Defining Video Quality Requirements: A Guide for Public Safety

Volume 1.0

Developed by:

Video Quality in Public Safety Working Group

This procurement guide was sponsored by the Office for Interoperability and Compatibility (OIC) within the U.S. Department of Homeland Security. It was developed in partnership with emergency responders, the Department of Commerce's Public Safety Communications Research (PSCR) program, and private sector partners.

Executive Summary

Often, emergency responders must consider a multitude of factors before making video component procurement decisions, such as installation, testing, support, redundancy, and training. Emergency responders involved in the procurement process - either of a video system in part or in its entirety - will find this guide to be a valuable tool because it considers an end-to-end system. For example, this guide identifies needs associated with video stream as it travels from the scene (camera) through the system to the end user viewing the scene on a remote display.

The guide provides an overview of video systems, defines functional concepts of video quality, explains how to generalize a use case with a use class, and provides a brief explanation of the qualitative aspects of video components. There is a wide range of information that exists related to video quality and selection of video components such as installation, maintenance, training, and interoperability. While this guide does not provide detailed specifications and standards for video components, the Video Quality in Public Safety Working Group (VQiPS WG) plans to release future guidance on technical performance specifications and standards that address various components of the video system.

Determining Use Cases

A video system must deliver video to the end users in such a way that they are able to accurately recognize objects and take action based on what they see. The first step in procuring video equipment is to determine the use case. A use case is a set of functional requirements based on the content of the observed scene and the task being performed by an end user. For instance, the scene of interest could be a large crowd on a train platform, a license plate on a moving vehicle, or a plume of smoke, and an end user's task might be to view a scene in real time through the video apparatus and alert emergency responder officials if something is awry. Alternatively, the video apparatus may capture and record footage for an end user to review at a later date. These applications for use are called "use cases." This guide will introduce users to different use cases, enabling users to determine which level of quality is necessary, and making it possible to procure an appropriate video system with the required level of video quality.

Use Classes

Although a particular video use case may seem unique, it almost certainly has features common to other use cases. *Use classes* represent combinations of shared features across various *use cases*. Video footage from a police car and aerial video footage of a wildfire, although different in many respects, are similar in that they are capturing an image that is moving at a high degree. By answering five questions about a particular use case, the reader can determine which general use class applies. Key aspects to consider include

1. Usage Timeframe - Is the video used for real-time applications or recorded for later use?
2. Discrimination Level - What is the end user's ultimate goal?
3. Target Size - How much of the frame does the object or person of interest occupy?
4. Motion - How much motion (either target or camera) and how much spatial detail are in the video frame?
5. Lighting Level - Is the lighting generally uniform, or are there near-black to daylight ranges in the video frame?

Core Video System Components

In addition to understanding use cases and use classes in procurement of video systems, it is also important to understand the various components of video systems and which components impact quality. To address those issues, this document describes various core video system components that directly affect video quality, such as: Lens Configuration, Image Capture, Processing, Transport, Storage, and Display.

Qualitative Guidance

Lastly, the document will provide qualitative guidance to help the reader understand features of system components and define the impact those components have on video quality based on an identified use class. This guidance is intended to educate readers on the issues involved, tradeoffs, and units of measure associated with video components. This general synopsis informs the reader how certain use characteristics and scene content can affect video component features.

Table of Contents

List of Figures

List of Tables

I. Introduction

In recent years, the exponential growth of Closed Circuit Television (CCTV) and other video technology has been instrumental in addressing a wide range of emergency response concerns. The emergency response community, including police, fire, and emergency medical service (EMS) are using video applications in transportation, crime, and public works efforts. With emergency responders increasingly relying on CCTV technology and systems, they need to increase their attention on video quality issues so that they can use and share images across interoperable emergency response systems.

To respond to this growing need, the Office for Interoperability and Compatibility (OIC) within the U.S. Department of Homeland Security (DHS) partnered with the U.S. Department of Commerce's Public Safety Communications Research (PSCR) program to develop a partnership of local, state, and Federal representatives to address these concerns. This partnership, along with a combination of participants from the private sector and academia, are working to enhance and standardize video quality through the formation of the Video Quality in Public Safety Working Group (VQiPS WG).

The VQiPS WG has developed this guide to inform and assist the emergency response community in identifying the appropriate video system components that impact video quality. The guide is intended for emergency responders who are involved in maintaining and procuring a video system.

A. Background

At the first VQiPS conference in February 2009, OIC and PSCR initiated the VQiPS WG, and defined how the group would address the most pressing video quality issues. The VQiPS WG includes local, state, and Federal representatives from a variety of disciplines including law enforcement, fire services, EMS, transportation, and telecommunications. The VQiPS WG also includes representatives from non-profit research organizations, academic institutions, and the video industry.

The activities of the VQiPS WG and the research and development support of OIC and PSRC are all part of a collaborative process to provide representatives of local, tribal, state, and Federal governments with access to information that will assist them in the procurement of video components and systems. OIC partners with PSCR to support research, development, testing, and evaluation (RDT&E) of video system standards and performance requirements. PSCR uses a structured approach to identify video quality needs and specifications and conducts research and lab testing to identify performance specifications for the core video system component areas.

With an end goal to articulate a common set of requirements for the procurement of video components and systems that meet the end users specific needs, the VQiPS WG has two main purposes: 1) to provide the emergency response community with the knowledge they need to purchase and employ the appropriate video systems; and 2) to collectively communicate emergency responders' needs to industry and standards-making bodies. In order to achieve those purposes, the VQiPS WG developed an action plan to complete the following key initiatives:

1. Develop a set of application-independent usage scenarios
2. Develop guidance material needed to help the emergency response communities perform the following:
    a. Assess video quality needs
    b. Match needs to technical performance specifications and standards to support procurement

3. Develop a glossary of common terms
4. Compile an inventory of existing standards and specifications that address various components of the video system for specific usage scenarios
5. Develop a common library of test clips that represent the use cases

This document addresses elements 1, 2a, and 3 of the above action plan. Currently, the VQiPS WG is addressing the remaining elements (2b, 4, and 5) and will make the results available to the emergency response community in the near future.

B. Problem Statement

Video applications are quickly emerging as an essential component of effective emergency response communications. For example, emergency responders can use video to provide aerial images of wildfires to firefighters, to monitor highway traffic, to assess the scene of an accident or as evidence in a criminal case. In the past, practitioners relied on manufacturers to build and provide video equipment and system specifications. However, video technology has evolved, resulting in more complex video systems and a multitude of video systems and components from which to choose in the procurement process. Since many emergency response agencies do not have the tools, support, and information they need to make informed video system-purchasing decisions, they have a major challenge to procure video systems that attain the desired video quality.[1]

C. Intended Audience

This document addresses the needs of emergency responders who intend to procure video systems, regardless of organization size, system size, or specific video application. There are two specific categories of potential users of this guide:

1. Emergency response practitioners or persons representing a group of end users within an agency involved in evaluating video systems. This guide will aid in determining video quality needs and selection of core video system components.
2. The technical employee or support contractor – the person writing specifications for video systems and developing procurement documents who is not the end user. This guide can serve as a communication tool between an end user and integrator.

This guide will assist those individuals who are responsible for evaluating and procuring video systems that meet the needs of end users. Because there are often multiple end users, the minimum quality requirements should be established, when feasible, for the user with the most stringent video quality needs that are consistent with the most critical use of the system.

D. Document Scope

This guide will enable emergency response agencies to more clearly describe an agency's video quality needs. It will provide qualitative guidance for key video system components and provide a better understanding of which video components impact video quality. The document's goal is to educate the end user on common components of video systems, which will enable them to purchase the appropriate

[1] *"Video quality" is the ability of the emergency response agency to use the required video to perform the purpose intended. For example, if the purpose of the video is to capture vehicle license plates in a range of outdoor conditions, video quality is measured in the ability of the video outputs to provide that specific information across a range of environmental conditions.*

video system. Because this guide will not directly advise users on which video system to purchase, readers should seek consultations with experienced video professionals to determine appropriate systems and obtain information on jurisdictional procurement regulations.

This document addresses the core components of a video system and the aspects of the scene content that apply to any video system, regardless of size. The term "core components" refers to equipment in the video system that can change the video signal, thereby affecting the quality of the delivered video. Other considerations for a video system include, but are not limited to, camera placement, security, weatherization, etc., and are not covered by this guide. Highly complex or unique video applications may need additional requirements that are outside the scope of this guide. For example, the addition of a complex package of video analytics for use with the video system may require additional research and consideration in the preparation of procurement specifications.

This guide is a first step in providing the end user with guidance in selecting video components that affect video quality, such as installation, maintenance, training, and interoperability. In future documents that build on this guide, OIC, PSCR, and the VQiPS WG plans to provide detailed guidance on technical performance specifications and standards that can be applied to various usage scenarios.

E. How to Use This Guide

Following the introduction of key concepts, this guide will address two things. The first is an outline of the steps end users can take to generalize a use case; and the second is how to use that information in capturing user needs through the association with a Generalized Use Class. This process is illustrated in Figure 1.

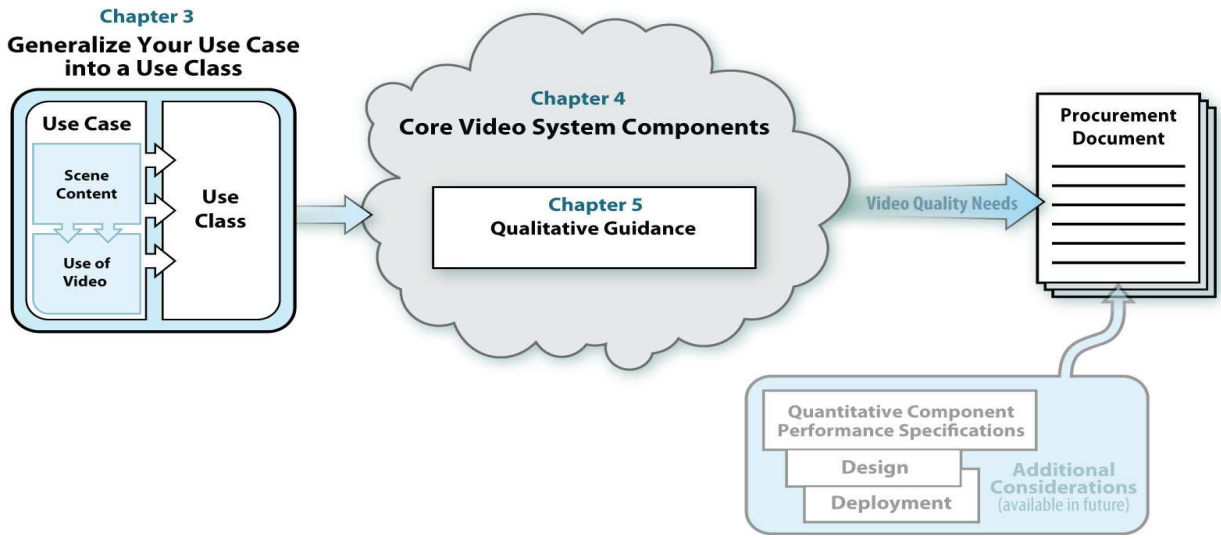

Figure 1. How to Get the Appropriate Video Quality

Section 2 outlines the fundamental concepts used in the document. Section 3 contains a questionnaire designed to help the reader identify needs in the form of a Generalized Use Class, which is referenced in the remaining sections. Section 4 describes the core video systems components. Section 5 provides qualitative information which relates back to the Generalized Use Class developed in Section 3. Appendix A contains an extensive glossary that defines commonly used technical terms.

II. Fundamental Concepts

This section defines video quality, use case, and a Generalized Use Class.

A. Video Quality

Video Quality is the video delivered to end users that allows them to recognize objects.

Other terms used to refer to video quality are "visual intelligibility" and "visual acuity." These equate to a visual extension of a "can you hear me" audio test, rephrased as "can you see me?" This guide reflects this concept; as it allows a user to specify end-to-end system performance or individual component performance. This guide is based on the following key concepts:

- Every application is trying to recognize a desired target to a particular level of discrimination.
- The ability to perform a specified task determines the required video quality being delivered.

B. Use Case

The first step to getting the appropriate video quality to match a user's needs is to clearly define functional requirements, or use case. At the most basic level, this depends on the answers to only two questions:

1. What is in the scene of interest, or scene content?
2. What is the desired task to be accomplished from viewing that scene?

The answers to these two questions define the use case. All emergency response video systems must present a scene of interest to a remote user *in sufficient detail* for the user to make a decision or perform a task based on recognition of what is happening in the scene. For example, the end user must be able to read the characters in a license plate or determine the identities of individuals at a local convenience store while performing surveillance.

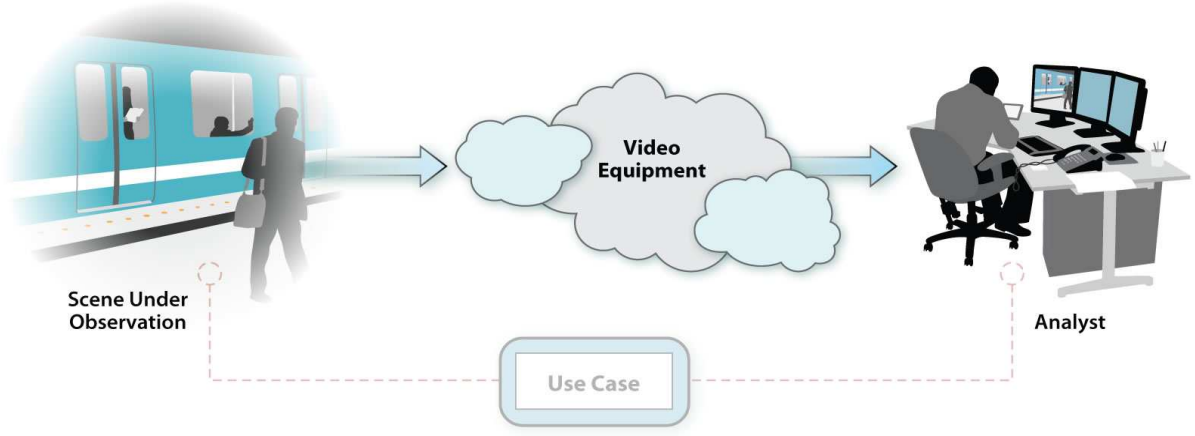

Figure 2. Use Case

Figure 2 illustrates the role that video equipment plays in bringing scene content back to the end user. The performance required of the video equipment depends on the specific use case. A use case considers the scene captured by the video system and the task being performed by the emergency response practitioner (or end user). Figure 2 shows a use case in which an agency has installed video

cameras at a train station. The scene content comprises the platform, the train (when it is in the station), and the individuals on the platform. Understanding the end user's needs for video feeds coming into the command center represents a critical component in assessing the type of video system required. For example, what are the feeds being principally used for? Are they being used to monitor the arrival of trains (perhaps to ensure tracks are clear and to notify service and response personnel of an incoming influx of persons into the station)? Are they being used to monitor the flow of passengers on the platform (to look for disturbances or guide response assets in the event of an emergency)? Or are they being used to positively identify and conduct surveillance on suspicious individuals in the crowd and follow them through the station? Later sections of this guide will define how users can identify the aspects of the scene content and use those impact requirements to inform which core video equipment components are necessary.

C. Generalized Use Class

This guide's fundamental premise is that use cases for seemingly different applications have similar quality requirements. This means that, upon closer examination, seemingly disparate video applications may actually have the same minimum requirements to perform a desired recognition task. While one video application may seem unique, it almost certainly has features common to other video applications. Figure 3 illustrates this idea. For example, identifying license plates and monitoring wildfires seem to be very different applications; however, they have many common minimum video requirements. Thus, users can develop performance specifications based on a definite set of Generalized Use Classes. This eliminates the need to create separate performance specifications for every possible application because there are specific Generalized Use Classes that exist.

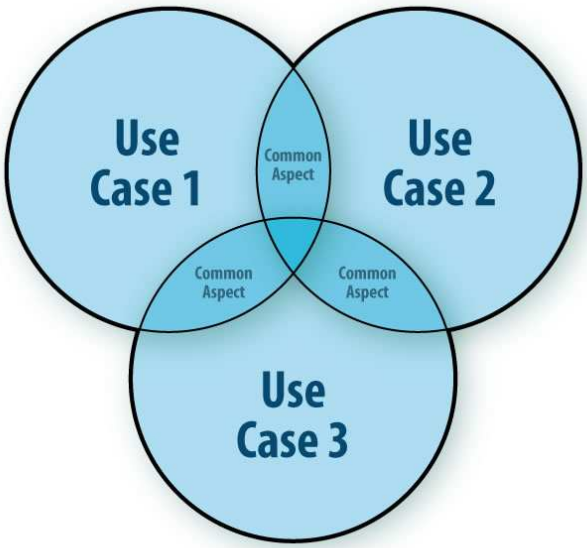

Figure 3. Multiple Use Cases Have Aspects in Common

Using this theory, this guide presents a finite set of questions that will lead the reader to identify an appropriate Generalized Use Class. These questions are related to how the user intends to use the video images and includes questions related to common aspects such as target size, motion, lighting level, usage timeframe, and discrimination level. The following section will provide a questionnaire to determine these common aspects.

III. Generalize a Use Case into a Use Class

This section provides examples and explains how to translate the reader's unique use case into a Generalized Use Class. A description of common aspects that make up a Generalized Use Class such as discrimination level, timeframe, target size, motion, and lighting is followed by a questionnaire designed to guide the reader through a process of choosing values related to these common aspects. The particular combination of values serves as an easily identifiable Generalized Use Class that describes an agency's video quality needs.

> An agency or organization may have more than one use case associated with its mission. Each use case should be carefully defined and analyzed as a use class in order to determine the overall most restrictive use class. For example, if law enforcement and fire officials share a video system, law enforcement may need to recognize individuals with high-level detail, while fire may only need to recognize the presence of smoke. In this case, law enforcement has a more restrictive use case.

After the reader has used the questionnaire to determine the Generalized Use Class, subsequent sections of the guide refer to the Generalized Use Class to provide qualitative guidance for the core video system components. The VQiPS Working Group will make more detailed standards and performance specifications available in subsequent publications.

A. Generalized Use Class Aspects

A use class consists of important aspects of specific use cases that are common to other use cases, and generalizations can be made between them. As shown in Figure 2, all use cases have an analyst and a scene under observation. The generalized aspects are derived from both the analyst's intended use of the video (Use Characteristics) and what is in the scene under observation (Scene Content). The next section describes five Generalized Use Class Aspects, each of which can impact the quality of the video content as seen and used by the end user.

Use Characteristics

1. Discrimination Level*

Video may be used to identify a wide range of detail, from motion detection to positive identification of a person for forensic evidence. Not every video system needs to perform positive identification. The video system selected should conform to the application requirements, without over- or under-specifying the system.

2. Usage Timeframe

To what level of discrimination does the user need to recognize the target?

If a user needs to determine only whether there are people present in a scene, "General Elements of the Action" would suffice. If the user requires large-scale recognition, such as the distinction between a car

* *Term is defined in Appendix A: Glossary*

and a van, then "Target Class Recognition" fits the users' system needs. A value of "Target Characteristics" indicates the need to recognize gender and markings, and distinguish smaller actions, and "Target Positive ID" indicates the most specific discrimination level.

Scene Content

3. Target Size

The size of the region of interest (target) with respect to the size of the field of view directly affects the ability to recognize that target when the camera is at its maximum optical zoom. The larger the target, relative to the field of view, the more details can be discerned. The perceived target size is dependent on the actual target size, its distance from the camera, and the camera's field of view. Figures 4 and 5 demonstrate the difference between a large target size and a small target size. PSCR is developing measurements to more precisely define target size.

Figure 4. Example of Target Size: Large

Figure 5. Example of Target Size: Small

4. Motion in the scene (e.g., background, target or camera)

Motion can come from the target (e.g., a car driving by), the background (e.g., a large crowd), or from the camera itself moving (e.g., a dash-mounted camera in a police car). Motion affects the length of time a desired target is shown in the video frame, and can cause the target to blur. High motion can be caused by either many moving objects within the scene (see Figure 6) or a single object moving quickly.

Figure 6. Example of Motion in the Scene: High

5. Lighting Level

Lighting levels can vary from very dark (e.g., nighttime or indoors) to very bright (e.g., daylight or spotlight), affecting the ability of the camera to capture the image. The presence of both very bright areas and very dark areas in the frame simultaneously is known as high dynamic range, and can impair target recognition, as shown in Figure 7.

Figure 7. Example of Lighting Level: Variable

The combinations of the end user's specific needs in these five areas comprise the Generalized Use Class. There are many more aspects that affect video, and each of these parameters has an infinite number of possible values. This document addresses the most important aspects and defines a manageable number of choices for each. VQiPS WG made a concerted effort to provide a balance between complexity and simplification.

Given the aspects and possible values described above, Figure 8 illustrates the aspects that make up a Generalized Use Class.

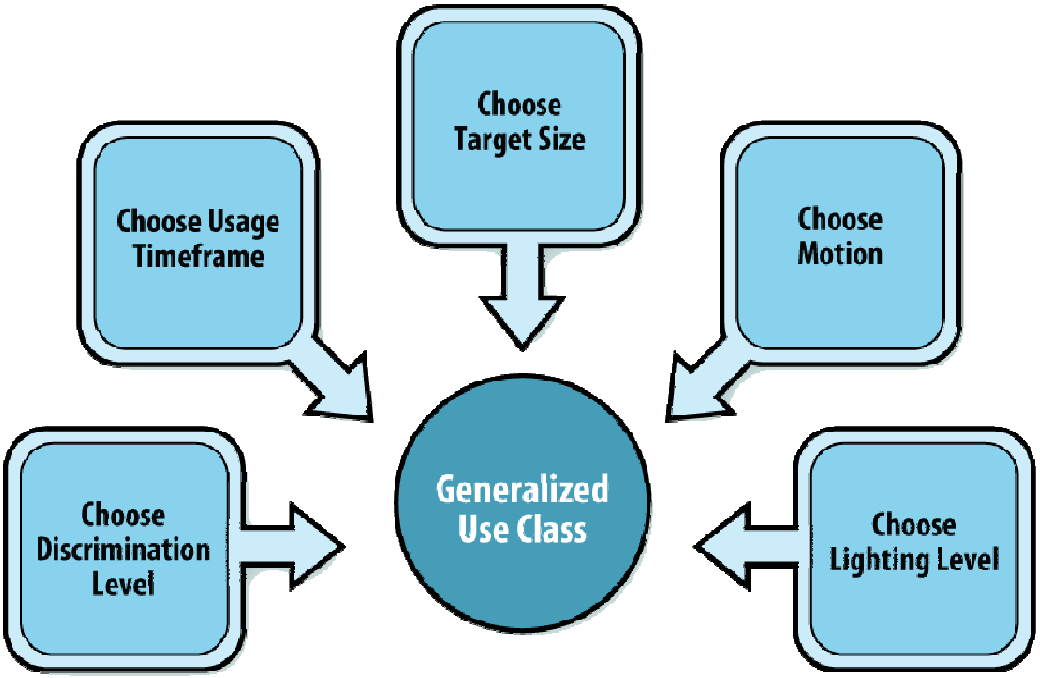

Figure 8. Generalized Use Class Aspects

The end user determines the specific value for each aspect. The combination of the individual choices form the user's Generalized Use Class.

B. Generalized Use Class Questionnaire

Table 1 contains the Generalized Use Class questionnaire, which identifies each of the aspects with a brief description, followed by a small set of choices for each aspect. The user should match the appropriate video application with the appropriate Generalized Use Class. The user should use the most restrictive case when making selections below.

Use Characteristics				
Aspect	**Question for End User**	**Value**	**Definition**	**Example**
Discrimination Level	What is the end user's ultimate goal?	☐ General Elements of the Action	High-level description of actions that took place	People or person present
		☐ Target Class Recognition	Large-scale recognition	Car vs. van
		☐ Target Characteristics	Medium-scale detail recognition	Gender, markings, smaller actions
		☐ Target Positive ID	Enough detail to make a positive recognition	Face, object, alpha-numeric
Usage Timeframe	Is the video used for real-time applications or recorded for later use?	☐ Live or real-time	The video will be viewed at the same time it is being shot	Security monitor being viewed by security personnel
		☐ Recorded	The video will be saved and capable of being played back	Forensic video
Scene Content				
Target Size	How much of the frame does the object or person of interest occupy?	☐ Large	The target occupies a large percentage of the frame	
		☐ Small	The target occupies a smaller percentage of the frame	
Motion	How much motion (either target or camera) and how much spatial detail are in the video frame? If the camera is required to pan-tilt-zoom, the scene complexity could be higher.	☐ High	There is a lot of motion or edges in the video	
		☐ Low	Low complexity, there is not much motion, or many edges	
Lighting Level	Is the lighting generally uniform, or are is there near-black to daylight ranges in the video frame?	☐ Constant Lighting - High	At a comparatively bright level.	
		☐ Constant Lighting - Low	At a comparatively dim level.	
		☐ Variable	Ranges from bright to dim	

Table 1. Generalized Use Class Questionnaire

C. Generalized Use Class Examples

The following three examples demonstrate how to convert a specific use case into a Generalized Use Class. The first two demonstrate how two seemingly different applications may actually have the same video quality needs, because they belong to the same Generalized Use Class. The third demonstrates a different resulting Generalized Use Class.

Application 1

Description: Police in-car camera used to read license plates in real time (Figure 7).

The in-car camera must accurately read a license plate of a moving car from a moving vehicle, at speeds of up to 70 mph. The application of video in this example involves the police officers in the car, the dispatcher, and command and control. The police car follows the target car, the back of the target car is filmed, and the acquisition of the license plate number is attempted in real time. The alphanumeric character is the target. The motion sources are the target and the camera. The lighting is variable.

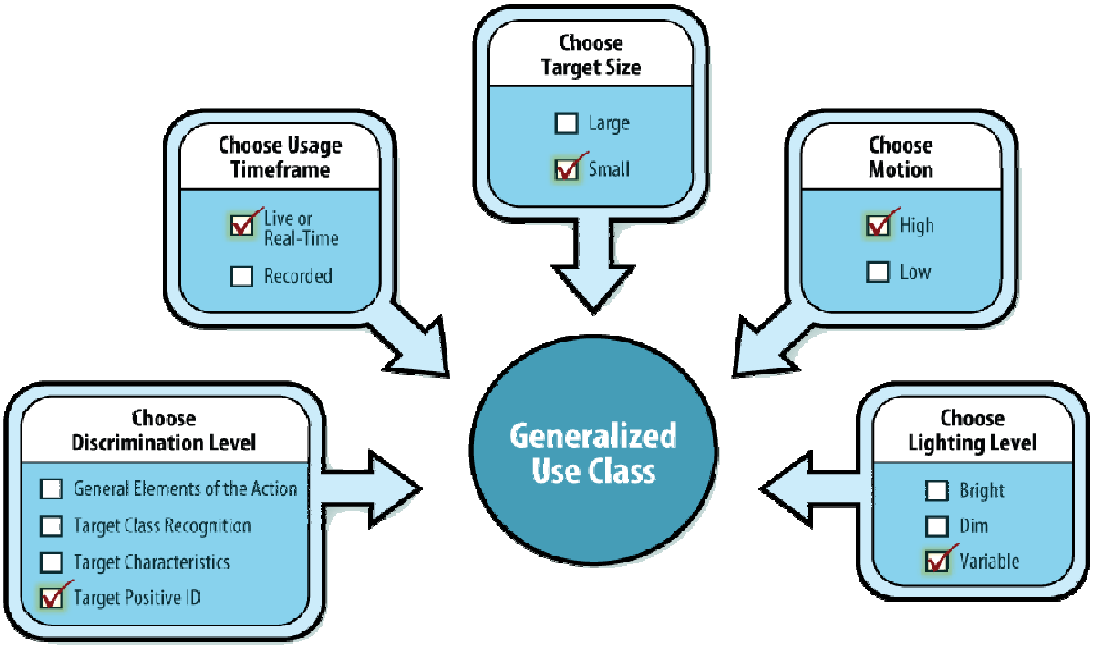

Figure 9. Application 1: Generalized Use Class

Application 2

Description: Video shot by a firefighter from a helicopter circling a building fire is used to recognize smoke features from small plumes (e.g., velocity or color) in real time. Command and control personnel on the ground use the video to determine the color and velocity of smoke plumes.

The target is a section of a small plume of smoke, and the motion sources are the target and camera. The lighting is variable.

Although Applications 1 and 2 demonstrate two different uses of video, the use cases belong to the same Generalized Use Class (Figure 9).

Application 3

Description: Stored surveillance footage is used as courtroom evidence to verify the number of people in a store aisle during an incident.

The end use of the store surveillance is to verify the number of people in the scene. The users are forensic analysts. The sequence of events deals with the people that walk through a store during a period of two minutes. The target is the number of people. The motion sources are the people at walking speed. The lighting is indoor lighting.

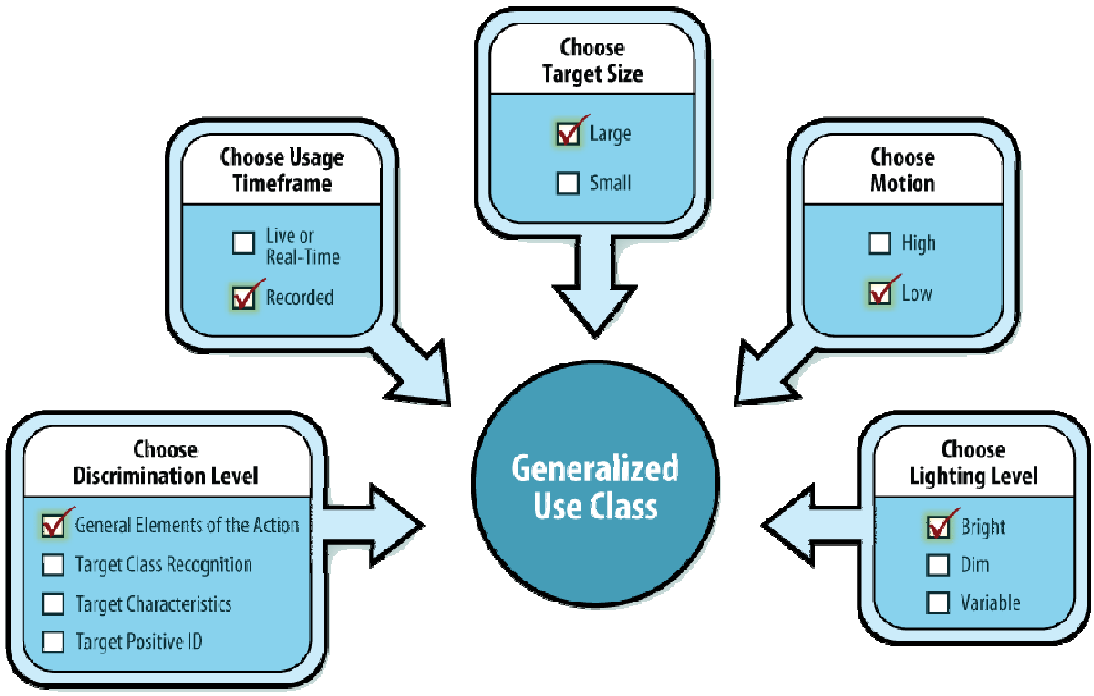

Figure 10. Application 3: Generalized Use Class

The use case in Application 3 belongs to a different Generalized Use Class, as shown in Figure 10.

IV. Core Video System Components

This section provides a summary of the fundamental components of a video system. These components, as shown in Figure 11, provide the foundation for any basic video system. Each component affects video quality (i.e., each component has the potential to alter the video in a way that impacts its ability to be used). The user can use the Generalized Use Class that he created based on the selections from Table I to identify performance specifications for the video system components in future guidance material. This section provides qualitative information that will help the reader develop qualitative requirements for system components. Future guidance material will provide detailed specifications and additional considerations.

The following sections provide a general description of the components and convey how each can affect video quality.

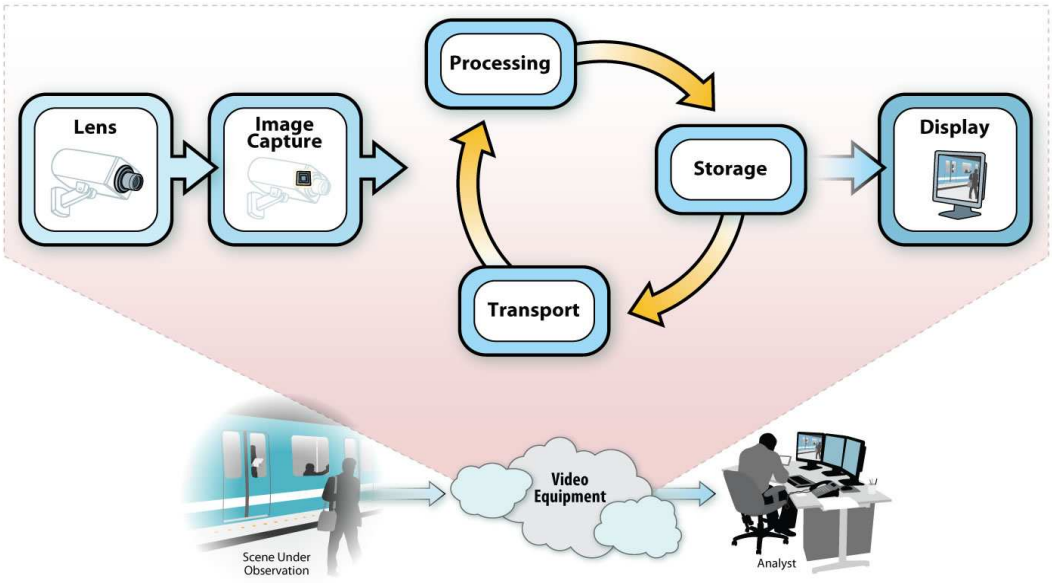

Figure 11. Core Video System Components

A. Lens Configuration

Description

The optical component of a camera system is a lens or series of lenses used to create an image on some sort of media, such as photographic film or electronic means. A lens can be a simple convex surface or composed of a number of optical elements in order to correct the many optical aberrations that arise. A lens may be permanently fixed to a camera or may be interchangeable with lenses of different focal lengths, apertures, and other properties.

Attributes that might affect video quality:

- **Lens Aberration** - Lenses do not form perfect images; there is always some degree of distortion or aberration introduced by the lens which causes the image to be an imperfect replica of the object.
- **Field of View*** - Extent of the observable world that is seen at any given moment through the lens.
- **Focal Length*** - Determines the field of view, and the apparent size of the objects relative to the image size.
- **Aperture*** - Relates to lens opening to reduce or increase light that reaches the image capture surface. Controls the brightness of the image and the fastest shutter speed usable.
- **Depth of Field*** - The range of distances that appear acceptably sharp in the image.

B. Image Capture

Image capture is the process of recording data, such as an image or video sequence.

Description

The Image Capture process consists of converting the information (i.e., light) from a real scene into a stream of information that is suitable for the remaining links, via a photographic or electronic medium.

In the case of modern video, the chain is modified slightly. The camera is in front of a scene and it has optics (usually just a lens, but it could be a night-vision system). The lens presents focused light to the internal workings of the camera—a projection of the information from the scene. The camera converts the projected information into a stream of electronic data that can support subsequent processing, storage, and viewing. For digital images, the capture process converts light into a digital form via a sensor and digitization.

Attributes that might affect video quality

- Resolution at which it captures
- Frame rate at which it captures
- Fidelity of the colors used
- Dynamic range of the recording medium
- Number of bits per pixel (digital cameras)
- Noise (analog cameras)
- Infrared capability of image capture system

C. Processing

Description

Processing refers to any enhancement, restoration, or other operation that is performed on a video signal. This could also refer to any processing that occurs automatically as part of a system; for example,

* *Term is defined in Appendix A: Glossary*

the processing performed inside a digital camera to convert an image into an image file format. The three main file formats for digital photographs are RAW, TIFF and JPEG.

Attributes that might affect video quality

- **Compression*** – Also referred to as coding, compression involves electronically processing a digital video picture so that it uses less storage and allows more video to be sent through a transmission channel. Most methods for compression result in a loss of fidelity that is not recoverable. Compression can be used to reduce the amount of bandwidth needed to transmit a video. A user must use a decoder to view a file that has been compressed (or encoded) or else the video cannot be viewed. There are open-source video encoder/decoders that exist on the market; however there are many proprietary systems that require their own specific decoder.
- **Digitization** - Converting an analog video source to a digital format.
- **Enhancement for analysis** - Many methods are available to increase clarity to certain parts of the video. Examples are frame averaging, edge enhancement, and color balancing.
- **Delay** – Video images can be delayed which can result in incomplete or inaccurate real-time decision-making.

D. Transport

Transport refers to the effects of moving or copying from one location to another.

Description

Transport and Network are terms that go hand-in-hand, depending on the Information Technology Engineer preference. This document will refer to it as transport. The transport can be wired (including fiber optics) or wireless, or any combination of these. The distance of the transport can range from a few feet within a building, to the other side of the world, or into outer space. The transport has unpredictable effects on the transmission of the electrical signal between two or more electronic devices.

Attributes that might affect video quality

- **Available bandwidth** - How much data a network is able to carry affects the speed and size of the video signal that is able to reach the destination.
- **Network sharing** - Other users on the network may reduce the available bandwidth.
- **Loss of data (digital)*** - When digital information is transmitted; it is broken into short blocks of data called packets. Packets are sent separately and then reassembled on the receiving end of the system. For many reasons some packets are lost in transmission, causing a loss of some pieces of the video picture.
- **Loss of data (analog)*** - Noise can interfere with an analog signal (e.g., "snow" on analog TV), permanently obscuring portions of the video field.
- **Delay** - Video images can be delayed which can result in incomplete or inaccurate real-time decision-making.

** Term is defined in Appendix A: Glossary*

E. Storage

Description

Video can be used for real-time (e.g., monitoring or tactical) applications or stored for future analysis. Improperly stored video may be unusable due to loss or degradation of data, for example improper storage of video would be a critical issue in evidentiary and forensic video applications. Video must be stored simultaneously at a high bit rate and low bit rate to prevent irretrievable data loss. For example, some systems may provide a low bit rate stream for wireless monitoring while simultaneously storing a higher bit rate version locally.

In order to decrease the bit rate, storage is also often preceded by some form of processing. File format can be altered to fit different media, such as coding the video in MPEG 2 for storage on a DVD and playback with a DVD player. A series of alterations or physical custody changes made to a video file is called the "storage chain." The storage chain should be monitored and documented very closely since almost every change in file format results in a loss of data.

Attributes that might affect video quality:

- Physical degrading of storage media over time (e.g., tapes stretching, breaking, or being exposed to magnetic fields)
- Physical custody of the media

F. Display

Description

To present a true quality picture of video footage captured, the emergency response community depends on a good quality image display unit to aid in accurately communicating information to the end users.

Emergency medical services increasingly use display in medical diagnosis, in firefighting for research and training, and in law enforcement for evidence in the courtroom. Selecting the proper display for the end user's specific video applications can be as important to achieving the user's goal for the video footage, as selecting the appropriate camera equipment.

Attributes that might affect video quality

- "Trueness" of the colors displayed
- Aspect ratio used

V. Qualitative Guidance

This section provides qualitative guidance for each aspect of the reader's use class that was determined in Section 3. This section makes general recommendations about how use characteristics and scene content affect component features. It educates readers on the issues involved, tradeoffs, and units of measure associated with the components. This section's organization mirrors the Questionnaire in Section 3.

A. Usage Timeframe

Usage timeframe answers the question: "In what timeframe will the video be used?" (i.e., will the video be used in real-time or will it be recorded?).

Capturing real-time video

Real-time surveillance requires integration of cameras and high-quality displays. In defining their needs, users should consider whether cameras will be used for recording video stream, even if the primary usage is in real-time (i.e. the recording could well have forensic or analytic uses down the line). High-resolution cameras require high storage demands because they record video stream and capture minute levels of detail.

If the real-time use of the video system involves analytics (using computer processing to aid in detection of objects, behaviors, or motion), the needs of those systems will dictate many aspects of the camera, lens, and mount. For example, will the video system be used for detection and alert purposes if people approach or loiter near critical infrastructure? Users must take into account factors such as how far away the infrastructure is, how large it is, and whether it is well lit.

Storing video

Videos can be stored for possible future analysis. Proper storage is critical in evidentiary and forensic video applications. For example, if video is stored only at a very low bit rate to save space on the storage media, then data will be irretrievably lost. Those accustomed to storing word-processing documents or digital photos might be shocked at how rapidly video files consume storage space, which can range from single video cassette recorders or a single hard drive, to systems with multiple cassette recorders or huge arrays. Depending on the frame rate, resolution, and compression of the video, a user may need to store terabytes of data. One clear implication of this: the rules for retention, both within an organization and the records-keeping laws in a particular jurisdiction, will affect the amount of storage needed.

Storage is also often proceeded by some form of processing, altering the file format to fit differing media, such as coding the video in MPEG 2 so that it can be stored on a DVD and played back with a DVD player. A series of alterations or physical custody changes made to a video file is called the "storage chain." Almost every change in file format results in a loss of data, so the storage chain should be monitored and documented very closely.

B. Discrimination Level

The discrimination level answers the following question: to what level of discrimination does the user need to recognize a target of interest?

High discrimination of detail for recognition, identification

For example, if the video will be used for positive identification, reading license plates, or detecting small objects, and not for simple motion detection (i.e., did a person cross a boundary?), look for the following features:

- **High-Resolution Camera** - Resolution is measured in mega pixels or lines. More megapixels or more lines offer a greater ability to capture detail. The tradeoff for this ability is the greater amount of data produced by these cameras can increase the need for bandwidth and storage.
- **Large-Imaging Sensor** - Sensor (or "imager") size is measured in fractions of inches. Large sensors, such as a 1/2-inch sensor, can capture more light than a 1/3-inch or 1/4-inch sensor.

If fidelity is especially important, users should pay attention to other aspects of the camera, such as the manner in which the camera is connected to viewing or storing systems, and the compression ratio of the video signal.

- The **lens*** should offer low distortion and high resolution.
- The **communications network*** needs to accurately transmit all signals. If digital, a high-bandwidth, reliable communications network may be needed. If analog, the communications network should have a good ratio of signal to noise.
- **Compression*** should be kept to a minimum, since a low compression level will result in lower image quality. The amount of storage available and the rules governing retention of the video can determine the amount of compression required.

C. Target Size

Target size refers to the size of the object of interest with respect to the field of view.

Capture small or distant objects

Cameras used to record small or distant objects should have**:**

- **Telephoto, Zoom*, or Varifocal lens** - The degree to which lenses bring distant objects closer or make objects appear farther away (but capture wide fields of view) is called the **focal length**.* Focal length is measured in mm. Lenses with longer focal lengths (called telephoto or "long lenses") are more telescopic and can make distant objects appear larger to the camera's sensor, so that images will be sharper. The drawback is that the longer the lens or the more it is zoomed in, the less **field of view*** the camera will capture. The advantage of a varifocal or zoom lens is that it can act as a wide angle lens and capture a wide scene, and also zoom in on small or distant objects. One tradeoff of long lenses is their susceptibility to capture less light, resulting in less functionality in dark environments. Furthermore, lenses that are telephoto and admit a large amount of light are usually large and expensive.
- **High-Resolution Camera** - Resolution is measured in mega pixels or lines. More megapixels or more lines offer a greater ability to capture detail. The tradeoff for this ability is the greater amount of data produced by these cameras can increase the need for bandwidth and storage.
- **Large-Imaging Sensor** - Sensor (or "imager") size is measured in fractions of inches. Large sensors, such as a 1/2-inch sensor, can capture more light than a 1/3-inch or 1/4-inch sensor.

* *Term is defined in Appendix A: Glossary*

If faithful capture or recognition of these small objects is especially important, users should pay attention to other aspects of the camera, such as the way the camera is connected to viewing or storing systems and the amount that the video signal is compressed:

- The **lens*** should offer low distortion and high resolution.
- The **communications network*** needs to accurately transmit all signals. If digital, a high-bandwidth, reliable communications network may be needed. If analog, the communications network should have a good ratio of signal to noise.
- **Compression*** should be kept to a minimum, since a low compression level will result in lower image quality. The amount of storage available and the rules governing retention of the video can determine the amount of compression required.

D. Motion

Motion refers to the motion in the scene of interest (e.g., background, target, or camera).

Camera or objects in motion

The ability for a video system to clearly capture moving objects, or to capture scenes if the camera is in motion, is determined by several factors. Systems are better suited for this situation if they have:

- **Fast Shutter Speed** - Shutter speed is the length of time that the camera sensor is exposed to the image it is capturing for each of the still-photos that comprise the video. If there's enough light to do so, it's better to have fast or "short" or "high" shutter speeds (measured in fractions of seconds) so that while each image is being recorded, the scene being recorded on the camera has less of a chance to move and thereby blur the image. One way to decrease the need for the environment to be bright is to use a wide-aperture lens.
- **Wide-Aperture lens** - The ability for lenses to admit more light is measured in f-stops; the smaller a lens' f-stop number, the more light is allowed to pass through the lens. The advantage of a smaller f-stop number is that when more light hits the sensor, the camera uses shorter shutter speeds and takes more pictures. However, this come at a price because lens' with small f-stop number require wide aperture lenses, and those lens' have difficulty keeping both near and distant parts of the scene in focus at the same time (a quality known as **depth-of-field***).
- **Wide-Angle Lens** - If the camera or object is moving, it's easier to keep the camera on the object if the lens is capturing a wider scene. This ability of a lens to capture a wide scene is a function of its "focal length," measured in millimeters, with smaller focal length lenses capturing wider scenes, but making them appear smaller or farther away.
- **Large Imaging Sensor** - Sensor size is measured in fractions of inches. The sensor is to digital cameras what film is to conventional cameras. Large sensors such as a 1/2-inch sensor can capture more light than a 1/3-inch or 1/4-inch sensor.

E. Lighting Level

Lighting level is an obvious aspect that impacts selection of video equipment and refers to light available to illuminate the scene of interest.

* *Term is defined in Appendix A: Glossary*

Low-Light Situations

The ability of video systems to work in low light is measured in their "lux" rating. Lux is a measure of the amount of light present; cameras that have a lower lux rating can work in darker environments.

As with high-motion applications (described in Section V. Qualitative Guidance, D. Motion) when selecting lenses for low-light applications, try to select those with larger apertures (lower f-stop number). The larger opening will transmit more light to the camera's sensor. This will give the added benefit of reducing motion-blur, since each image will be captured more quickly. In other words, users will be able to use faster "shutter speeds."

Camera considerations for very little or no light:

Black and White Camera: Most black and white cameras are better suited for low-light environments than most color cameras.

Day/Night Camera: This tradeoff may not be easy, but the increasing availability of "day/night" cameras designed for color during the day and black and white at night increases the number of options for wide-ranging lighting situations.

Infrared Camera: There are also cameras available that work in zero lux, or with no visible light. This is possible because these systems are sensitive to infrared light, and they use a form of infrared lighting that's not visible to the naked eye.

Changing-light situations

If the video system will be used in environments where the light can fluctuate from bright to dim, be sure to consider "auto-iris" lenses. These are lenses that automatically adjust their sensitivity in changing light situations so that the lighting level of the video appears as even and constant as possible.

VI. Ongoing VQiPS Efforts

OIC, the VQiPS WG, and PSCR are continuing their collaborative and complementary efforts to identify standards development guidance, video quality performance qualifications and other information that is important to those procuring video systems. OIC will continue to publicize the benefits of using this guidance document with local, state and Federal emergency responders to build ongoing support throughout the emergency response community. Future rewards of this continued outreach will be new stakeholder champions within the VQiPS community and adoption of standards by industry and standards development organizations.

OIC continues to participate in and provide support to the VQiPS WG to deliver future products, including compiling an inventory of existing standards and specifications that address various components of the video system core components for specific usage scenarios (or Generalized Use Classes). With this information, the emergency response community will be able to match particular needs to technical performance specifications and standards.

Funded by OIC, PSCR is working with industry and the emergency response community to develop a set of application-independent usage scenarios and conduct lab research to develop video quality performance qualifications. PSCR is developing performance specifications that will be made available to the emergency response community upon completion. For example, PSCR is developing a common library of test clips that represent the use cases.

This video clip library can be found at: http://www.cdvl.org/

Moreover, PSCR established a Web site as a focal point to communicate the progress of PSCR's video quality efforts. Please visit http://www.pscr.gov/projects/video_quality/video_about.php for additional information.

VII. Conclusion

Using the qualitative guidance contained within this document, readers will be better informed and able to understand features of video system components that have an impact on video systems. By generating one or more Generalized Use Classes, the emergency response community will be able to identify and represent a more accurate representation of their video quality needs. As a result, users will be able to more clearly describe video quality needs when procuring and evaluating components and systems that have a direct impact on video transmission, processing, and quality as experienced by the end user. Future efforts will leverage the results of this guide to address ongoing issues related to video quality.

Appendix A: Glossary

This glossary defines terms that are used in the document, *Defining Video Quality Requirements: A Guide for Public Safety*, and contains terminology and explanations of concepts relevant to the video industry. The purpose of the glossary is to inform the reader of commonly used vocabulary terms in the video domain. This glossary was compiled from various industry sources.

Term	Definition
A	
AGC	Automatic Gain Control A circuit for automatically controlling amplifier gain in order to maintain a constant output voltage with a varying input voltage within a predetermined range of input-to-output variation.
Aliasing	Something other than what it appears to be. Stair steps on what should be a smooth diagonal line are an example of spatial alias. Wagon wheels appearing to move backwards are an example of temporal alias. Aliases are cause by sampling and can be reduced or eliminated by pre-filtering, which can appear to be a blurring effect. Defects in the picture typically caused by insufficient sampling (violation of the Nyquist sampling rate) in the analog to digital conversion process or poor filtering of digital video. Defects are typically seen as jagged diagonal lines and twinkling or brightening in picture detail. Examples are: Temporal Aliasing - such as rotating wagon wheel spokes appearing to rotate in the reverse direction. Raster Scan Aliasing - such as sparkling or pulsing effects in sharp horizontal lines. Stair-Stepping - stepped or jagged edges in diagonal lines or the diagonal parts of a letter. (Tektronix Glossary of Video Terms)
Analog	A continuous electrical signal that carries information in the form of variable physical values, such as amplitude or frequency modulation. A signal which moves through a continuous range of settings or levels. An adjective describing any signal that varies continuously as opposed to a digital signal that contains discrete levels representing the binary digits 0 and 1. (Tektronix Glossary of Video Terms)
Analytics	The science of analysis. Arriving at an optimal or realistic decision based on existing data. In the video industry it is often used for analyzing video to detect and determine temporal events not based on single image. It has a wide range of application in safety and security to examine video for specific data, behavior, objects or attitude.
Aperture	The effective diameter of the lens that controls the amount of light reaching the photoconductive or photo emitting image pickup sensor.
Aperture Correction	Compensation for the loss in sharpness of detail because of the finite dimensions of the image elements or the dot-pitch of the monitor.
Artifact	A defect or distortion of the video image, introduced along the sequence from origination and image capture to final display. Artifacts may arise from the overload of channel capacity by excess signal bandwidth. Artifacts may also result from: sampling effects in temporal, spatial, or frequency domains; processing by the transfer functions; compromises and inadequacies in the system employed; cascading of minor defects; basically any other departure of the total system from “complete transparency” resulting in visual errors. (Tektronix Glossary of Video Terms)
Aspect Ratio	The ratio of width to height for the frame of the televised picture. 4:3 for standard systems,

Term	Definition
	5:4 for 1K x 1K, and 16:9 for HDTV.
Attenuation	In general terms, a reduction in signal strength.
Auto Balance	A system for detecting errors in color balance in white and black areas of the picture and automatically adjusting the white and black levels of both the red and blue signals as needed for correction.
Auto Light Range	The range of light, e.g., sunlight to moonlight, over which a TV camera is capable of automatically operating at specified output.
Automatic Brightness Control	In display devices, the self-acting mechanism which controls brightness of the device as a function of ambient light.
Automatic Frequency	An arrangement whereby the frequency of an oscillator is automatically maintained within specified limits.
Automatic Gain Control	See AGC.
Automatic Iris Lens	A lens that automatically adjusts the amount of light reaching the imager.
Automatic Light Control	The process by which the illumination incident upon the face of a pickup device is automatically adjusted as a function of scene brightness.
B	
Back Porch	That portion of the composite picture signal which lies between the trailing edge of the horizontal sync pulse and the trailing edge of the corresponding blanking pulse.
Bandwidth	The range of signal frequencies that a piece of audio or video equipment can encode or decode; the difference between the limiting frequencies of a continuous frequency band. Video uses higher frequency than audio, thus requires a wider bandwidth (High-Tech Production Glossary of Video Terms)
Bar Test Pattern (SMPTE)	Special test pattern for adjusting color TV receivers or color encoders. The upper portion consists of vertical bars of saturated colors and white. The power horizontal bars have black and white areas and I and Q signals.
Bit Depth	The number of levels that a pixel might have, such as 256 with an 8-bit depth or 1024 with a 10-bit depth. (Tektronix Glossary of Video Terms)
Bit Rate	The rate at which the compressed bit stream is delivered from the storage medium to the input of a decoder. The digital equivalent of analog bandwidth. The speed at which bits are transmitted, usually expressed in bit per second. Video information, in a digitized image for example, is transferred, recorded, and reproduced through the production process at some rate (bits/s) appropriate to the nature and capabilities of the origination, the channel, and the receptor. The amount of data transported in a given amount of time, usually defined in Mega (million) bits per second (Mbps). Bit rate is one means used to define the amount of compression used on a video signal. Uncompressed D1 has a bit rate of 270 Mbps. MPEG-1 has a bit rate of 1.2 Mbps. (Tektronix Glossary of Video Terms)
Blooming	This effect is sometimes called whiter-than-white. Blooming occurs when the white voltage level is exceeded and screen objects become fuzzy and large. The defocusing of regions of a picture where brightness is excessive. (Tektronix Glossary of Video Terms)
Bounce	Sudden variations in picture presentation (brightness, size, etc.,) independent of scene illumination.

Term	Definition
Brightness	The attribute of visual perception in accordance with which an area appear to emit more of less light. (Luminance is the recommended name for the photo-electric quantity which has also been called brightness.)
Broadband	In television system use, a device having a bandpass greater than the band of a single VHF television channel.
Burned-In-Image	Also called burn. An image which persists in a fixed position in the output signal of a camera tube after the camera has been turned to a different scene or, on a monitor screen.
C	
CCD	See Charge Coupled Device.
C Mount	The first standard for CCTV lens screw mounting. It is defined with the thread of 1'' (2.54 mm) in diameter and 32 threads/inch, and the back flange-to-CCD distance of 17.526 mm (0.69''). The C-mount description applies to both lenses and cameras. C-mount lenses can be put on both, C-mount and CS-mount cameras; only in the latter case an adaptor is required. (Tektronix Glossary of Video Terms)
CCTV	See Closed-Circuit Television.
Candela	A unit for measuring luminous intensity. One candela is approximately equal to the amount of light energy generated by an ordinary candle. Since 1948 a more precise definition of a candela has become: "the luminous intensity of a black body heated up to a temperature at which platinum converges from a liquid state to a solid". (Tektronix Glossary of Video Terms)
Charge-Coupled Device (CCD)	A semiconductor device that converts optical images to electronic signals. CCDs are the most commonly found type of image sensor in consumer camcorders and video cameras. Serial storage technology that uses MOS capacitors. A solid-state image sensor that converts light energy to electricity. (Tektronix Glossary of Video Terms)
Chroma	That quality of color which embraces both hue and saturation. White, black, and grays have no chroma.
Chroma Control	A control of color television receiver that regulates the saturation (vividness) of colors in a color picture.
Chroma Detector	Detects the absence of chrominance information in a color encoder input. The chroma detector automatically deletes the color burst from the color encoder output when the absence of chrominance is detected.
Chromatic Aberration	An optical defect of a lens which causes different colors or wave lengths of light to be focused at different distances from the lens. It is seen as color fringes or halos along edges and around every point in the image.
Chromaticity	The color quality of light which is defined by the wavelength (hue) and saturation. Chromaticity defines all the qualities of color except its brightness.
Chrominance	A color term defining the hue and saturation of a color. Chrominance does not refer to brightness.
Chrominance Signal	That portion of the NTSC color television signal which contains the color information.

Term	Definition
Clamp	A device which functions during the horizontal blanking or synchronizing interval to fix the level of the picture signal at some predetermined reference level at the beginning of each scanning line.
Clamping	The process that established a fixed level for the picture level at the beginning of each scanning line.
Clipping	An electronic limit usually imposed in cameras to avoid overly bright or dark signals. When improperly applied can result in loss of picture information in very bright or very dark areas; Also used in switchers to set the cutoff point for mixing video signals. The electronic process of shearing off the peaks of either the white or black excursions of a video signal for limiting purposes. Sometimes, clipping is performed prior to modulation, and sometimes to limit the signal, so it will not exceed a predetermined level. (Tektronix Glossary of Video Terms)
Closed-Circuit Television	Video primary used for surveillance and security that is not broadcast to the general public.
Coaxial Cable	A particular type of cable capable of passing a wide range of frequencies with very low signal loss. Such a cable in its simplest form consists of a hollow metallic shield with a single wire accurately placed along the center of the shield and isolated from the shield.
CODEC (Coding/Decoding)	The algorithm used to capture analog video or audio in digital form. Used to implement the physical combination of the coding and decoding circuits. A device for converting signals from analog to coded digital and then back again for use in digital transmission schemes. Most codecs employ proprietary coding algorithms for data compression. (Tektronix Glossary of Video Terms)
Color	Describes how close a color is to the mathematical representation of the color [that attempts to render what can be seen by the human eye]. (Tektronix Glossary of Video Terms)
Color Burst	That portion of the composite color signal, comprising a few cycles of a sine wave of chrominance subcarrier frequency, which is used to establish a reference for demodulating the chrominance signal; Normally approximately 9 cycles of 3.579545 MHz.
Color Edging	Extraneous colors appearing at the edges of colored objects, and differing from the true colors in the object.
Color Encoder	A device which produces an NTSC color signal from separate R, G, and B video inputs.
Color Fringing	Spurious colors introduced into the picture by the change in position of the televised object from field to field.
Color Purity	The degree to which a color is free of white or any other color. In reference to the operation of a tri-color picture tube it refers to the production of pure red, green or blue illumination of the phosphor dot face plate.
Color Saturation	The degree to which a color is free of white light.
Color Sync Signal	A signal used to establish and to maintain the same color relationships that are transmitted.
Color Transmission	The transmission of a signal which represents both the brightness values and the color values in a picture.

Term	Definition
Communications Network	The path over which all signals are transmitted.
Complementary Metal Oxide Semiconductor (CMOS)	A type of digital camera sensor.
Composite Video Signal	The combined picture signal, including vertical and horizontal blanking and synchronizing signals.
Compression	The process of electronically processing a digital video picture to make it use less storage or to allow more video to be sent down a transmission channel. The process of removing picture data to decrease the size of a video image. The reduction in the volume of data from any given process so that more data can be stored in a smaller space. There are a variety of compression schemes that can be applied to data of which MPEG-1 and MPEG-2 are called lossy since the data produced by compression is not totally recoverable. There are other compression schemes that are totally recoverable, but the degree of compression is much more limited. (Tektronix Glossary of Video Terms)
Contrast	The range of light to dark values in a picture or the ratio between the maximum and minimum brightness values.
Contrast Range	The ratio between the whitest and blackest portions of television image.
Convergence	The crossover of the three electron beams of a three-gun tri-color picture tube. This normally occurs at the plane of the aperture mask.
Core Components	Equipment in the video system that can change the video signal, thereby affecting the quality of the delivered video.
Crosstalk	An undesired signal from a different channel interfering with the desired signal.
D	
dB	Basically, a measure of the power ratio of two signals. In system use, a measure of the voltage ratio of two signals, provided they are measured across a common impedance.
Decibel (dB)	A measure of the power ratio of two signals. In system use, a measure of the voltage ratio of two signals provided they are measured across common impedance.
Decoder	Device used to recover the component signals from a composite (encoded) source. Decoders are used in displays and in various processing hardware where components signals are required from a composite source such as composite chroma keying or color correction equipment. Device that changes digital signals to analog, or reconstructs information (data) by performing the inverse (reverse) functions of an encode process. (Tektronix Glossary of Video Terms)
Definition	The aggregate of fine details available on-screen. The higher the definition of an image, the greater the number of details [that can be discerned by the human eye or displayed]. During video recording and subsequent playback, several factors can conspire to cause a loss of definition. Among these are the limited frequency response of magnetic tapes and signal losses associated with electronic circuitry employed in the recording process. These losses occur because fine details appear in the highest frequency region of a video signal and this portion is usually the first casualty of signal degradation. Each additional generation of a

Term	Definition
	videotape results in fewer and fewer fine details as losses are accumulated. (Tektronix Glossary of Video Terms)
Depth of Field	The in-focus range of a lens or optical system around an item of interest. It is measured from the distance behind an object of interest, to the distance in front of the object of interest, when the viewing lens is specifically focused on the object of interest. Depth of field depends on subject-to -camera distance, focal length of the lens, and f-stop.
Depth of Focus	The range of sensor-to-lens distance for which the image formed by the lens is clearly focused.
Digital imager	A fundamental component in every digital camera. The imager records the view received from the camera lens.
Digital Signal	An electronic signal where every different value from the real-life excitation (sound, light) has a different value of binary combinations (words) that represent the analog signal (Tektronix Glossary of Video Terms). An analog signal that has been converted to a digital form (High-Tech Productions Glossary of Video Terms)
Digital Signal Processing (DSP)	When applied to video cameras, DSP means that the analog signal from the CCD sensors is converted to a digital signal. It is then processed for signal separation, bandwidth settings and signal adjustments. After processing, the video signal either remains in the digital domain for recording by a digital video recorder (DVR) or is converted back into an analog signal for recording or transmission. DSP is also used in other parts of the video chain, including DVRs, and switching and routing devices. (Tektronix Glossary of Video Terms)
Discrimination Level (also known as level of discrimination)	Qualitatively: Capacity for seeing distinctly fine details that have a very small angular separation. Quantitatively: Any of a number of measures of spatial visual resolution such as the reciprocal of the value of the angular separation in minutes of arc of two neighboring objects (points or lines or other specified stimuli) which the observer can just perceive to be separate. (Tektronix Glossary of Video Terms)
Display	The ultimate image presented to a viewer; the process of presenting that image. CRT, LCD, LED or other photo luminescent panel upon which numbers, characters, graphics or other data is presented. (Tektronix Glossary of Video Terms)
Distortion	The deviation of the received signal waveform from that of the original transmitted waveform.
Distribution Amplifier	A device that provides several isolated outputs from one looping or bridging input, and has a sufficiently high input impedance and input-to-output isolation to prevent loading of the input source.
Dynamic Range	The difference between the maximum acceptable signal level and the minimum acceptable signal level.
E	
EIA Sync	The signal used for the synchronizing of scanning specified in EIA Standards RS-170, RS-330, RS-343, or subsequent issues.

Term	Definition
Equalizer	An electronic circuit that introduces compensation for frequency discriminative effects of elements within the television system, particularly long coaxial transmission systems.
F	
Fiber Optics (use of light transmitted through fibers)	The technology of transferring information, e.g. in communications or computer technology, through thin flexible glass or plastic tubes optical fibers using modulated light waves. (Encarta World English Dictionary)
Fidelity: precision of reproduction	the extent to which an electronic device such as a stereo system or television accurately reproduces sound or images
Field	In interlaced scan systems, the information for one picture is divided up into two fields. Each field contains one-half of the lines required to produce the entire picture. Adjacent lines in the picture are in alternate fields. Half of the horizontal lines (262.5 in NTSC and 312.5 in PAL) needed to create a complete picture. One complete vertical scan of an image. In a progressive scanning system, all of the scanning lines comprising a frame also comprise a field. An area in a window in which you can type text. A television picture is produced by scanning the TV screen with an electron beam. One complete scan of the screen is called a field. Two fields are required to make a complete picture, which is called a frame. The duration of a field is approximately 1/60 of a second in NTSC and 1/50 or 1/60 of a second in PAL. f) One half of a complete interlaced video picture (frame), containing all the odd or even scanning lines of the picture. (Tektronic glossary)
Field of View	The maximum angle of view that can be seen through a lens.
Focal Length	(Of a lens) the distance from the focal point to the principal point of the lens. The focal length is usually measured in millimeters of the lens. Focal length is an indication of the lens capability to capture a wide angle of view or a narrow view of objects that are far away (telephoto).
Focal Plane	A plane (through the focal point) at right angles to the principal point of the lens.
Focal Point	The point at which a lens or mirror will focus parallel incident radiation.
Footcandle	See lumen/ft 2.
Footlambert (FL)	A unit of luminance equal to 1/candela per square foot or to the uniform luminance at a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot. A lumen per square foot is a unit of incident light and a footlambert is a unit of emitted or reflected light. For a perfectly reflecting and perfectly diffusing surface, the number of lumens per square foot is equal to the number of footlamberts.
Frame	The total area, occupied by the television picture, which is scanned while the picture signal is not blanked. A frame consists of all the information required for a complete picture. For interlaced scan systems, there are two fields in a frame. For progressive video, these lines contain samples starting from one time instant and continuing through successive lines to the bottom of the

Term	Definition
	frame. A complete picture composed of two fields. In the NTSC system, 525 interlaced horizontal lines of picture information in 29.97 frames per second. In the PAL system, 625 interlaced horizontal lines of picture information in 25 frames per second. One complete video image containing two fields. There are 30 frames in one second of NTSC video.
Frame Rate, also known as Frame Frequency	The rate at which frames of video data are scanned on the screen. In an NTSC system, the frame rate is 29.97 frames per second. For PAL, the frame rate is 25 frames per second. The number of frames per second at which a video clip is displayed. The rate at which frames are output from a video decoding device or stored in memory. (Tektonix Glossary)
Frame Transfer	A CCD imager where an entire matrix of pixels is read into storage before being output from the camera. Differs from Interline Transfer where lines of pixels are output
Frequency Interlace	The method by which color and black and white sideband signals are interwoven within the same channel bandwidth.
Frequency Response	The range of frequencies that a piece of equipment can process and is directly related to the system's ability to uniformly transfer signal components of different frequencies over the entire video spectrum without affecting their amplitudes. This parameter is also known as gain/frequency distortion or amplitude versus frequency response. The amplitude variation maybe expressed in dB, percent or IRE.
Front Porch	The portion of a composite picture signal which lies between the leading edge of the horizontal blanking pulse and the leading edge of the corresponding sync pulse.
F-Stop	(Also known as F Number F System) the speed or ability of a lens to pass light. It is calculated by dividing the focal length of the lens by its diameter. The F-Stop also is a factor in more areas of focus in the image known as Depth of Field.
G	
Gain	An increase in voltage or power, usually expressed in dB.
Gamma	A numerical value, or the degree of contrast in a video picture, which is the exponent of that power law which is used to approximate the curve of output magnitude versus input magnitude over the region of interest. Since picture monitors have a nonlinear relationship between the input voltage and brightness, the signal must be correspondingly pre distorted. Gamma correction is always done at the source (camera). (Tektronix Glossary)
Gamma Correction	To provide for a linear transfer characteristic from input to output device.
Genlock	A device used to lock the frequency of an internal sync generator to an external source.
Ghost	A spurious image resulting from an echo.
Gray Scale	Variations in value from white, through shades of gray, to black on a display.
H	
High Definition Television (HDTV)	General term for proposed standards pertaining to consumer high-resolution TV. A TV format capable of displaying on a wider screen (16 x 9) as opposed to the conventional 4 x 3)

Term	Definition
	and at higher resolution. Rather than a single HDTV standard the FCC has approved several different standards, allowing broadcasters to choose which to use. This means new TV sets will have to support all of them. All of the systems will be broadcast as component digital. By HDTV, we normally understand transmission, rendering and display systems that feature about double the number of scanning lines, improved color quality, and less artifacts than that of today's composite systems. (Tektronix glossary)
Hue	Corresponds to colors such as red, blue, etcetera. A color wheel contains basic pigments. All the hues of the rainbow encircle the cone's perimeter. The wavelength of the color which allows color to be distinguished such as red, blue and green. Often used synonymously with the term tint. It is the dominant wavelength which distinguishes a color such as red, yellow, etc. Most commonly, video hue is influenced by: a camera's white balance or scene lighting. Video color processors, such as the Video Equalizer, are the main tools used to adjust and correct hue problems.
Hue, Saturation and Intensity (HSI)	Color space system based on the values of Hue, Saturation and Intensity. Intensity, analogous to luma, is the vertical axis of the polar system. The hue is the angle and the saturation is the distance out from the axis. (Tektronix Glossary)
Hue, Saturation and Lightness (HSL)	Nearly identical to HSI except Intensity is called Lightness. Both serve the same function. (Tektronix Glossary)
Hue, Saturation and Value (HSV)	Nearly identical to HSI and HSL except Intensity and Lightness are called Value. All three serve the same function. (Tektronix Glossary)
Hum	Electrical disturbance at the power supply frequency or harmonics thereof.
I	
Image	A bit stream duplicate of the original data. (SWGIT/SWGDE) An imitation or representation of a person or thing, drawn, painted, photographed, etc.
Image Intensifier	A device that intensifies low light-level images to light levels that can be seen with the human eye or can be detected by a video camera. (Lambert Instruments)
Image Plane	The plane in which an image produced by an optical system is formed; if the object plane is perpendicular to the optical axis, the image plane will ordinarily also be perpendicular to the axis.
Impedance (input or output)	The total of the resistance, measured in ohms, that a circuit presents to the flow of alternating current at a given frequency. The characteristics of a system component that determines the type of transmission cable to be used. The cable used must have the same characteristic impedance as the component. Video distribution has standardized on 75-ohm coaxial and 124-ohm balanced cable. (Columbia University)
Incident Light	The direct light that falls on an object.
Insertion Loss	The signal strength loss when a piece of equipment is inserted into a line.
Interference	Disturbance to the normal or expected operation electronic devices, equipment and systems. The inhibition or prevention of clear reception of broadcast signals. (McGraw Hill Sci-Tech Dictionary)

Term	Definition
Interline Transfer	A technology of Charged-Coupled Device (CCD) design, where rows of pixels are output from the camera. The sensor's active pixel area and storage register are both contained within the active image area. This differs from "frame transfer" cameras that move all active pixels to a storage register outside of the active area.
Interlaced Scanning	A technique of combining two television fields in order to produce a full frame. The two fields are composed of only odd and only even lines, which are displayed one after the other but with the physical position of all the lines interleaving each other, hence interlace. (SWGIT/SWGDE)
Iris	An adjustable aperture built into a camera lens to permit control of light transmission through the lens. (Glossary of photographic terms)
Isolation Amplifier	An amplifier with input circuitry and output circuitry designed to eliminate the effects of changes made at either upon the other. They provide electrical isolation and a safety barrier.
J	
Jitter	Small, rapid variations in a waveform due to mechanical disturbances or to changes in the characteristic of components. Supply voltages, imperfect synchronizing signals, circuits, frequency pulses, etc.
L	
Lens	One or more pieces of curved optical glass or similar material designed to form an image of an object by converging or diverging rays of light from the object. (Britannica Concise Encyclopedia)
Lens Preset Positioning	Follower Pots are installed on lens that allows feedback to the controller information relevant to zoom and focus positioning allowing the controller to quickly adjust to a preselected scene and arrive in focus at the proper focal length automatically.
Lens Speed	The ability of a lens to transmit light, represented as the ratio of the focal length to the diameter of the lens. The largest lens opening (smallest f-number) at which the lens can be set. A fast lens transmits more light and has a larger opening than a slow lens. (Glossary of photographic terms)
Light	Electromagnetic radiation that has a wavelength in the range from about 400 to 750 nanometers (nm) and may be perceived by the normal unaided human eye. (McGraw Hill Sci-Tech Dictionary)
Line Amplifier	An amplifier for audio or video signals that in installed in the transmission line to boost the signal as it travels over certain distances; also called program amplifier.
Loop Through	(Also known as looping. The method of feeding a series of high impedance circuits (such as multiple monitor/displays in parallel) from a pulse or video source with a coax transmission line in such a manner that the line is bridged (with minimum length stubs) and that the last unit properly terminates the line in its characteristic impedance. This minimizes discontinuities or reflections on the transmission line.
Loss	The ratio of the power at one point in a transmission system to the power at a point farther along the line; usually expressed in decibels. The actual power that is lost in transmitting signal from one point to another through a medium or along a line. (McGraw Hill Sci-Tech Dictionary)
Low-Frequency Distortion	An undesired change in a waveform or signals which occur at low frequencies. In television, generally considered as any frequency below the 15.75-kHz line frequency.

Term	Definition
Lumen (LM)	A unit of measurement of the amount of brightness that comes from a light source. Lumens define "luminous flux," which is energy within the range of frequencies we perceive as light. (Computer Desktop Encyclopedia)
Lumen/FT2	A unit of incident light. It is the illumination on a surface one square foot in area on which a flux of one lumen is uniformly distributed, or the illumination at a surface all points of which are at a distance of one foot from a uniform source of one candela.
Luminance	(Photometric Brightness) Luminous intensity of any surface in a given direction per unit of projected area of the surface viewed from that direction. The amount of brightness, measured in lumens that is given off by a pixel or area on a screen. (McGraw Hill Sci-Tech Dictionary, Computer Desktop Encyclopedia)
Luminance Signal	(Y signal) That portion of the NTSC color television signal which contains the luminance or brightness information.
Lux	International System (SI) unit of illumination, equal to one lumen per square meter. Lux is a measurement in light intensity.
M	
Matrix Switcher	A combination or array of electromechanical or electronic switches which route a number of signal sources to one or more designations.
Mega Pixel	The term "Pixel" comes from the phrase "Picture element." One mega pixel is equal to 1,000 pixels. For the most part, the larger number of pixels the better the quality of the picture.
Modulation	The process, or results of the process, whereby some characteristic of one signal is varied in accordance with another signal. The modulated signal is called the carrier. The carrier may be modulated in three fundamental ways: by varying the amplitude, called amplitude modulation; by varying the frequency, called frequency modulation; by varying the phase, called phase modulation.
Monitor	(display) A device that accepts video signals from a computer or video camera and displays information on a screen; a video display.
Monochrome	Black and white with all shades of gray.
Monochrome Signal	In monochrome television, a signal wave for controlling the brightness values in the picture. In color television, that part of the signal wave which has major control of the brightness values of the picture, whether displayed in color or in monochrome.
Monochrome Transmission	The transmission of a signal wave which represents the brightness values in the picture, but not the color (chrominance) values.
Motion Picture Expert Group (MPEG)	A group of standards for encoding and compressing audiovisual information such as movies, video, and music. MPEG compression is as high as 200:1 for low-motion video of VHS quality, and broadcast quality can be achieved at 6 Mbps. Audio is supported at rates from 32 kbps to 384 kbps for up to two stereo channels.
N	
National Television Systems Committee (NTSC)	Abbreviation for National Television Systems Committee. A committee that worked with the Federal Communications Commission in formulating standards for the present day United States color television system.

Term	Definition
ND Filter	A filter that attenuates light evenly over the visible light spectrum. It reduces the light entering a lens, thus forcing the iris to open to its maximum.
Noise	The word "noise" originated in audio practice and refers to random spurts of electrical energy or interference. In some cases, it will produce a "salt-and-pepper" pattern over the televised picture. Heavy noise is sometimes referred to as "snow".
Non-Composite Video	A video signal containing all information except sync.
NTSC	Abbreviation for National Television Systems Committee. A committee that worked with the FCC in formulating standards for the present day United States color television system.
O	
Output	The signal level at the output of an amplifier or other device.
P	
Packet	One unit of binary data capable of being routed through a computer network. To improve communication performance and reliability, each message sent between two network devices is often subdivided into packets by the underlying hardware and software.
Pan and Tilt	A device upon which a camera can be mounted that allows movement in both the azimuth (pan) and in the vertical plane (tilt).
Pan/Tilt Preset Positioning	Follower pots are installed on pan/tilt unit to allow feedback to the controller and provides information relevant to horizontal and vertical positioning, allowing the controller to quickly adjust to a pre-selected scene automatically.
Patch Panel	A panel where circuits are terminated and facilities provided for interconnecting between circuits by means of jacks and plugs.
Peak Pulse Amplitude	The maximum absolute peak value of a pulse, excluding those portions considered to be unwanted, such as spikes.
Peak-to-Peak	The amplitude (voltage) difference between the most positive and the most negative excursions (peaks) of an electrical signal. A full video signal measures one volt peak to peak.
Picture Element	See Pixel
Pixel	Short for Picture Element. The most basic unit of an image displayed on a computer or video display screen. Pixels are generally arranged in rows and columns; a given combination among the pixels of various brightness and color values forms an image.
Primary Colors	Three colors wherein no mixture of any two can produce the third. In color television these are the additive primary colors red, blue and green.
Processed Image	Any image that has undergone enhancement, restoration or other operation.
Progressive Scan	Display scan pattern where each line of the frame is scanned sequentially.
R	
Raw Image Format	A camera raw image file contains minimally processed data from the image sensor of a digital camera, image or motion picture film scanner. Raw files are so named because they are not yet processed and therefore are not ready to be printed or edited with a bitmap

Term	Definition
	graphics editor. Normally, the image is processed by a raw converter in a wide-gamut internal colorspace where precise adjustments can be made before conversion to a "positive" file format such as TIFF or JPEG for storage, printing, or further manipulation, which often encodes the image in a device-dependent colorspace.
Real Time	Of or relating to systems that update information at the same rate as they receive data, enabling them to direct or control a process such as video recording and display. Sometimes referred to as live or real life timing of events.
Recognition	The determination by any means of the individuality of persons, or of objects such as aircraft or cars. 2. The determination that an object is similar within a category of something already known; e.g., car, truck, man.
Resolution	The act, process, or capability of distinguishing between two separate but adjacent parts or stimuli, such as elements of detail in an image, or similar colors. (the Encyclopedia of Photography, 3rd Edition)
Resolution (horizontal)	The amount of resolvable detail in the horizontal direction in a picture. It is usually expressed as the number of distinct vertical lines, alternately black and white, which can be seen in a distance equal to picture height.
Resolution, Limiting	The details that can be distinguished on the television screen. Vertical resolution refers to the number of horizontal black and white lines that can be resolved in the picture height. Horizontal resolution refers to the black and white lines resolved in a dimension equal to the vertical height and may be limited by the video amplifier bandwidth.
Resolution (vertical)	The amount of resolvable detail in the vertical direction in a picture. It is usually expressed as the number of distinct horizontal lines, alternately black and white, which can theoretically be seen in a picture.
Retained Image	Also called image burn. A change produced in or on the target which remains for a large number of frames after the removal of a previously stationary light image and which yields a spurious electrical signal corresponding to that light image.
RF (Radio Frequency)	Frequency at which coherent electromagnetic radiation of energy is useful for communication purposes. Also, the entire range of such frequencies.
Ripple	Amplitude variations in the output voltage of a power supply caused by insufficient filtering.
Roll	A loss of vertical synchronization which causes the picture to move up or down on a receiver or monitor.
S	
Saturation	In color, the degree to which a color is diluted with white light or is pure. The vividness of a color, described by such terms as bright, deep, pastel, pale, etc. Saturation is directly related to the amplitude of the chrominance signal.
Scanning	The process of moving the electron beam of a pickup tube or a picture tube across the target or screen area of a tube.
Sensitivity	In television, a factor expressing the incident illumination upon a specified scene required to produce a specified picture signal at the output terminals of a television camera.
Shutter	Ability to control the integration (of light) time to the sensor to less than 1/60 second; e.g: stop motion of moving traffic.

Term	Definition
Signal-to-Noise Ratio	The ratio between useful television signal and disturbing noise or snow.
Society of Motion Picture and Television Engineers (SMPTE)	A global organization, based in the United States, which, among other things, sets standards for baseband visual communications. This includes film as well as video standards.
Snow	Heavy random noise.
Spike	A transient of short duration, comprising part of a pulse, during which the amplitude considerably exceeds the average amplitude of the pulse.
Standard Minimum Signal	1000 microvolts at 75 ohms (0dB mV) in RF systems; 0.7-VPP non-composite, 1-VPP composite in video systems.
Streaming	A low-bit-rate encoding format intended for use over networks and the Internet. Streaming files match the encoded bit rate to the connection speed of the user, so the remote viewer can play audio or video with minimal stoppage without first downloading the entire video file.
Sync	A contraction of "synchronous" or "synchronize".
Sync Generator	A device for generating a synchronizing signal.
Sync Level	The level of the peaks of the synchronizing signal.
Sync Signal	The signal employed for the synchronizing of scanning.
Synchronize	To keep two sequences playing at the same rate (in sync). A slide show or a series of video clips can be synced to the beat on an audio track. A talking-head video needs to maintain lip-sync, so that the audio matches the mouth movements of the speaker.
Synchronizing	Maintaining two or more scanning processes in phase.
T	
Tearing	A term used to describe a picture condition in which groups of horizontal lines are displaced in an irregular manner.
Test Pattern	A chart especially prepared for checking overall performance of a television system. It contains various combinations of lines and geometric shapes. The camera is focused on the chart, and the pattern is viewed at the monitor for fidelity.
Time Lapse Video Recording	The process by which images are recorded at less than the standard rate of frames per second (NTSC - 29.97; PAL - 25.00) thus extending the period of time that can be covered by the storage medium. (SWGIT/SWGDE)
Transcode	To convert from one compression format to another (that is, from DV video from a camcorder to MPEG-2 for DVD). Preferably done intelligently to minimize loss of quality from repeated compression, and not requiring fully decompressing the input and then recompressing to the output.
Transients	Signals which exist for a brief period of time prior to the attainment of a steady-state condition. These may include overshoots, damped sinusoidal waves, etc.
U	

Term	Definition
Use Case	In software and systems engineering, a “use case” is a description of a system’s behavior in response to external stimuli. This technique is used to develop functional requirements by specifying the system’s behavior through scenarios. This concept can be expanded to apply to video systems that are used to perform specific tasks. A use case is a combination of the scene being observed and the task being performed by an end user (or analyst).
V	
Variable Bit Rate (VBR)	A compression scheme in which each unit of input material can be compressed to different sizes. For MPEG-2 video, for example, this means that "easier" sequences (that is, with no motion) can compress to very small sizes, whereas "hard" sequences (with lots of motion and scene cuts) can compress to much larger sizes. VBR compression can take better advantage of the overall available bandwidth of a video transmission or DVD player by allocating the available bits intelligently to the difficult parts of a sequence
Video Electronic Standards Association (VESA)	VESA’s mission is to promote and develop timely, relevant, open display and display interface standards, ensuring interoperability, and encouraging innovation and market growth. Its vision is to be one of the leading, worldwide standards organizations and internationally recognized voices in the video electronics industry.
Video	The electronic representation of a sequence of images, depicting either stationary or moving scenes. It may include audio.
Video Amplifier	A wideband amplifier used for passing picture signals.
Video Band	The frequency band width utilized to transmit a composite video signal.
Video Distribution Amplifier	A device used to divide single video signals, while boosting their strength for delivery to multiple video devices.
Video Quality	The ability of the emergency response agency to utilize the required video to perform the purpose intended. For example if the purpose of the video is to capture license plates on vehicles, in a range of outdoor conditions video quality is measured in the ability of the video outputs to provide that specific information across a range of environmental conditions.
Video Signal (Non-Composite)	The picture signal. A signal containing visual information and horizontal and vertical blanking (see also Composite Video Signal) but not sync.
Y	
Y Signal	A signal transmitted in color television containing brightness information. This signal produces a black and white picture on a standard monochrome receiver. In a color picture it supplies fine detail and brightness information.
Z	
Zoom	To enlarge or reduce, on a continuously variable basis, the size of a televised image primarily by varying lens focal length.
Zoom Lens	An optical system of continuously variable focal length, the focal plane remaining in a fixed position.

Appendix B: Acronyms

Acronym	Phrase
DHS	Department of Homeland Security
MPEG	Motion Picture Expert Group
NTSC	National Television Systems Committee
OIC	Office for Interoperability and Compatibility
PSCR	Public Safety Communications Research
SMPTE	Society of Motion Picture and Television Engineers
VESA	Video Electronic Standards Association
VQiPS	Video Quality in Public Safety

Appendix C: Acknowledgements

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Organization
National Institute of Standards and Technology
Naval Surface Warfare Center Panama City Division
Indiana Forensic Institute
Johns Hopkins University, Applied Physics Laboratory
Public Safety Communications Research Project
International Association of Chiefs of Police
Deloitte
Public Safety Communications Research Program
Georgia Technology Authority
Scientific Working Group on Imaging Technology
Office for Interoperability and Compatibility, U.S. Department of Homeland Security
Wolf Technical Services
National Association of State EMS Officials
System Development Integration Enterprises, LLC
Naval Surface Warfare Center Panama City Division
Los Angeles County Sheriff's Department
Transportation Security Administration, U.S. Department of Homeland Security
Public Safety Communications Research Project
Security Industry Association
Kiamichi Technology Centers (EMS Training)
City of Boise, Fire Department
Pittsboro Fire Department
Security Industry Association
System Development Integration Enterprises, LLC