcorder weighing 15 lb, excessive weight can make muscles shake just from the sheer effort of supporting it after awhile. Somewhere in between is the ideal weight for a particular operator.

In addition, since 8 mm videotape is so much smaller than VHS videotape, most camcorders employing it are smaller and lighter than their VHS counterparts. They are carried in front of the operator's body and face, whereas VHS models are typically carried on the shoulder, as simple video cameras are. The compact version of VHS, called VHS-C, can be carried in front of the operator like 8 mm camcorders also, since their videotapes are much smaller than standard VHS videotapes. If the camcorder is carried in front of the operator, the device is typically lighter than one carried on the shoulder, but it has only the operator's two hands to support and steady it. If the camcorder is carried on the shoulder, the device is typically heavier than the 8 mm or VHS-C varieties, but the shoulder support is both quite strong and very stable or steady.

All cameras and camcorders come with a screw mount on the bottom for attaching to a tripod. A tripod can serve to simplify surveillance, as the burden of supporting the machine is moved to the tripod, and there is no risk of a human operator wavering off target.

5.5 Equipment Compatibility

If your entire contingent of video equipment is of VHS format and you acquire one 8 mm camcorder, then when you want to view the tapes you have recorded with the 8 mm camcorder, you will have to use the camcorder for playback. In addition, within the VHS universe, if you acquire a VHS-C camcorder, you will need an adapter to play its tapes on standard VHS systems. These adapters are usually included with VHS-C systems.

5.6 Helpful and Useless Features

The ability to switch off automatic features is invaluable if an operator is skilled in the use of a particular piece of video equipment. There is always a situation where autofocus is undesirable or ill-suited or the operator must force the *iris* open to gain detail for the features of a face against a brighter background.

Since camcorders are already quite a mature product, most of the features that are required to obtain quality images are available on almost every model. Manufacturers try to distinguish their products through the addition of features that can be generally considered useless for video surveillance applications. Part of the reason for this is in most cases it costs the manufacturer so little to include features (e.g., titling, strobe effects, artful fades or dissolves from one take to another) that they are just installed as a matter of course. This is especially true as microprocessors evolve and drop in price. It is conceivable that, since the complexity of the device is increased to incorporate these features, the chance is increased that an officer not so experienced with video equipment might press the wrong button and actually lose the ability to accurately record information.

5.7 Viewfinders

Are some viewfinders bigger and better than others? Until recently, viewfinders were almost always just a small (about 1 in diagonal) monochrome *CRT* connected electrically to the body of the camera/camcorder. More recently, color LCD viewfinders are coming to dominate the camera and camcorder market. These viewfinders are typically mounted within an enclosure that can swivel up and away from the body to allow the user to get the camera lower for shots of children or to shoot under a fence, for example. The viewfinder is made comfortable to place against the user's face by including an eyecup of very flexible rubber molded to approximate the average user's facial contours. Since the user is actually placing his eye up to the eyecup within 1 in or 2 in of the CRT within the viewfinder and the eye can't focus at that distance, a lens is provided within the viewfinder between the eye and the CRT. This lens can be adjusted to match the natural focal length of the user's eye so that extended use of the viewfinder is comfortable.

In addition to viewfinders, many consumer camcorders are available with a 2-in to 4-in LCD monitor that flips out from the camera body to tilt and swivel. Many camcorders with an LCD monitor also have a viewfinder, although some models have totally replaced the viewfinder with the monitor.

It is not a straightforward choice to select between the types of viewfinders. The small viewfinder must be held to the eye but the required stance is stable, and the aiming motion is quite natural, ensuring the intended subject gets recorded on the tape. The LCD monitor allows more flexibility in holding the camera and a larger display on which to read all the information provided by the camcorder. It also allows the videographer to interact more directly with those around, making the subjects more comfortable with the presence of the camera. Sacrificed are a little bit of stability and precision. If possible, a camcorder with both would be desirable and provide the most flexibility.

5.8 Battery Life and Replacement

Rechargeable batteries[8] supplied by the camcorder manufacturer are intended to last for 2 h – the length of time available for recording on one videotape (8 mm and VHS). When one tape is completely full of recorded material, tapes and batteries can be swapped simultaneously, and then the expended battery can be connected to the recharging unit so it can be ready in 2 h. Multiple batteries are rarely supplied with the camcorder, so it will be necessary to specify extra batteries at the time of purchase of the camcorder. Even though extra batteries are not included, some units provide charging capacity for two other batteries while another is being used.

Some of the more compact camcorders carry their rechargeable batteries in a compartment under the hand strap. Thus, during camcorder operation, the user's hand wraps around the battery compartment. This can be a good attribute, because the warmth that the hand provides also keeps the battery warm and, electrically, more potent. This can also be bad, because it can be less than convenient to try to exchange batteries in a hurry when a panel has to be removed and batteries have to be removed out from under the hand strap.

5.9 Tapes – Cost versus Quality; Problems Reading Tapes

It is commonly felt (and consumer product testing firms have found) that tape is tape is tape, and all tapes record the full bandwidth of their respective formats (e.g., VHS, 8 mm, S-VHS). There does not seem to be a difference even between regular grade and "high-grade" tapes. Also, there is no good reason to pay extra for tapes designated as "hi-fi," since any tape can record high-quality sound in a VCR that records in the VHS hi-fi format.

The defect that is found on videotapes manifests itself as "dropout," where the signal is lost temporarily, so the playing machinery must resynchronize. It is the frequency of these dropouts that determines the relative quality of videotapes. It is worth noting that the average viewer does not notice most dropouts, although this is little consolation to work as critical as law enforcement and corrections. As a general rule, it may be a better approach to buy brand-name tapes on sale than to buy off-brand tapes that may not have satisfied the same types of quality manufacturing standards.

As far as reading tapes, there should not be any problems except for those associated with the environment. The heads that read the tape are actually dipoles mounted in the surface of the rotor, and the helical rotor actually does not touch the tape being

[8] For more information on batteries, consult the "New Technology Batteries Guide," NIJ Guide 200-98. This and other NIJ guides are available from NIST/OLES, 100 Bureau Dr., Stop 8102, Gaithersburg, Maryland, 20899-8102.

transported across it at an angle but forces a film of air between its own surface and the tape because of friction and high rotation speeds. Moisture particles in the atmosphere (from simple humidity or outright rain) can be larger than the gap between the rotor and the tape, causing drag and improper operation. This can be sensed and relayed to the operator, usually with a "DEW" indicator, such as an LED. When this indicator appears, remove the battery and let the camera sit (with all doors open) in a dry spot for a couple of hours (or overnight) before trying to use it again. This should give the moisture enough time to evaporate.

5.10 Maintenance for a Machine with Tape Heads?

While some newer camcorders and VCRs have self cleaning heads, head cleaning is one of the most common maintenance tasks for these devices. Here is a paragraph from one manufacturer's operating instructions:

> Cleaning the Heads: It is recommended that head cleaning be performed by a qualified service technician. Please contact your nearest Service Center. An alternate solution is to obtain a head–cleaning cassette. There are many types of cleaning cassettes, so be sure to follow the cleaning instructions carefully. Excessive use of the cleaning cassette could shorten head life. Use this cassette only when a head clogging symptom occurs.

Cleaning heads on any helical scan device, whether VCR or camcorder, is almost a judgement call. They do not need to be cleaned exceedingly often unless the work they record or reproduce is critical. When cleaning is necessary, it can best be done by disassembling or reaching in with special equipment – in other words: professionally. It can be done with head cleaning tapes, which consist of an abrasive material manufactured into a cassette just like a standard videotape. They are first wet with a head cleaning fluid and then "played" in the camcorder or VCR. Sometimes, because of their abrasiveness, they are not recommended by the manufacturer of the camcorder or VCR, and sometimes they just do not do the job very well anyway.

5.11 Documentation/Instructions

Camcorders are manufactured exclusively in foreign lands. Unfortunately, manufacturers believe, for some reason, it is not necessary to hire native speakers from target market countries to write or assist in the writing of documentation for these pieces of equipment. The result can sometimes be confusing and frustrating.

Documentation has been found to be complete. The technical writers working for the manufacturer try to make documentation complete for a unit by binding together manuals for several closely related units. This is not enough, however, since the writing is often poor in grammar and clarity. If a camcorder does NOT have a particular feature, such as the capability of turning off autofocus, it probably will not say so in the manual. The obvious intent is not to highlight a lack of something in the product, but it might be beneficial to the user to know it as soon as possible.

6. Summary

With all the advances in videography today, there will come a day in the not-too-distant future when still photography will no longer be the preferred technique for recording data for most law enforcement and corrections needs. As the resolution and electronic shutter speeds of video equipment continue to improve and the costs of video units are reduced even further, the current advantages of conventional photography will diminish. Also, digital video and multimedia computing could have a significant impact on the future of video surveillance and how the data are gathered and processed. That is why the basic concepts of this guide are important to both imminent purchasing decisions and planning in anticipation of new technologies.

This guide has attempted to convey the many aspects of video in enough detail to allow a fundamental understanding of technical parameters and how they relate to law enforcement needs. It is hoped, however, that the discussions of the guide will have stimulated readers to conduct subsequent investigations into the ever-changing capabilities and applications of video gear. Only by having a clear recognition of what the potential benefits are, can those in the law enforcement and corrections communities hope to take advantage of the ongoing video revolution.

7. Glossary

amplified light – An attribute of a camera or other video device indicating use of a special module to amplify ambient light before it gets to the pick up unit.

amplitude – The voltage level of a signal. Could be relative (e.g., peak-to-peak for ac signals) or absolute (for dc signals).

aspect ratio – In facsimile or television, the ratio of the width to the height of a picture, document, or scanning field. NTSC television has standardized the aspect ratio at 4:3 (i.e., the picture is wider than it is high by a factor of 1 1/3). If an image is not reproduced at the intended aspect ratio, objects in the image are distorted.

automatic iris control – An automatic control that regulates the amount of light that reaches the video pickup unit.

auxiliary jacks – Any of a number of connectors that a piece of video equipment can have to allow it to be connected to and interwork with other equipment.

bandwidth – The difference between the limiting frequencies within which performance of a device, in respect to some characteristic, falls within specified limits. An analogy to bandwidth might be the width of a street or a highway, where each lane is a radio frequency.

battery – A device used for storing energy until it is required for use by a piece of equipment. Enables equipment to work without being plugged into a wall outlet.

battery memory – In rechargeable batteries, refers to the tendency of some batteries to "remember" the level to which they were charged or discharged, reducing the overall useful storage capacity of the battery. (See NIJ Guide 200-98, "New Technology Batteries Guide," for more information.)

black balance – See *white balance*.

blue-only control – A switch that turns off the red and green electron guns in a monitor. This allows for the monitor to be calibrated based on the signal from the blue gun only.

book mark – A feature of camcorders and recorders that allows the user to quickly find the end of previously recorded material so that additional recording can resume from that point.

brightness – A qualitative attribute of visual perception in which a source appears to emit a given amount of light. In monitors, overall brightness is dependent on the high-voltage level and the dc-grid bias.

broadcast quality – A generic descriptor indicating a piece of equipment is of sufficient quality to be used regularly by the broadcast television industry. Typically, the requirement is that resolution be greater than 450 TVL.

CCD (charge coupled device) – These tiny light-to-electric-charge transducers are placed in rectangular arrays on silicon wafers and used as video pickup devices instead of electron tubes. The signal is read out from the array sequentially from side-to-side and top-to-bottom to determine one video frame.

chrominance – In color television, that signal or portion of the composite signal that bears the color information.

clarity – A qualitative term generally referring to the combination of resolution, contrast, and color accuracy.

CM (contrast maximization) – a technique for autofocusing cameras and camcorders based on maximizing the contrast of the video signal.

color – Having a non-white spectral characteristic.

comb filter – a filter which helps to minimize the loss of resolution and reduce streaking and wavy edges on fine patterns. Common in middle range to high-end television displays and monitors.

contrast – In display systems, the relation between (a) the intensity of color, brightness, or shading of an area occupied by display elements, a display group, or a display image on the display surface of a display device and (b) the intensity of an area not occupied by a display element, a display group, or a display image. For a monitor, contrast is determined by the peak-to-peak amplitude of the video signal.

counter – In cameras and recorders, counters are used to keep track of tape position between start and finish. Counters can be in arbitrary units, time counting up, or time counting down.

CRT (cathode ray tube) – the vacuum (electron) tube that generates an image in a television monitor using cathode-ray electrons.

dB (deciBels) – 1) one tenth of the common logarithm of the ratio of relative powers (P), equal to 0.1 bel. The formula is given by $dB = 10 \log_{10} (P_1/P_2)$. 2) One-twentieth of the common logarithm of the ratio of relative voltages (V) or currents (I), equal to 0.1 bel. The formula is given by $dB = 20 \log_{10} (V_1/V_2)$ for voltage and $dB = 20 \log_{10} (I_1/I_2)$ for current.

dichroic lens – A lens in a camera which splits the incoming light into the three primary colors (red, green, and blue) so they can be picked up by separate CCDs or different areas on one CCD.

digital zoom – A relatively new feature of digital cameras whereby they use only a portion of the pickup device and magnify the image to fill the full frame.

distance – The position of the subject relative to the camera.

DSO (digital storage oscilloscope) – an electronic test instrument used primarily for making visible the instantaneous value of one or more rapidly varying electrical quantities as a function of time or of another electrical or mechanical quantity. Its storage function allows several values to be recorded (and displayed together).

DV in/out – IEEE 1394 (also known as “FireWire”) interface available on digital camcorders.

dynamic contrast control – An automatic control to maximize the contrast of a scene. Generally, use of dynamic contrast control produces an improvement in overall picture quality.

electron beam spot size – The diameter of the focused electron beam that causes the phosphor on a monitor screen to fluoresce.

edit controller – A jack on a piece of equipment that allows it to be precisely controlled by another device for the purpose of editing tapes.

electron tube – A vacuum tube designed to focus and direct beams of electrons. A common type of electron tube is a television picture tube (i.e., a CRT).

electronic shutter – Use of electronics to simulate placing a shutter in front of a video pick-up device.

environmentally robust – A manufacturer’s subjective claim that their equipment can operate in a variety of temperature, humidity, lighting and physically abusive conditions.

fade – A non-abrupt interruption of the signal. In video, generally refers to a graceful transition from one video signal to another.

filters – In electronics, a device that transmits only part of the incident energy and may thereby change the spectral distribution of energy.

flying erase head – In camcorders and recorders, a recording technique that allows for a single frame to be erased from a video tape and then immediately replaced with a frame from another source. This allows for smooth transitions between scenes.

focus – The mechanism used to ensure that the scene produces a sharp image on the video pickup device.

gain-up – A control to increase the gain on the output of the video pickup device in low-light situations.

headphone jack – On video equipment, this is usually a 1/8 in stereo phono jack.

high definition television (HDTV) – Television that has approximately twice the horizontal and twice the vertical emitted resolution specified by the NTSC standard.

high-speed shutter – A physical or electronic shutter that operates at faster than 1/60 s.

hue – The visible spectral content of an image or part of an image, which depends on the phase angle of the chrominance signal. The phase is varied with respect to a color synchronizing signal by a "tint" or "hue" control. This control is subjectively set for the correct hue of any known color on the screen (e.g., green grass or blue sky), then all other hues are automatically corrected, since the color synchronization holds all hues in the proper phase with respect to each other.

image stabilization – A camcorder or camera feature to reduce the visible effects of shake and wobble introduced by hand-holding the camera. Two techniques are currently used to accomplish this. The first is through the use of a deformable prism. As the camera/lens detects shake and vibration, the prism is reshaped to provide stability to the image. The second is to electronically remove the effects of shake and distortion by modifying the output signal from the pick-up device.

index – A feature that "marks" the videotape each time recording is started, enabling the user to easily find a particular recorded section of tape.

infrared light – The region of the electromagnetic spectrum bounded by the long-wavelength extreme of the visible spectrum (approximately 0.7 µm) and the shortest microwaves (approximately 0.1 mm).

infrared playback – See wireless playback.

inputs – The types of signals that a device can receive, and the connectors through which those signals are received.

intensifier – A device placed in front of a camera or camcorder's pickup device that amplifies available light from a scene.

IR ranging – An autofocus technique that uses an infrared signal to determine the optimum focusing distance.

iris – The adjustable physical opening that light passes through en route to the video pickup unit.

intermediate frequency (if) – A frequency to which a carrier frequency is shifted as an intermediate step in transmission or reception.

LANC – Sony's edit control interface for high-end consumer equipment.

LCD monitor – A viewing device for a camera or camcorder that is based on liquid crystal display technology and is 2 in to 4 in in size.

lens compatibility – Indicates a camera has many interchangeable lenses, including interchangeability with those of other manufacturers.

lens mount – The physical connection between the lens and the camera. The most common lens mount for video cameras is the “C” mount.

light (1) – In a strict sense, the region of the electromagnetic spectrum that can be perceived by human vision, i.e. , the visible spectrum, which is approximately the wavelength range of 0.4 µm to 0.7 µm.

light (2) – An attachment for a camera or camcorder to help illuminate scenes where available light is too low to allow recording of a satisfactory image.

low light – Low-light cameras typically have published minimum acceptable light levels between 0.1 lux and 2 lux.

luminance – In color television, that signal or portion of the composite signal that bears the brightness information.

lumen – A well-defined measure of light power emitted by a source.

lux – The light level incident on a 1 square meter area when a lumen of light is distributed across it.

macro mode – A special mode for some lenses that allows focusing at closer distances than normal to provide greater magnification of a small object or detail on a larger object.

microphone holder – A bracket on a camera or camcorder that allows attachment of an external microphone.

minimum illumination – The minimum ambient light level (usually given in lux) required to give the camera a sufficient signal to make an “acceptable” picture. Each manufacturer has a different definition of acceptable.

monitor bridging – a mode in which a monitor can receive and display a video signal and then pass it on to another device without modification.

motion sensor – An automatic sensor in a camera or camcorder that allows the system to be activated when motion is detected and deactivated at a specified interval after motion ceases.

multiple heads – In video playback units, multiple heads improve the image quality during high-speed and slow-motion playback.

multiple mounting holes – For cameras, multiple tripod mounting holes enable the camera to be balanced atop the tripod to provide more stable images.

noise – A disturbance that affects a signal and may distort the information carried by the signal, or, loosely, any disturbance tending to interfere with the normal operation of a device or system.

noise reduction – Using filtering or digital signal processing techniques to reduce the amount of noise in an image. Noise reduction figures of 6 dB are common.

NTSC (National Television System Committee) – denotes the body that set the original standards for American television and is also used as a reference to the television standard they published.

NTSC video – The North American standard (525-line interlaced raster-scanned video) for the generation, transmission, and reception of television signals. Note: In addition to North America, the NTSC standard is used in Central America, a number of South American countries, and some Asian countries, including Japan.

optical zoom – The zoom achieved by a lens.

phase – Of a periodic, varying phenomenon (e.g., an electrical signal or electromagnetic wave), any distinguishable instantaneous state of the phenomenon, referred to a fixed reference or another periodic varying phenomenon. Note: The phase of a periodic phenomenon can also be expressed or specified by angular measure, with one period usually encompassing 360° (2 π radians).

photo mode – a camcorder/videotape recorder "captures" a single frame of video and records that one frame for 6 s to 10 s on the videotape, essentially making a still photo on the videotape.

pixel – In a raster-scanned imaging system, the smallest discrete scanning line sample that can contain gray scale information. An abbreviation for picture element.

playthrough – The condition of taking a known input, passing it through a device, and comparing the output of the device with that known input.

radio frequency (rf) tuner – The part of a circuit that can be adjusted to resonate at a particular frequency. Allows "channels" to be received from broadcast or cable systems.

remote control – a device that is detached from the main chassis of a piece of equipment, yet provides a mechanism for the user to control that piece of equipment. The two most common types of remote control are wired and wireless. Wired remotes require a physical connection (via wire) from the remote control to the main chassis. Wireless remotes typically use an infrared signal to communicate between the remote control and the main chassis.

resolution – A measurement of the smallest detail that can be distinguished by a video system or device under specific conditions.

rf (radio frequency) – any frequency within the electromagnetic spectrum normally associated with radio wave propagation. Normally, information signals are modulated to be transmitted at a radio frequency.

RGB (red-green-blue) – pertaining to the use of three separate signals to carry the red, green, and blue components, respectively, of a color video image.

RS-170A (EIA-170) – An Electronic Industries Alliance (EIA) standard describing a black and white television system containing 525 lines in two interlaced fields at a field rate of 59.94 Hz. This is the basis of the modern, North American NTSC television system.

saturation – In video systems, the level of color relative to the maximum handling capacity for that color. The level of saturation is dependent on the level of the chrominance component of the video signal.

scan rate – The frequency at which the electron beam scans a single line of an image. This is 15.7 kHz for an NTSC system and can be as high as 100 kHz for computer monitors.

screen size – the diagonal dimension of a display screen (measured in inches or centimeters). Sometimes part of a display screen may be hidden behind a plastic housing (i.e., the case of the display), thus causing a mismatch between the published screen size and the viewable screen size.

self timer – A feature of a camcorder or video recorder that allows it to turn itself on and/or off at a particular time or time interval.

sensitivity – In an electronic device (e.g., a communications system receiver such as a television), the minimum input signal required to produce a specified output signal having a specified signal-to-noise ratio or other specified criteria.

shutter – A device that opens and closes, allowing or disallowing light to reach the video pickup device.

signal – Detectable transmitted energy that can be used to carry information.

SNR – signal-to-noise ratio – the ratio of the amplitude of the desired signal to the amplitude of noise signals at a given point in time. Note 1: SNR is expressed as 20 times the logarithm of the amplitude ratio or 10 times the logarithm of the power ratio. Note 2: SNR is usually expressed in dB and in terms of peak values for impulse noise and root-mean-square values for random noise. In defining or specifying the SNR, both the signal and noise should be characterized (e.g., peak-signal-to-peak-noise ratio), to avoid ambiguity.

speaker – An electrical signal to audio sound pressure transducer.

special effects (special FX) – Any number of features added by camera manufacturers that affect the video in special ways. Includes fades, wipes, and solarization.

still video – Recording a single frame of video to several seconds of videotape, essentially creating a still image that can be annotated with audio (i.e., use the audio recording tracks to record information about the picture).

S-VHS (Super VHS) – the same as standard VHS except that the luminance carrier is shifted to a higher frequency, allowing for greater carrier bandwidth and, hence, greater resolution (about 400 TVL).

S-VHS -C– A piece of equipment using S-VHS videotape in a smaller cassette.

synchronization signal – a signal used to synchronize pieces of video equipment to a common clock. In medium- and large-sized video facilities, it is necessary to synchronize all pieces of equipment to avoid problems when recording or playing video.

TIFF (Tagged Image File Format) – a standardized file format used to store images.

time-lapse – The technique of recording one frame at a time at specified intervals. When played back at normal speed, time appears compressed, allowing viewing of a whole day's worth of video in just a few minutes.

tint – See hue.

titling – Referring to the ability to overlay text or symbols onto a video signal. An example of titling is credits at the beginning or end of a movie.

TVL (television lines) – a unit of horizontal resolution for video devices.

VCR (video cassette recorder) – denotes all formats of video tape recorder except reel-to-reel.

VHS (video home system) – a piece of equipment using ½ in video tape and a cassette approximately 4 in by 7 1/2 in.

VHS -C – A piece of equipment using standard VHS video tape in a smaller cassette.

video – An electrical signal containing timing (synchronization), luminance (intensity), and often chrominance (color) information that, when displayed on an appropriate device, gives a visual image or representation of the original image sequences.

viewfinder compatibility – Implies that a camera or camcorder has a jack to which an LCD monitor can be attached.

white balance – A camera control that controls the overall intensity of a video signal. Most cameras come with an automatic white balance adjustment that can be overridden in situations where the content of the scene is not "average" (i.e., the subject is either lighter or darker than average).

wind screen – a device (typically sponge rubber) that is used to cover a microphone and prevent wind from striking the diaphragm and causing extraneous (usually annoying) noise while still allowing sound waves to pass through, creating an audio signal.

wireless playback – A feature on some camcorders and recorders that allows playback on a television or monitor without physically connecting wires.

This is accomplished through the use of an infrared transmitter in the camcorder/recorder and an infrared receiver that needs to be attached to the television/monitor. The receiver is usually included as a part of the package.

YIQ – Luminance, In-phase, Quadrature (the letter Y is commonly used in video work as a symbol for luminance).

Appendix A. Information Resources on the Web

Below is a list of web addresses for companies selling video equipment that might be useful in video surveillance applications. This is not a comprehensive list. Inclusion or exclusion neither implies that the products of one company are better than the products of another for a given application, nor does it imply that all claims made by these companies are accurate. Before purchasing any product, check as many options as possible.

http://www.advancedalarms.com

http://www.advdig.com

http://www.canon.com

http://www.cohu.com

http://www.concealedcameras.com

http://www.dxsystems.com

http://www.eagletcs.com

http://www.electrophysics.com

http://www.eyeqsys.com

http://www.jeffhall.com

http://www.jvc.com

http://www.midniteyes.com

http://www.midwestcommunications.com

http://www.p2comm.com

http://www.panasonic.com

http://www.rock2000.com

http://www.rparker.com

http://www.sharpcom.com

http://www.sharpelectronics.com

http://www.sony.com

http://www.spiderweb1.com/pi-supply

http://www.spyman.com

http://www.spyshops.com

http://www.spysite.com

http://www.spyworld.com

http://www.spyzone.com

http://www.supercircuits.com

http://www.visualmethods.com

http://www.wireless-experts.com

http://www.wirelesstech.com

http://www.xybion.com

Appendix B: Effect of Low Light Situations on Cameras

To provide more detailed information on the effects of shooting in low-light situations, testing on actual video gear was conducted in a major Federal video-quality laboratory. This appendix illustrates how image quality changes as light levels change. In addition, one image enhancement technique, useful for extracting a useable image from footage taken in too little light, is demonstrated. This technique can be employed by someone with moderate computer skills working with commercial software on a standard personal computer.

B.1 Working in Less-Than-Ideal Light

To illustrate the effects of using cameras in low-light situations, experiments were conducted to show how the ability to distinguish human faces changes as light decreases. Furthermore, the experimental results illustrate the impact of both optical and digital zoom and differences in manufacturers' claims of a certain light level rating.

This test was designed and conducted in this way. A one-eighth scale photograph of a recognizable person was mounted in front of the camera in a controlled lighting environment. Each of the two camcorders in the test were aimed at the picture and positioned such that the head and shoulders of the individual in the picture filled the frame at each of three distances: minimum, full optical zoom, and full digital zoom. Lighting levels started at a level high enough to generate a good quality picture and were then decreased to approximately 2.4 lux. At that point, a 0.9 neutral density filter (which blocks 90 percent of the light passing through) was added to the camera lens, allowing the room lights to be 10 times brighter than what the camera actually was seeing. Using this technique allowed the experiment to proceed to the camcorders seeing an effective light level of 0.1 lux.

Light readings were taken with a Tektronix J18 Photometer and J1811 Illuminance Head with the sensor positioned over the face in the photograph. Once the reading was taken, the sensor was moved aside, and video of the photograph was recorded.

Table B-1 lists the camcorders used in this experiment and the relevant specifications of those devices. One might notice the maximum aperture varies for Camera B but not for Camera A. This is because Camera B uses a variable aperture zoom. Variable aperture zooms generally have a smaller maximum aperture as the lenses are zoomed to their highest magnification. This is a disadvantage in low-light surveillance situations, but there are tradeoffs. Variable aperture lenses are smaller and less expensive to design and manufacture than fixed aperture zooms, such as the one used in Camera A.

Table B-1. Cameras used in the low-light experiment and their specifications

	Camera A	**Camera B**
Tape format	Mini-DV	Mini-DV
Optical zoom	10x(5.9–59 mm)	14x(5.2–72.8 mm)
Maximum aperture	f 1.6	f 1.8 – 3.2
Digital zoom	2x	2.5x
Total zoom range	20x	35x
Minimum light rating	4 lux	2.5 lux

Figures B-1 and B-2 show the facial identification ability of Camera A and Camera B (respectively) at 14 different light levels. There are many things to note in these two figures. For Camera A, the minimum light level to achieve facial identification is about 0.8 lux. For Camera B, it is about 1.5 lux. This is especially interesting given that Camera B has a lower minimum

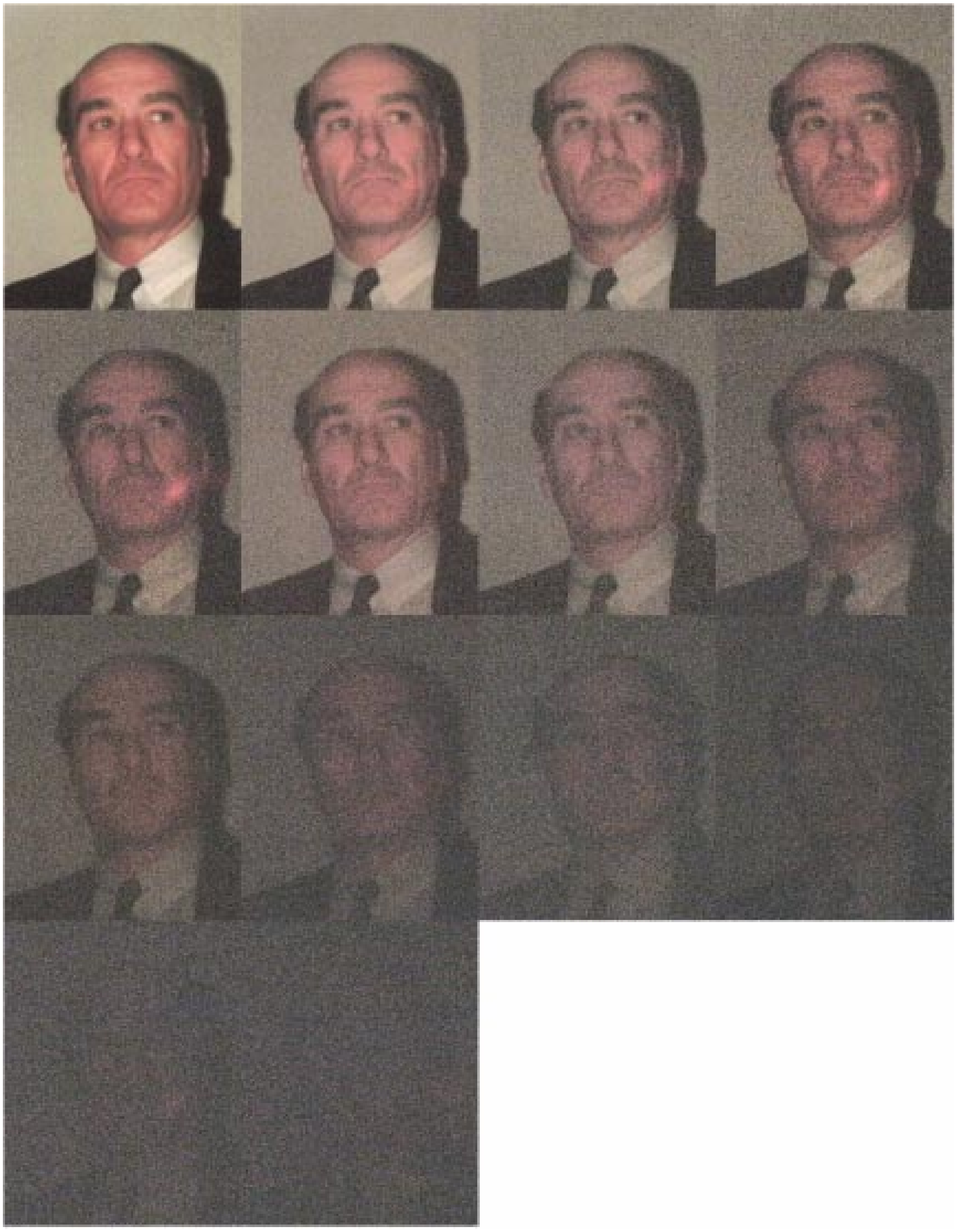

Figure B-1. Effect of diminishing light level on image integrity. Camera = Camera A. Distance = minimum distance. Light levels (in lux, from top left): Row 1 - 19.0, 7.6, 4.3, 3.4. Row 2 - 2.2, 2.2*, 1.5*, 1.0*. Row 3 - 0.8*, 0.5*, 0.35*, 0.24*. Row 4 - 0.17*, 0.10* (* indicates effective light level while using 0.9 neutral density filter.)

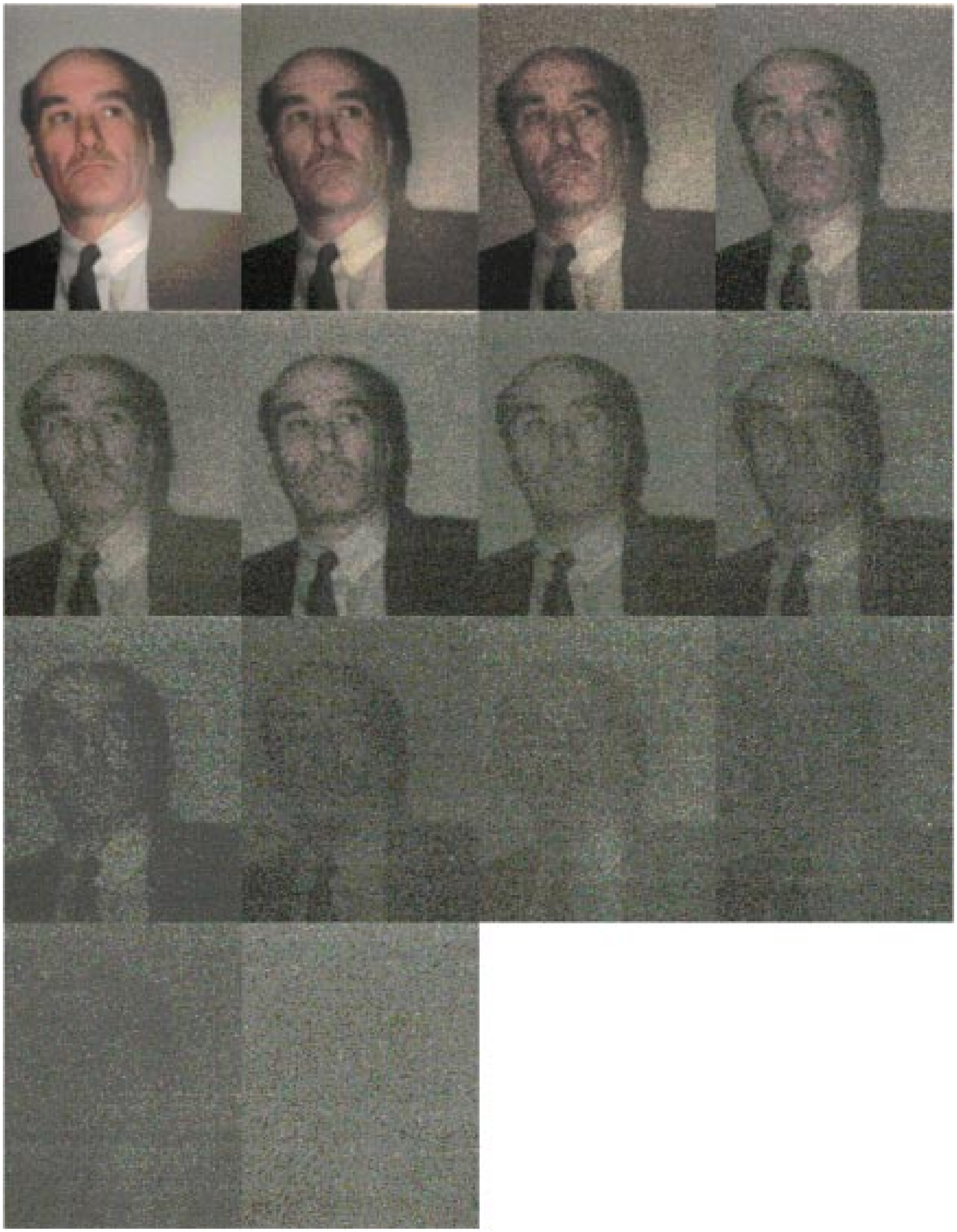

Figure B-2. Effect of diminishing light level on image integrity. Camera = Camera B. Distance = minimum distance. Light levels (in lux, from top left): Row 1 - 19.4, 7.6, 4.4, 3.3. Row 2 - 2.4, 2.5*, 1.5*, 1.0*. Row 3 - 0.8*, 0.5*, 0.36*, 0.24*. Row 4 - 0.17*, 0.11* (* indicates effective light level while using 0.9 neutral density filter.)

light rating. In fact, it is useful to compare image quality of the two camcorders at their respective minimum light rating. Camera A provides a much more colorful and identifiable face at approximately 4 lux than Camera B does near its rated 2.5 lux. This is just visual evidence of the lack of measurement standards for camera and camcorder specifications. In both sets of images, one can notice "hot spots" or spots that are brighter than they should be. This is due to reflections off the image. Because the camera lenses had such a wide field of view for generating these data, it was possible for them to pick up the brightness of the lighting source reflecting off the glossy image paper. Finally, for this part of the experiment, the lens of Camera A was about 9.5 in from the image, while the lens of Camera B was about 8.5 in distant. The required difference in placement is consistent with the difference in the shortest focal length for the lens: 5.9 mm for Camera A and 5.2 mm for the Camera B.

Figures B-3 and B-4 are similar to B-1 and B-2 except they were taken at the maximum optical zoom levels of Camera A and Camera B, respectively. Again, note the minimum useable light level for Camera A is about 0.8 lux. Camera B, however, does not produce an identifiable image below 3.4 lux, a significant shift from closest zoom range. This is due to the variable aperture zoom employed. The shift of minimum acceptable light from 1.5 lux to 3.4 lux mirrors the change in maximum aperture from f 1.8 to f 3.2. For this part of the experiment, Camera A was positioned at 54.5 in from the subject while Camera B was positioned at 69.5 in. Again, the difference is consistent with the focal length of their lenses (59 mm for Camera A and 72.8 for Camera B).

Figures B-5 and B-6 reveal the effects of using digital zoom in addition to the optical zoom. Immediately noticeable is the increased speckling or grain. This is because the cameras only use a portion of the CCD array to pick up the image: 50 percent for Camera A, 40 percent for Camera B. Camera B shows significantly more degradation from using the digital zoom than Camera A does. It also requires significantly more light for a useable picture. The lowest acceptable light level for identification is 31 lux. For Camera A, it is still possible to identify the subject at 4.3 lux. For this experiment, Camera A was 131 in from the subject and Camera B was 175 in.

B.1.1 Enhancing the Images

There may come an occasion when it is absolutely necessary to record video in light levels below what is known to be acceptable for the purposes of the surveillance. In these situations, it is best to take the highest quality video possible (i.e., stable camera, as little motion in the scene as possible). Afterwards, it may be possible to extract some useful information from the tape using image processing techniques.

One of the simplest techniques involves "capturing" or recording a sequence of video frames to a computer's hard disk and then averaging the images to improve the signal-to-noise ratio. Figure B-7 shows the effects of averaging 30 frames of video for Camera A at maximum optical zoom. Note it is possible to identify the subject at a light level of 0.23 lux.[9] This is a significant improvement over the 0.8-lux light level that was required without averaging (fig. B-3). The procedure to accomplish this follows.

To begin, the video was taken using Camera A, a digital camcorder. The camcorder was connected to an IBM-compatible personal computer (133 MHz Pentium™ running Microsoft Windows 95®) with the Canon Video DK-1 DV Capture Kit installed using the cable supplied with the capture kit. (This capture kit is compatible with all digital camcorders that have an IEEE 1394 "Fire Wire" interface, and has no relationship to the manufacturer of Camera A or Camera B.) Using the supplied software (DV Commander®), 30 consecutive frames were saved on the PC's hard drive. The frames had 640 x 480 pixel resolution and were saved as *TIFF* (Tagged Image File Format) images. The files were then individually

[9] At a light level of 0.23 lux, the image in the viewfinder of the camcorder was almost totally noise. Only the vaguest outline of the person in the image was discernable.

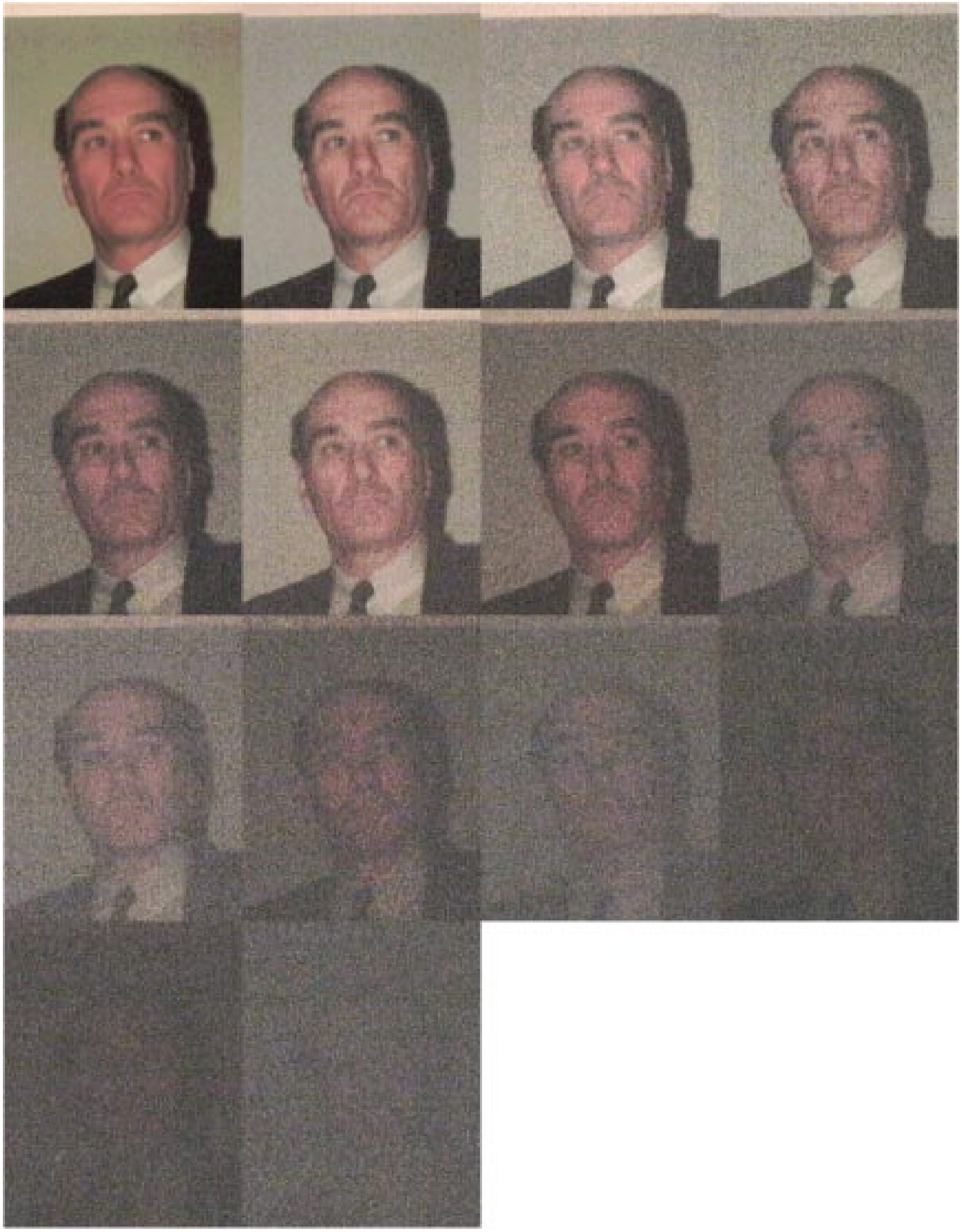

Figure B-3. Effect of diminishing light level on image integrity. Camera = Camera A. Distance = maximum optical zoom. Light levels (in lux, from top left): Row 1 - 19.0, 7.5, 4.6, 3.3. Row 2 - 2.4, 2.4*, 1.5*, 1.0*. Row 3 - 0.8*, 0.5*, 0.35*, 0.23*. Row 4 - 0.17*, 0.10* (* indicates effective light level while using 0.9 neutral density filter.)

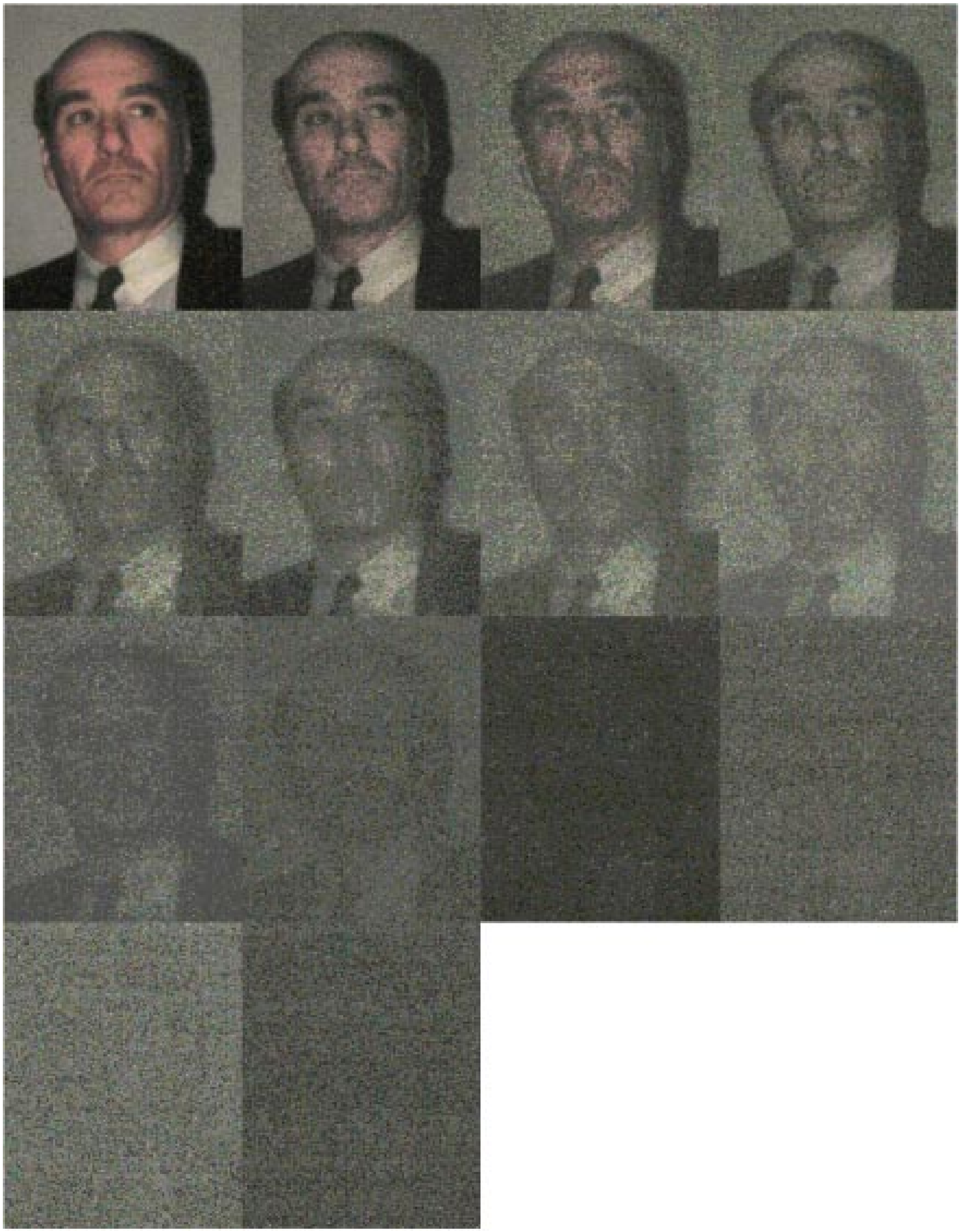

Figure B-4. Effect of diminishing light level on image integrity. Camera = Camera B. Distance = maximum optical zoom. Light levels (in lux, from top left): Row 1 - 19.4, 7.6, 4.4, 3.4. Row 2 - 2.3, 2.3*, 1.5*, 1.0*. Row 3 - 0.8*, 0.5*, 0.37*, 0.23*. Row 4 - 0.16*, 0.10* (* indicates effective light level while using 0.9 neutral density filter.)

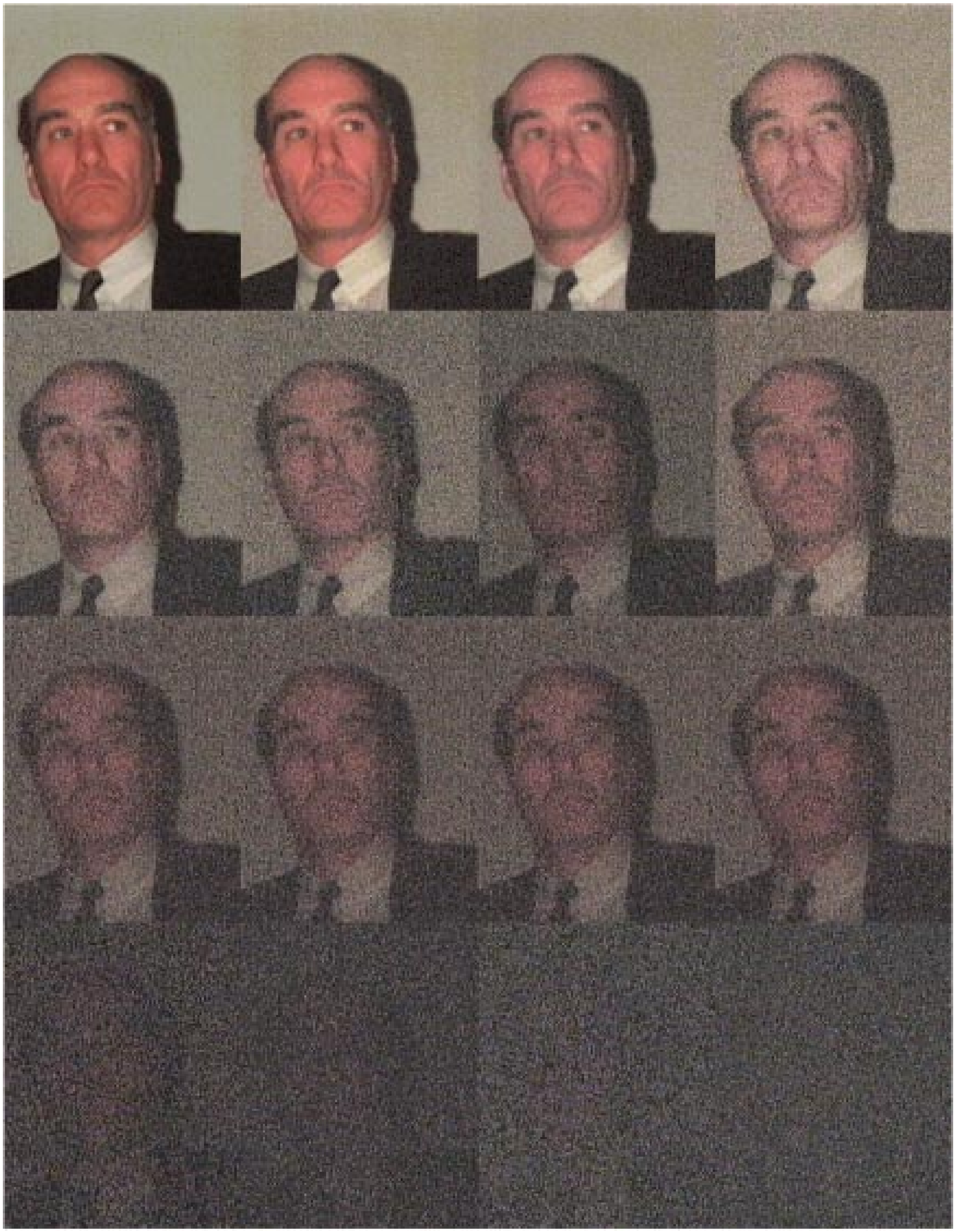

Figure B-5. Effect of diminishing light level on image integrity. Camera = Camera A. Distance = maximum digital zoom. Light levels (in lux, from top left): Row 1 - 51, 31, 19.4, 7.7. Row 2 - 4.3, 3.4, 2.3, 2.3*. Row 3 - 1.5*, 1.0*, 0.8*, 0.5*. Row 4 - 0.35, 0.24, 0.16*, 0.10* (* indicates effective light level while using 0.9 neutral density filter.)

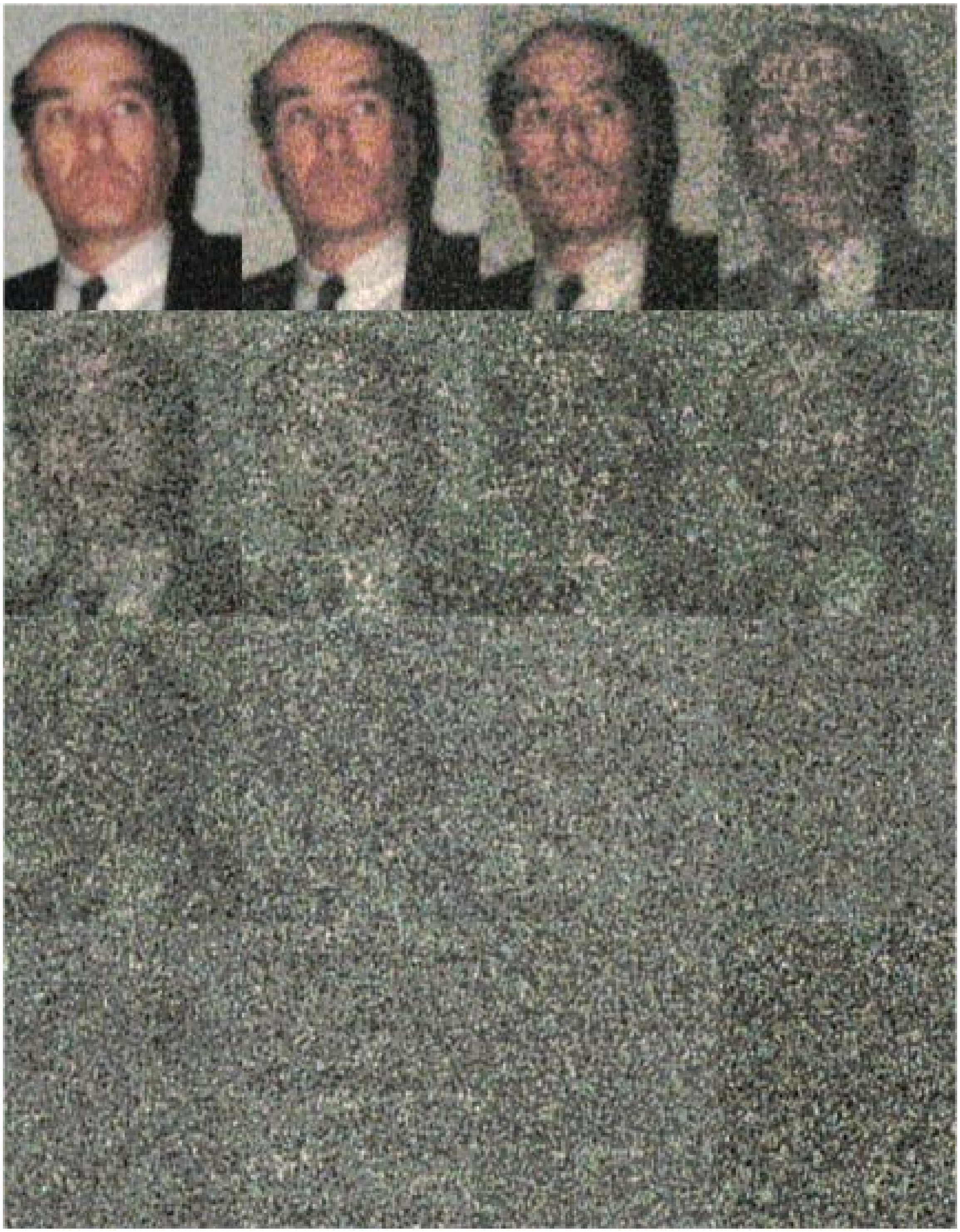

Figure B-6. Effect of diminishing light level on image integrity. Camera = Camera B. Distance = maximum digital zoom. Light levels (in lux, from top left): Row 1 - 51, 31, 19.0, 7.6. Row 2 - 4.4, 3.5, 2.4, 2.4*. Row 3 - 1.5*, 1.0*, 0.8*, 0.5*. Row 4 - 0.36*, 0.23*, 0.16*, 0.11* (* indicates effective light level while using 0.9 neutral density filter.)

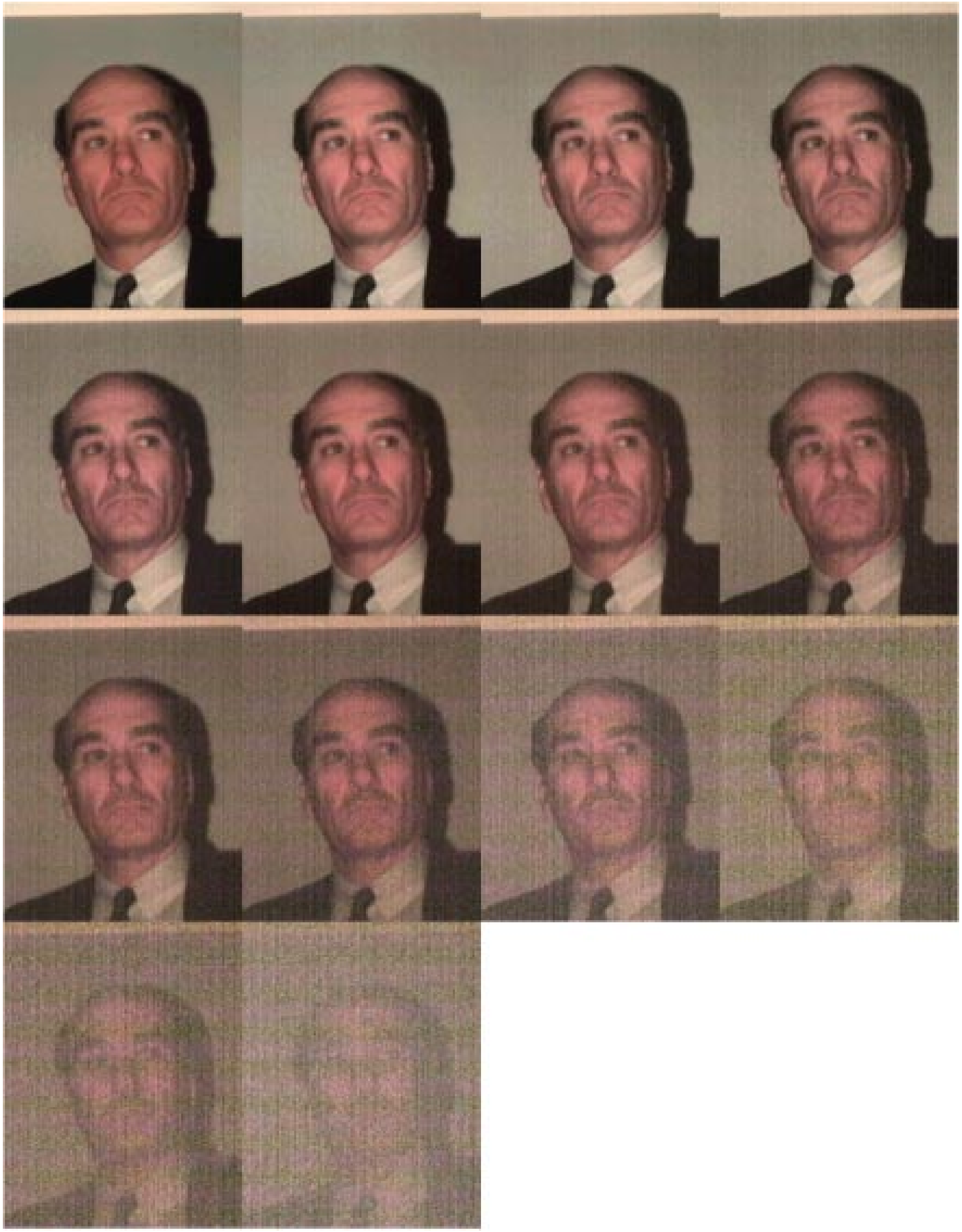

Figure B-7. Effect of diminishing light level on ability of signal processing techniques to improve image integrity. Camera = Camera A. Distance = maximum optical zoom. Light Levels (in lux, from top left): Row 1 - 19.0, 7.5, 4.6, 3.3. Row 2 - 2.4, 2.4*, 1.5*, 1.0*. Row 3 - 0.8*, 0.5*, 0.35*, 0.23*. Row 4 - 0.17*, 0.10* (* indicates effective light level while using 0.9 neutral density filter.)

loaded into a scientific computing package (IDL®), where they were individually scaled to maximize contrast. All the images were summed on a pixel-by-pixel basis, and then that result was divided (also pixel-by-pixel) by the number of frames (30). The resulting image was once again scaled to maximize contrast and then saved to a separate file. Each image in figure B-7 is cropped[10] from one of these averaged files.

While image processing using IDL® might be beyond the average computer user, there are PC-based graphics-design software packages that can be used to achieve the same goal. One such package is Adobe® Photoshop®. Using Photoshop®, one can read the TIFF images as separate files. For each image, the content can be copied and pasted into a layer of a master image. Once in a master image, each layer should be adjusted using the "Auto Levels" feature (pressing Control+Shift+L simultaneously), and the opacity should be adjusted to 100/*number of frames* percent. (For this reason it is best to try to have a number of frames that will evenly divide into 100.) Once all layers have been adjusted, the layers can be combined (i.e., flattening the image) and the image can be saved.

B.2 Summary

This appendix has provided an overview of how diminishing light can effect the images produced by video equipment. In doing this, it showed how the low-light threshold of a camera or camcorder could be visually assessed. Finally, a brief introduction into image enhancement was given showing useful information can be extracted from videotape footage even when direct viewing does not reveal anything useful.

[10]The cropping was done only to provide a more compact display in the figure.

U.S. Department of Justice
Office of Justice Programs
810 Seventh Street N.W.
Washington, DC 20531

Janet Reno
Attorney General

Daniel Marcus
Acting Associate Attorney General

Laurie Robinson
Assistant Attorney General

Noël Brennan
Deputy Assistant Attorney General

Jeremy Travis
Director, National Institute of Justice

For grant and funding information contact:
Department of Justice Response Center
800–421–6770

Office of Justice Programs
World Wide Web Site
http://www.ojp.usdoj.gov

National Institute of Justice
World Wide Web Site
http://www.ojp.usdoj.gov/nij